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Science and Technology Issues for the 118th Congress

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SUMMARY

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Science and Technology Issues for the 118th Congress

The federal government supports scientific and technological advancement directly by funding and performing research and development and indirectly by creating and maintaining policies that encourage private sector efforts. Additionally, the federal government regulates many aspects of science and technology (S&T) activities. Federal S&T support has led to scientific breakthroughs and new technologies ranging from jet aircraft and the internet to communications satellites and defenses against disease.

Many science and technology policy issues that may come before the 118th Congress represent areas of continuing Member interest. Examples include cross-cutting issues that affect scientific and technological progress, agricultural research, climate change, Defense Department research, earth science, space, and water. Other issues represent new or rapidly transforming areas such as biotechnology, energy, information technology and social media, financial technology, and telecommunications. Some of these S&T issue areas are described briefly below.

Cross-Cutting Issues

Issues that cut across multiple S&T disciplines include federal R&D funding, interagency S&T coordination, the adequacy of the domestic science and engineering workforce, the role of patents and other intellectual property policies, and tax incentives.

Agriculture

The federal government funds billions of dollars of agricultural research annually. The 118th Congress may consider issues related to funding this research, as well as specific issues related to climate change science at the U.S. Department of Agriculture.

Climate Change

S&T considerations permeate deliberations on climate change and may be grouped into five interrelated topics: climate change-related science and the ocean-climate nexus; clean energy research, development, demonstration, and deployment; climate change and infrastructure; S&T for adaptation and resilience to climate change; and carbon capture, utilization, and sequestration.

Biotechnology and Biomedical Research

Recent advances in biotechnology and biomedical research hold the promise of longer and healthier lives and more productive industry while raising policy challenges. Some issues that the 118th Congress may face include those relating to the bioeconomy; the National Institutes of Health; oversight of engineering biology; regulation of laboratory-developed tests; monitoring of environmental DNA and RNA; and the convergence of biotechnology, digital data, robotics, and artificial intelligence.

Defense

The Department of Defense (DOD) relies on a robust research and development effort to develop new military systems and improve existing systems. Issues that may come before the 118th Congress regarding DOD's S&T activities include budgetary concerns and the effectiveness of programs to transition R&D results into fielded products and how DOD encourages innovation.

Energy

Energy-related S&T issues that may come before the 118th Congress include biofuels, offshore energy technologies, and hydrogen pipelines.

Earth and Environmental Sciences

Earth-science-related issues that may come before the 118th Congress include those raised by the National Spatial Data Infrastructure system, the ShakeAlert earthquake early warning system and seabed mining of critical minerals.

Financial Technology

Financial technology, or *fintech*, refers to a broad set of technologies being deployed across a variety of financial industries and activities, including those related to cryptocurrency, investor applications, and consumer finance applications.

Information Technology and Social Media

The rapid pace of advancements in information technologies presents several issues for congressional policymakers, including those related to artificial intelligence, cybersecurity, social media platforms, big tech and online platforms, immersive technologies, and law enforcement access to platforms and its use of facial recognition technology and social media.

Space and Aviation

Congress has historically had a strong interest in space policy and aviation issues. Issues that may come before the 118th Congress include the funding and oversight of the National Aeronautics and Space Administration, issues related to the commercialization of space, Earth-observing satellites, and advanced air mobility technologies.

Telecommunications

Telecommunication technologies present several issues for policymakers in the 118th Congress, including those related to 5G technologies, broadband deployment and the digital divide, undersea cables, federal spectrum auctions and allocations, and Federal Communications Commission and National Telecommunications and Information Administration spectrum programs.

Water

Water research and technology topics include issues relating to water data and aquatic ecosystem information, water infrastructure and water use, and water quality.

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Introduction

The federal science and technology (S&T) policymaking enterprise is composed of an extensive and diverse set of stakeholders in the executive, legislative, and judicial branches. The enterprise fosters, among other things, the advancement of scientific and technical knowledge; science, technology, engineering, and mathematics (STEM) education; the application of S&T to achieve economic, national security, and other societal benefits; and the use of S&T to improve federal decisionmaking.

Federal responsibilities for S&T policymaking are highly decentralized. Many House and Senate committees have jurisdiction over important elements of S&T policy. In addition, congressional appropriations committees provide funding for federal agency S&T programs. Congress also enacts laws to establish, refine, and eliminate programs, policies, regulations, regulatory agencies, and regulatory processes that affect science, technology, and engineering research and development (R&D) or rely on S&T data and analysis. Not only are congressional authorities related to S&T policymaking are diffuse; there are dozens of informal congressional caucuses in areas of S&T policy such as R&D, specific S&T disciplines, and STEM education.

The President formulates annual budgets, policies, and programs for consideration by Congress; issues executive orders and directives; and directs the executive branch departments and agencies responsible for implementing S&T policies and programs. The Office of Science and Technology Policy (OSTP), in the Executive Office of the President, advises the President and other Administration officials on S&T issues.

Executive agency S&T responsibilities are also diffuse. Some agencies have broad S&T responsibilities, such as the National Science Foundation (NSF). Others use S&T to meet a specific federal mission (e.g., defense, energy, health, space). Regulatory agencies have S&T responsibilities in areas such as nuclear energy, food and drug safety, and environmental protection.

Federal court cases and decisions often affect U.S. S&T policy. Decisions can have an impact on the development of S&T (e.g., decisions regarding the U.S. patent system); S&T-intensive industries (e.g., the break-up of AT&T in the 1980s); and the admissibility of S&T-related evidence (e.g., DNA samples).

The issues identified below represent those that CRS experts have identified as particularly relevant to the 118th Congress. Each section serves as a brief introduction to the topic and identifies other CRS products and the appropriate CRS experts to contact for further information and analysis.

Cross-Cutting Issues

This section discusses issues that cut across multiple S&T disciplines. It addresses federal R&D funding; interagency S&T coordination; the adequacy of the domestic science and engineering workforce; and federal efforts to boost regional innovation, ensure agency scientific integrity, and provide public access to the results of federally supported R&D. It also addresses issues relating to the commercialization of results of federal R&D investments, the role of patents and other intellectual property policies, tax incentives, China's S&T and industrial policies, and the security of U.S. research.

Federal Funding for Research and Development

The federal government has long supported the advancement of scientific knowledge and technological development through investments in R&D, which have led to scientific breakthroughs and new technologies, from jet aircraft and the internet to communications satellites and defenses against disease. Federal R&D funding seeks to address a broad range of national interests, including national defense, health, safety, the environment, and energy security; advance knowledge generally; develop the scientific and engineering workforce; and strengthen U.S. innovation and competitiveness.

Between FY2008 and FY2013, federal R&D funding fell from $140.1 billion to $130.9 billion in current dollars, a reduction of $9.3 billion (6.6%). The decline was a reversal of sustained growth in federal R&D funding for more than half a century and stirred debate about the potential long-term effects on U.S. technological leadership, innovation, competitiveness, economic growth, and job creation. From FY2013 to FY2017, federal funding grew, rising to an all-time current dollar high of $155.0 billion in FY2017.

A change in R&D accounting by the Office of Management and Budget (OMB) to exclude certain late-stage development activities—primarily at the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA)—from total federal R&D calculations obscures comparison of funding levels for FY2018 and later years with funding from before FY2018. As calculated by OMB, current dollar federal R&D funding was $135.8 billion in FY2018 and has risen annually to an estimated $159.6 billion in FY2022. Concerns by some about the adequacy of federal R&D funding have been exacerbated by increases in the R&D investments of other nations (China in particular), globalization of R&D and manufacturing activities, and trade deficits in advanced technology products (reaching an all-time high in 2022)—an area in which the United States previously ran trade surpluses (most recently in 2001). In addition, R&D funding decisions may be affected by differing perspectives on the appropriate role of the federal government in advancing S&T.

As the 118th Congress undertakes the appropriations process it may consider two overarching issues: (1) the level of federal R&D investment and (2) how available funding will be prioritized and allocated. The CHIPS and Science Act (P.L. 116-117) authorized substantial increases in the budgets of several leading federal R&D agencies, though the realization of these authorization levels still requires appropriations. Conversely, low or negative growth in the federal government's overall R&D investment may require movement of resources across disciplines, programs, or agencies to address priorities. Congress continues to play a central role in defining the nation's R&D priorities as it makes decisions with respect to the size and distribution of aggregate, agency, and programmatic R&D funding.

For Further Information

John F. Sargent Jr., Specialist in Science and Technology Policy

CRS Video WVB00604, *Federal Research and Development (R&D) Funding in President Biden's FY2024 Budget*

CRS Report R47564, *Federal Research and Development (R&D) Funding: FY2024*

CRS Report R47161, *Federal Research and Development (R&D) Funding: FY2023*

CRS Report R46869, *Federal Research and Development (R&D) Funding: FY2022*

White House Office of Science and Technology Policy

Congress has a long-standing interest in the development and implementation of science and technology (S&T) policies across the federal government as well as the effective coordination of multi-agency research and development (R&D) initiatives. To ensure a permanent source of S&T-related advice and policy coordination within the White House, Congress established the Office of Science and Technology Policy (OSTP) within the Executive Office of the President (EOP) through the National Science and Technology Policy, Organization, and Priorities Act of 1976 (P.L. 94-282).

In addition to OSTP, the White House S&T advisory structure includes two councils, for which OSTP provides operational and administrative support: the National Science and Technology Council (NSTC) and the President's Council of Advisors on Science and Technology (PCAST). Established in 1993 by Executive Order 12881, the NSTC is composed of representatives from departments and agencies with significant S&T responsibilities and is charged with coordinating S&T policy across the federal government. Established in 1990 by Executive Order 12700, PCAST is an independent Federal Advisory Committee composed of external experts who advise the President on matters involving policy affecting science, technology, and innovation as well as on matters involving S&T information needed to inform public policy in other areas.

OSTP is statutorily charged with advising the President on S&T matters; coordinating the implementation of S&T priorities across the federal government; and engaging with external partners in industry, academia, civil society organizations, and other governmental bodies. Accordingly, several issues related to the activities and focus of OSTP (as well as the advisory bodies it supports, the NSTC and PCAST) are of potential interest to the Congress, including staffing practices and potential conflict-of-interest concerns; workplace culture and past congressional oversight activity; persistent vacancies of Senate-confirmed leadership positions within OSTP; the stature and influence of PCAST; and the efficacy of federal S&T coordination efforts.

For example, Congress has charged the NSTC with specific statutory duties related to the coordination of multi-agency R&D initiatives. The 118th Congress might consider the efficacy of NSTC coordination efforts in the congressionally mandated areas of quantum information science and artificial intelligence R&D. In doing so, Congress may consider issues and options related to potential resource constraints as well as the adequacy of the NSTC's organization and current authorities to maintain continuity across presidential Administrations.

For Further Information

Emily G. Blevins, Analyst in Science and Technology Policy

CRS Report R47635, *The White House Office of Science and Technology Policy: Issues and Options for the 118th Congress*

CRS Report R47410, *The Office of Science and Technology Policy (OSTP): Overview and Issues for Congress*

CRS Video WVB00602, *The White House Office of Science and Technology Policy: Issues for the 118th Congress*

Adequacy of the U.S. Science and Engineering Workforce

The adequacy of the U.S. science and engineering (S&E) workforce has been an ongoing concern of Congress for more than 70 years. Scientists and engineers are widely believed to be essential to

U.S. technological leadership, innovation, manufacturing, and services and thus vital to U.S. economic strength, national defense, and other societal needs. Congress has enacted many programs to support the education and development of scientists and engineers. Congress has also undertaken broad efforts to improve STEM skills to prepare a greater number of students to pursue S&E degrees. In addition, some policymakers have sought to increase the number of foreign scientists and engineers working in the United States through changes in visa and immigration policies.

Most experts agree that there is no authoritative definition of which occupations comprise the S&E workforce. Rather, the selection of occupations included in any particular analysis of the S&E workforce may vary depending on the objective of the analysis. The policy debate about the adequacy of the U.S. S&E workforce has focused largely on professional-level computer occupations, mathematical occupations, engineers, and physical scientists. Accordingly, much of the analytical focus has been on these occupations. However, some analyses may use a definition that includes some or all of these occupations, as well as life scientists, S&E managers, S&E technicians, social scientists, and related occupations.

Many policymakers, business leaders, academics, S&E professional society analysts, economists, and others hold differing views with respect to the adequacy of the S&E workforce and related policy issues. These issues include whether there is a shortage of scientists and engineers in the United States, what the nature of any such shortage might be (e.g., too few people with S&E degrees, mismatches between skills and needs, geographical mismatches), and whether the federal government should undertake policy interventions or rely upon market forces to resolve any shortages in this labor market. Among the key indicators used by labor economists to assess the existence of occupational labor shortages are employment growth, wage growth, and unemployment rates.

Concerns about U.S. overreliance on overseas sources of semiconductor microchips—used ubiquitously throughout the economy and in national security systems—were highlighted during debate over the establishment of an incentive program for domestic production of microchips. With the passage of P.L. 117-163 (widely known as the CHIPS and Science Act), some analysts and industry advocates have asserted the need for expanded immigration of skilled technical workers to meet the needs of the semiconductor fabrication and related facilities established in the United States with the support of the act's provisions.

For Further Information

John F. Sargent Jr., Specialist in Science and Technology Policy

Jill H. Wilson, Analyst in Immigration Policy

CRS Report R47159, *Temporary Professional Foreign Workers: Background, Trends, and Policy Issues*

Federal Efforts to Boost Regional Innovation

The geographic concentration of interconnected companies and institutions in a specific industry can provide opportunities to leverage talent, infrastructure, supply chains, and other spillover effects that are advantageous to companies and economic growth. For decades, state, local, and regional stakeholders have pursued cross-sector, multidisciplinary approaches to economic development through the facilitation of such industry clusters. Industry clusters are generally designed to address structural or institutional challenges related to entrepreneurship and innovation, access to capital, infrastructure, and workforce needs and may be implemented in concert with programs that provide direct assistance to individual firms. Research suggests that

firms in innovation-based industries particularly benefit from the advantages of a regional innovation ecosystem, including more quickly understanding consumer demand and access to feedback from other entrepreneurs.

Recent executive and legislative branch actions indicate increased federal interest and support for regional innovation efforts. In July 2021, the Economic Development Administration (EDA) allocated $1 billion of supplemental funding for economic recovery activities to the Build Back Better Regional Challenge, a grant initiative to support new or existing regional industry clusters. Additionally, Congress required the establishment of several new regional innovation programs in the CHIPS and Science Act (P.L. 117-167), including the Regional Technology and Innovation Hubs Program at EDA, the Regional Innovation Engines Program at NSF, and the Regional Clean Energy Innovation Program at the Department of Energy (DOE).

The 118th Congress may wish to examine the implementation of these new programs, including the coordination of federal programs and place-based resources; the scale, scope, and duration of federal involvement; the long-term sustainability of supported efforts; ensuring inclusive innovation and economic growth; and institutional capacity-building and small business engagement, among others. A related congressional issue may be the level of funding needed for both new and existing regional innovation programs.

For Further Information

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Julie M. Lawhorn, Analyst in Economic Development Policy

Adam G. Levin, Analyst in Economic Development Policy

Emily G. Blevins, Analyst in Science and Technology Policy

CRS Insight IN12170, *Economic Development Administration Announces Phase 1 of New Tech Hubs Program*

CRS Insight IN11925, *Regional Technology and Innovation Hubs: An Overview and Issues for Congress*

CRS Report R47495, *Regional Innovation: Federal Programs and Issues for Consideration*

Federal Scientific Integrity Policies

The results of R&D help inform the decisions that policymakers and the public make on a wide range of issues, including human health and safety, the environment, agriculture, energy, and transportation. For example, scientific information is essential to the review and approval of drugs and medical devices and the setting of air quality standards. There is broad agreement among policymakers and the scientific and engineering community about the need to ensure the integrity of the conduct, communication, and management of R&D, and its use in policy development and decisionmaking.

Some policymakers and others allege that presidential Administrations of both parties have violated principles of scientific integrity. Assertions of such violations include weighting the membership of federal advisory committees toward a particular viewpoint or constituency, targeting individual scientists for harassment or adverse actions, appointing agency officials with significant conflicts of interest or antagonistic views toward an agency's mission, improperly editing scientific documents, and using the budget process to impede the implementation or formulation of science-based policies.

Following the guidance of a 2010 memorandum issued by OSTP, more than 20 federal departments and agencies have developed and implemented scientific integrity policies. There is, however, no uniform definition of *scientific integrity* across the federal government, and a review of the effectiveness of scientific integrity policies by the National Science and Technology Council found, among other things, that "violations involving high-level officials are the most problematic and difficult to address." Some experts have expressed concern over the variation in scope and specificity of federal agency scientific integrity policies and recommended that Congress enact scientific integrity legislation that would create a clear set of standards and mechanisms for enforcement. The 118th Congress may wish to consider such legislation in addition to conducting oversight over the implementation of current policies.

Further Information

Marcy E. Gallo, Analyst in Science and Technology Policy

CRS Report R46614, *Federal Scientific Integrity Policies: A Primer*

Public Access to Scientific Publications Resulting from Federally Funded R&D

The federal government invests approximately $150 billion each year in R&D to address a broad range of national interests, from advancing public health to strengthening U.S. competitiveness. A key component in the transformation of R&D results into innovative products and services is the dissemination of knowledge through scientific publications. According to OSTP, federally funded R&D accounted for between 195,000 and 263,000 of the 2.9 million peer-reviewed scientific articles published worldwide in 2020.

