Science
(dollars in thousands)

FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request
$7,026,000	$7,026,000	$7,799,211

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 (U.S.). 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 2021 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/Science-Features/Science-Highlights.

Highlights and Major Changes in the FY 2023 Request

The FY 2023 Request for SC is $7,799.2 million, an increase of 11.0 percent above the FY 2021 Enacted level, to implement the Administration's objectives 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 2023 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 accelerator and energy technologies.

The Request increases investments in Administration priorities including basic research on climate change and clean energy, artificial intelligence (AI) and machine learning (ML), and biopreparedness. SC's Reaching a New Energy Sciences Workforce (RENEW) initiative doubles to expand targeted efforts to increase participation and retention of individuals from underrepresented groups in SC research activities. SC initiates three new research initiatives to include SC Energy Earthshots; Funding for Accelerated, Inclusive Research (FAIR); and Accelerate Innovations in Emerging Technologies (Accelerate). The Request also supports ongoing investments in priority areas including microelectronics, critical materials, quantum information science (QIS), exascale computing, fundamental science to transform manufacturing, and accelerator science and technology. These initiatives position SC to address new research opportunities through more collaborative, cross-program efforts.

In FY 2023, SC requests funding for three new research initiatives:

- SC Energy Earthshots: The SC Energy Earthshots initiative will support both small group awards and larger center awards through the Energy Earthshot Research Centers (EERCs). EERCs will bring together multi-investigator, multi-disciplinary teams to address key research challenges at the interface between basic research and applied research and development activities. EERCs will entail collaboration within each team awards involving academic, national laboratory, and industrial researchers by SC and DOE energy technology offices, establishing a new era of cross-office research cooperation.
- Funding for Accelerated, Inclusive Research (FAIR): The FAIR initiative will provide focused investment on enhancing research on clean energy, climate, and related topics at Minority Serving Institutions (MSIs), including attention to underserved and environmental justice regions. The activities will improve the capability of MSIs to perform and propose competitive research and will build beneficial relationships between MSIs and DOE national laboratories and facilities.
- Accelerate Innovations in Emerging Technologies (Accelerate): The Accelerate initiative will support scientific research to accelerate the transition of science advances to energy technologies. The goal is to drive scientific discovery to sustainable production of new technologies across the innovation continuum, to provide experiences in working across this continuum for the workforce needed for industries of the future, and to meet the nation's needs for abundant clean energy, a sustainable environment, and national security.

The Request supports SC's basic research portfolio, which includes extramural grants and contracts supporting nearly 29,000 researchers located at over 300 institutions and the 17 DOE national laboratories, spanning all fifty states and the District of Columbia. In FY 2023, SC's suite of 28 scientific user facilities will continue to provide unmatched tools and capabilities for nearly 34,000 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 also continues to update its business processes for awards management and research related activities to advance diversity, equity, and inclusion in its extramural research programs. SC allocates Working Capital Fund charges for common administrative services to the research programs and the Program Direction account.

SC supports the following FY 2023 Research Initiatives.

(dollars in thousands)

	FY 2021 Enacted	FY 2022 Annualized CR	FY 2023 Request	FY 2023 Request vs FY 2021 Enacted
Office of Science				
Fundamental Science to Transform Advanced Manufacturing	–	–	27,000	27,000
Biopreparedness Research Virtual Environment (BRaVE)	–	–	51,756	51,756
Accelerator Science and Technology Initiative	11,411	11,411	28,872	17,461
Microelectronics	30,182	30,183	47,701	17,519
Quantum Information Science	270,391	276,464	293,426	23,035
Integrated Computational & Data Infrastructure	11,974	14,321	–	-11,974
Critical Materials/Minerals	17,000	17,000	25,000	8,000
Revolutionizing Polymers Upcycling	14,500	14,500	14,500	–
Artificial Intelligence and Machine Learning	124,354	126,308	169,000	44,646
Exascale Computing	479,945	445,000	268,000	-211,945
Reaching a New Energy Sciences Workforce (RENEW)	–	–	60,000	60,000
Advanced Computing	–	–	37,661	37,661
Funding for Accelerated, Inclusive Research (FAIR)	–	–	35,508	35,508
Accelerate Innovations in Emerging Technologies	–	–	40,051	40,051
National Virtual Climate Laboratory (NVCL)	–	–	3,000	3,000
Climate Resilience Centers	–	–	5,000	5,000
Urban Integrated Field Laboratory	–	–	22,000	22,000
SC Energy Earthshots	–	–	204,250	204,250
Total, Research Initiatives	**959,757**	**935,187**	**1,332,725**	**+372,968**

