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Opening Statement

Thank you, Chairman Manchin, Ranking Member Barrasso, and distinguished Members of the Committee. It is with great pleasure that I join you today to represent the Department of Energy (DOE or the Department) at this hearing. As members of this Committee know, the DOE Office of Science (SC) is a cornerstone of the research ecosystem in the United States (U.S.). Through basic and use-inspired research and the development and operation of cutting-edge tools, SC enables advances in areas of science and technology of critical importance to our economic and national security, including a just and equitable clean energy and climate change transition. S.3699, to be referred to as the *Department of Energy Science for the Future Act of 2022*, recognizes and reinforces the importance of SC and the community of researchers it supports, both at DOE's National Laboratories and at U.S. colleges and universities, to advance all of the DOE missions, including energy, security, and environmental management. At the same time, the Committee, through this legislation, has clearly stated the importance of SC in addressing a much broader range of science and technology challenges. These challenges include addressing the ongoing COVID-19 pandemic and ensuring the security of SC-supported research, both of which require close coordination with other Federal departments and agencies. This is an ambitious bill, and I commend the Committee for its vision.

I am also here today to speak to several additional bills of significance to the DOE. Bill Number S. 3428, to be referred to as the *Fission for the Future Act of 2022*, is a strong statement of support to the Department for continued public private partnerships to advance demonstration and deployment of next-generation nuclear power concepts. At the same time, the bill aligns with the Department's Energy Justice efforts, with consideration for helping disadvantaged communities as we transition towards a carbon-free power sector in the decades to come.

Bill number S.2733, to be referred to as the *U.S. Enrichment Corporation Fund Termination and Transfer Act*, rescinds the authorization of the U.S. Enrichment Corporation (USEC) Fund and moves the funds still in its coffers to the general fund of the Treasury. We look forward to working with Congress on this further.

S.2232, to be referred to as the *Restore and Modernize our National Laboratories Act of 2021* is, along with the parallel provisions in the *DOE Science for the Future Act*, a recognition of the foundational importance that the DOE's 17 National Laboratories play in sustaining U.S. leadership in science and technology and for tackling the most pressing challenges of our time. The National Laboratories are known internationally as powerhouses of innovation and are host

to many of the world's leading capabilities for scientific discovery and technology development. As Secretary Granholm describes them, they're the Nation's "solutions factories." This complex of 17 laboratories has its origins in the Manhattan Project, with some of the labs entering their eighth decade of operation. DOE recognizes that significant investment is required to ensure that DOE's Laboratories are positioned to continue their long history of groundbreaking discovery.

Finally, H.R.3119, to be referred to as the *Energy Emergency Leadership Act*, and S.2302 would assign the Department's responsibilities in energy sector security and in responding to energy sector emergencies to an Assistant Secretary at the Department. Disruptions to the energy system in the U.S. can have devastating consequences, and the Department's Office of Cybersecurity, Energy Security, and Emergency Response plays an essential role in mitigating the risk of disruptions and responding rapidly when disruptions occur. Executing on this mission requires a team of professionals with the unique training and experience needed to understand and mitigate the risks and respond rapidly when crises do occur.

I look forward to discussing the legislation more in depth.

S.3699

Introduction

The Office of Science's (SC) core mission is to deliver both the scientific discoveries and major scientific tools that will transform our understanding of nature and advance the energy, economic, and national security goals of the U.S. It is the largest Federal sponsor of basic research in the physical sciences and the lead in supporting fundamental scientific research for our energy future. Over decades, the investments and accomplishments in basic research and enabling research capabilities we've made have provided the foundation for countless new technologies that have benefited large and small businesses and launched new industries. These investments have contributed immensely to our Nation's economy, national security, and quality of life.

SC continues this work today.

The core science programs in SC—Advanced Scientific Computing Research (ASCR), Biological and Environmental Research (BER), Basic Energy Sciences (BES), Fusion Energy Sciences (FES), High Energy Physics (HEP), and Nuclear Physics (NP)—along with the Offices of Isotope R&D and Production (IRDP) and Accelerator R&D and Production (ARDP) support research conducted at hundreds of universities and all 17 of DOE's National Laboratories, including the 10 for which SC has direct stewardship responsibility. SC supports different types of research programs—from single investigators and small teams to large, multi-disciplinary, multi-institutional collaborations. These programs probe fundamental questions to address nature's most compelling mysteries—from fundamental subatomic particles, atoms, and molecules that form the building blocks of our universe, to highly complex and dynamic systems, such as energy storage processes, microbial cells, and carbon cycling in the environment. The knowledge gleaned from this research provides the foundation for new discoveries and innovations that are essential to fulfilling the Department's missions.