In 2013, OSTP directed each federal agency with annual R&D expenditures over $100 million to develop and implement a plan to support increased public access to the results of federally funded R&D. The OSTP memorandum required, among other things, the use of a 12-month, post-publication embargo before making scientific publications publicly available. Critics of the embargo period argue that it requires American taxpayers to pay twice—once to fund the research and then again to view the results. On the other hand, some commercial publishers and nonprofit scientific societies that publish research journals argue that the embargo period is critical to ensuring subscription revenues that support editing and production costs and other activities such as scientific conferences.

In August 2022, OSTP issued a memorandum directing all federal agencies to develop new or update existing public access plans requiring scientific publications resulting from federally funded R&D to be publicly accessible immediately upon publication. The memorandum also requires that scientific data underlying such publications be made publicly accessible at the time of publication. Federal agencies are required to develop and implement their new or updated public access plans by December 31, 2025.

Some Members of Congress and others have questioned how the policy will be implemented and its potential impacts. For example, concerns have been raised that publishing costs will shift from journal subscribers to researchers and the agencies that fund them. Shifting publishing costs to researchers may create equity concerns in which an early career scientist or researcher from a less-well-resourced institution may not be able to afford the cost of publishing or be forced to choose between publishing and a professional development opportunity. The 118th Congress may wish to examine implementation of the new public access policy and its potential impacts on cost, researchers, and the publishing industry.

For Further Information

Marcy E. Gallo, Analyst in Science and Technology Policy

CRS Insight IN12049, *Public Access to Scientific Publications Resulting from Federally Funded R&D*

Commercializing the Results of Federal R&D Investments

Inventions resulting from research conducted at federally owned laboratories or with federal funding (e.g., research grants) often have application beyond the scope and goals of the original research. Without further investment and sufficient private sector incentives, however, the potential commercial value of federally funded inventions may not be fully realized.

Current mechanisms to encourage the commercialization of federal R&D results are governed by two main pieces of legislation from the 1980s, as amended: the Stevenson-Wydler Technology Innovation Act of 1980 (35 U.S.C. §§3710 et seq.) and the Bayh-Dole Act of 1980 (35 U.S.C. §§200 et seq.).

Significant changes in the global S&T landscape, economic conditions, and national security posture have led some policymakers and analysts to ask whether aspects of these laws may need reevaluation. For example, critics point to loopholes in the Bayh-Dole Act's "Preference for U.S. Industry" provision (35 U.S.C. §204) that have allowed federally owned intellectual property and covered inventions to be manufactured abroad. These critics argue that the ability of competitor nations to access U.S.-developed technology—especially emerging technologies—poses an economic and national security threat.

Proponents of maintaining the current laws argue that exceptions that permit foreign manufacturing when U.S. industry is unable to meet production demands are beneficial. They also maintain that additional restrictions placed on the licensing and manufacturing of federally funded inventions could reduce incentives for the private sector to commercialize federal R&D.

When considering how best to encourage the commercialization of federally funded research, the 118th Congress may wish to consider increased oversight to ensure agency enforcement of existing U.S. manufacturing requirements and whether to enact statutory changes to existing requirements. Congress might also consider whether digital products that result from work at federal laboratories should be eligible for copyright and whether current requirements for invention disclosure and utilization reporting are adequate for assessing the success of commercialization efforts.

For Further Information

Emily G. Blevins, Analyst in Science and Technology Policy

Marcy E. Gallo, Analyst in Science and Technology Policy

CRS Insight IN12019, *U.S. Technology Made in China: The Role of Federal Technology Licensing Policies*

Patents and Innovation Policy

The U.S. patent system is designed to encourage scientific and technological innovation by offering a limited-time monopoly on an invention in exchange for its public disclosure. The 118th Congress, when considering approaches to encouraging innovation and economic growth, may

choose to address certain aspects of patent policy, including patent subject matter eligibility standards, the Patent Trial and Appeal Board (PTAB), and inventor diversity.

Patent subject matter eligibility standards determine the types of inventions that may be patented and may significantly influence innovation incentives. In the wake of a series of Supreme Court decisions that restricted patent eligibility, stakeholders in the biotechnology and computer software industries (among others) have argued that uncertainty over patent eligibility in their fields has reduced investment and inhibited innovation. In response, the U.S. Patent and Trademark Office (USPTO) issued new guidance to patent examiners clarifying how to apply subject matter eligibility standards, and bills were introduced in the 117th Congress to change statutory eligibility standards and abrogate Supreme Court decisions (e.g., S. 4734 and H.R. 5874).

In 2011, Congress created the PTAB, an administrative body within the PTO, as a way to improve patent quality. PTAB proceedings often provide a faster and less expensive forum in which to challenge the validity of issued patents than federal court litigation. Some stakeholders argue that the PTAB offers a fair and efficient means to adjudicate patent validity issues, but others contend that the process is biased against patent holders. Several hearings were held in the 117th Congress on PTAB, and a number of bills were introduced that sought to reform or eliminate PTAB processes (e.g., S. 2891, S. 4417, and H.R. 5874).

The USPTO does not currently track patent inventors' demographic information. If collected through patent applications, such data could potentially assist policymakers in assessing the existence or scope of potential systematic inequities embedded in the patent system that might inhibit innovation. Some critics of collecting this information raise concerns about privacy violations. Bills introduced during the 117th Congress sought to require the PTO to request voluntary inventor demographic information on patent applications (e.g., S. 632 and H.R. 1723).

For Further Information

Emily G. Blevins, Analyst in Science and Technology Policy

Kevin J. Hickey, Legislative Attorney

CRS Video WVB00518, *Patents and Innovation Policy*

CRS Report R47267, *Patents and Innovation Policy*

CRS Report R45918, *Patent-Eligible Subject Matter Reform: Background and Issues for Congress*

CRS Legal Sidebar LSB10615, *Supreme Court Preserves Patent Trial and Appeal Board, but with Greater Executive Oversight*

CRS Report R46525, *Patent Law: A Handbook for Congress*

CRS In Focus IF12259, *Equity in Innovation: Trends in U.S. Patenting and Inventor Diversity*

Intellectual Property Law

Intellectual property (IP) rights, including patents and copyrights, play a critical role in encouraging innovation, creativity, and the dissemination of knowledge. Based on activity in the 117th Congress, it appears that several areas of IP law may be of interest to the 118th Congress.

In addition to the innovation policy issues discussed above (see "Patents and Innovation Policy"), patents play a particularly important role in the pharmaceutical industry. While some stakeholders argue that robust patent rights are necessary to support costly R&D for new drugs, others argue

that patents can unduly delay or deter generic competition and contribute to higher drug prices. Several bills in the 117th Congress sought to reduce drug prices by limiting certain alleged pharmaceutical patenting practices (e.g., patent "evergreening," "product hopping," "thickets," and "pay-for-delay" settlements). Other bills sought to facilitate coordination between PTO and the Food and Drug Administration (FDA) on pharmaceutical patents (S. 4430) or respond to the Biden Administration's support for a waiver of IP protections for COVID-19 vaccines under international IP treaties (e.g., H.R. 7430).

Copyrights grant authors of original creative works (e.g., books, music, computer code) the exclusive right to reproduce, perform, and sell their works. Two significant copyright reforms were implemented during the 117th Congress. The Music Modernization Act, which changed the copyright licensing process for online distribution of musical works, came into full effect in January 2021. The Copyright Alternative in Small-Claims Enforcement Act of 2020 established the Copyright Claims Board as a small-value copyright claims administrative tribunal, which began hearing claims in 2022. Other copyright issues include proposed reforms to the Digital Millennium Copyright Act of 1998 (e.g., S. 3880, H.R. 6566) and continued debate over whether broadcast radio should pay royalties to play sound recordings (e.g., S. 4932, S.Con.Res. 9).

As to trademarks—another area of federal IP—the 117th Congress saw increased efforts to combat fraudulent trademarks through PTO regulations implementing the Trademark Modernization Act of 2020. Introduced bills also addressed whether increased remedies are needed to combat infringing goods sold by online e-commerce platforms (e.g., S. 1843).

For Further Information

Kevin Hickey, Legislative Attorney

CRS In Focus IF10986, *Intellectual Property Law: A Brief Introduction*

CRS Infographic IG10033, *Intellectual Property: Forms of Federal IP Protection*

CRS Report R46679, *Drug Prices: The Role of Patents and Regulatory Exclusivities*

CRS Legal Sidebar LSB10422, *COVID-19 Medical Countermeasures: Intellectual Property and Affordability*

CRS In Focus IF11478, *Digital Millennium Copyright Act (DMCA) Safe Harbor Provisions for Online Service Providers: A Legal Overview*

Tax Incentives for R&D Investment

The 118th Congress may wish to consider new federal tax policies to promote technological innovation, considered a key contributor to long-term economic growth.

In general, R&D lays the foundation for technological innovation. Businesses finance much of the R&D performed in the United States. But owing to the inability of companies to capture all the economic returns to their R&D investments, they tend to invest less in R&D than those returns would warrant, particularly in basic research.

Economists regard such underinvestment as a market failure that should be remedied through a mix of public policies. One option is to provide tax incentives for increased business R&D investment. The federal government offers one such incentive: a research tax credit under Section 41 of the Internal Revenue Code (IRC). There are two choices for the credit: one equal to (1) 20% of qualified research expenses (QREs) above a base amount linked to past ratios of research spending to business receipts, or (2) 14% of QREs above a base amount linked to recent R&D investments.

The 118th Congress may wish to consider several issues concerning U.S. R&D tax incentives. One issue is whether to reinstate an expensing allowance for QREs (to immediately deduct them from income) under IRC Section 174. (The option to expense expired at the end of 2021.) In general, expensing lowers the marginal effective tax rate (METR) for the returns to 0%. Under current law, domestic QREs have to be amortized over five years, which may boost the METR for domestic R&D investments to 8.4% in 2022-2025, according to one analysis.

Another issue is whether to increase the IRC Section 41 tax credit's incentive effect. The effective rates of the two credit options are substantially less than their statutory rates under current law. Some argue that their effective rates should be larger than the statutory rates to deliver the needed stimulus to raise domestic business R&D investment to levels consistent with its economic returns. In addition, there is evidence that the current credit does little to benefit entrepreneurial start-up firms. Some argue that the credit should be fully refundable for small entrepreneurial firms in their early years, when they typically sustain operating losses that keep them from immediately benefiting from the credit.

For Further Information

Gary Guenther, Analyst in Public Finance

CRS Report RL31181, *Federal Research Tax Credit: Current Law and Policy Issues*

CRS Insight IN11887, *Tax Treatment of Research Expenses: Current Law and Policy Issues*

China's Science, Technology, and Industrial Policies

China's state-led industrial and related S&T policies aim to create competitive advantages for China in strategic and emerging industries, in part by accessing basic and applied research, technology, talent, and training from the United States and U.S. allies. The Chinese government says it is pursuing a policy of technology independence, but its approach involves sustaining and expanding its access to U.S. and foreign technology, capabilities, research, and talent.

China's *Medium- and Long-Term Plan in Science in Technology (2006-2020)* set technological innovation as the core driver of China's development, a focus that was reinforced at the Communist Party of China's 20th Party Congress. China's process of indigenous innovation involves the acquisition, assessment, distribution, absorption, and adaptation of foreign technology that China rebrands as indigenous Chinese capabilities.

China's *Made in China 2025* industrial policies aim to establish China's leadership in emerging technologies that are critical to future commercial, government, and military capabilities. Priority areas include advanced manufacturing, aerospace, artificial intelligence, information technology, new materials, robotics, and semiconductors. China's military-civil fusion program seeks to leverage these *Made in China 2025* technological advancements for military development.

China's *14th Five-Year Plan (FYP) for 2021-2025 and Economic Goals out to 2035* prioritizes leveraging global basic research to support China's development of indigenous capabilities in strategic technologies. China is focusing on currently unrestricted pathways, such as U.S. basic and applied research and open source technology platforms. China has incentivized some of its citizens to participate in U.S. research to acquire capabilities in targeted areas that support China's goals. China is also encouraging domestic firms to establish R&D centers overseas to access foreign technical knowledge and capabilities and is offering incentives for leading foreign S&T experts to work in China.

China's industrial and S&T policies have been a U.S. policy focus because of the asymmetrical tactics that China has used to implement them. U.S. law enforcement and counterintelligence

agencies have highlighted China's use of forced or incentivized technology transfer, industrial subsidies, licensing and joint venture requirements, state-directed cyber intrusions and IP theft, and government-funded acquisitions of foreign firms in strategic sectors. These issues are likely to remain a key area of focus in the 118th Congress as China seeks to sustain and expand its access to U.S. innovation and S&T capabilities.

For Further Information

Karen M. Sutter, Specialist in Asian Trade and Finance

Michael D. Sutherland, Analyst in International Trade and Finance

CRS In Focus IF12510, *U.S.-China Science and Technology Cooperation Agreement*

CRS In Focus IF11684, *China's 14th Five-Year Plan: A First Look*

CRS Report R46767, *China's New Semiconductor Policies: Issues for Congress*

CRS In Focus IF11627, *U.S. Export Controls and China*

R&D Security

The federal government invests extensively in S&E R&D to achieve national objectives, including economic competitiveness and national security. Many in Congress are concerned about security vulnerabilities in the U.S. R&D enterprise and are interested in protecting it against compromise by foreign competitors and potential military adversaries.

In general, U.S. policy for federally funded basic and applied research is to encourage openness and broad dissemination of results (see National Security Decision Directive NSDD-189, 1985). When openness would present a national security concern, however, the federal government can use restrictions such as classification and export controls to prevent certain nations (e.g., Russia, China, Iran, and North Korea) and their proxies from accessing certain results and technologies. Some emerging fields may not yet be subject to these controls, so Congress enacted a provision in the Export Control Reform Act of 2018 (50 U.S.C. §4817) requiring the Bureau of Industry and Security of the Department of Commerce to "establish appropriate controls, including interim controls, on the export, reexport, or transfer (in country) of emerging and foundational technologies." Some Members may be interested in strengthening these protections.

Recently, Congress has also focused on the security of U.S. R&D that is significant for economic competitiveness in light of organized efforts, both licit and illicit, by China and other nations to access economically important U.S. R&D outputs to aid their defense and commercial sectors. Classification and export controls were not designed to address commercial aspects of the R&D security threat.

Some Members have been concerned with co-option of U.S. citizen researchers through foreign talent recruitment programs (e.g., China's Thousand Talents program) and the use of foreign nationals at U.S. universities and other institutions—such as students, faculty, visiting scholars, and postdoctoral researchers—to acquire and report on research activities, progress, and results. Congress has considered increasing threat awareness among U.S. academic researchers, strengthening disclosure requirements for U.S. researchers with foreign ties, and changing policies for foreign students at U.S. universities.

The 118th Congress may continue to monitor threats to the security of U.S. R&D, conduct oversight to examine the progress of ongoing efforts to address those threats, and consider additional measures that may enhance the ability of the United States to protect the results of federally funded R&D.

For Further Information

Marcy E. Gallo, Analyst in Science and Technology Policy

Daniel Morgan, Specialist in Science and Technology Policy

John F. Sargent Jr., Specialist in Science and Technology Policy

Karen Sutter, Specialist in Asian Trade and Finance

Jill H. Wilson, Analyst in Immigration Policy

CRS Insight IN11524, *China Issues New Export Control Law and Related Policies*

CRS In Focus IF11684, *China's 14th Five-Year Plan: A First Look*

Semiconductors and the CHIPS Act

Semiconductors (also known as integrated circuits, microelectronic chips, or computer chips) are tiny electronic devices (based primarily on silicon or germanium) composed of billions of components that can process, store, sense, and move data or signals. Semiconductors are a uniquely important enabling technology, fundamental to nearly all modern industrial and national security activities, as well as essential building blocks of other emerging technologies, such as artificial intelligence, autonomous systems, and quantum computing. The federal government and U.S. companies pioneered semiconductor development throughout the 1960s and 1970s, and the United States led the world in semiconductor manufacturing. A variety of factors subsequently led to a concentration of semiconductor manufacturing in East Asia. These factors included other nations subsidizing the construction and operation of semiconductor fabrication facilities (fabs); lower operating costs abroad; outsourcing of manufacturing by fabless semiconductor design firms that previously manufactured their own chips; and a preference for being physically proximate to electronics business clusters in the region.

Policymakers became increasingly concerned about the potential implications of this trend for economic and national security reasons, and noted the risks associated with ensuring an adequate supply of semiconductors resulting from potential disruption of East Asian manufacturing and shipping due to trade disputes, natural hazards, or armed conflict. The COVID-19 pandemic and consequent interruption of semiconductor supplies to the United States—and the subsequent effects on U.S.-based industries—bolstered these concerns. U.S. overreliance on semiconductor production in East Asia and its vulnerability to disruption has been an ongoing source of concern for many Members of Congress.

To address these concerns, Congress enacted the National Defense Authorization Act for Fiscal Year 2021 (2021 NDAA, P.L. 116-283), which authorized an incentive program for building and equipping semiconductor fabs in the United States, as well as research and development (R&D) activities to support U.S. leadership in semiconductor technology. In July 2022, Congress enacted the CHIPS and Science Act (P.L. 117-167), which President Biden signed into law in August 2022. The CHIPS Act of 2022 (Division A of P.L. 117-167) establishes and appropriates $39.0 billion to a CHIPS for America Fund to bolster semiconductor manufacturing capacity in the United States by providing financial incentives for building, expanding, and equipping domestic fabrication facilities and companies in the semiconductor supply chain. The fund also provides $11.0 billion for semiconductor R&D activities at the National Institute of Standards and Technology and in partnership with U.S. industry through a National Semiconductor Technology

Center, a National Advanced Packaging Manufacturing Program, and the establishment of up to three Manufacturing USA institutes. P.L. 117-167 also provided appropriations for three additional funds that seek to bolster U.S. semiconductor capabilities for national defense, workforce development, and international cooperation. Implementation of these provisions began in 2023.