Note:

- *The Integrated Computational and Data Initiative is rolled into Advanced Computing Initiative in FY 2023.*

Highlights of the FY 2023 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 U.S. The ASCR Request of $1,068.7 million, is an increase of $53.7 million, or 5.3 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 includes $227.0 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 $150.0 million of this effort will go to the Argonne Leadership Computing Facilities to continue deployment of the exascale systems and support for early science users and Exascale Computing Project (ECP) project teams. To ensure progress during and after ECP, the Request increases support for basic research in applied math and computer science, as well as the Scientific Discovery through Advanced Computing (SciDAC) institutes, while transitioning research and development efforts from ECP. The Request supports new activities to support the FAIR initiative to expand clean energy research and capabilities at MSIs; the Accelerate initiative to support fundamental research that accelerates the transition of science to technologies; and the SC Energy Earthshots initiative, including the establishment of new Energy Earthshot Research Centers. ASCR's Applied Mathematics and Computer Science programs will develop new scalable energy efficient algorithms and software. The Request also supports additional SciDAC partnerships with the Department's Applied Energy programs, NIH, and other agencies, to improve emergency response as well as investments to broaden and use the foundation of AI. Investments in QIS testbeds, Centers, and networking are maintained. Efforts under the advanced computing infrastructure that enables data-driven science are expanded to address increasing demand from upgrades at Office of Science user facilities. The Request also continues 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 advanced computing infrastructure. The Request also provides robust support for ASCR user facilities operations to ensure the availability of high-performance computing and networking to the scientific community as well as upgrades to maintain U.S. leadership in these essential areas. This includes planning for an upgrade to the National Energy Research Scientific Computing Center (NERSC). To increase participation and retention of underrepresented groups in areas relevant to ASCR, the Request continues support for the Computational Science Graduate Fellowship and RENEW.

- *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 $2,420.4 million is an increase of $175.4 million, or 7.8 percent, above the FY 2021 Enacted level. The Request focuses resources on the highest priorities in early-stage fundamental research, operation and maintenance of a complementary suite of scientific user facilities, and facility upgrades. High priority areas in core research include clean energy, critical materials/minerals, manufacturing including next-generation microelectronics, biopreparedness, QIS, data science including AI/ML and related infrastructure, exascale computing, and accelerator science and technology. The Request includes funding for the FAIR initiative to expand clean energy research and capabilities at MSIs and the Accelerate initiative to support fundamental research that accelerates the transition of science to technologies. In the SC Energy Earthshots Initiative, the Request includes support for a new research modality of Energy Earthshot Research Centers, which will address key research challenges at the interface between currently supported basic research and applied research and development activities, to realize the stretch goals of the DOE Energy Earthshots. The Request continues 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 recompetition and the Fuels from Sunlight Energy Innovation Hub awards. The Request also increases funds for the DOE Established Program to Stimulate Competitive Research, to strengthen participation of underrepresented institutions and regions, and for RENEW, with targeted efforts to increase participation and retention of underrepresented groups in research areas relevant to BES. BES maintains a balanced suite of complementary tools, including supporting operations of five x-ray

light sources, two neutron sources, and five nanoscale science research centers (NSRCs) at approximately 90 percent of the funding level required for normal operations based on a 2018 baseline. The Request provides continuing support for the ongoing construction activities for the Advanced Photon Source Upgrade (APS-U), Advanced Light Source Upgrade (ALS-U), Linac Coherent Light Source-II High Energy (LCLS-II-HE), Proton Power Upgrade (PPU), Second Target Station (STS), and Cryomodule Repair and Maintenance Facility (CRMF). 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. The Request provides Other Project Costs to begin planning for the NSLS-II Experimental Tools-III (NEXT-III) and High Flux Isotope Reactor Pressure Vessel Replacement (HFIR-PVR) projects.