Many of the transformative scientific discoveries made by our research community are enabled by our stewardship of 28 scientific user facilities, which are available to all researchers based on

the scientific merit of their proposed research. These tools include the world's most powerful computers, brightest X-ray light sources, most intense neutron sources, fastest information network, and specialized capabilities, such as nanofabrication and multiple modes of imaging, within centers for nanoscience and bio-characterization. The Department continues to invest in the development of the next generation of scientific tools to maintain U.S. leadership in scientific discovery and technology development to support our Nation's economic competitiveness and national security.

Science is undergoing a rapid evolution, and the *DOE Science for the Future Act* would support the Department in facilitating this transition. It is becoming more data-centric and more democratic. Multiple scientists in different locations can increasingly produce, share, and analyze the output of research conducted at cutting-edge facilities and apply advanced artificial intelligence (AI) tools to find hidden patterns in increasingly massive data sets. Collaboration is essential to making scientific advances, whether across disciplinary boundaries, between institutions and federal agencies, or amongst nations. The breakthroughs of the future cannot be made if we fail to encourage talented students from across all of society to study science, technology, engineering, and mathematics (STEM) subjects and become scientists and engineers. The research on this is clear—more diverse scientific communities are more effective at debating and evaluating theories and evidence.

The Act underscores the importance that DOE's 17 National Laboratories have and will continue to play a foundational role in U.S. leadership in science and technology and in tackling the most pressing challenges of our time. They are where scientific collaboration takes place, where world-leading experimental tools provide crucial insights into nature, and where solutions to our most urgent challenges are being developed. We need look no further than the ongoing COVID-19 pandemic. It was at DOE's scientific user facilities where researchers from the National Laboratories, universities, and industry collaborated to reveal the structure of the spike protein on SARS CoV-2, the virus that causes COVID-19, using X-ray and neutron sources, and where vaccine binding was modeled using DOE's high-performance computers. The future of DOE's national laboratories depends upon fundamental research supported by SC in emerging technologies. SC supported research led to the development of CRISPR-cas9 for gene editing, enabled deployment of the fastest high-performance computers in the world, produced the superconducting materials needed to enable advanced accelerators and next-generation fusion devices, and advanced production technology to expand the portfolio of available isotopes needed for applications as diverse as medicine and national security. DOE's scientific user facilities collect massive amounts of data, which are shared using SC's world-leading Energy Sciences Network and analyzed using state-of-the-art AI-based models running on the Nation's fastest supercomputers. DOE is indeed uniquely positioned to support a transformation of scientific practice.

In the sections below, I will highlight important themes we're addressing at the Department and the role of SC in those efforts. As you will see, the examples demonstrate how SC's efforts, in coordination with the efforts of our applied offices at DOE and our interagency partners, will position the U.S. to rise to the challenges of the 21st century. Any reauthorization of the Office of Science must enable us to pursue these goals.

Maintaining the Openness and Security of DOE's Scientific Enterprise

America's leadership in science and technology is underpinned by the unique strengths of our open scientific enterprise. The openness of our innovation ecosystem enables international collaboration that advances the frontiers of science and attracts the world's most talented scientists and engineers to our shores. However, it is clear that certain foreign governments, including the People's Republic of China, Russia, Iran, and others, seek to acquire our technologies, using both illicit strategies and legal means that pose unacceptable risks to research security and integrity. DOE, with significant support from SC, is managing these risks while maintaining an open, collaborative, and world-leading enterprise. We do this with the understanding that if our policies to address research security and integrity challenges significantly diminish our ability to attract and welcome global scientific talent, or if they fuel xenophobia, then we will have done more damage to ourselves than any competitor or adversary could. We also recognize that openness and security are not diametrically opposed but complementary: maintaining our openness is essential to preserving our national security and scientific leadership.

Over the last several years, DOE has acted decisively to protect our scientific enterprise. We have established an agency-wide body to coordinate issues related to research security and have instituted policies to manage risks to research security. These policies include prohibiting Federal and DOE National Laboratory personnel from participating in foreign government sponsored talent recruitment programs from certain countries, centralizing oversight of international engagements undertaken by each national laboratory and utilizing our Science and Technology Risk Matrix to manage risks associated with critical and emerging technologies that do not otherwise have control mechanisms. We utilize the Risk Matrix to guide and manage foreign engagements, cooperative research and development agreements, strategic partnership projects, official travel, and access to our labs.

The Department welcomes discussions with Congress on how to support DOE and our sister agencies in developing and maintaining tools and processes for research security, such as DOE's Science and Technology Risk Matrix and associated Directives that we use to manage risks to our research enterprise. Research security measures must be informed by a dynamic understanding of the threats coupled with a deep understanding of the science and technology. Only then can the Department make informed determinations that weigh benefits against potential risks. These tools also support evidence-based decision-making processes for research security that do not create excessive administrative burdens while reducing the risk of misappropriation of DOE-funded research by entities of concern.