For Further Information

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CRS Report R47508, *Semiconductors and the Semiconductor Industry*

CRS Report R47523, *Frequently Asked Questions: CHIPS Act of 2022 Provisions and Implementation*

CRS Report R47558, *Semiconductors and the CHIPS Act: The Global Context*

CRS Video WVB00589, *Science and Technology Q&A: Semiconductors and the CHIPS Act of 2022*

CRS Report WPD00059, *Science and Technology Podcast: Semiconductors and the CHIPS Act of 2022*

CRS In Focus IF12000, *Semiconductor Shortage Constrains Vehicle Production*

Agriculture

The federal government funds billions of dollars of agricultural research annually. The 118th Congress may wish to consider issues related to funding this research, as well as specific issues related to climate change science at the U.S. Department of Agriculture (USDA) and the regulation of agricultural biotechnology.

Agricultural Research Funding

The USDA Research, Education, and Economics (REE) mission area consists of four agencies: the Agricultural Research Service, the Economic Research Service, the National Agricultural Statistics Service, and the National Institute of Food and Agriculture. Additionally, REE's Office of the Chief Scientist coordinates research programs and activities across the department.

REE has the primary federal responsibility for advancing scientific knowledge about agriculture. Its agencies conduct and fund research that spans the biological, physical, and social sciences broadly related to agriculture, food, and natural resources. Congress provided the REE mission area programs and activities approximately $3.6 billion in FY2022 discretionary appropriations through the Consolidated Appropriations Act, 2022 (P.L. 117-103), and authorized approximately $122 million of mandatory funding per year through the Agriculture Improvement Act of 2018 (2018 farm bill, P.L. 115-334). USDA directs nearly half of this federal funding to states and local partners, primarily through grants.

The most recent farm bill (P.L. 115-334), enacted in December 2018, reauthorizes many existing USDA research and education programs, and authorizes new programs, through FY2023. Congress has appropriated limited funding for some of the new programs. For example, the 2018 farm bill authorized the Agriculture Advanced Research and Development Authority (AGARDA) pilot program. AGARDA is intended to operate under the Office of the Chief Scientist to address long-term and high-risk research challenges in the agriculture and food sectors. It is modeled on

federal advanced research entities such as the Defense Advanced Research Projects Agency and the Advanced Research Projects Agency—Energy. Congress authorized appropriations of $50 million annually for AGARDA from FY2019 to FY2023. Congress appropriated $1 million for AGARDA for FY2022 for planning purposes and to hire staff. Congress allocated no funding to carry out research.

The 118th Congress may wish to consider reviewing AGARDA and other new programs established in the 2018 farm bill that have received limited or no appropriations. The 2018 farm bill is expected to expire in 2023, and with this in mind, Congress may begin to consider new programs or revisions to existing programs for the next farm bill.

For Further Information

Lisa Benson, Analyst in Agricultural Policy

CRS Report R45897, *The U.S. Land-Grant University System: Overview and Role in Agricultural Research*

CRS In Focus IF12023, *Farm Bill Primer: Agricultural Research and Extension*

CRS Report R40819, *Agricultural Research: Background and Issues*

Climate Change Science at USDA

The 118th Congress may be interested in research related to climate change and agriculture and how USDA is carrying out plans to address the needs of agricultural producers in the context of changing climatic conditions. Some farmers and agricultural groups have called on USDA to increase its engagement in helping farmers adapt to changing climatic conditions, which may include increased instances of drought and extreme rainfall, historically unseasonable temperatures, and changes in the dates of first and last frost. Agricultural research could, for example, identify best management practices under different environmental conditions.

USDA published its *Action Plan for Climate Adaptation and Resilience* in 2021. This plan identifies the areas of S&T where USDA believes it needs to increase its support to meet national objectives. Financial investments in climate-related agriculture practices by both Congress and USDA since 2021 have generally offered producers incentives to adopt agricultural and forestry practices that will further climate-related goals. The 118th Congress may wish to consider reviewing how investments in USDA research programs and policies align with its Action Plan.

For Further Information

Megan Stubbs, Specialist in Agricultural Conservation and Natural Resources

CRS In Focus IF11404, *Greenhouse Gas Emissions and Sinks in U.S. Agriculture*

Regulation of Agricultural Biotechnology

The 118th Congress may continue to oversee USDA's implementation of regulations related to the labeling of bioengineered foods and the regulation of agricultural biotechnology. As plants and animals that are developed with new biotechnology tools become more common, Congress could consider whether to revisit the 1986 Coordinated Framework for the Regulation of Biotechnology that governs U.S. biotechnology regulation.

In 2016, Congress enacted P.L. 114-216, requiring the establishment of a national standard for the mandatory labeling of foods containing *bioengineered* or *genetically engineered* (GE) ingredients. USDA finalized its National Bioengineered Food Disclosure Standard regulations in

2018, and mandatory compliance began in January 2022. However, in September 2022, a U.S. district court remanded two provisions in USDA's regulation that allow GE foods to be labeled only with an electronic or digital disclosure (QR code) and allow text message disclosure on packaging without requiring additional on-package labeling (7 C.F.R. §§66.106 and 66.108). Following the court's ruling, USDA is expected to revise these provisions in its labeling regulations. The case, *Natural Grocers et al. v. Perdue et al.* (3:20-cv-05151), was brought by the Center for Food Safety on behalf a coalition of nonprofits and food retailers.

The emergence of new biotechnology tools (e.g., genome editing) are addressed in two other regulations. In May 2020, USDA finalized its SECURE Rule, which regulates GE organisms under the Plant Protection Act (7 U.S.C. §§7701 et seq.) and exempts certain categories of modified plants, including those consistent with many existing genome-edited plants. While some producer groups view USDA's regulation as supportive of innovation, some consumer and exporter groups claim it lacks sufficient oversight and transparency. In December 2020, USDA announced plans to transfer responsibility for regulating agricultural animals produced or modified with genetic engineering to USDA from the FDA. Further action is pending.

For Further Information

Renée Johnson, Specialist in Agricultural Policy

CRS Report R46737, *Agricultural Biotechnology: Overview, Regulation, and Selected Policy Issues*

CRS Report R46183, *The National Bioengineered Food Disclosure Standard: Overview and Selected Considerations*

CRS In Focus IF11573, *USDA's SECURE Rule to Regulate Agricultural Biotechnology*

Biotechnology and Biomedical Research

Recent advances in biotechnology and biomedical research hold the promise of longer and healthier lives and more productive industry while raising policy challenges. Some issues that the 118th Congress may face include those relating to the bioeconomy; the National Institutes of Health; oversight of engineering biology; regulation of laboratory-developed tests; monitoring of environmental deoxyribonucleic acid (DNA) and ribonucleic acid (RNA); and the convergence of biotechnology, digital data, robotics, and artificial intelligence.

Bioeconomy

The bioeconomy is the portion of the economy based on products, services, and processes derived from biological resources (e.g., plants and microorganisms). According to the McKinsey Global Institute, "as much as 60 percent of the physical inputs to the global economy could, in principle, be produced biologically." Many experts view growing the bioeconomy as a means to address societal challenges such as climate change, food security, energy independence, and environmental sustainability. However, the cross-cutting nature of the bioeconomy poses potential challenges to effective policymaking, including the harmonization of policies and coherent governance.

On September 12, 2022, President Biden issued Executive Order 14081, "Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy," which prescribes a "whole-of-government approach to advance biotechnology and biomanufacturing towards innovative solutions." According to the White House, "global industry

is on the cusp of an industrial revolution powered by biotechnology. Other countries are positioning themselves to become the world's resource for biotechnology solutions and products."

The 118th Congress may wish to consider a number of issues regarding advancement of the U.S. bioeconomy, including the development and implementation of a national bioeconomy strategy, federal investments in bioeconomy-related research and development, expanding the bioeconomy workforce, promoting and furthering the development of regional bioeconomies, increasing the market for bio-based products and services, and increasing public awareness and acceptance of bio-based products and services. Conversely, Congress may decide there is no need to restructure federal activities and policies, including some long-standing efforts (e.g., bio-based fuels or agricultural biotechnology), under a bioeconomy framework.

For Further Information

Marcy E. Gallo, Analyst in Science and Technology Policy

Todd Kuiken, Analyst in Science and Technology Policy

CRS Report R46881, *The Bioeconomy: A Primer*

CRS Report R47274, *White House Initiative to Advance the Bioeconomy, E.O. 14081: In Brief*

CRS Report R47265, *Synthetic/Engineering Biology: Issues for Congress*

National Institutes of Health (NIH) and Biomedical Research

NIH is the lead federal agency for medical and health research. NIH funds basic, translational, and clinical research, with basic research comprising about half of its funded research. NIH supports *intramural research* conducted at NIH research facilities (about 10% of its budget) as well as *extramural research* through grants, contracts, and other mechanisms at research institutions nationwide and globally (over 80% of its budget). NIH's FY2022 enacted program level is $46.2 billion. NIH represents about one-fifth of total federal R&D spending, and close to half of non-DOD research and development funding.

NIH is a large agency made up of 27 institutes and centers (ICs) and the Office of the Director. Each research IC receives separate appropriations, sets its own priorities, and manages its programs in coordination with the Office of the Director. Funding levels vary widely among the ICs. The National Cancer Institute has the highest FY2022 enacted funding level at $6.9 billion, and the John E. Fogarty International Center (focus on global health) has the lowest FY2022 funding level at $87 million. Aside from setting funding levels for individual IC accounts, Congress has not designated funding for specific disease or research areas, except in a few cases (e.g., Alzheimer's disease research).

In FY2022, Congress funded a new Advanced Research Projects Agency for Health (ARPA-H)—an agency focused on advancing health innovations by funding high-risk, high-reward research. ARPA-H is housed within NIH but functions independently. Moving forward, Congress may wish to consider the respective roles for NIH and ARPA-H in health research.

NIH is arguably at an inflection point at the start of the 118th Congress. Its long-time director, Dr. Francis Collins, stepped down in 2021, and a new director has yet to be appointed. Some IC director positions are also vacant, and new leadership could lead to an overall shift at the agency. In recent years, NIH has received some praise, especially for its role in research and development supporting COVID-19 vaccines and tests. On the other hand, some have criticized the agency as it relates to research security, including its role in funding controversial "gain-of-function" research and its oversight of funded research in China. Some have also critiqued the agency as

risk-averse in its approach to funding research and the slow pace of some of its research initiatives, such as its Long COVID research. The 118th Congress may wish to consider how best to ensure that NIH-funded research—and U.S. biomedical science more broadly—is productive, secure, and effective.

For Further Information

Kavya Sekar, Analyst in Health Policy

CRS Report R43341, *National Institutes of Health (NIH) Funding: FY1996-FY2024*

CRS Report R47568, *Advanced Research Projects Agency for Health (ARPA-H): Overview and Selected Issues*

Oversight of Engineering Biology

Engineering biology is the application of engineering principles and the use of systematic design tools to enable the reprogramming of living cells at the genetic level for a specific functional output. As the field of engineering biology is developing rapidly, distinctions are not always clear among engineering biology, synthetic biology, and other related terms such as GE, genome engineering, and biotechnology. Engineering biology may find use in multiple sectors, including biomanufacturing, medicine, consumer products, agriculture, smart materials, energy generation, adaption to and mitigation of climate change, environmental conservation, pollution remediation, and others. On September 12, 2022, President Biden issued Executive Order 14081, "Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy." An accompanying White House press release stated that "global industry is on the cusp of an industrial revolution powered by biotechnology" and that "other countries are positioning themselves to become the world's resource for biotechnology solutions and products."

Applications of engineering biology have become more complex, novel, and designed for broader use in the environment—for example, to control disease transmission and reduce the impacts of invasive species on natural population. Applications designed for release into the environment may have biosecurity implications. For example, gene drives, a system of biasing inheritance to increase the likelihood of sexually reproducing species passing on a modified gene to offspring, could potentially spread and persist throughout the environment with irreversible effects on organisms and ecosystems. These potential ecological impacts could have biosecurity and strategic implications for the United States. For example, if a staple crop or ecosystem were impacted by an engineering biology application, deliberately or by accident, it could affect U.S. food and water supply chains and global food security systems.

In the 118th Congress, policymakers may wish to consider whether the current U.S. regulatory system, research and infrastructure investments, and agency expertise appropriately balance the broad cross-cutting issues associated with engineering biology (e.g., biosafety, biosecurity, and ecological impacts) while maintaining U.S. competitiveness and leadership in biotechnology.

For Further Information

Todd Kuiken, Analyst in Science and Technology Policy

Marcy E. Gallo, Analyst in Science and Technology Policy

CRS Video WVB00526, *CRS Science and Technology Seminar Series: Engineering Biology Issues for the 118th Congress*

CRS Report R47265, *Synthetic/Engineering Biology: Issues for Congress*

CRS Report R47274, *White House Initiative to Advance the Bioeconomy, E.O. 14081: In Brief*

Regulation of Laboratory-Developed Tests (LDTs)

Regulation of LDTs—a class of in vitro diagnostic devices that is designed, manufactured, and used within a single laboratory—has been debated for many years, driven in part by an increase in the number and complexity of LDT genetic tests. FDA has traditionally exercised enforcement discretion over LDTs, meaning that most have not undergone FDA premarket review. Regardless, FDA has asserted authority over certain LDTs that it considers to be higher risk—in particular, direct-to-consumer genetic tests and pharmacogenetic tests. In 2014, FDA published draft guidance outlining a comprehensive risk-based regulatory framework for LDTs. This guidance was never finalized, although FDA published a discussion paper in 2017 summarizing the comments received on the draft guidance and presenting a modified proposed framework for an approach to LDT oversight.

The COVID-19 pandemic highlighted issues around FDA regulation of LDTs. Specifically, although FDA generally exercises enforcement discretion over LDTs, most COVID-19 LDTs have nevertheless been subject to Emergency Use Authorization (EUA) requirements in the same way as other medical products, including other in vitro diagnostics. In August 2020, the Department of Health and Human Services (HHS) announced that FDA was prohibited from requiring premarket review for all LDTs without first undergoing notice-and-comment rulemaking. Pursuant to this announcement, FDA temporarily halted review of COVID-19 LDT EUA submissions. HHS rescinded this policy on November 15, 2021.

Two bills addressing LDT regulation were introduced early in 2020 in response to the long-standing debate and partially spurred by the pandemic: the VALID Act (H.R. 6102, S. 3404), which would establish a comprehensive regulatory scheme for all in vitro clinical tests, and the VITAL Act (S. 3512), which would exclude LDTs from regulation by the FDA. The VALID Act was again introduced in the 117th Congress (S. 2209/H.R. 4128) and was incorporated into a Senate user fee bill (S. 4348, Subtitle C—In Vitro Clinical Tests), which did not pass. The 118th Congress might wish to consider similar legislation.

For Further Information

Amanda Sarata, Specialist in Health Policy

CRS In Focus IF11389, *FDA Regulation of Laboratory-Developed Tests (LDTs)*

DNA as Data

Environmental deoxyribonucleic acid (eDNA) and environmental ribonucleic acid (eRNA) are trace amounts of genetic material collected from an environmental sample such as soil, sediments, water, or air. An eDNA/RNA sample can be compared against primers, or specific partial sequences of DNA/RNA, developed from reference databases of previously sequenced DNA/RNA from known species. The results of that comparison can be used to identify and track a species of interest, identify the presence of small or rare species, and detect the presence of non-native plants or animals, as well as microbes, viruses, and other pathogens. For example, analysis of eRNA in wastewater and sewage has been used to detect and monitor the presence of the virus that causes COVID-19.

How sequences and other data are collected, analyzed, and stored in these reference databases could have an impact on how eDNA/RNA data can be used for research and decisionmaking. The availability, quality, and selection of a primer, or DNA sequence, from one database over another

can affect the analysis of an eDNA/RNA sample. For example, to accurately identify a particular species, or to conduct a broad, multi-species survey (a technique known as metagenomics) requires reference sequences of particular quality and length from all species of interest. Whether databases are private or publicly managed can affect access to datasets for eDNA analysis. Databases that contain genetic sequence information can also have implications for biosafety and biosecurity.

The 118th Congress may wish to consider the appropriate level of federal investment in eDNA/RNA techniques, the development and maintenance of genetic sequence information databases, and the development of federal standards/protocols for applying eDNA/RNA tools. Policymakers may also consider regulation of the collection, use, retention, and access to digital DNA/RNA sequence data and how local, state, and federal agencies currently use or could use eDNA/RNA for decisionmaking.

For Further Information

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Anna E. Normand, Analyst in Natural Resources Policy

Caitlin Keating-Bitonti, Analyst in Natural Resources Policy

Anne A. Riddle, Analyst in Natural Resources Policy

John F. Sargent Jr., Specialist in Science and Technology Policy

CRS In Focus IF12356, *Digital Biology: Implications of Genetic Sequencing*

CRS Video WVB00593, *Science and Technology Q&A: Environmental DNA (eDNA)*

CRS Report WPD00061, *Science and Technology Podcast: Environmental DNA (eDNA)*

CRS In Focus IF12285, *eDNA/eRNA: Scientific Value in What's Left Behind*

Convergence of Biotechnology, Digital Data, Robotics, and Artificial Intelligence

As biotechnology has advanced, it has built upon advances in other fields of S&E such as nanotechnology, artificial intelligence, robotics, and digital data management. Advances in DNA sequencing technologies have made it possible to sequence entire genomes (the genetic information responsible for the development and function of an organism) in greater depth and at lower cost. The resulting digital sequence information can be stored in proprietary or public databases, many of which are publicly funded and freely accessible to interested parties to download. Gene synthesis technologies can use this information to "write" DNA, turning the data back into actual genetic material. This ability to both read and write DNA is a fundamental enabling technology for biotechnology. Biofoundries that combine biology, computer-aided design, robotics, and engineering technologies in a single facility increasingly provide an integrated infrastructure that enables the rapid design, construction, and testing of engineered organisms for biotechnology applications and research.