- *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 $903.7 million is an increase of $150.7 million, or 20.0 percent, above the FY 2021 Enacted level. All BER research is informed by the community and the federally chartered BER Advisory Committee. The U.S. and the world face profound challenges due to climate change with a narrow window of opportunity to pursue action to avoid the most catastrophic impacts. The Request for Biological Systems Science supports a possible five-year renewal for the Bioenergy Research Centers (BRCs). The renewed BRCs will provide new, fundamental research underpinning the production of clean energy and chemicals from sustainable biomass resources for translation of basic research results to industry. The BRCs will continue clean energy innovative research while initiating new inter-BRC collaborations to tackle complex clean energy challenges. The Accelerate initiative will focus on emerging technologies to develop capabilities that scale from laboratory fabricated ecosystems to field ecosystems, through the use of integrated sensor networks and the development and application of novel in situ sensors, imaging, Omics analysis, and autonomous controls and continuous data acquisition and analysis. These technologies can be deployed in the future at user facilities to bring new capabilities for climate science and clean energy research, broadening the impact and providing equitable access to underrepresented communities. Biopreparedness Research Virtual Environment (BRaVE) will increase to provide the cyber infrastructure, computational platforms, and next generation experimental research capabilities within a single portal allowing distributed networks of scientists to work together on multidisciplinary research priorities and/or national emergency challenges. BER contributes to the SC Energy Earthshots initiative through initiation of Earthshot Energy Research Centers, as well as enhancing cross-cutting research on negative carbon emissions, through understanding the key factors controlling soil carbon residence over time through detailed characterization of soil-plant-microbe-environment processes governing carbon turnover. Additional core research to underpin emerging and future Earthshots will also be initiated. Computational Biosciences efforts will support the initiative on Advanced Computing to deploy a flexible multi-tier data and computational management architecture for microbiome system dynamics and behavior. Research in Biomolecular Characterization and Imaging Science will develop QIS-enabled techniques complementing tools and approaches at Office of Science user facilities for predictive understanding of biological processes. BER will participate in the FAIR initiative to provide focused investment on enhancing biological research on clean energy, climate, and related topics at MSIs, including attention to underserved and environmental justice regions. Earth and Environmental Systems Sciences research will focus on improving the representation of physical and biogeochemical processes to enhance the predictability of Earth system models. Environmental System Science integrates physical and hydrobiogeochemical sciences to provide scale-aware predictive understanding of above- and below-surface terrestrial ecosystems. Atmospheric System Research will investigate cloud-aerosol-precipitation interactions to improve fine resolution cloud resolving models and to enhance the Energy Exascale Earth System Model (E3SM) down to spatial scales of 3 km. The Integrative Artificial Intelligence Framework for Earth System Predictability (AI4ESP) effort will develop advanced software, AI, and unsupervised learning approaches for running on future DOE computer architectures accelerating predictive capabilities and reducing uncertainty across the DOE climate model-data-experiment enterprise. Research on coastal estuaries will be continued, with a focus on the Chesapeake Bay, Puget Sound, and Great Lakes, adding clean water related research. Research involving field-based observing and modeling will be enhanced through Urban Integrated Field Laboratories to incorporate environmental justice as a key tenet of research involving climate-sensitive regions. Additionally, the National Virtual Climate Laboratory (NVCL) will continue to further provide unified access to climate science to MSIs and HBCUs, connecting frontline communities with the key climate science capabilities and workforce training opportunities at the DOE national laboratories. Planning and implementation activities continue for a network of