Research security is maximized when there is a consistent approach across funding agencies and coordination with the global science community. DOE continues to actively co-chair the National Science and Technology Council (NSTC) Subcommittee on Research Security to ensure a coordinated interagency approach to implementing National Security Presidential Memorandum-33 on strengthening protections of U.S. government-supported research. In addition, DOE continues to engage with allies and partners through State Department-led efforts to exchange information on experiences and best practices on research security. This coordination is essential in order to reduce uncertainty and establish clear, consistent guidelines

for researchers to follow on topics such as disclosure requirements, entities of concern, and penalties for those who violate our research security policies. As this Committee considers appropriate language to support the Department's research security activities, we encourage you to take a coordinated approach with your colleagues in the committees that have jurisdiction over other funding agencies to ensure consistency and to avoid undue burden on our Nation's researchers, with the shared aim of protecting taxpayer-funded research and maintaining America's leadership in science and technology.

Increasing Participation and Training the Next Generation

For nearly seven decades, DOE has trained and educated scientists, engineers, and technicians, providing a pipeline for talent that serves DOE's science and technology enterprise, as well as that of the Nation. SC strives to advance diversity, equity, inclusion, and accessibility (DEIA) to ensure that the Nation's STEM ecosystems are robust and second to none. Further, SC has a long history of supporting research at Historically Black Colleges and Universities and other Minority Serving Institutions (MSIs) and at institutions unrepresented in the Federal R&D landscape, such as through the Established Program to Stimulate Competitive Research, or EPSCoR. We recognize the great value and opportunity to increase the competitiveness of underrepresented institutions and are committed to increasing financial assistance to these institutions, including those in EPSCoR eligible jurisdictions, to further SC's goals to increase and broaden participation in its research programs and increase institutional research capacity. Meeting this shared goal will require careful planning over several years, in close collaboration with these institutions, to ensure they are prepared to effectively compete for additional funding from across the SC portfolio, including through collaborations with their colleagues at DOE's National Laboratories and other U.S. research institutions.

However, we recognize the need to be more intentional in our efforts to reach individuals and institutions underrepresented in our research portfolio. Expanding opportunities to underrepresented groups is foundational to SC's mission in STEM education and workforce development. The Department is strongly committed to continuing its efforts to ensure that the next generation of scientists and engineers needed to support DOE's mission is inclusive and representative of the Nation.

In 2020, SC established an internal group to develop recommendations for increasing participation of MSIs and individuals from underrepresented groups in SC research, especially in research projects led by faculty from these institutions. Between August and December of 2021, the SC programs hosted over 15 listening sessions and discussions with groups of researchers, faculty, and students from a broad range of institutions to understand barriers to participation in SC programs and identify opportunities to overcome those barriers, including changes to the way SC has historically managed programs. We are working to implement these recommended actions and opportunities.

SC's largest contribution to the training of the next generation of skilled scientists, engineers, and technicians is through research awards to colleges, universities, and the DOE National Laboratories, providing support for over 8,500 undergraduate and graduate students and postdoctoral researchers. In addition, through the Office of Workforce Development for

Teachers and Scientists (WDTS), SC currently supports over 1,000 paid undergraduate internships at all 17 DOE National Laboratories. Over the past 20 years, WDTS has supported more than 14,000 undergraduate research internships for students from 2-year and 4-year institutions. A significant focus of WDTS outreach and recruitment efforts is on connecting with individuals historically underrepresented in STEM. SC also supports targeted graduate training programs, such as the Computational Sciences Graduate Fellowship in high-performance computing applied to scientific and technical challenges (a partnership between SC and the National Nuclear Security Administration); the U.S. Particle Accelerator School for training in accelerator and detector R&D; and the Office of Science Graduate Student Research program, which provides supplemental funding for graduate students to conduct part of their thesis research at a DOE National Laboratory.

Within the FY 2022 President's Budget Request, SC proposed to initiate a new activity, Reaching a New Energy Sciences Workforce, or RENEW, which would significantly expand undergraduate and graduate student training opportunities to underrepresented and underserved groups, including Tribal communities, Historically Black Colleges and Universities, Hispanic Serving Institutions, and other MSIs; place greater emphasis in its competitive solicitations for financial assistance on encouraging applications from MSI institutions and in partnerships with MSIs; and increase outreach activities to institutions historically underrepresented in the SC research portfolio.

Addressing the Climate Crisis: Accelerating New Discoveries in Energy and Climate Science

Clean, efficient, and affordable energy systems of the future—whether they tap fusion processes that power the sun, store vast amounts of electricity, or make fuel from splitting water or converting carbon dioxide—will be realized not just by incremental improvements in today's technologies, but by leveraging new materials and chemical transformations to enable exquisite control of physical and chemical processes and convert energy efficiently from one form to another. The ability to control these processes may also be inspired by processes employed by nature, which allow plants to convert sunlight into energy and carbon dioxide into biomaterials. Advances in these areas are essential to the success of the Department's Energy Earthshots—integrated, cross-Departmental research and development (R&D) programs designed to rapidly address tough technological challenges—providing the critical fundamental knowledge required to drive the next generation of energy technologies.