This has led to the establishment of new industries and the emergence of new communities of practice. At the same time, increased access to digital sequence information, combined with advances in artificial intelligence and robotics, has raised biosafety and biosecurity concerns. Questions include, for example: Who should have access to these capabilities? What limits should be placed on the services that may be provided in order to prevent the deliberate or accidental development and use of a potential biological threat?

The United States has multiple, overlapping policies that provide guidance and oversight for life sciences research and its associated applications. In the 118th Congress, policymakers may wish to consider whether current policies to address the convergence of biotechnology, digital data, robotics, and artificial intelligence are sufficient and adequately balanced or whether new oversight authorities are needed to manage the emerging biosafety and biosecurity issues without unduly stifling innovation.

For Further Information

Todd Kuiken, Analyst in Science and Technology Policy

CRS Report R47849, *Artificial Intelligence in the Biological Sciences: Uses, Safety, Security, and Oversight*

CRS Report R47114, *Oversight of Gain of Function Research with Pathogens: Issues for Congress*

CRS Report R47265, *Synthetic/Engineering Biology: Issues for Congress*

Climate Change

S&T considerations permeate deliberations on climate change and may be grouped into five interrelated topics:

1. climate-change-related science and the ocean-climate nexus;
2. clean energy research, development, demonstration, and deployment;
3. climate change and infrastructure;
4. S&T for adaptation and resilience to climate change; and
5. carbon capture, utilization, and sequestration.

Legislation regarding climate change and water policy was enacted in the 117th Congress, providing a new landscape for charting the 118th Congress's priorities in these issue areas.

Climate Change-Related Science and the Ocean-Climate Nexus

The U.S. Global Change Research Program (USGCRP) is an interagency program required by the Global Change Research Act of 1990 (P.L. 101-606) that coordinates global climate change research across 13 government agencies. For FY2021, enacted appropriations for this purpose were approximately $3.2 billion. The Sixth Assessment Report of the Intergovernmental Panel on Climate Change, published in 2022, provides current information on climate change science and relied, in part, on U.S. federal investment in global climate change science.

In 2017, USGCRP published the Climate Science Special Report, Volume I (CSSR), which found that human-related greenhouse gas (GHG) emissions are accumulating in the atmosphere, intensifying the natural GHG effect, and increasing acidity of the global oceans. It concluded that the increase in GHG emissions is driving global land and ocean warming and other climate changes that are now unprecedented in the history of modern civilization. It also stated

> [B]ased on extensive evidence, that it is extremely likely that human activities, especially emissions of greenhouse gases, are the dominant cause of the observed warming since the mid-20th century. For the warming over the last century, there is no convincing alternative explanation supported by the extent of the observational evidence.

The ocean is an integral part of the global climate system, as it absorbs, retains, and transports heat, water, and carbon. This interplay is referred to as the ocean-climate nexus. The CSSR stated, "Oceans currently absorb about 26% of the human-caused CO_2 [carbon dioxide] anthropogenically emitted into the atmosphere." This absorption is causing acidification of the ocean, affecting some marine species. Ocean acidification is an area of ongoing research by federal science agencies. The ocean also absorbs heat resulting from GHG warming. The CSSR stated, "The world's oceans have absorbed about 93% of the excess heat caused by greenhouse gas warming since the mid-20th century, making them warmer and altering global and regional climate feedbacks."

The 118th Congress may wish to examine the role of the federal government in supporting federal climate change and ocean-based science. This assessment may involve oversight of how the executive branch implements legislation enacted in the 117th Congress. For example, P.L. 117-169, commonly referred to as the Inflation Reduction Act of 2022, provided appropriations for a range of climate-related objectives, including research. The 118th Congress may wish to examine how appropriations provided in P.L. 117-169 support climate research, whether subsequent congressional support for climate change science is warranted, and how appropriations may be allocated.

For Further Information

Caitlin Keating-Bitonti, Analyst in Natural Resources Policy

Jonathan Haskett, Analyst in Environmental Policy

CRS Report R47583, *Is That Climate Change? The Science of Extreme Event Attribution*

CRS Report R45086, *Evolving Assessments of Human and Natural Contributions to Climate Change*

CRS Report R47172, *Geoengineering: Ocean Iron Fertilization*

CRS Report R47300, *Ocean Acidification: Frequently Asked Questions*

CRS Report R47082, *Intergovernmental Panel on Climate Change: Sixth Assessment Report*

Clean Energy Research, Development, Demonstration, and Deployment

Many analysts see a path to stabilizing climate change as involving improved energy efficiency, decarbonization, and electrification of the world's economies. Many options could potentially provide additional security and health benefits, while their costs may depend on public and private investments in research, development, demonstration, and deployment (RDD&D), as well as efforts to facilitate transitions in businesses, employment, and communities.

A large majority of federal climate-change-related expenditures is aimed at advancing "clean energy," though Members may disagree about what should be included as a clean energy technology. For example, clean energy might include advanced fossil fuels, renewable energy, biofuels, energy efficiency, energy storage, vehicles and their fuels, nuclear energy, the electricity grid, and ocean carbon sequestration and direct capture of $CO_2$from the atmosphere, among others. Clean energy may include those technologies and practices that reduce GHG emissions for agriculture, industry, and additional sectors.

Some clean energy incentives focus on "supply-push" of technologies (e.g., R&D funding and federal financial assistance), while others emphasize "demand-pull" (e.g., tax incentives for

purchasers). Numerous examples suggest that coordinated use of both supply- and demand-side policies could be most effective. The magnitude of federal expenditures for climate change technologies, the performance of federally supported programs, and priorities for policy tools and technologies may be topics for Congress to evaluate regarding their role in incentivizing or de-incentivizing clean energy technologies.

The 117th Congress passed legislation that includes clean energy RDD&D provisions. The 118th Congress may consider oversight of how the Administration implements the legislation or amending the law to achieve a different policy direction or outcome. Legislation key to clean energy RDD&D from the 117th Congress includes

- P.L. 117-169, commonly known as the Inflation Reduction Act of 2022, includes tax incentives for deployment of many clean energy technologies, grants and rebates for some clean energy technologies, and provisions for clean energy demonstration projects under an advanced industrial facilities deployment program, among other provisions.
- The Infrastructure Investment and Jobs Act (IIJA, P.L. 117-58) includes funding for multiple technology demonstration programs, including hydrogen, energy storage, carbon removal, and advanced nuclear energy. Other provisions fund infrastructure seen as necessary to enable greater use of certain clean energy technologies.
- P.L. 117-167, commonly knowns as the CHIPS and Science Act of 2022, includes funding for a low-emissions steel manufacturing research program and a regional technology and innovation hub program, among others provisions.

For Further Information

Jonathan Haskett, Analyst in Environmental Policy

CRS Report R47262, *Inflation Reduction Act of 2022 (IRA): Provisions Related to Climate Change*

CRS Report R47034, *Energy and Minerals Provisions in the Infrastructure Investment and Jobs Act (P.L. 117-58)*

CRS In Focus IF11861, *DOE's Carbon Capture and Storage (CCS) and Carbon Removal Programs*

CRS In Focus IF11404, *Greenhouse Gas Emissions and Sinks in U.S. Agriculture*

CRS Report R47107, *Domestic Steel Manufacturing: Overview and Prospects*

CRS In Focus IF12188, *What Is the Blue Economy?*

Climate Change and Infrastructure

Current infrastructure investment decisions may shape not only future GHG emissions for decades to come but also the resilience of infrastructure to future climate conditions. Regarding GHG emissions, infrastructure's influence on future emissions is particularly strong for energy supply, transportation, industry, buildings, and communities. For example, in transportation, choices among transportation modes and choices in how to power transport occur in the context of the infrastructure that supports refueling (e.g., distribution of electric charging stations). Congressional interest in S&T for more climate-resilient infrastructure may stem from multiple events, including the effects of hurricanes and hot and cold extremes from 2017 to 2022 on electricity provision in Puerto Rico, Texas, and western states; the flood and wind disruption and

damage at military installations in Nebraska and Florida; and concerns regarding the ability of western water infrastructure to meet water supply demands during drought conditions.

Infrastructure resilience relates both to avoiding damages and to maintaining and recovering functionality from extreme weather events that may change with a warming climate in frequency and intensity in some U.S. regions. Congress may wish to consider the merits of altering federal R&D activities, for example, to support S&T related to infrastructure that would reduce GHG emissions. Congress may also revisit how support for S&T informs weather-related technical specifications and guidelines for infrastructure and the choice of protective measures (including the role of natural or nature-based features in infrastructure design and investment evaluations).

In addition to the conduct of oversight, or legislation that may be introduced, in the 118th Congress, the extent to which climate change is considered as part of infrastructure investments is likely to be shaped by how the Administration implements IRA (P.L. 117-169). For example, IRA authorized and funded a direct loan program for electricity transmission projects that promote the use of renewable energy sources, which may emit less GHG than fossil fuels. Additionally, IIJA (P.L. 117-58) includes some infrastructure provisions that might help reduce GHG emissions, such as increasing the use of public transportation and intercity passenger rail by providing more public funding. Regarding more climate-resilient infrastructure, IRA also included provisions related to contingency planning for climate-related effects on weather events that could affect the electric grid. IIJA provided federal funding for "protective features" designed to reduce the risk of infrastructure damage from extreme weather events.

For Further Information

Jonathan Haskett, Analyst in Environmental Policy

CRS In Focus IF11921, *Surface Transportation and Climate Change: Provisions in the Infrastructure Investment and Jobs Act (P.L. 117-58)*

CRS Insight IN11981, *Electricity Transmission Provisions in the Inflation Reduction Act of 2022*

CRS In Focus IF12034, *Extreme Weather and Lifeline Infrastructure Resilience: Provisions in the Infrastructure Investment and Jobs Act (IIJA)*

CRS Insight IN11980, *Offshore Wind Provisions in the Inflation Reduction Act*

CRS Report R47286, *Flooding: Selected Federal Assistance and Programs to Reduce Risk*

CRS Report R46892, *Infrastructure Investment and Jobs Act (IIJA): Drinking Water and Wastewater Infrastructure*

CRS Report R46719, *Green Building Overview and Issues*

S&T for Adaptation and Resilience to Climate Change

Congress may wish to review federal programs and funding for S&T to support adaptation or resilience to observed and projected climate change in light of recent scientific assessments. Congress may also review federal outlays for relief and recovery following extreme weather events, some of which have been statistically linked to GHG-induced climate change. With respect to this linkage, statistical analysis can sometimes be used to determine whether part of the increased intensity of an extreme weather event can be attributed to GHG-induced climate change.

Some issues related to infrastructure technology are discussed above, and there are additional S&T issues associated with adaptation and resilience. For example, technological R&D needs

may include new crop seed varieties suited to emerging climate conditions, better means to manage floodwaters, advanced air conditioning technologies for buildings, improved wildfire management techniques, and others. Improvements in climate change projections, particularly at the local scale, could assist assessment of vulnerabilities and preparation for opportunities and risks. Research leading to an improved understanding of the various costs and benefits of adaptation techniques could also assist adaptation and resilience.

Congress may wish to address the federal role in supporting S&T that can facilitate effective state, local, and private decisionmaking on adaptation and resilience to climate change. A federal role, in addition to funding for S&T, may include increasing public access to scientific research, climate and seasonal projections, impact assessments, and adaptation decision tools, as well as training to facilitate productive use of such decision tools. Congress may wish to examine whether federal financial support for resilience enhancements and disaster recovery encourages or discourages the recognition of vulnerabilities and adaptation needs in private, state, and local adaptation decisionmaking. One question, for example: Does federal support for disaster recovery after a flood encourage or discourage activities that would mitigate flood risk? Congress may also review efforts that the federal government has begun to incorporate projections of the effects of climate change into federal agency management of federal personnel, lands and waters, infrastructure, and operations. The effectiveness of agency actions to promote adaptation and resilience could depend, in part, on the adequacy and appropriate use of scientific information and available technologies.

For Further Information

Jonathan Haskett, Analyst in Environmental Policy

CRS Report R47551, *Solar Geoengineering and Climate Change*

CRS Report R47215, *Hazard-Resilient Buildings: Sustaining Occupancy and Function After a Natural Disaster*

CRS Report R46911, *Drought in the United States: Science, Policy, and Selected Federal Authorities*

CRS Report R47286, *Flooding: Selected Federal Assistance and Programs to Reduce Risk*

CRS In Focus IF12034, *Extreme Weather and Lifeline Infrastructure Resilience: Provisions in the Infrastructure Investment and Jobs Act (IIJA)*

CRS In Focus IF11921, *Surface Transportation and Climate Change: Provisions in the Infrastructure Investment and Jobs Act (P.L. 117-58)*

CRS In Focus IF11827, *Climate Change: Defining Adaptation and Resilience, with Implications for Policy*

CRS In Focus IF12161, *Climate Change and Adaptation: Department of Defense*

Carbon Capture, Utilization, and Sequestration

Carbon capture, utilization and sequestration (or storage)—known as CCUS—seeks to capture CO_2 at its source, store it underground, or utilize it for another purpose or product. (CCUS is sometimes referred to as CCS—carbon capture and storage.) CCUS could reduce the amount of CO_2 emitted at large stationary sources. Carbon utilization has recently gained interest as a means of converting CO_2 into potentially commercially viable products, such as chemicals, fuels, cements, and plastics. Direct air capture, a related emerging technology, is intended to remove

atmospheric CO_2 directly from the atmosphere. Capturing CO_2 is the most costly and energy-intensive step in the process.

Federal law and regulations specify certain requirements for CO_2 underground injection wells, which are regulated by the Environmental Protection Agency or delegated states. Currently in the United States, two commercial-scale facilities are capturing and injecting CO_2 into underground reservoirs for geologic sequestration.

Since FY2010, Congress has provided a total of $9.2 billion (in constant 2022 dollars) in annual appropriations for the DOE research arm conducting most federal CCUS research activity. Additionally, IIJA (P.L. 117-58) provided supplemental appropriations of $8.5 billion for CCUS for FY2022-FY2026 and $3.6 billion for direct air capture for the same time period. IRA (P.L. 117-169) increased the "Section 45Q" tax credit for underground carbon sequestration, among other provisions.

In recent years, proponents of CCUS and some Members of Congress have called for increased federal support for building out CO_2 pipeline and storage infrastructure related to CCUS. Others oppose investment in CCUS and prefer to focus climate and energy policy on renewable energy exclusively. CCUS technology and the federal role in development of the U.S. CCUS industry may continue to be of interest in the 118th Congress.

For Further Information

Angela Jones, Analyst in Environmental Policy

Ashley Lawson, Analyst in Energy Policy

CRS Report R44902, *Carbon Capture and Sequestration (CCS) in the United States*

CRS In Focus IF11501, *Carbon Capture Versus Direct Air Capture*

CRS Report R46192, *Injection and Geologic Sequestration of Carbon Dioxide: Federal Role and Issues for Congress*

CRS In Focus IF11861, *DOE's Carbon Capture and Storage (CCS) and Carbon Removal Programs*

CRS In Focus IF11455, *The Section 45Q Tax Credit for Carbon Sequestration*

CRS In Focus IF11639, *Carbon Storage Requirements in the 45Q Tax Credit*

Defense

S&T play an important role in national defense. DOD relies on a robust R&D effort to develop new military systems and improve existing systems. Issues that may come before the 118th Congress regarding DOD's S&T activities include budgetary concerns, the effectiveness of programs to transition R&D results into fielded products, and how DOD encourages innovation.

DOD Research, Development, Test, and Evaluation

DOD spends more than $100 billion per year on research, development, testing, and evaluation (RDT&E). In FY2022, enacted RDT&E funding was $119.3 billion. Roughly 80%-85% of this is spent on the design, development, and testing of specific military systems. Examples of such systems include large integrated combat platforms such as aircraft carriers, fighter jets, and tanks, among others. They also include much smaller systems such as blast gauge sensors worn by individual soldiers. The other 15%-20% of the RDT&E funding is spent on what is referred to as

DOD's Science and Technology Program. The Program includes activities ranging from basic science to demonstrations of new technologies in the field. The goal of DOD's RDT&E spending is to provide the knowledge and technological advances necessary to maintain U.S. military superiority.

DOD's RDT&E budget contains hundreds of individual line items. Congress provides oversight of the program, making adjustments to the amount of funding requested for any number of line items. These changes are based on considerations such as whether DOD has adequately justified the expenditure or the need to accommodate larger budgetary adjustments.

RDT&E priorities and focus, including those of the S&T portion, do not change radically from year to year, though a few fundamental policy-related issues regularly attract congressional attention. These include ensuring that S&T—particularly basic research—receives sufficient funding to support next-generation capabilities, seeking ways to speed the transition of technology from the laboratory to the field, and ensuring an adequate supply of S&T personnel. Additionally, the impact of budgetary constraints, including continuing resolutions, on RDT&E may be of interest to the 118th Congress.

In addition, as U.S. federal defense-related R&D funding's share of global R&D funding has fallen from about 36% in 1960 to about 3% in 2020, some have become concerned about the ability of DOD to direct the development of leading technologies and to control which countries have access to it. Today, commercial companies in the United States and elsewhere in the world are leading development of groundbreaking technologies in fields such as artificial intelligence, autonomous vehicles and systems, and advanced robotics. DOD has sought to build institutional mechanisms (e.g., the Defense Innovation Unit) and a culture for accessing technologies from nontraditional defense contractors. DOD's ability to maintain a technology edge for U.S. forces may depend increasingly upon these external sources of innovation for its weapons and other systems.