climate resilience centers affiliated with an HBCU or MSIs; the centers will serve as the translational agent connecting BER climate science with broader socioeconomic and environmental justice issues for equitable solutions. All activities will enhance research capacity at the affiliated universities and bring interdisciplinary strength and diversity to DOE's climate research. The Data Management effort will continue data archiving and management capabilities, including AI/ML tools. The Request supports operations of BER's three scientific user facilities: the DOE Joint Genome Institute (JGI), the Environmental Molecular Sciences Laboratory (EMSL), and the Atmospheric Radiation Measurement Research Facility (ARM). The ARM user facility will initiate campaigns using the aerial capability. All BER facilities will continue a multiyear instrumentation refresh to ensure these facilities are delivering the state-of-the-art capabilities required by the scientific community. BER increases support for the SC-wide RENEW initiative.

- *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 $723.2 million is an increase of $51.2 million, or 7.6 percent, above the FY 2021 Enacted level. The Request is aligned with the recommendations of the recent Long-Range Plan (LRP) developed by the Fusion Energy Sciences Advisory Committee. The Request supports research and facility operations at the DIII-D national fusion facility at 90 percent 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) as well as enhanced collaborative research at other facilities to support the NSTX-U research program priorities. The Request continues to support collaborations by U.S. scientists at overseas superconducting tokamaks and stellarators and other international facilities with unique capabilities, enabled by U.S. hardware and intellectual contributions; continues to support research activities in AI/ML for both fusion energy and discovery plasma science applications and in QIS both at the QIS Research Centers and for core research addressing FES priorities. The Request supports research activities in Materials, Fusion Nuclear Science, Advanced Manufacturing, and Enabling R&D; continues to support research activities both in Theory and Advanced Computing activities and Scientific Discovery through Advanced Computing (SciDAC) in partnership with ASCR; and continues to support research activities in both High-Energy-Density Laboratory Plasmas 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 (INFUSE) program and through initiation of a new milestone-based cost-share program. The Request provides support for the U.S. Contributions to ITER project focusing on the design, fabrication, and delivery of in-kind hardware components for Subproject 1, provides construction cash contributions to support the ITER Organization assembly and installation of the hardware contributions from all the ITER Members; and continues to support an ITER Research program to prepare the U.S. fusion community to take full advantage of ITER Operations. 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 continues to address a key recommendation in the LRP by supporting the "Future Facilities Studies" activity focused on the design of next step facilities like a Fusion Pilot Plant. The Request also initiates a new activity to support research on the scientific foundation and technologies for inertial fusion energy, following a key recommendation in the LRP. FES will increase its support for the RENEW initiative with targeted efforts to increase participation and retention of underrepresented groups in areas relevant to FES. In addition, FES will participate in two new SC research initiatives, FAIR and Accelerate.

- *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 $1,122.0 million is an increase of $76.0 million, or 7.3 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. High priority areas for core research include theoretical and experimental activities in pursuit of discovery science; fostering a diverse, highly skilled workforce; building R&D capacity; and conducting world-leading advanced technology R&D. In partnership with SC programs, HEP ensures broad access to exascale computing resources and promotes AL/ML, QIS, microelectronics, accelerator science and technology, and accelerate innovations in emerging technologies research to address cross-cutting challenges across the HEP program. Through RENEW, HEP broadens reach and increases pathways for physics and engineering students, and through FAIR, HEP invests in S&T infrastructure at MSIs. The Request will continue support for the multi-disciplinary QIS Research Center, Superconducting Quantum Materials and