Achieving atomic-, molecular-, and genomic -level control of materials and processes for future energy systems requires understanding the fundamental principles that can only be revealed by basic scientific research. Today, SC-supported research is entering a new era in which materials are precisely synthesized atom-by-atom to engineer specific functionalities, and sustainable chemical processes are designed at the molecular scale to support clean, safe, and economic alternatives and methodologies to traditional chemical products and processes. Likewise, through genome engineering techniques, modification of molecular level pathways found in nature will be enhanced to produce fuels and chemicals efficiently. These advances, supported by powerful computational tools, will allow us to predict the properties and dynamic behavior of materials, as

well as chemical processes, before they have been experimentally realized, accelerating the pace of discovery. Next-generation characterization tools will not only reveal the structure of the resulting materials and processes at the atomic level, but also allow us to observe how the atoms are incorporated into and contribute to the material's function, and how that functionality evolves over time while in use.

Addressing climate change requires understanding the complex interplay of atmosphere, land, ocean, cryosphere, and human components of the Earth system. These components are dynamic over enormous length and time scales, ranging from fractions of a second to years and from sub-millimeters to kilometers. Achieving this understanding requires the development of predictive models that incorporate the myriad interactions and feedbacks within the Earth system. SC's Energy Exascale Earth System Model is designed to leverage the power of the Nation's first exascale computing systems to link advanced predictive climate models with experiments, high-resolution field observations, and new approaches to integrate and analyze data that leverage AI and other state-of-the-art analytics. The predictions generated from these models will be critically important because they describe the resilience of energy and related infrastructures, as well as our quality of life.

SC is also developing new experimental sites to extend studies of climate change into mixed environments involving urban, coastal, and other vulnerable regions that are experiencing more extreme climate phenomena, such as severe heat waves, drought, flood, and wildfire. New Urban Integrated Field Laboratories, proposed in the fiscal year (FY) 2022 President's Budget Request (PBR), will incorporate environmental justice as a key tenet of DOE's research involving the most climate-sensitive and vulnerable communities, and in the future will include connecting frontline communities with the key climate science capabilities at the DOE National Laboratories.

For over 60 years, DOE and its predecessor agencies have supported basic scientific research in fusion energy with the vision of establishing commercial fusion as a source of clean, reliable energy. Deploying commercial fusion energy on the grid has garnered substantial interest in the private sector, as evidenced by billions of dollars of private sector investments over the last decade in a growing number of U.S.-based private fusion companies. However, before this vision can be realized, technical challenges remain that can only be addressed by fundamental research. To that end, SC will continue to invest in the research, as well in experimental and computational user facilities, needed to address the challenges associated with deploying commercial fusion energy on the grid. The new Material Plasma Exposure Experiment (MPEX), for example, will provide unique capabilities for studying the behavior of materials under the extreme conditions experienced in a fusion plasma, which will enable development of new, robust materials for fusion energy. These and other activities are priorities identified by the scientific community in the Fusion Energy Sciences Advisory Committee report "Powering the Future: Fusion and Plasmas."[1]

ITER remains critical to advancing our understanding of the science of burning plasmas and is helping to advance technologies that will be essential to future fusion power plants. As an

[1] https://infuse.ornl.gov/wp-content/uploads/2021/02/FESAC_Report_2020_Powering_the_Future.pdf

international open-science project, U.S. investment in ITER is highly leveraged—we support 9% of the cost but receive access to 100% of the scientific advances and technology development. Continued U.S. participation in ITER is necessary for the U.S. fusion community to remain at the forefront of the field, and to ensure a robust pipeline of fusion scientists and engineers needed for a future of accelerated fusion energy development and deployment.

Going forward, DOE will look to build on its existing partnerships with the private sector to advance fusion energy. Modeled on the Office of Nuclear Energy's Gateway for Accelerated Innovation in Nuclear (GAIN) program, the Innovation Network for Fusion Energy (INFUSE) program supports researchers at the DOE National Laboratories to collaborate with private fusion companies to accelerate the development of fusion energy technologies. The interest received from private fusion companies in this effort is encouraging and SC will look at ways to build on partnerships with the private sector to support development of advanced technology to enable full-scale fusion systems and, ultimately, a fusion pilot plant.

Pandemic preparedness and response

SC has deep expertise and resources at the intersection of biological, physical, and computational sciences, as well as world-leading user facilities, that can provide capabilities in bio-related research that are unique within the Federal research enterprise. Many of these foundational capabilities have been applied in partnership with other Federal agencies to support science and technologies critical to the Nation's future, and, in return, these partnerships have advanced DOE's core missions. For example, with the National Institutes of Health (NIH), DOE helped develop sequencing and bioinformatics tools to assist with mapping of the human genome as part of the Human Genome Project.