For Further Information

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Marcy E. Gallo, Analyst in Science and Technology Policy

CRS Report R44711, *Department of Defense Research, Development, Test, and Evaluation (RDT&E): Appropriations Structure*

CRS In Focus IF10553, *Defense Primer: RDT&E*

CRS Report R45403, *The Global Research and Development Landscape and Implications for the Department of Defense*

Innovation Capacity of DOD

R&D is a global enterprise, with the private sector driving technology development. Some assert that DOD has been slow to react and adapt to this new reality, raising concerns that the U.S. military may be unable to maintain its historical technological advantages. Congress and the executive branch have adopted a number of reforms to address the perceived concerns, including the reestablishment of the position of Under Secretary of Defense for Research and Engineering, the expansion of other transaction authority, and the creation of new organizations (e.g., the Defense Innovation Unit and the Air Force's AFWERX) and programs (e.g., the Rapid Innovation Program and the Accelerate the Procurement and Fielding of Innovative Technologies pilot program). Many of these efforts will likely require sustained management focus and oversight to ensure that DOD transforms into a more innovative, risk-tolerant R&D organization that delivers

new technologies to the warfighter in a timely and relevant manner. As Congress considers the impact of these reforms and their effectiveness, there are several issues it may wish to examine in the 118th Congress, such as

- The adequacy of DOD's investments in research, development, test, and evaluation programs;
- The sufficiency of DOD's strategic planning as it relates to the development and deployment of technologies deemed critical for national security, in particular emerging technologies;
- DOD's ability to attract and retain scientific and technical talent;
- How to measure the rate and extent of cultural change in innovation practices within DOD;
- The effectiveness of DOD's collaborations and cooperation with other federal agencies and allied nations in the development and implementation of technologies deemed critical for national security, in particular emerging technologies;
- The degree to which DOD is incorporating nontraditional contractors and small businesses into the defense industrial base; and
- How Congress can effectively balance its oversight responsibilities and the desire for transparency and accountability with the need for DOD to respond flexibly and nimbly to emergent opportunities.

For Further Information

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John F. Sargent Jr., Specialist in Science and Technology Policy

CRS Report R45403, *The Global Research and Development Landscape and Implications for the Department of Defense*

CRS Report R45088, *Defense Advanced Research Projects Agency: Overview and Issues for Congress*

CRS In Focus IF10834, *Defense Primer: Under Secretary of Defense for Research and Engineering*

Energy

Energy-related S&T issues that may come before the 118th Congress include biofuels, offshore energy technologies, and hydrogen pipelines.

Biofuels

Biofuels—transportation fuels produced from biomass—are an alternative to conventional fuels. Some see promise in producing fuels from a domestic feedstock that may reduce dependence on foreign energy sources, improve rural economies, and lower GHG emissions. Others regard biofuels as potentially more harmful to the environment (e.g., air and water quality concerns), more land-intensive, and prohibitively expensive to produce. The debate about biofuels is complex, as policymakers consider numerous factors (e.g., feedstock costs, the potential for certain advanced biofuels, environmental impact of biofuels). The debate can be even more

complicated because biofuels may be produced using numerous biomass feedstocks and conversion technologies.

Congress has supported biofuels for decades, with most of its attention on "first-generation" biofuels (e.g., cornstarch ethanol). Starting in 2002, the farm bills have contained an energy title with several programs to assist biofuel production and R&D. In addition, the DOE Office of Energy Efficiency and Renewable Energy supports domestic biofuel production R&D. Congress has also established tax incentives for biofuels (e.g., the biodiesel credit). While commercial-scale production of first-generation biofuels is well established, commercial-scale production for some advanced biofuels (e.g., cellulosic ethanol) has yet to materialize for various reasons.

In 2007, Congress expanded the main policy support for biofuel production—the Renewable Fuel Standard (RFS), which requires U.S. transportation fuel to contain minimum volumes of different classes of biofuels. The RFS is under scrutiny for various reasons, including concerns about program implementation, advanced biofuel pathway approval, and RFS compliance. These concerns, among others, create uncertainty for some stakeholders.

The 118th Congress may wish to consider whether to modify various existing biofuel policies, establish new biofuel initiatives, or maintain the status quo. Other topics of potential congressional interest include the development of a federal low-carbon fuel standard in lieu of or complementing the RFS and R&D into sustainable fuels for aviation, shipping, and other applications.

For Further Information

Kelsi Bracmort, Specialist in Natural Resources and Energy Policy

CRS Report R43325, *The Renewable Fuel Standard (RFS): An Overview*

CRS Report R45943, *The Farm Bill Energy Title: An Overview and Funding History*

CRS Report R46835, *A Low Carbon Fuel Standard: In Brief*

CRS Report R47171, *Sustainable Aviation Fuel (SAF): In Brief*

Offshore Energy Technologies

Technological innovations are key drivers of U.S. ocean energy development. They may facilitate exploration of previously inaccessible resources, provide cost efficiencies, address safety and environmental concerns, and enable advances in emerging sectors such as U.S. offshore renewable energy. Private industry, universities, and government are all involved in ocean energy R&D. At the federal level, both DOE and the Department of the Interior support ocean energy research.

With respect to U.S. offshore oil and gas, developers and federal regulators have focused on exploration of deepwater areas of the Gulf of Mexico. Industry interest in expanding deepwater activities has prompted improvements in drilling technologies and steps toward automated monitoring and maintenance. Government and industry seek to address concerns about safety, resilience, and security, including cybersecurity. Also of interest are technologies for decommissioning offshore oil and gas infrastructure as wells reach the end of their producing lifetimes. This could potentially include repurposing of assets for hydrogen transportation or CCUS, among other uses. Some companies operating in the Alaskan Arctic are pursuing technologies (such as ice-resistant drilling units) to extend the drilling season beyond the periods where sea ice is absent and are pursuing improvements to oil spill response capability in Arctic

conditions. DOE and the Department of the Interior undertake and fund Arctic energy R&D, including through DOE's Arctic Energy Office.

Among renewable ocean energy sources, only wind energy is poised for commercial application in U.S. waters. In March 2021, the Biden Administration announced a national goal to deploy 30 gigawatts of offshore wind by 2030. In addition to identified resources in the Atlantic region, wind energy has potential in the Great Lakes, offshore of the West Coast and Alaska, and offshore of the Gulf Coast. Identified priorities for offshore wind R&D include (1) technology advancement of the offshore wind plant; (2) improvements of resource and physical site characterization; and (3) technology improvements in installation, operations and maintenance, and supply chain issues for the U.S. market. For offshore wind plant technology advancement, the Biden Administration announced in September 2022 a Floating Offshore Wind Shot with a goal of reducing the costs of floating technologies by more than 70% by 2035. IRA (P.L. 117-169) appropriates $100 million for convening stakeholders and conducting analysis related to development of interregional transmission and transmission for offshore wind energy. The 118th Congress may wish to consider whether and how to support or incentivize development of offshore wind and other ocean renewables.

For Further Information

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Corrie E. Clark, Specialist in Energy Policy

CRS Insight IN11980, *Offshore Wind Provisions in the Inflation Reduction Act*

CRS Report R41153, *Changes in the Arctic: Background and Issues for Congress*

Hydrogen Pipelines

IIJA (§40315, P.L. 117-58) authorized an $8 billion program of Regional Clean Hydrogen Hubs, which would be centers of activity involving hydrogen production, delivery, and end use. Supplying hydrogen from sources such as regional hubs to power plants, industrial facilities, and vehicular fuel distribution centers could require the development of an expansive hydrogen pipeline network. Shipping hydrogen by pipeline in the United States is not new, but the existing pipeline network is small and located almost entirely along the Gulf Coast. The pipeline network required to support a hydrogen-based U.S. energy strategy would be much larger. Establishing such a network could pose technical challenges due to the chemical characteristics of hydrogen.

Hydrogen molecules are the smallest of all molecules and, therefore, are more prone than methane (the principal component of natural gas) to leak through joints, microscopic cracks, and seals in pipelines and associated infrastructure. Hydrogen can also permeate directly through polymer (plastic) materials, such as those typically used to make natural gas distribution pipes. The presence of hydrogen can deteriorate steel pipe, pipe welds, valves, and fittings through a variety of mechanisms, particularly embrittlement. Pipeline companies may use specialty steels or may modify their infrastructure and put other measures in place to manage embrittlement risks. Nonetheless, the potential for hydrogen embrittlement is a key safety consideration.

Some in Congress have called for federal initiatives to advance hydrogen pipeline-related research and development. For example, the chairman of the Senate Energy and Natural Resources Committee stated at a 2022 committee hearing

> We will certainly need to build some new infrastructure dedicated solely to transporting and storing hydrogen. There is also potential to adapt our country's extensive natural gas

> delivery network in the near-term to support a blend of hydrogen and natural gas.... More work is needed to look at the safety and feasibility of these modifications.

IIJA directs the Secretary of Energy to advance the safe and efficient delivery of hydrogen or hydrogen-carrier fuels in pipelines, including by retrofitting existing natural gas pipelines (§40313). Other legislative proposals, such as H.R. 9000 and H.R. 9018 in the 117th Congress, would have mandated studies to synthesize research results involving hydrogen pipeline materials and to determine outstanding research questions for hydrogen pipelines. The Senate Committee on Appropriations (H.Rept. 117-394) has encouraged DOE to include hydrogen pipeline-related research and development in its plans for transitioning segments of the economy to low-carbon fuels.

Executive agencies, such as the Department of Transportation's Pipeline and Hazardous Materials Safety Administration, may fund hydrogen pipeline research under existing research grant programs and may examine hydrogen pipeline technical issues through advisory committees and industry partnerships. Such activities may advance hydrogen pipeline design, operations, or safety research and the development of standards, which could be incorporated into industry practices or federal pipeline regulations.

For Further Information

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CRS Report R46700, *Pipeline Transportation of Hydrogen: Regulation, Research, and Policy*

CRS Report R47289, *Hydrogen Hubs and Demonstrating the Hydrogen Energy Value Chain*

Fusion Energy

The federal government has supported fusion energy R&D for decades. In recent years, congressional interest in fusion has grown in response to scientific progress by fusion researchers, the emergence of a growing commercial fusion industry, and hope that future fusion power plants can contribute to the nation's electricity needs without emitting carbon dioxide—a greenhouse gas that contributes to climate change.

A fusion power plant would have a number of potential advantages. Unlike today's fission-based nuclear reactors, fusion does not require uranium or plutonium, whose use has raised concerns about nuclear weapon proliferation and uranium imports from countries such as Russia. Fusion reactors also pose no meltdown risk and create little radioactive waste. Unlike power plants based on the combustion of fossil fuels, the operation of a fusion reactor would not directly emit carbon dioxide. On the other hand, developing operational fusion energy systems remains technically challenging.

Most federally funded fusion energy R&D is supported by the Fusion Energy Sciences program of the DOE Office of Science. The program focuses on basic research, though in recent years it has funded applied research, commercialization, and public-private partnerships. A priority for the program is ITER (initially the International Thermonuclear Experimental Reactor, *iter* also means "the way" in Latin), a fusion energy research and demonstration facility currently under construction in France. ITER is an international collaboration involving the United States, China, the European intergovernmental organization Euratom, India, Japan, South Korea, and Russia. It has a history of budget and schedule challenges. The total estimated U.S. share of the project's cost is $6.5 billion, and full operations are due to start in 2035. DOE plans to confirm a revised cost and schedule baseline during the 118th Congress. The DOE Advanced Research Projects

Agency–Energy (ARPA-E) also supports some fusion energy projects, along with other projects across the full range of energy technologies.

In the DOE National Nuclear Security Administration, the Inertial Confinement Fusion program seeks to use fusion science to improve stewardship of the U.S. nuclear weapons stockpile. The program includes the National Ignition Facility (NIF), which demonstrated fusion ignition in December 2022. (Ignition occurs when a fusion reaction releases more energy than was consumed to initiate and maintain the reaction.) The demonstration of ignition at the NIF increased interest in using related designs for fusion energy applications.

A new development in recent years is the emergence of a commercial fusion energy industry, involving several dozen companies and announced private investment approaching $5 billion. The approaches taken by the commercial fusion sector often use design strategies traditionally seen as alternative. Most companies are targeting delivery of electricity to the grid by the mid-2030s. Some observers consider that an ambitious goal.

In April 2023, after considering various options for the regulation of future commercial fusion energy systems, the Nuclear Regulatory Commission voted to use the "byproduct material" framework (10 C.F.R. Part 30). That approach would address any radioactive material present in a fusion facility but not the detailed operation of the facility. The commercial fusion industry generally considered this the least burdensome of the options under consideration.

Congress has taken several legislative actions regarding fusion energy in recent years, such as defining the term *advanced nuclear reactor* to include fusion reactors, which made fusion R&D potentially eligible for various DOE nuclear energy programs previously limited to fission; directing the Fusion Energy Sciences program to place more emphasis on commercialization and public-private partnerships and to support the design of a pilot plant that will bring fusion to commercial viability; and providing supplemental appropriations for fusion-related construction and equipment. Efforts in the 118th Congress may include oversight of DOE's implementation of these actions, oversight of budget and schedule issues with ITER, and appropriations decisions about funding for fusion R&D.

For Further Information

Daniel Morgan, Specialist in Science and Technology Policy

CRS In Focus IF12411, *Fusion Energy*

Earth and Environmental Sciences

Earth and environmental science-related issues that may come before the 118th Congress include the National Spatial Data Infrastructure system, the ShakeAlert earthquake early warning system, and emerging environmental issues associated with seabed mining of critical minerals to support the U.S. transition to clean energy technologies.

National Spatial Data Infrastructure

The National Spatial Data Infrastructure (NSDI) facilitates data development, information sharing, and collaborative decisionmaking across multiple sectors as called for in the FAA Reauthorization Act of 2018 (Subtitle F, Geospatial Data of Title VII, Flight R&D Act, P.L. 115-254). The GeoPlatform, a key element of NSDI, provides access to geospatial data from federal government resources and web-based geospatial services. Geospatial data include land cover resources (e.g., rocks, minerals, soils, vegetation, and water), topography, and the built

environment above and below ground (e.g., buildings and related structures, as well as water, energy, transportation, and communications infrastructure) among many other datasets. Geospatial data come from various federal resources, including the Landsat series of satellites, other NASA and National Oceanic and Atmospheric Administration (NOAA) earth-observing satellites, lidar and other instruments on aircraft (including the newer use of uncrewed aircraft systems, commonly called drones), and other ground-based observations. GeoPlatform provides open access to more than 100,000 datasets, cloud computing, and ArcGIS toolsets. The Federal Geographic Data Committee oversees the policy, planning, development, and implementation of the NSDI.

The 118th Congress may be interested in a number of S&T advances that facilitate NSDI—for example, Earth-observing satellites designed and operated by federal agencies (e.g., Landsat 9, see "Civil Earth-Observing Satellites") and cloud computing and geographic information system software developed and maintained by the private sector. Congress may also be interested in how any parallel S&T advances may improve and expand GeoPlatform to meet its primary objective of findable, accessible, interoperable, and reusable data for resource and land management, hazards assessment, and many other purposes. In addition, Congress may be interested in oversight of interagency collaborations and public-private partnerships to facilitate NSDI.

For Further Information

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CRS Report R46560, *Landsat 9 and the Future of the Sustainable Land Imaging Program*

The ShakeAlert Earthquake Early Warning System on the West Coast

Portions of all 50 states, as well as U.S. territories and the District of Columbia, are vulnerable to earthquake hazards and associated risks to varying degrees. People and automated systems receive an earthquake early warning (EEW) before potential strong ground shaking reaches their locations after detecting an earthquake so that people can protect themselves and automated systems can protect property. EEW is among the most challenging types of emergency communications, in part because earthquakes cannot be predicted and occur suddenly. Mass notification to high-risk areas must occur within seconds of earthquake detection to be effective.

The U.S. Geological Survey (USGS), with many partners, established the first operational EEW system, called ShakeAlert, in California, Oregon, and Washington, which began operations in 2019 to 2021. ShakeAlert benefits from innovations in earthquake science, earthquake modeling (e.g., using machine learning and artificial intelligence), seismic instruments, geodetic instruments, and telemetry. Geodetic instruments rely on the Global Positioning System (GPS) and other Global Navigation Satellite Systems and can quickly and precisely measure ground and/or water motions to provide warnings for many hazards, such as earthquakes, volcanic eruptions, and tsunamis. Geodetic instruments have the potential to improve EEW. However, ShakeAlert has not fully incorporated geodetic data into its EEW system. In addition, the United States faces challenges in operating and maintaining GPS, such as signal interference and the increasing number of proximate satellites in Earth orbit.

In 2021, EEWs sent via the Federal Emergency Management Agency (FEMA) communication pathways often did not arrive before intense shaking occurred. EEWs sent in 2021 via cell phone

applications over Wi-Fi or cellular networks were typically faster, and most alerts arrive before intense shaking occurs.

The 118th Congress may be interested in what S&T advances might improve earthquake warnings (e.g., incorporating geodetic data), in expanding ShakeAlert into other states and territories, and whether ShakeAlert could be used for other hazards. Also, Congress may be interested in how to improve emergency communications, especially for mass notifications, using FEMA communication pathways or the First Responder Network so that alerts arrive before the shaking occurs.