Systems (SQMS), involving 20 institutions and led by the Fermi National Accelerator Laboratory (FNAL). The Request will continue support for the Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment (LBNF/DUNE), Proton Improvement Plan II (PIP-II), and Muon to Electron Conversion Experiment (Mu2e) projects. The Request will also continue five Major Item of Equipment (MIE) projects: Accelerator Controls Operations Research Network (ACORN), Cosmic Microwave Background Stage 4 (CMB-S4), High-Luminosity Large Hadron Collider (HL-LHC) Accelerator, and A Toroidal LHC Apparatus (ATLAS) and Compact Muon Solenoid (CMS) Detector Upgrade Projects. The Fermilab Accelerator Complex and the Facility for Advanced Accelerator Experimental Tests II (FACET-II) will continue operations at 87 and 91 percent respectively of optimal. HEP supports laboratory-based accelerator and detector test facilities, and supports the maintenance and operations of large-scale experiments and facilities that are not based at a national laboratory, including the U.S. Large Hadron Collider (LHC) at CERN in Geneva, Switzerland; Sanford Underground Research Facility (SURF) in Lead, South Dakota; Vera C. Rubin Observatory in Chile; Dark Energy Spectroscopic Instrument (DESI) at the Mayall telescope in Arizona; Large Underground Xenon (LUX)-ZonED Proportional Scintillation in Liquid Noble gases (Zeplin) (LUX-ZEPLIN) (LZ) dark matter experiment at SURF; the Super Cryogenic Dark Matter Search at Sudbury Neutrino Observatory Laboratory (SuperCDMS-SNOLAB) experiment in the Creighton Mine near Sudbury, Ontario, Canada; and the Belle II experiment at the High Energy Accelerator Research Organization (KEK) in Tsukuba, Japan.

- *Nuclear Physics (NP)* supports experimental and theoretical research to discover, explore, and understand all forms of nuclear matter. The NP Request of $739.2 million is an increase of $26.2 million, or 3.7 percent, above the FY 2021 Enacted level. The Request supports safe, efficient, and cost-effective operations of four NP scientific user facilities at 90 percent optimal. 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 (ATLAS) 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. The Facility for Rare Isotope Beams (FRIB), which began operations in FY 2022, produces nuclei with extreme neutron-to-proton ratios to reveal the nature of nuclear binding and the structure of nuclei at the limit of nuclear existence. To maintain U.S. leadership throughout this century and to extend well beyond current scientific capabilities, NP supports R&D and Preliminary Engineering Design for the Electron-Ion Collider (EIC) 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 (GRETA), a ton-scale detector for neutrinoless double beta decay to determine if the neutrino is its own antiparticle, the High Rigidity Spectrometer (HRS) to realize the full scientific potential of FRIB, and the Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER) MIE at JLab. NP is the primary steward of the nation's fundamental nuclear physics research portfolio, providing over 95 percent of the investment in the U.S. nuclear physics basic research. The Request supports this research portfolio through support for 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. 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 artificial intelligence and machine learning which can benefit nuclear physics research and NP accelerator operations. The Request supports continued participation in the microelectronics initiative, with an emphasis on unique devices capable of surviving in cryogenic and high radiation environments and the RENEW activity with targeted efforts ensure a future nuclear physics workforce that is creative, innovative, and capable of meeting the Nation's needs via proactive stewardship of talent with diverse ideas and backgrounds. The Request includes support for two new initiatives: FAIR to further enhance diversity, equity, and inclusion in nuclear physics, and Accelerate to research how imaging advances within nuclear physics can apply to other fields.

- *Isotope R&D and Production (IRP) or DOE Isotope Program (DOE IP)* supports National Preparedness for critical isotope production and distribution to mitigate gaps and disruptions in supply chains of isotopes even during times of national