During the COVID-19 crisis, SC created the National Virtual Biotechnology Laboratory (NVBL) to more rapidly bring to bear capabilities at all 17 National Laboratories to address key issues, including personal protective equipment shortages, development of antiviral therapeutics, diagnostics, and epidemiological modeling, among others. In doing so, NVBL supported decision makers at the regional, state, and national levels, and collaborated with several Federal agencies, including NIH, Centers for Disease Control (CDC), Food and Drug Administration (FDA), and others. Through its NVBL framework, DOE contributed significantly to the Nation's COVID-19 response, demonstrating the critical impact of the National Laboratories.

Within just a few months, NVBL teams produced innovations in materials and advanced manufacturing that mitigated shortages in COVID-19 test kits and personal protective equipment, creating nearly 1,000 new jobs. They used DOE's high-performance computers and X-ray and neutron sources to rapidly identify promising candidates for antibodies and antivirals, directly contributing to the development of all three of the COVID-19 vaccines that have been authorized or licensed for use in the U.S., as well as Paxlovid and Sotrovimab, the first antiviral drug and therapeutic antibody, respectively, for the treatment of COVID-19 to receive FDA emergency use authorization.

NVBL researchers also supported FDA, CDC, and Department of Defense (DoD) efforts to establish national guidelines used in administering millions of COVID-19 tests. Researchers supported decision-makers at the local, state, and national levels by using AI and DOE's high-

performance computers to forecast disease transmission, stress on public health infrastructure, and economic impact, supporting decision-makers at the local, state, and national levels. NVBL teams also studied how to control indoor virus movement to minimize uptake and protect human health to develop controls to prevent the spread of the virus in schools, restaurants, transportation systems, and other venues.

The Emerging Biological Threat Preparedness Research Initiative authorized by the *DOE Science for the Future Act* is a critical step towards institutionalizing this whole-of-DOE approach to addressing current and future biological threats to the Nation. To that end, SC's proposed Biopreparedness Research Virtual Environment (BRaVE) initiative would support a virtual platform, similar to that of NVBL, to develop new capabilities and enable DOE's bioscience-related research assets to be rapidly mobilized in response to future national crises. Specifically, it will support development of DOE's next-generation analytical technologies, user facility resources, national preparedness for medical isotope processing, and biotechnological capabilities. As part of these efforts, BRaVE research teams will draw upon expanded capabilities provided at DOE's scientific user facilities, including high-performance computing resources, X-ray and neutron characterization facilities, and nanoscale research centers.

Research and Innovation for Critical and Emerging Technologies

To ensure the Nation's economic and national security, SC is investing in advancing foundational capabilities in critical and emerging technologies, including advanced computing, quantum information systems (QIS), AI and machine learning (ML), microelectronics, biotechnology, and isotope research and development. These advances will be realized by leveraging SC's core capabilities in materials science, computer science, chemistry, biology, and physics. These technologies are critical because they provide new and expanded research and development capabilities, not just for programs across SC, but for science and technology broadly. They will enable breakthroughs in the sectors of the future and contribute to addressing the climate crisis.

Advanced computing is central to advancing science and technology, from predicting the properties of new materials to modeling Earth systems. SC is making investments in mathematical, computational, and computer science research critical to the advancement of computing capabilities and in developing and providing world-leading high-performance computing (HPC) resources to our scientific community. As we close in on full deployment of Frontier—the Nation's first exascale computer located at Oak Ridge National Laboratory (ORNL)—we continue to look to the future, supporting the R&D needed to develop the next-generation of computing systems "beyond exascale."

SC is also addressing the increasing demand to store and share the massive amounts of data generated daily from its scientific user facilities. The current upgrade to SC's Energy Sciences Network (ESNet6) will help meet the need for highly reliable data transport capabilities optimized for the requirements of large-scale science. With increasing amounts of data, the need for new data analysis tools is becoming more important. SC continues to support research in AI by developing robust new algorithms to analyze and assimilate data sets, along with other tools and data-focused

approaches that minimize bias and are easily coupled with more traditional physics-based computer simulations.

Realizing tomorrow's data-centered technologies will present considerable computational, communications, and security challenges. High-performance computers and other IT infrastructure still require substantial energy consumption, which contributes to climate change, and potentially limits future advances in performance. SC continues to support development of hardware and software technologies that decrease the energy needs of advanced computing, as well as for increasingly larger data storage demands. For example, when fully deployed, Frontier will require only 20 MW of power for operations, a decrease of nearly 200x in energy use per operation relative to the Department's most advanced computer in 2010. This trend towards increasing energy efficiency must continue, however, and SC's expertise in materials science will be an important contributor to the development of future energy efficient computing systems by developing new approaches in microelectronics, data storage, and QIS.