For Further Information

Linda R. Rowan, Analyst in Natural Resources and Earth Sciences Policy

CRS Report R47121, *The ShakeAlert Earthquake Early Warning System and the Federal Role*

Seabed Mining

The transition to clean energy technologies has been driving U.S. interest in securing a domestic supply of critical minerals. Some scientists estimate that certain critical minerals, such as cobalt and manganese, are more abundant in seafloor deposits than in land deposits. Many of these seabed deposits are located in the deep ocean in areas beyond U.S. jurisdiction. U.S. interest, and most global interest, in deep-seabed mining in areas beyond national jurisdiction is focused primarily on a 4.5-million-square-kilometer area of the Pacific seafloor located between Hawaii and Mexico. This area of the Pacific is rich in polymetallic nodules, which contain nickel, manganese, copper, zinc, cobalt, and other minerals. Private industry and governments have been exploring areas of the ocean for the purposes of seabed mining. CRS identified no entities exploiting seabed minerals under international waters to date.

At the federal level, NOAA has authority to issue licenses to U.S. citizens for the purpose of seabed mining exploration in areas beyond U.S. jurisdiction and has issued licenses to several entities for that purpose, two of which are currently active. In addition, NOAA is the primary federal agency dedicated to exploring and studying the deep ocean. As directed by Congress, NOAA leads research and assessment of seabed mining activities' potential impacts to proposed mining areas of interest beyond U.S. jurisdiction.

The emergence of the seabed mining industry in areas beyond national jurisdiction raises questions about the potential impacts seabed mining may have on deep-sea ecosystems. Government, industry, and universities are all involved in studying the potential environmental impacts of seabed mining activities. In 1980, Congress directed NOAA to assess the effects on the deep-sea environment from seabed mineral exploration and commercial recovery activities. For more than two decades, NOAA studied the recovery of deep-sea benthic organisms (i.e., those living on or in the seafloor sediment) from sediment disturbance as a means of assessing the potential impacts of seabed mining activities. These studies focused primarily on the potential ecosystem impacts of collecting and removing polymetallic nodules from the seafloor.

The 118th Congress may consider whether additional authorities or funding may be useful in understanding and addressing potential environmental and ecosystem impacts from future deep-seabed mining. With current and growing interest in exploiting the deep ocean for seabed minerals, the 118th Congress may consider changes to NOAA's research on the environmental impacts of collecting polymetallic nodules in the deep sea by studying different seabed mineral deposits (e.g., ferromanganese crusts, polymetallic sulfides). In addition, the 118th Congress may also consider expansion of NOAA's ocean exploration campaigns to further document deep-sea

life in order to provide a baseline for understanding whether—and to what degree—deep-sea life is vulnerable or resilient to human disturbance.

For Further Information

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CRS Report R47324, *Seabed Mining in Areas Beyond National Jurisdiction: Issues for Congress*

Financial Technology, or "Fintech"

Financial technology, or *fintech*, refers to a broad set of technologies being deployed across a variety of financial industries and activities. This section considers cryptocurrency, investor applications, and consumer finance applications.

Cryptocurrency

Cryptocurrencies are designed to function as payment and value storage systems, which the National Institute of Standards and Technology (NIST) described as "electronic cash protected through cryptographic mechanisms instead of a central repository or authority." Cryptocurrencies are typically exchanged across and cleared on public blockchains. Satoshi Nakamoto, an anonymous individual or collective, introduced the first cryptocurrency, Bitcoin, in a whitepaper in 2008.

Cryptocurrency attempts to replace aspects of the current financial system, of which a central tenet is trust, with one that is trustless and *permissionless*. For example, there are a variety of safeguards built into the traditional financial system that seek to foster trust and inspire confidence, including, among others, regulation and government backstops. Cryptocurrency, on the other hand, relies on a series of separate but concurrent incentives for network participants, such as rewards and pseudonymity, which are expected to work even when those participants are operating in their own self-interest. Users can participate in *on-chain* transactions—those facilitated directly on a blockchain (i.e., ledger) network—or in intermediated transactions with platforms such as cryptocurrency exchanges and payments companies.

The system emerged as a payment tool, but its attractiveness as a speculative investment soon eclipsed that use. The two most prevalent cryptocurrencies are Bitcoin and Ethereum, which combined represent slightly more than half of the entire crypto market. According to industry websites that track data, there are more than 10,000 cryptocurrencies. Volatility and rapid growth characterize the crypto market. Most recently, after reaching a record high of more than $3 trillion in November 2021, the market capitalization fell to below $900 billion in November 2022, reportedly due to various interconnected factors such as higher interest rates and failures of various crypto-related entities. Growth in the industry and various crypto company failures may prompt the 118th Congress to consider changes in the way the industry is regulated, either by drawing crypto finance further into the regulatory perimeter or alternatively walling it off from the traditional financial system to preclude the potential for systemic risk.

For Further Information

Paul Tierno, Analyst in Financial Economics

CRS Report R45427, *Cryptocurrency: The Economics of Money and Selected Policy Issues*

CRS Report R46332, *Fintech: Overview of Innovative Financial Technology and Selected Policy Issues*

CRS In Focus IF11997, *Bank Custody, Trust Banks, and Cryptocurrency*

CRS Insight IN12047, *What Happened at FTX and What Does It Mean for Crypto?*

Investment Activities

In recent years, financial innovation in capital markets has fostered a new asset class—called *digital assets*, which include cryptocurrencies—and introduced new forms of fundraising, trading, and other investment activities.

IIJA (P.L. 117-58) defines *digital asset* as "any digital representation of value, which is recorded on a cryptographically secured distributed ledger or any similar technology as specified by the [Treasury] Secretary." The oversight of digital assets is split among different agencies. Some aspects of existing regulation have drawn policy debates about regulatory uncertainty, especially with regard to how previously enacted laws and regulations could be applied to new activities and products. Some digital assets meet the legal definition of *securities* and are primarily regulated by the Securities and Exchange Commission (SEC), which oversees securities offers, sales, and investment activities. Those that do not meet the definition of *securities* may be legally considered commodities under the Commodities Exchange Act (P.L. 74-675) and fall under the oversight of the Commodity Futures Trading Commission, which also oversees U.S. derivatives markets.

New S&T have brought greater investor access through retail investor digital engagement practices (DEPs). DEP tools are deployed in investment advisory services where broker-dealers and investment advisers use websites or mobile applications to interact with retail investors, such as collecting investor data or providing financial advice. DEPs often deploy game-like features, behavioral prompts, differential marketing, and predictive data analytics. The SEC is soliciting public input on how broker-dealers and investment advisers, including robo advisers, mitigate conflict of interest concerns. Specifically, the SEC is concerned about how the DEPs' profit optimization designs may encourage investors to invest in ways that would prioritize the profitability of the firms (as opposed to their retail investor clients). Digital asset market events in 2022 have exposed the industry's structural vulnerability and perceived regulatory gaps. More policy debates relating to the SEC's digital asset jurisdiction and potential legislative fixes to address the perceived regulatory gaps are likely during the 118th Congress.

For Further Information

Eva Su, Analyst in Financial Economics

CRS Report R46208, *Digital Assets and SEC Regulation*

CRS Insight IN12052, *SEC Jurisdiction and Perceived Crypto-Asset Regulatory Gap: An FTX Case Study*

Consumer Products

Beyond the retail investment activities discussed in the prior section, fintech also has the potential to change other consumer finance products and services, including in consumer payments and lending markets. Modern technologies—such as internet access, mobile technology, electronic payment improvements, alternative data, and artificial intelligence—have been used to create new fintech products for consumers. Some recent fintech products include "peer to peer" payments, digital wallets, consumer data aggregation services, marketplace lending, and "Buy Now, Pay Later" financing.

New technology could potentially improve consumer experiences, lower the cost of providing financial products, and expand access to underserved consumers. For example, internet-based or mobile financial products may be able to help consumers manage their finances better and provide more affordable access to financial services. In addition, consumer loan underwriting—when a lender evaluates the likelihood that a loan applicant will make timely repayment—can potentially be enhanced by these new technologies. For example, alternative data and artificial intelligence may be able to better price default risk for lenders, which could expand credit access or make credit less expensive for some consumers.

New technologies could pose certain consumer protection and data security risks, raising questions over what consumer information is appropriate to collect and use. Policymakers designed many of the financial laws and regulations before the most recent technological changes. This raises questions concerning whether the existing legal and regulatory frameworks, when applied to fintech, effectively mitigate risks without unduly hindering the development of beneficial technologies. In addition, fintech products often access sensitive consumer financial data, which may introduce privacy and cybersecurity concerns. Fintech innovations may also have impacts on market competition, such as potentially creating systemic risks. Moreover, consumer loan underwriting models using alternative data and artificial intelligence could introduce fair lending risks due to biases in data or model development. The Consumer Financial Protection Bureau (CFPB) is the primary consumer protection regulator for consumer financial products and services. The 118th Congress may continue to be interested in how existing laws apply to consumer fintech products, how these products should be regulated by the CFPB, and whether new laws are necessary to regulate these products.

For Further Information

Cheryl Cooper, Analyst in Financial Economics

CRS In Focus IF11682, *Introduction to Financial Services: Consumer Finance*

CRS In Focus IF11630, *Alternative Data in Financial Services*

CRS In Focus IF12079, *Digital Wallets and Selected Policy Issues*

Information Technology and Social Media

Rapid advancements in information technologies present several issues for congressional policymakers, including those related to artificial intelligence, cybersecurity, social media platforms, big tech and online platforms, immersive technologies, law enforcement access to platforms and social media, and blockchain technologies.

Artificial Intelligence

In recent years, the Administration and Congress have been increasingly engaged in supporting artificial intelligence (AI) R&D and working to address policy concerns arising from AI development and use. Congressional activities focused on AI increased substantially in the 116th and 117th Congresses, including multiple committee hearings in the House and Senate, the introduction of numerous AI-focused bills, and the passage of AI provisions in legislation. Enacted legislation has included the National AI Initiative Act of 2020 within the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (P.L. 116-283); the AI in Government Act of 2020 within the Consolidated Appropriations Act, 2021 (P.L. 116-260); and provisions focused on AI activities at NSF, DOE, and NIST within P.L. 117-167, the CHIPS and Science Act.

AI holds potential benefits and opportunities, such as through augmenting human decisionmaking and optimizing performance for complex tasks. It also presents challenges and pitfalls, such as through perpetuating or amplifying bias and failing in unexpected ways. The ready availability in 2022 of software (i.e., ChatGPT) that can intelligently (1) respond to questions, and (2) draft prose documents may represent a sentinel event in popular use of AI.

There are several broad concerns related to AI, spanning multiple sectors, that could be considered in the 118th Congress. These include

- the impact of AI and AI-driven automation on the workforce, including potential job losses and the need for worker retraining;
- the challenges of educating students in AI, from teaching foundational concepts at the K-12 level to supporting doctoral-level training to meet increasing demand for AI expertise;
- the balance of federal and private sector funding for AI;
- whether and how to increase access to public datasets to train AI systems for use in the public and private sectors;
- the development of standards and testing protocols and algorithmic auditing capabilities for AI systems;
- the need for and effectiveness of federal and international coordination efforts in AI, as well as concerns over international competition in AI R&D and deployment; and
- the incorporation of ethics, privacy, security, transparency, and accountability considerations in AI systems, including such applications as facial recognition technologies.

There are additional national security concerns about the potential use of AI technologies that Congress could address, such as the potential for "deep fakes" to influence elections and erode public trust, the balance of human and automated decisionmaking in military operations, and concerns about the dissemination of U.S.-developed AI technologies and federally funded AI research results to potential competitors or adversaries.

For Further Information

Laurie A. Harris, Analyst in Science and Technology Policy

Kristen Busch, Analyst in Science and Technology Policy

CRS Report R47843, *Highlights of the 2023 Executive Order on Artificial Intelligence for Congress*

CRS Video WVB00615, *Artificial Intelligence: Recent Advances and Issues for Congress*

CRS Report R47644, *Artificial Intelligence: Overview, Recent Advances, and Considerations for the 118th Congress*

CRS In Focus IF12426, *Generative Artificial Intelligence: Overview, Issues, and Questions for Congress*

CRS Report R47569, *Generative Artificial Intelligence and Data Privacy: A Primer*

CRS Report WPD00050, *CRS Science and Technology Podcast: Artificial Intelligence*

CRS Video WVB00554, *Science and Technology Q&A: Generative AI and Data Privacy*

CRS In Focus IF11333, *Deep Fakes and National Security*

Cybersecurity

Cybersecurity is not an end state. Rather, it is a risk management process that information technology (IT) system owners and operators use to ensure that data, devices, systems, and networks

- maintain *confidentiality* among authorized parties,
- preserve the *integrity* of both the data and the technology, and
- are *available* when users desire.

Some cybersecurity issues persist across multiple Congresses. For example, the 117th Congress

- explored policy options to ensure the *confidentiality* of internet-based communications (i.e., data security and privacy) by enacting national privacy legislation;
- investigated ways that nation-state actors compromised the *integrity* of IT vendors' products in order to compromise their customers; and
- considered cybersecurity incident reporting requirements as a way to better understand and mitigate ransomware attacks that attack the *availability* of data and systems.

The 117th Congress enacted a variety of cybersecurity-related legislation. Funding in the American Rescue Plan Act provided resources for federal agencies to transition to the zero-trust architecture (i.e., the continuous authentication of a user in a system). Legislation and oversight also addressed federal support for the cybersecurity of state and local governments. IIJA provided $1 billion to state and local governments to improve their cybersecurity posture. Congress also created programs to address cybersecurity education, improve cybersecurity at schools, and increase federal information sharing and technical assistance to state and local governments.

One new area of ongoing congressional interest is the relationship between the private sector and the federal government. Two ways this manifested in the 117th Congress was in the examination of the role of cybersecurity companies and IT vendors in national cybersecurity (e.g., following the Solarwinds attack) and a requirement that all companies report when they experience a cybersecurity incident. Such concerns are likely to continue in the 118th Congress.

For Further Information

Chris Jaikaran, Specialist in Cybersecurity Policy

CRS Report R46974, *Cybersecurity: Selected Cyberattacks, 2012-2022*

CRS In Focus IF10683, *DHS's Cybersecurity Mission—An Overview*

CRS Video WVB00609, *The Evolution of the Cybersecurity Legislative Debate for the 118th Congress*

CRS Report WPD00048, *The Homeland Security Act at 20: Cybersecurity*

CRS In Focus IF10559, *Cybersecurity: A Primer*

CRS In Focus IF10920, *Cyber Supply Chain Risk Management: An Introduction*

CRS Report R47011, *Cybersecurity: Deterrence Policy*

Social Media Platforms

Scrutiny of social media platforms—such as Facebook, Twitter, TikTok, and YouTube—has focused on their content moderation practices, including the spread of misinformation as well as the censorship of lawful content. Section 230 of the Communications Act of 1934, enacted as part of the Telecommunications Act of 1996, protects interactive computer service providers and their users from liability for publishing, and in some instances restricting access to, another's content. Two states—Texas and Florida—have passed laws that limit social media platforms' ability to moderate content. Legal challenges to these laws are pending.

Some Members of Congress have also expressed interest in other aspects of social media platforms. These concerns include the use of algorithms to amplify or remove content; the use of social media by law enforcement; and the national security, data privacy, and foreign influence risks posed by TikTok, a social media platform owned by Chinese company ByteDance. The 117th Congress passed legislation to ban TikTok from certain government devices. While other concerns—such as competition among platforms—are applicable to social media, they are typically part of broader discussions of online platforms (discussed separately in "Big Tech and Online Platforms").

In the 116th and 117th Congresses, there were multiple bills and hearings related to social media platforms. Some bills would have amended Section 230 in a manner that would allow social media companies to be held liable for hosting or removing certain content or for using algorithms to rank, sort, and recommend content, with some exceptions. Others would have required increased transparency for social media platforms' content moderation practices or imposed requirements unrelated to content moderation. The 118th Congress may be interested in similar legislation related to social media platforms.

For Further Information

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Valerie Brannon, Legislative Attorney

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Chris Linebaugh, Legislative Attorney

Kristin Finklea, Specialist in Domestic Security

Eric Holmes, Legislative Attorney

Chris Linebaugh, Legislative Attorney

Stephen P. Mulligan, Legislative Attorney

CRS Report R47753, *Liability for Algorithmic Recommendations*

CRS In Focus IF12462, *Social Media Algorithms: Content Recommendation, Moderation, and Congressional Considerations*

CRS Video WVB00562, *Social Media Content Moderation*

CRS Video WVB00520, *Online Content Moderation: A Legal Primer for the 118th Congress*

CRS Report R46662, *Social Media: Misinformation and Content Moderation Issues for Congress*

CRS Report R46751, *Section 230: An Overview*

CRS Video WVB00521, *Section 230: A Legal Primer for the 118th Congress*

CRS Report R46543, *TikTok: Technology Overview and Issues*

CRS Insight IN12131, *TikTok: Recent Data Privacy and National Security Concerns*

CRS Legal Sidebar LSB10940, *Restricting TikTok (Part I): Legal History and Background*

CRS Legal Sidebar LSB10942, *Restricting TikTok (Part II): Legislative Proposals and Considerations for Congress*

CRS Legal Sidebar LSB10972, *Montana's TikTok Ban and Pending Legal Actions*

CRS Legal Sidebar LSB10748, *Free Speech Challenges to Florida and Texas Social Media Laws*

CRS In Focus IF12180, *False Speech and the First Amendment: Constitutional Limits on Regulating Misinformation*

CRS Legal Sidebar LSB10742, *Online Content Moderation and Government Coercion*

CRS Report R47049, *Children and the Internet: Legal Considerations in Restricting Access to Content*

CRS Report R47008, *Law Enforcement and Technology: Using Social Media*

Big Tech and Online Platforms

Technological developments have allowed companies to offer various services through online platforms, transforming existing industries and creating new markets. Some of these companies collect data from their users, such as the users' behavior on the platform and personally identifiable information. This data can be used for various purposes, including providing services for customers and obtaining revenue from sending targeted advertisements to specific individuals. The collection of consumer data has raised concerns about consumer data privacy and may contribute to the dominance of some companies that have been able to collect large amounts of various types of data.