crisis; efforts include mitigating U.S. dependence on foreign supply of key isotopes. The IRP Request is $97.5 million. Isotopes are high-priority commodities of strategic importance for the nation and are essential in medical diagnosis and treatment, discovery science, clean energy, national security, advanced manufacturing, space exploration and communications, biology, archeology, quantum information science, climate and environmental 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, enabling emerging technology and promoting U.S. scientific, technical and industrial strengths. A high priority remains the dedicated research effort to develop large scale production capabilities of the alpha-emitter actinium-225 (Ac-225) that has shown stunning success in the treatment of diffuse cancers and infections. The Request continues support for the U.S. Stable Isotope Production and Research Center, which will provide significant stable isotope production capacity for the nation, mitigating dependence on sensitive countries. 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, cost effectively repurposing unwanted product. The Request maintains effort in the Advanced Manufacturing initiative, pursuing innovative approaches to robotics, target manufacturing, such as ink jet printing of thin film targets for isotope production, modular automated systems for radioisotope purification and processing, and modern enrichment technology. As part of the Biopreparedness Research Virtual Environment (BRaVE) Initiative, the DOE IP continues to advance the development of the Radioisotope Science Center research project in a disadvantaged area near the University of Missouri Research Reactor (MURR) to bring more science opportunities and high-tech jobs to an impoverished area, while also mitigating single point failures in core competencies and capabilities. Funding will further develop the conceptual design of a new long-term facility at ORNL, the Radioisotope Processing Facility (RPF). This will increase the limited radiochemical processing capabilities in the DOE complex and enable the Program to make available certain new isotopes and provide nuclear assurance of the Nation's readiness to respond to disruptions in global isotope supply chains. Critical efforts continue in the ongoing SC Quantum Information Science (QIS) initiative that will enable the domestic production of isotopes of interest for QIS. Funding continues participation in the RENEW initiative, supporting the Isotope Program Traineeship to promote innovative and transformative approaches to isotope production and processing, including advanced manufacturing, artificial intelligence and machine learning, and robotics; the Traineeship emphasizes participation of minority serving institutions and increasing the diversity and equity of workforce development opportunities in the Program. The Request also supports two new initiatives. Investment in the FAIR initiative will support investments at specific institutions in disadvantaged areas in order to promote environmental justice through place-based science and the provision of technical jobs and capabilities associated with isotope research and production. Participation in the Accelerate Initiative advances the readiness of novel medical isotopes that have shown great promise for cancer and disease diagnosis and treatment for use in innovative radiopharmaceutical therapeutics through the support of translational research in coordination with the NIH.

- *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 partnerships to advance new technologies for use in SC's scientific facilities and in commercial products. The ARDAP Request of $27.4 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 inclusive workforce development. Also, the Request supports participation in the new FAIR initiative. The Request supports operation of the Brookhaven National Laboratory Accelerator Test Facility at 94 percent of optimal. Accelerator Production activities support partnerships to develop advanced superconducting wire and cable, superconducting accelerators, and advanced radiofrequency power sources for accelerators.

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

Scientific Workforce

For more than 60 years SC and its predecessors have fostered a vibrant ecosystem for the training of a highly skilled scientific and technological workforce. In addition to the undergraduate internships, graduate thesis research, and visiting