SC is providing leadership in QIS through investments in research programs and five National QIS Research Centers, established in FY 2020. Each of these centers is led by a National Laboratory in partnership with researchers from universities and industry. These centers are developing workforce training programs, including paid internship opportunities for students, who will be part of the future QIS workforce. In addition, SC held a workshop in March 2021 that recommended actions to assist colleges and universities in developing curricula to train students for employment in QIS-related jobs. These efforts are among the measures outlined in the "Quantum Information Science and Technology Workforce Development National Strategic Plan,"[2] recently released by the NSTC Subcommittee on Quantum Information Science, which was co-chaired by Dr. Steve Binkley, the Principal Deputy Director and Acting Director of SC.

Demands for continued advances in computing and power technologies underscore the need to rethink the fundamentals of microelectronics. The 2018 SC-sponsored "Basic Research Needs for Microelectronics"[3] workshop report outlined advances needed in the foundational science required to meet future needs in microelectronics—including materials science, chemistry, physics, synthesis and fabrication technologies, architectures, algorithms, and software. SC is positioned at the convergence of these scientific disciplines and is in a unique position to both play a critical role in the advancement of microelectronic technologies over the coming decades, and to benefit from the resultant capabilities in computing, sensing, power, and communications that are critical to SC user facilities and other applications in its research efforts. SC is active in interagency planning for microelectronics, including participating on the Subcommittee on Microelectronics Leadership under the NSTC, contributing to the drafting of a National Strategy on Microelectronics Research, and is collaborating with the Department of Commerce (DOC) in planning for an incentives program to support the U.S. semiconductor industry.

SC research in biological systems, including biology of plants, fungi, and microbes, create the foundational knowledge for developing cost-effective and sustainable processes for producing fuels, materials, managing carbon, plastics and waste recycling, and other applications. These

[2] https://www.quantum.gov/wp-content/uploads/2022/02/QIST-Natl-Workforce-Plan.pdf
[3] https://science.osti.gov/-/media/bes/pdf/reports/2019/BRN_Microelectronics_rpt.pdf

research efforts have also produced tools to support the broader research community, such as the CRISPR-cas9 process for gene editing, computational modeling, and new imaging techniques that have enabled observation of cellular processes at the molecular level. SC investments in fundamental biology and advanced characterization, computational, and imaging tools will catalyze technologies that will contribute to a vigorous bioeconomy.

Finally, isotopes are of strategic national importance. They are essential to many current applications and enable development of emerging technologies for medical diagnosis and treatment, discovery science, national security, industrial processes, space exploration, and QIS, to name a few. The new Office of Isotope R&D and Production, which stewards the DOE Isotope Program (DOE IP), has the unique responsibility to produce critical radioactive and stable isotopes for the Nation (either not commercially available or in short supply). For many isotopes, DOE IP is one of only a few producers in the world, and often the only producer. Robust partnerships with Federal agencies and industry help to ensure DOE IP is able to meet demands for production of available isotopes and focus R&D on novel isotopes needed for broad applications. For example, the partnership between DOE IP and the National Cancer Institute has enabled the transition of promising medical isotopes from the laboratory to clinical trials.

In the coming years, DOE IP will be completing two projects—the Stable Isotope Production and Research Center and Radioisotope Processing Facility—that will significantly expand on the program's existing laboratory and university-based capabilities in R&D and production of both stable and radioisotopes. DOE-IP will continue to support R&D at the Facility for Rare Isotope Beams (FRIB)—SC's newest scientific user facility at Michigan State University—to extract and process unreacted isotopes collected after experiments. To assist the DOE IP in planning for the future of the isotope research and production, SC will pursue establishing a dedicated advisory committee for the program.

Expanding our understanding of the universe

SC-supported research in high energy and nuclear physics expand our understanding of the universe, from the subatomic scale to the cosmic scale. Our investments ensure that the U.S. maintains its leading roles in these highly international efforts. Many of the groundbreaking discoveries made through the support provided by these programs and their predecessors at DOE—from the discovery of the top quark and the Higgs Boson to the discovery and characterization of the quark-gluon plasma to the recent measurements at the Muon g-2 experiment that call into question the standard model of physics—have been possible only through the coordinated efforts of thousands of scientists in the U.S. and abroad working together at some of the most complex scientific instruments ever conceived. Additionally, SC's support for research in fundamental physics requires the development of cutting-edge technologies, many of which have found widespread and high-impact use in fields as diverse as medicine, communication, environmental management, and national security. The *DOE Science for the Future Act* provides a clear recognition of this fact and helps position SC to continue to facilitate the development of, and participation by U.S. researchers, in current and future large-scale science projects based both in the U.S. and abroad.

The HEP program's mission is to understand how the universe works at its most fundamental level by discovering the elementary constituents of matter and energy, probing the interactions between them, and exploring the basic nature of space and time. U.S. investments in this area have been guided since 2014 by the report of the Particle Physics Project Prioritization Panel (P5), a multiyear scientific community effort that identified five intertwined science drivers of particle physics with great promise for discovery.[4] We pursue breakthroughs in these areas through a global program that includes national and international partnerships that have enabled the U.S. to host world-leading facilities like the future Large Baseline Neutrino Facility and Deep Underground Neutrino Experiment (LBNF/DUNE), and for U.S. scientists to access the most advanced facilities located abroad.