Congressional interest in companies that operate online platforms have largely focused on Alphabet (Google's parent company), Amazon, Apple, Meta Platforms (formerly Facebook), and at times Microsoft—companies collectively known as "Big Tech." Issues related to Big Tech include how the companies collect and use consumer data, whether the companies use anticompetitive methods to obtain and maintain market dominance, and whether to implement additional privacy protections for content accessed by individuals under the age of 16 or 18.

The 118th Congress may wish to pursue legislation related to online platforms in addition to those specifically related to social media platforms (discussed separately in "Social Media Platforms"). Numerous bills and hearings in the 116th and 117th Congresses were related to consumer data privacy and market dominance concerns, including bills to create a comprehensive federal data protection law, to create competition-related requirements for online platforms that meet certain criteria, and to amend antitrust laws. Some bills would have increased funding for federal antitrust enforcers—the Federal Trade Commission (FTC) and the antitrust division of the Department of Justice.

For Further Information

Clare Cho, Analyst in Industrial Organization and Business

Kristen Busch, Analyst in Science and Technology Policy

Jay Sykes, Legislative Attorney

Chris Linebaugh, Legislative Attorney

Eric Holmes, Legislative Attorney

CRS Report R47662, *Defining and Regulating Online Platforms*

CRS Report R47298, *Online Consumer Data Collection and Data Privacy*

CRS In Focus IF11448, *How Consumer Data Affects Competition Through Digital Advertising*

CRS In Focus IF11207, *Data Protection and Privacy Law: An Introduction*

CRS Legal Sidebar LSB10889, *Regulating Big Tech: CRS Legal Products for the 118th Congress*

CRS Video WVB00561, *Consumer Data Privacy: Policy and Legal Considerations*

CRS Video WVB00553, *Science and Technology Q&A: Dark Patterns*

CRS In Focus IF12244, *Unfair or Deceptive Acts or Practices (UDAP) Enforcement Authority Under the Federal Trade Commission Act*

CRS Legal Sidebar LSB10839, *FTC Considers Adopting Commercial Surveillance and Data Security Rules*

CRS Legal Sidebar LSB10846, *The EU-U.S. Data Privacy Framework: Background, Implementation, and Next Steps*

CRS Report R46739, *Mergers and Acquisitions in Digital Markets*

CRS Legal Sidebar LSB10635, *The FTC's Competition Rulemaking Authority*

CRS Legal Sidebar LSB10725, *Antitrust Issues in Labor Markets*

CRS Report R47018, *Stop the Presses? Newspapers in the Digital Age*

Metaverse and Immersive Technologies

Many in Congress have maintained an interest in policy issues related to technologies used to access computer-simulated environments and participate in virtual activities on the internet. These technologies show potential to support new ways for users to interact, work, socialize, transact, and access services in an immersive virtual world, which has come to be called the metaverse. Metaverse services are likely to feature three key characteristics that differentiate them from traditional online applications: (1) an immersive user experience; (2) real-time, persistent network access; and (3) interoperability across networked platforms. Technologies enabling metaverse services include extended reality (e.g., augmented reality, mixed reality, and virtual reality), advanced wireless communications (e.g., fifth generation and next generation), and digital assets.

Some experts have expressed concerns that the immersive, persistent, and real-time environment and large-scale, distributed virtual platforms in the metaverse could reproduce and magnify a number of existing issues, such as content moderation, data privacy, competition, and digital inclusion. Some Members of Congress have shown interest in each of these issues in the context of existing online platforms and may consider addressing them in the specific context of the metaverse. In the recently enacted Research and Development, Competition, and Innovation Act (P.L. 117-167), Congress identifies "immersive technology" among an initial list of 10 "key technology focus areas." The act tasked NSF and other federal agencies with carrying out activities and programs in those focus areas to support research and technology transfer and

increase capabilities to enhance the competitive advantage and leadership of the United States in the global economy.

While the development trajectory of the metaverse is uncertain, the 118th Congress may be interested in a range of metaverse-related issues as it continues to shape internet and information policies. For example, Congress may be concerned about whether the metaverse and other internet platforms are open, free, interoperable, reliable, and secure and support innovation, competition, privacy, and trust. Through oversight of federal agencies such as the National Telecommunications and Information Administration (NTIA), the Federal Communications Commission (FCC), and FTC, Congress may wish to to address content moderation, data privacy, competition, digital inclusion, and other internet governance issues that could be more challenging in the metaverse than on the current internet platforms. Congressional oversight could include assessments of federal investments in immersive technologies and whether they will enhance and preserve U.S. competitiveness and leadership in the digital economy.

For Further Information

Ling Zhu, Analyst in Telecommunications Policy

CRS Report R47224, *The Metaverse: Concepts and Issues for Congress*

CRS Video WVB00498, *The Metaverse: Concepts and Policy Issues for Congress*

Evolving Technology and the Debate over "Lawful Access"

Technological advances present both opportunities and challenges for U.S. law enforcement. Some developments have increased the quantity and availability of digital content and information for investigators and analysts. Other advances have presented new hurdles for law enforcement. For example, while some believe that law enforcement now has access to more information than ever before, other observers express concern that law enforcement's investigative capabilities may be outpaced by the speed of technological change, preventing investigators from accessing certain information they may otherwise be authorized to obtain. Specifically, law enforcement officials cite strong, end-to-end encryption, or what they have called *warrant-proof* encryption, as preventing lawful access to certain data. Companies employing such strong encryption have stressed they do not hold encryption keys. This means they may not be readily able to unlock, or decrypt, the devices or communications—even for law enforcement presenting an authorized search warrant or wiretap order.

The tension between law enforcement capabilities and technological change—including sometimes competing pressures for technology companies to provide data to law enforcement as well as to secure customer privacy—has received congressional attention for several decades. For instance, in the 1990s the *crypto wars* pitted the federal government against technology companies, and this strain was underscored by proposals to build in vulnerabilities, or *back doors*, to certain encrypted communications devices as well as to restrict the export of strong encryption code. In addition, Congress passed the Communications Assistance for Law Enforcement Act (CALEA; P.L. 103-414) in 1994 to help law enforcement agencies maintain their ability to execute authorized electronic surveillance as telecommunications providers turned to digital and wireless technology. More recently, there have been questions about whether CALEA should be amended to apply to a broader range of entities that provide communications services.

The debate over lawful access to information originally focused on data in motion, or law enforcement's ability to intercept real-time communications. More recent technology advances have affected law enforcement's capacity to access not only real-time communications but stored content, or data at rest. Some officials have urged the technology community to develop a means

to assist law enforcement in lawfully accessing certain data. At the same time, law enforcement entities have taken their own steps to bolster their technology capabilities. The 118th Congress may wish to consider possible legislation that would address law enforcement's concerns and customer privacy issues involving access to communications and data.

For Further Information

Kristin Finklea, Specialist in Domestic Security

CRS In Focus IF11769, *Law Enforcement and Technology: the "Lawful Access" Debate*

Law Enforcement Use of Social Media

As the ways in which individuals interact continue to evolve, social media has had an increasing role in facilitating communication and sharing content online. Law enforcement relies on social media as a tool for information sharing as well as for gathering information to assist in investigations. For instance, law enforcement may use social media to connect with the community, such as pushing out bulletins on wanted persons or establishing tip lines to crowdsource information. Social media is also an investigative tool that can help establish leads and collect evidence on potential suspects.

There are no federal laws that *specifically* govern law enforcement agencies' use of information obtained from social media sites, but their ability to obtain or use certain information may be influenced by social media companies' policies, law enforcement agencies' own social media policies, and the rules of criminal procedure. Law enforcement may require social media platforms to provide access to certain restricted information through a warrant, subpoena, or other court order. While some have suggested that social media can provide a wealth of information for law enforcement and intelligence analysts, some observers have suggested that agencies may be reluctant to regularly analyze public social media posts for various reasons, including that it could be viewed as spying on the American public and could subsequently chill free speech protected under the First Amendment.

Although there is no specific legislative framework at the federal level that governs law enforcement use of social media, there are laws and policies governing law enforcement investigations and intelligence gathering broadly. Some observers, however, have questioned whether the nature of social media may place it in a qualitatively different category than law enforcement's use of other investigative tools and have suggested that there should be enhanced boundaries regarding law enforcement operations that utilize social media. For instance, some have suggested that law enforcement agencies should have written, publicly available policies on their use of social media; they should obtain local government approval before using these online spaces; they should obtain judicial approval for conducting undercover operations using social media; there should be restrictions on law enforcement contacting minors via social media; and law enforcement's use of social media should be audited. These types of proposals could be a subject of discussion in the 118th Congress.

For Further Information

Kristin Finklea, Specialist in Domestic Security

CRS Report R47008, *Law Enforcement and Technology: Using Social Media*

CRS Insight IN11999, *Law Enforcement Investigations of Extremist Calls to Action on Social Media*

Blockchain and Distributed Ledger Technologies

Blockchain is a database technology that records and stores information in blocks of data that are linked, or "chained," together. This system enables tamper-resistant recordkeeping, generally without a centralized authority or intermediary. Blockchain is one example of the larger family of distributed ledger technologies (DLTs). Since its popularization after the publication of the Bitcoin white paper in 2008, blockchain has been most commonly associated with cryptocurrencies, but more recently, public and private sector actors have used blockchain applications in fields such as supply chain management, asset registration, and digital identity and ownership.

The emergence of new blockchain applications—including Web3, non-fungible tokens, decentralized finance, and other novel use cases—have raised policy concerns among some stakeholders, ranging from technological classification to financial regulation and energy consumption. In 2022, President Biden signed Executive Order 14067 on the responsible development of digital assets, which established policy objectives around national security, financial stability, environmental impact, and other issues related to digital assets, but it could also implicate other blockchain applications.

The 117th Congress enacted legislation related to blockchain and DLTs. The CHIPS and Science Act (P.L. 117-167) directed the White House OSTP to establish a blockchain and cryptocurrency specialist position. In addition to numerous hearings and bills on the financial regulation of digital assets, the 117th Congress also held blockchain-focused hearings, such as "Cleaning Up Cryptocurrency: The Energy Impacts of Blockchains" and "Securing U.S. Leadership in Emerging Compute Technologies."

The 118th Congress may wish to consider similar legislation to create comprehensive regulatory frameworks for specific blockchain applications, such as digital assets, or oversight actions to influence the future development and growth of distributed ledger technologies.

For Further Information

Kristen Busch, Analyst in Science and Technology Policy

CRS Report R47064, *Blockchain: Novel Provenance Applications*

CRS Report R47189, *Non-Fungible Tokens (NFTs)*

CRS In Focus IF12075, *Web3: A Proposed Blockchain-Based, Decentralized Web*

CRS Video WVB00495, *Boom or Bust? Blockchain Technologies and Policy Issues*

Space and Aviation

Congress has historically had a strong interest in space policy and aviation issues. Issues that may come before the 118th Congress include the funding and oversight of NASA, issues related to the commercialization of space, Earth-observing satellites, and advanced air mobility technologies.

NASA

Spaceflight has attracted strong congressional interest since the establishment of NASA in 1958. Issues facing the 118th Congress include the goals and strategy of NASA's human spaceflight program, the relationship between NASA and the commercial space sector, and implementation of the NASA Authorization Act of 2022 (Division B, Title VII, of P.L. 117-167, the CHIPS and

Science Act). Congress may address these and other topics through oversight hearings, NASA reauthorization legislation, and the annual appropriations process.

As directed by the NASA Authorization Act of 2010 (P.L. 111-267), NASA is pursuing a two-track strategy for human spaceflight. First, for crew transport to low Earth orbit, NASA has been supporting the development of commercial capabilities. After years of reliance on Russian spacecraft following the end of the space shuttle program in 2011, in 2020 a NASA-contracted U.S. commercial spacecraft carried a crew to the International Space Station (ISS) for the first time. A second commercial crew transport provider is expected to begin operational flights in 2023.

Second, for human exploration beyond Earth orbit, NASA is developing a crew capsule called Orion and a heavy-lift rocket called the Space Launch System (SLS). These are key elements of the Artemis program for human exploration of the moon and eventually Mars. The first test flight of Orion and the SLS occurred in late 2022, and the first test flight with a crew on board is expected in 2024. The progress of Orion and SLS testing, the development of other components of Artemis (such as the Human Landing System), and the schedule for an operational Artemis mission including a lunar landing may all draw attention in the 118th Congress.

The relationship between NASA and the commercial space sector continues to evolve. Rather than acquiring government-owned systems, NASA increasingly contracts for commercial services, including crew and cargo transport to the ISS, the Human Landing System, and a planned sequence of robotic lunar landers. Some in Congress would prefer a more traditional government-owned approach, especially for systems affecting the safety of astronauts. A related topic is the future of the ISS, which NASA has proposed to transition after 2025 to a combination of public-private partnerships and commercial service contracts.

The NASA Authorization Act of 2022 includes policy direction about the Artemis program, the ISS, NASA programs in science, space technology, STEM education, and other matters. NASA's implementation of that policy direction may be a subject for congressional oversight in the 118th Congress.

For Further Information

Daniel Morgan, Specialist in Science and Technology Policy

CRS Report R43419, *NASA Appropriations and Authorizations: A Fact Sheet*

Section in NASA in CRS Report R47564, *Federal Research and Development (R&D) Funding: FY2024*

Commercial Space

Since the earliest days of spaceflight, U.S. companies have been involved as contractors to government agencies. Increasingly, though, space is becoming commercial. A majority of U.S. satellites are now commercially owned, providing commercial services, and launched by commercial launch providers. Congressional and public interest in space is also becoming more focused on commercial activities, such as companies flying private individuals into space, collecting business data with fleets of small Earth-imaging satellites, or providing timely satellite images of events in the news such as the war in Ukraine.

Some observers have identified a distinct "new space" sector of relatively new companies focused on private spaceflight at low cost. One factor driving this trend is NASA's reliance on commercial providers for access to the ISS, but "new space" companies are also focused on other markets. These include the launch of national security satellites for DOD, the launch of

commercial satellites for U.S. and foreign companies, and the provision of commercial services such as satellite communications and space tourism.

Multiple federal agencies regulate the commercial space industry, based on statutory authorities that were enacted separately and have evolved over time. The Federal Aviation Administration (FAA) licenses commercial launch and reentry vehicles (i.e., rockets and spaceplanes) as well as commercial spaceports. NOAA licenses commercial Earth remote sensing satellites. The FCC licenses commercial satellite communications. The Departments of Commerce and State license exports of space technology. In the past few years, several of these agencies have made significant changes in their regulations affecting commercial space, and additional regulatory action is underway or expected on topics such as orbital debris and in-space servicing, assembly, and manufacturing. In addition, a statutory moratorium on FAA regulations to protect the health and safety of humans aboard commercial spacecraft is set to expire in October 2023. The 118th Congress may wish to examine the implementation of these regulatory changes and consider whether additional legislation is required. Related ongoing efforts, such as the proposed reorganization of space offices in the Commerce Department, the creation of a new Space Bureau at the FCC, and the shift from DOD to civil responsibility for space situational awareness (e.g., issuing alerts when orbiting satellites may be about to collide) are also likely to attract congressional attention. Some observers also anticipate new legislative proposals regarding mission authorization (i.e., authorities for regulation of emerging commercial space activities not covered by the current licensing regimes).

How the federal government makes use of commercial space capabilities continues to evolve. NASA used to own and operate the space shuttles that contractors built for it, but since 2012 it has contracted with commercial service providers to deliver cargo into orbit using these providers' spacecraft. DOD has its own satellite communications and reconnaissance capabilities. It also procures communications bandwidth and imagery from commercial satellite companies. Agencies are considering a host of new opportunities, including acquisition of weather data from commercial satellites, acquisition of science data from commercial lunar landers, and expanded commercial utilization of the ISS for technology development and demonstration as well as other purposes. The 118th Congress may address these developments primarily through oversight of agency programs and decisions on agency budgets.

For Further Information

Daniel Morgan, Specialist in Science and Technology Policy

Rachel Lindbergh, Analyst in Science and Technology Policy

CRS In Focus IF12508, *Commercial Human Spaceflight Safety Regulations*

CRS Video WVB00629, *Disruptive Technology Series: Space Debris: Preventing It, Avoiding It, and Removing It*

CRS In Focus IF11940, *Commercial Human Spaceflight*

CRS In Focus IF12403, *Commercial Space Launch and the April 2023 Starship Mishap*

CRS Report WPD00053, *CRS Science and Technology Podcast: Commercial Space Launch*

Civil Earth-Observing Satellites

The constellation of civil Earth-observing satellites launched and operated by the U.S. government performs a wide range of observational and data collecting activities. These activities include measuring the change in mass of polar ice sheets, wind speeds over the ocean, and land

cover change, as well as the more familiar daily measurements of key atmospheric parameters that enable modern weather forecasts and storm prediction. Satellite observations of Earth's ocean and land surface help with short-term seasonal forecasts of El Niño and La Niña conditions, which are valuable to U.S. agriculture and commodity interests; identification of the location and size of wildfires, which can assist firefighting crews and mitigation activities; and long-term observational data on the global climate, which are used in models to assess the degree and magnitude of current and future climate change and its impacts.