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[a] In compliance with the reporting requirements in the America COMPETES Act of 2007 (P.L. 110-69, section 1008)
[b] https://science.osti.gov/-/media/bes/pdf/BESat40/Polymer_Upcycling_Brochure.pdf
[c] https://science.osti.gov/-/media/bes/pdf/reports/2019/BRN_Microelectronics_rpt.pdf
[d] https://science.energy.gov/ascr/community-resources/program-documents/
[e] http://science.osti.gov/~/media/hep/hepap/pdf/May%202014/FINAL_P5_Report_Interactive_060214.pdf
[f] https://www.osti.gov/biblio/1638794/
[g] https://science.osti.gov/~/media/bes/pdf/reports/2018/Quantum_computing.pdf
[h] https://science.osti.gov/-/media/bes/pdf/reports/2020/Transformative_Mfg_Brochure.pdf?la=en&hash=95094B9257DCFD506C04787D96EEDD942EB92EEC
[i] https://science.osti.gov/~/media/bes/pdf/reports/2016/BRNQM_rpt_Final_12-09-2016.pdf
[j] https://science.osti.gov/~/media/ber/berac/pdf/Reports/BERAC-2017-Grand-Challenges-Report.pdf
[k] https://science.osti.gov/-/media/ber/pdf/community-resources/2019/GEMS_Report_2019.PDF?la=en&hash=0D7092AD5416A28207F0F95F94E00921D308A113
[l] https://science.osti.gov/~/media/fes/pdf/program-news/Frontiers_of_Plasma_Science_Final_Report.pdf
[m] https://science.osti.gov/-/media/fes/fesac/pdf/2020/202012/FESAC_Report_2020_Powering_the_Future.pdf?la=en&hash=B404B643396D74CE7EDAB3F67317E326A891C09C
[n] https://science.osti.gov/-/media/fes/pdf/workshop-reports/FES-QIS_report_final-2018-Sept14.pdf
[o] https://science.osti.gov/-/media/fes/pdf/workshop-reports/FES_ASCR_Machine_Learning_Report.pdf
[p] https://science.osti.gov/~/media/ber/pdf/community-resources/Technologies_for_Characterizing_Molecular_and_Cellular_Systems.pdf
[q] https://science.osti.gov/np/nsac/reports/
[r] https://science.osti.gov/-/media/bes/pdf/reports/2021/SC_User_Facilities_rpt_print.pdf

faculty opportunities provided through SC's Office of Workforce Development for Teachers and Scientists, to sustain a strong workforce pipeline for DOE mission, the SC research program offices support undergraduates, graduate students, and postdoctoral researchers through sponsored research awards at universities and the DOE national laboratories nationwide. The research program offices also support targeted undergraduate and graduate-level training in areas critically important to DOE mission (such as those associated with scientific user facilities) but not readily available in universities, such as particle accelerator and detector physics, neutron and x-ray scattering, nuclear chemistry, instrumentation, isotope R&D, and computational sciences at the leadership computing level. To help attract critical talent for stimulating fresh ideas and forward thinking, SC supports the Early Career Research Program, which funds individual research programs to identify and award outstanding rising scientists early in their careers in the disciplines supported by SC[s]. To retain highly accomplished researchers, SC initiated the Distinguished Scientist Fellows opportunity to recognize leading DOE laboratory staff and sponsoring their innovative efforts to enrich, sustain, and promote scientific and academic excellence in SC mission research and community at large through partnership between institutions of higher education and national laboratories. SC coordinates with other DOE offices and other agencies on best practices for STEM training programs and evidence-based program evaluation efforts through internal DOE working groups and active participation in all the inter-agency working groups of the National Science and Technology Council's Committee on Science, Technology, Engineering, and Mathematics Education (CoSTEM). 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 continues the activity, Reaching a New Energy Sciences Workforce (RENEW), for targeted efforts to expand participation and retention of HBCUs and other MSIs, community colleges, and individuals from underrepresented groups in SC research and workforce development 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. The Request continues support for these honorary awards.

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.

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

Future Year Energy Program
(dollars in thousands)

	FY 2023 Request	FY 2024	FY 2025	FY 2026	FY 2027
Office of Science	$7,799,211	$7,977,000	$8,162,000	$8,350,000	$8,542,000

Outyear Priorities and Assumptions

In the FY 2012 Consolidated Appropriations Act (P.L. 112-74), Congress directed the Department to include a future-years energy program (FYEP) in subsequent requests that reflects the proposed appropriations for five years. This FYEP shows outyear funding for each account for FY 2024 - FY 2027. The outyear funding levels use the growth rates from and match the outyear account totals published in the FY 2023 President's Budget for both the 050 and non-050 accounts. Actual future budget request levels will be determined as part of the annual budget process.

Office of Science priorities in the outyears include the following:

- Increase investments in Administration priorities 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.
- Ensure optimal operations of all scientific user facilities.
- Continue to invest in infrastructure and utility upgrades at all national laboratories.
- Invest in ongoing and new line-item construction projects and major items of equipment to ensure the United States maintain world leading and state-of-the-art scientific user facilities.