SC, through HEP, has played an important role in the collaboration between the U.S. and the European Organization for Nuclear Research (CERN) at the Large Hadron Collider (LHC), the world's largest and highest-energy particle collider. This collaboration continues with the High Luminosity upgrade of the LHC accelerator and two large detectors, which will increase the particle collision rate and increase the reach for finding new physics. SC is leading in the development of LBNF/DUNE, the next big international mega-science project. When complete, this multi-location facility will be the centerpiece of a U.S.-hosted world-leading neutrino research program. It will use the world's most intense neutrino beam and large, sensitive underground detectors to reveal answers to fundamental mysteries of the universe.

Going forward, the scientific community is set to undertake the next iteration of the P5 process that led to the highly influential 2014 strategic plan. When completed in 2023, the community's next strategic plan is expected to help HEP chart a course to support this scientific community through the rest of the decade. HEP looks forward to working with the Committee to build on the support provided by the *DOE Science for the Future Act* in order to implement this vision.

The NP program focuses on discovering, exploring, and understanding all forms of nuclear matter—including not only the familiar forms of matter we see around us, but also exotic forms that existed in the first moments of the universe and that may exist today inside neutron stars. The overarching goal of this program is to understand why matter takes on the specific forms observed in nature. The science supported by NP covers an extraordinary range in both time and scale, and the community requires access to a variety of facilities with unique capabilities to study these systems.

To meet this need, NP supports operations at multiple national accelerator user facilities, including the Relativistic Heavy Ion Collider (RHIC), the Continuous Electron Beam Accelerator Facility (CEBAF), the Argonne Tandem Linear Accelerator System (ATLAS), and FRIB. When it begins science operations this year, FRIB will uniquely afford access to eighty percent of all isotopes predicted to possibly exist in nature, including over 1,000 never produced on Earth. The operations of these facilities will be further enhanced by deployment of data analytics tools for autonomous decision making, currently under development through support from NP as well as parallel efforts being advanced across the SC programs.

[4] https://www.usparticlephysics.org/wp-content/uploads/2018/03/FINAL_P5_Report_053014.pdf

Looking to the future, SC will lead an international effort to build an Electron Ion Collider (EIC). The *DOE Science for the Future Act* sends a strong message of support to the Department on this project of critical importance to the field. Led by Brookhaven National Laboratory in partnership with Thomas Jefferson National Accelerator Facility, the EIC will provide the scientific community with an unprecedented ability to discover how the mass of everyday objects is dynamically generated by the interaction of quarks and gluons inside protons and neutrons. It will enable progress in long-standing "grand challenge" questions, such as the ultimate limits of nuclear existence, and illuminate the astrophysical sites and isotopic paths to heavy element production in the cosmos.

S.3699 and S.2232

Laboratory Restoration and Modernization

The DOE mission is supported by the 17 DOE National Laboratories. SC supports research across the entire laboratory complex, with the largest share of contributions going to the 10 SC-stewarded National Laboratories. The expertise of the laboratory staff, and the research capabilities they help develop and operate, are invaluable assets that serve to advance the frontiers of fundamental scientific discovery, train the scientific and technical workforce in the U.S., and develop the tools and advanced instrumentation that keep our Nation at the forefront of innovation. The DOE National Laboratories are essential resources that the Nation turns to in time of emergencies. The optimal operation of this complex is indispensable to the country's leadership in science and technology development to ensure our energy, economic, and national security.

The DOE National Laboratories were established from the 1940's to 1960's, with some approaching 80 years of service. The research facilities at these Laboratories—including general research laboratories, specialized research centers, accelerators, light sources, high-performance computers, and two nuclear reactors—are supported by general-purpose infrastructure and a vast network of utilities that form the backbone of each site. The 10 SC-stewarded laboratories alone comprise an infrastructure portfolio worth nearly $22 billion, consisting of more than 1,600 buildings accounting for 24 million gross square feet, roads, utilities, and other supporting infrastructure assets on more than 18,000 acres of land. Today, nearly two-thirds of this support infrastructure, including utility systems, is rated as substandard or inadequate, with current deferred maintenance costs totaling $1 billion. This results in unplanned outages, costly repairs, elevated safety risks, and inefficiencies that impact our ability to maximize contributions to science and society. S.2232, to be referred to as the "*Restore and Modernize Our National Laboratories Act*", supports the Department's effort to pursue a robust portfolio of maintenance and modernization construction projects across the entire DOE laboratory complex, which enables our continued innovation in the conduct of scientific discovery itself to address modern problems, including the application of AI and automation to scientific discovery.

Furthermore, S.3699 provides renewed support for the SC Science Laboratories Infrastructure (SLI) program, which enables scientific and technical innovation at the SC-stewarded laboratories by funding and sustaining general purpose infrastructure. Since 2006 and with the support of Congress, the SLI program has invested over $1.8 billion to support general purpose buildings and utilities in line-item construction, general plant, and focused utility projects that

have successfully provided modern, reliable, and mission-ready facilities and infrastructure to support the SC mission now and into the future. The Department's continued emphasis on addressing core infrastructure issues across the DOE laboratory complex will enhance the ability of these laboratories to continue delivering scientific and technical leadership for the next 80 years and beyond.

S. 3428

Bill Number S. 3428, to be referred to as the Fission for the Future Act of 2022, supports the deployment of next generation advanced nuclear energy technologies by establishing a program at DOE that would provide additional Federal assistance for such efforts. Specifically, the bill prioritizes helping communities with retired or retiring fossil fuel generation facilities transition to a clean energy future using nuclear energy technology. This future includes non-electric applications for nuclear energy such as heating, hydrogen production, industrial processes, desalination, and isotope production. Furthermore, the support for fossil communities, Tribes, and institutions of higher education and workforce development in this bill is consistent with the Department's equity and justice considerations.

DOE currently supports efforts to deploy next generation advanced nuclear energy technology by leveraging retiring energy generation assets. For example, TerraPower recently announced siting of a Natrium reactor at a retiring coal plant in Wyoming. TerraPower has a cooperative agreement with DOE—specifically in the Office of Nuclear Energy's (NE) Advanced Reactor Demonstration Program—to advance this project. The partnership includes private sector companies, universities, and National Laboratories. This project is a great example of what successful public-private partnerships can achieve in advancing energy solutions.

H.R. 3119 and S. 2302

The energy sector is uniquely critical—providing power and fuel on which all other U.S. critical infrastructure sectors depend to operate. A disruption in our energy system can have a devastating impact on national security, the U.S. economy, and the livelihoods of millions of Americans. We have experienced the devastating impacts of disruption through multiple events just this year. This mission of DOE's Cybersecurity, Energy Security, Emergency Response (CESER) and its responsibilities are critical, and it has been a goal of Secretary Granholm to strengthen the office, including with new leadership and renewed focus. It remains the Department's position that that emergency preparedness and management is best handled by a stable, professional set of employees who have developed relationships with industry partners. We do not want a learning curve when crises happen, and with extreme weather events escalating, having consistent, professional, nonpartisan leadership at the helm of this office is crucial. The Department looks forward to working with the Committee to support cyber and emergency response and protect the nation's grid and energy assets.

Conclusion

Chairman Manchin, Ranking Member Barrasso, and members of the Committee, thank you again for the opportunity to speak about the Department in its science and advanced energy technology missions.

As reflected in the FY 2022 PBR, SC will continue to invest in the most compelling foundational research, in providing advanced tools for scientific discovery and technology development, and in a laboratory complex that is unequivocally the world's most comprehensive collection of scientific and technical expertise.

We will continue to make necessary investments in the sectors of the future, and do so in partnership with our interagency colleagues, to advance science and technology that will dominate the 21st Century—including AI, QIS, microelectronics, and systems biology. We will continue to overcome the key scientific challenges needed to realize abundant, affordable, and clean energy technologies for the future, including fusion energy, to tackle the climate crisis, and to address the ongoing COVID-19 global pandemic and other emerging threats.

To engage these challenges, we will leverage cross-disciplinary teams of experts with diverse perspectives and backgrounds from universities and National Laboratories, and from partnerships with other Federal agencies and international institutions. This approach will allow us to address these critical issues by conducting science at scales not possible by individual researchers, individual institutions, or even individual countries.

To ensure that we have the talent needed to meet these challenges, we are developing our future workforce, with a strong commitment to the principles of diversity, equity, inclusion, and accessibility. This commitment extends to our National Laboratories, to the research and facilities we support in the scientific community, to our own staff, to the processes we use in pursuit of the mission, and to the investments we make in workforce development programs.

NE will continue to pursue robust public private partnerships to accelerate the development and deployment of the next-generation of nuclear fission technologies, a key source of carbon-neutral power that will be critical to meeting this Administration's goals for net zero emissions in the energy sector and beyond.

We look forward to discussions on how best to take advantage of the unique strengths of all of our Federal R&D funding agencies in order to bolster the U.S. research enterprise and global competitiveness. As described above, we are leading the way in advancing the science and developing the technology that will enable innovations in many of the priority technology areas, including AI/ML, HPC, semiconductors, QIS, synthetic biology, energy storage, and others. We will do so by working closely with our colleagues at the NSF, DOC, DOD, and other agencies supporting R&D to expand coordination and collaboration to maximally leverage our investments towards these shared goals.

I would be happy to take any questions you have.