Congress continues to be interested in the performance of NASA, NOAA, and USGS in building and operating Earth-observing satellites. NASA's Earth-observing satellites are primarily for research purposes, but some of the data they provide are also used operationally. Congress has often taken an interest in the relationship between NASA's Earth Science research program and the operational programs at NOAA and USGS. Congress is also interested in the agencies' ability to continually improve satellite technology and capabilities and keep to budgets and schedules so that critical space-based observations are not missed due to cost overruns and delays.

Congressional interest in NOAA in the 118th Congress is likely to focus on the congressionally approved restructuring of the National Environmental Satellite, Data, and Information Service, the ongoing development of the Geostationary Operational Environmental Satellite (GOES) and Joint Polar Satellite System (JPSS) weather satellites, and plans for other future satellites. NOAA has launched several GOES satellites in the past few years, including GOES-16 in 2016, GOES-17 in 2018, and GOES-18 in 2022. NOAA expects to launch the last satellite in the series (GOES-U) in 2024. Three polar-orbiting JPSS satellites—Suomi National Polar-orbiting Partnership, NOAA-20, and JPSS-2—are currently flying. NOAA is on schedule to launch two additional satellites in this system (JPSS-3 and JPSS-4) in 2028 and 2032, respectively. Future NOAA Earth-observing satellite coverage includes the Geostationary Extended Observations program, among others. The 118th Congress may continue to require updates on NOAA satellite design, construction, and budget and timelines for operations, as indicated in explanatory language accompanying recent annual appropriations legislation. Congress may also wish to provide oversight of NOAA's partnerships with NASA, other agencies, and the commercial sector in the development and deployment of polar-orbiting and geostationary satellites.

In September 2021, NASA and the USGS launched Landsat 9, the latest satellite in a series that began in 1972, to provide medium-resolution images of Earth's surface. Landsat 9 is essentially a rebuild of Landsat 8. Together, they acquire around 1,500 images of Earth per day, with a repeat visit every eight days, on average. The 118th Congress may wish to consider the future of the Sustainable Land Imaging Program under which NASA and the USGS develop, launch, and operate Landsat satellites, including Landsat Next, the mission planned to follow Landsat 9. When considering the agencies' forthcoming proposal for Landsat Next, the 118th Congress may consider whether to pursue the development of another satellite similar to Landsat 9 or to explore alternatives, such as technological improvements, cost-saving opportunities, public-private partnerships, and international cooperation and data sharing.

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Advanced Air Mobility

Advanced Air Mobility (AAM) refers to a novel transportation system for flying passengers and cargo, typically over relatively short distances ranging from about 10 miles up to roughly 150 miles, using advanced aircraft technologies, principally electric aircraft and aircraft with vertical takeoff and landing capabilities. Future AAM aircraft are envisioned to operate similarly to remotely operated or highly autonomous drones, although initially flights will be piloted. The future introduction of AAM concepts using small electric-powered vertical takeoff and landing (eVTOL) aircraft poses unique challenges to address the regulation and management of low altitude airspace, flight procedures, infrastructure needs, and related policy issues.

The AAM concept was first introduced in 2016 with visions of an on-demand urban air transportation system operating eVTOL aircraft using a network of vertiports (VTOL hubs with multiple VTOL pads and charging infrastructure) and smaller single pad vertistops located in urban and suburban settings. The use cases for eVTOL aircraft have since expanded to include regional passenger operations to and from small airports; air cargo deliveries; public service operations such as police, fire, and medical services; agricultural operations such as crop dusting; and private and recreational flights.

A number of companies are engaged in R&D of marketable passenger-carrying AAM vehicles capable of carrying from two to about eight people. The end goal of these projects is to develop uncrewed and largely autonomous AAM vehicles and supporting infrastructure, although initially flights will be piloted. Future AAM concepts for passenger-carrying operations are envisioned to function in a manner similar to concepts being developed for self-driving vehicles deployed in taxi fleets and ride-share systems: A passenger would simply input an origin and a destination into an application interface, and AI built into a connected reservation system and integrated with computers onboard the vehicle would handle scheduling, logistics, navigation, and flight guidance.

There are a number of complex technical challenges related to operational safety and efficiency and the development of ground infrastructure to support AAM operations and electric aircraft. Additionally, the future introduction of AAM technologies raises a number of policy issues, including potential landowner rights to low altitude airspace over their properties; noise and privacy concerns; and the appropriate role of federal, state, and local governments and private industry stakeholders in accessing, regulating, and managing airspace and flight operations.

Congress has expressed support for promoting and fostering AAM concepts and addressing policy issues regarding this emerging technology. The Advanced Air Mobility Coordination and Leadership Act (P.L. 117-203) mandated the establishment of a federal working group to develop a national strategy for AAM. It also requires a Government Accountability Office study assessing the interests, roles, and responsibilities of federal, state, local, and tribal governments regarding AAM aircraft and operations.

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CRS Report R42781, *Federal Civil Aviation Programs: In Brief*

Telecommunications

Telecommunication technologies present several issues for policymakers in the 118th Congress, including those related to 5G technologies, broadband deployment and the digital divide, undersea cables, federal spectrum auctions and allocations, and FCC and NTIA spectrum programs.

5G Telecommunications Technologies

Wireless providers are upgrading to fifth-generation (5G) telecommunication technologies, as 5G promises faster speeds, more bandwidth, greater interconnectedness of devices, and less lag time for users, including consumers, businesses, government, and military users. Recognizing that U.S. leadership in fourth-generation technologies yielded significant economic gains for the country, Congress in general has taken action to accelerate the deployment of secure 5G networks.

The 118th Congress may continue to focus on U.S. leadership in 5G, U.S. competitiveness with China, and security of 5G networks in the United States and abroad. It may wish to consider legislation to provide additional funding to the Secure and Trusted Communications Network Reimbursement Program, established in P.L. 116-124 to fund the replacement of Chinese equipment (i.e., Huawei and ZTE equipment) in U.S. networks. In December 2020 (P.L. 116-260), Congress appropriated $1.9 billion to the FCC for the program. The FCC received $4.98 billion in requests from companies seeking to replace untrusted equipment in their networks.

Congress may also wish to continue its oversight of restrictions imposed under Section 889 of the John S. McCain National Defense Authorization Act for FY2019 (P.L. 115-232), enacted August 13, 2018. Within one year of enactment, the act restricts federal agencies from purchasing "covered" (i.e., Chinese) telecommunications and video surveillance equipment and services due to national and cybersecurity concerns. Within two years of enactment, the act restricts U.S. agencies from doing business with companies that use covered equipment and restricts the use of federal grant and loan funds for covered equipment. Some agencies, such as DOD and the U.S. Agency for International Development (USAID), received waivers from the restrictions, providing them additional time to implement these provisions. DOD's waiver expired on September 30, 2022, and USAID's limited waiver is to expire on September 30, 2028. Congress may choose to continue its oversight of agency implementation of these provisions and consider the impact of the restrictions on the U.S. telecommunications industry, equipment users (e.g., defense industry, universities, international nonprofits), and security of U.S. networks.

Congress may also wish to assess progress on existing 5G R&D programs in DOD, NIST, and NSF and new programs funded under the CHIPS and Science Act of 2022 (P.L. 116-283), which provided $1.5 billion to NTIA for the Public Wireless Supply Chain Innovation Fund to develop open and interoperable network solutions (e.g., Open Radio Access Network technologies).

The 118th Congress may be interested in monitoring the deployment of 5G in rural regions through oversight of the recent funding programs in IIJA (P.L. 117-58) and the FCC's 5G Fund for Rural America, which is expected to be awarded after the FCC finalizes its broadband maps.

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CRS Report R47012, *U.S. Restrictions on Huawei Technologies: National Security, Foreign Policy, and Economic Interests*

CRS Insight IN11663, *Secure and Trusted Communications Networks Reimbursement Program: Frequently Asked Questions*

Broadband Deployment and the Digital Divide

Broadband internet service is delivered through a variety of technologies and allows users to send and receive data at volumes and speeds that support a wide range of applications. Broadband technologies are currently being deployed throughout the United States, primarily by the private sector. While broadband deployment continues to progress, there are communities that lack broadband services entirely or lack affordable broadband service options. These communities are typically in rural and tribal areas but may also be in urban areas. The gap between those who have access to broadband internet services and those who do not is often termed the "digital divide." As classrooms, workplaces, and social activities migrated online during the COVID-19 pandemic, the digital divide became increasingly apparent. The 117th Congress passed two bills—the American Rescue Plan Act of 2021 (P.L. 117-2) and IIJA (P.L. 117-58)—which included broadband appropriations aimed at addressing the digital divide.

The largest federal broadband grant program is the Broadband Equity, Access, and Deployment (BEAD) program under the IIJA. This program provides $42.45 billion to states and territories for broadband deployment, connectivity, mapping, and adoption projects. The BEAD program is among a total of $48 billion broadband grants administered by NTIA under the IIJA. The calendar years of 2023 and 2024 will be a critical implementation window for these grants, as NTIA will review applications and distribute significant portions of the funding.

The 118th Congress could consider a range of broadband-related issues as it continues to address the digital divide. These include ongoing funding for the broadband programs of USDA's Rural Utilities Service, the future of the FCC's long-standing Universal Service Fund broadband programs, oversight of broadband investments under the IIJA, adequacy of the currently established benchmark broadband speed, sufficiency of mapping efforts pursuant to the Broadband Deployment Accuracy and Technological Availability Act (P.L. 116-130), streamlining broadband deployment regulation, potential broadband workforce challenges, how new broadband technologies may increase coverage, and the role of municipalities as broadband providers.

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CRS In Focus IF12111, *Bridging the Digital Divide: Broadband Workforce Considerations for the 118th Congress*

Undersea Telecommunication Cables

Commercial undersea telecommunication cables, which are privately owned and operated, carry approximately 99% of transoceanic digital communications (e.g., voice, data, internet), including international financial transactions, and serve as the physical backbone for the internet. Recent incidents involving cables—damage from a volcanic eruption in Tonga that damaged an undersea telecommunication cable, an attempted cybersecurity attack on a third-party system connected to an undersea cable in Hawaii, and threats from Russian ships near cables that enable communications among North Atlantic Treaty Organization nations—have raised concern among U.S. officials. The U.S. government has strengthened processes for reviewing foreign ownership interest of cables landing in the United States, denied approval of a license application for a cable connecting the United States to China, restricted the use of untrusted equipment in undersea cables, established an outage reporting system for cables, and expanded its cable repair fleet.

The 118th Congress may wish to consider previous policies and recommendations to strengthen cable security, including increased U.S. government oversight. A 2017 report found that the majority of disruptions are caused by human activity (e.g., fishing, anchoring) and natural disasters, with new cybersecurity risks emerging. An FCC advisory committee identified a need for a lead agency to coordinate U.S. government agency review of cable landing applications, facilitate communication between the U.S. government and private sector owners, promote protection standards (e.g., protection zones, spatial separation), and participate in international cable protection organizations.

For Further Information

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CRS Report R47648, *Protection of Undersea Telecommunication Cables: Issues for Congress*

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FCC Spectrum Allocation and Interference Concerns

Radio spectrum consists of frequencies of electromagnetic radiation that are allocated for various wireless services, including mobile communications, radar systems, satellites, navigation systems, and radio and television broadcasting. It is a critical and limited resource for a nation's economic well-being.

The FCC, an independent agency, manages nonfederal use of the radio spectrum. The FCC allocates segments of spectrum for various uses, such as radio broadcasting, mobile communications, and satellite services. It grants licenses to nonfederal entities to use specific frequencies within those bands and sets terms and conditions on use to serve the public interest, avoid interference between users, and promote the most efficient use of spectrum. NTIA, an agency of the Department of Commerce, manages federal use of radio spectrum. Together, the two agencies manage use of the nation's spectrum.

Since much of the radio spectrum is already in use by federal and nonfederal users, finding spectrum for new wireless technologies is challenging. The FCC has taken action to allocate spectrum for 5G wireless communications, holding auctions of several spectrum bands to grant licenses to the highest bidders, to support 5G deployment and development of 5G technologies, and to promote U.S. competitiveness in telecommunications. However, in some instances, incumbent users, including federal agencies, lost spectrum to 5G, while others raised concerns that 5G use would cause interference with mission-essential functions in nearby bands. Congress has pressed for greater coordination between the FCC and NTIA and the development of a long-term spectrum strategy to identify bands for next generation technologies while also protecting federal use.

The 118th Congress may wish to consider options that address both the economic benefits of expanded 5G deployment and federal agency concerns about the impact of 5G use on agency missions. The 118th Congress may consider designating bands for auction or authorizing the FCC to auction bands for 5G and next generation technologies. Other potential actions could include funding or incentivizing private investment in R&D of spectrum-sharing capabilities, interference mitigation methods, and upgrades to federal receivers and systems to avoid interference from 5G systems in neighboring bands.

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NTIA Federal Spectrum Issues

In the United States, as noted in the previous section, the FCC regulates nonfederal spectrum use, and NTIA has the delegated authority to assign and manage frequencies for federal use. NTIA also presents to the FCC the views of the executive branch agencies on spectrum issues. The FCC and NTIA coordinate spectrum allocations, which are not perpetual and may be reassigned. Over 90% of U.S. radio spectrum is shared between federal and nonfederal users. The FCC and NTIA coordinate this sharing to avoid harmful interference and resolve technical, procedural, and policy differences. By statute (47 U.S.C. §922), the two agencies must meet regularly to conduct joint spectrum planning.

To help address the growing demand for spectrum used by advanced wireless communication services, including 5G communications, Congress has directed NTIA to identify federal frequencies that can be reallocated to the FCC for commercial or shared use. A major challenge of spectrum repurposing is that users operating in adjacent frequencies do not always agree on measurement of harmful interference and mitigation methods. This issue has drawn congressional attention as, in several cases, the FCC issued licenses for commercial use, while NTIA and federal agencies using adjacent frequencies raised concerns that, for example, a new 5G service could cause harmful interference to nearby federal devices and operations. Some of these interference disputes will continue in the 118th Congress.

The 118th Congress may wish to consider a range of federal spectrum issues as it continues to shape national spectrum policy to weigh public and private interests in wireless operations, to make spectrum allocation and access efficient and sustainable, to facilitate deployment of wireless broadband services, and to ensure U.S. competitiveness and leadership in advanced wireless communications technologies. The issues may include (1) whether to renew efforts to develop, formalize, and implement a national strategy to manage spectrum resources, particularly to inventory, assess, and create a pipeline of spectrum availability and use to help plan for current and long-term demand; (2) oversight of the FCC and NTIA, particularly their collaboration in repurposing federal spectrum for commercial services and their coordination in addressing disputes of frequency allocation and interference; and (3) oversight and assessment of federal resources and efforts invested in spectrum-related R&D, particularly in dynamic spectrum sharing and advanced wireless communications technologies.

For Further Information

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CRS Video WVB00471, *National Spectrum Policy: Concepts, Issues, and Options for Congress*

Water

The reliable supply of water in sufficient quantities supports the U.S. population and economy, including public and ecosystem health, agriculture, and industry (e.g., energy production, fisheries, manufacturing, and navigation). Federal water research activities and facilities span numerous agencies and laboratories and include both cooperative agreements with and grants to nonfederal researchers. Drinking water contamination and recent droughts, floods, and storms have increased interest in innovative technologies and practices (including approaches that mimic nature, often referred to as *green infrastructure* or *nature-based infrastructure*). The 118th Congress may wish to consider water research and technology topics, which can be broadly divided into water data and aquatic ecosystem information, water infrastructure and water use, and water quality.

Water Data and Aquatic Ecosystem Information

Science and research agencies collect marine and freshwater data using in situ and remote technologies and may also conduct related modeling of past, current, and future conditions and issue associated forecasts and outlooks. Topics of interest related to water data and aquatic ecosystem information research may include the following:

- Water monitoring infrastructure and science programs (e.g., programs for drought, groundwater and streamflow, evapotranspiration, and water quality);
- Next-generation water observing systems, modeling frameworks and machine learning for informing predictions;
- Water-related weather, climate, and Earth system science, including hurricane, rainfall, and associated in situ and remote sensing monitoring and data collection (see, for example, "Civil Earth-Observing Satellites");
- Monitoring and modeling ocean and coastal changes (e.g., warming, acidification, loss of oxygen, relative sea-level rise rates);
- Monitoring and management of aquatic invasive species and harmful algal blooms;
- Standardization, access, dissemination, and use of water data; and
- Coordination of water science and research.

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CRS Report R46921, *Marine Harmful Algal Blooms (HABs): Background, Statutory Authorities, and Issues for Congress*

Water Infrastructure and Water Use

Water infrastructure research includes techniques to prolong and improve the performance of existing infrastructure and the development of next-generation infrastructure technologies. Some water infrastructure and water use research topics include

- water augmentation and efficiency technologies and science, including stormwater capture, water reuse, and groundwater storage and recovery;
- technologies and materials for monitoring and rehabilitating aging infrastructure, such as structural health monitors and leak detection;
- use of forecasts in the operation of existing reservoirs;
- resilience of infrastructure to droughts, floods, hurricanes, and other natural hazards through gray and green technologies; and
- costs and benefits of utilizing and expanding natural or nature-based features to support water storage, navigation, and other activities.

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CRS Report R46911, *Drought in the United States: Science, Policy, and Selected Federal Authorities*

Water Quality

Quality of drinking water, surface water, groundwater, and marine water is important for public health, environmental protection, food security, and other purposes. Technologies for preventing contamination and for identifying and treating existing contamination is an ongoing research topic for the federal government. Some research topics include

- analytical methods and treatment technologies to detect and manage emerging contaminants (e.g., cyanotoxins associated with harmful algal blooms, per- and polyfluoroalkyl substances, and microplastics);
- technologies to prevent and manage contamination at drinking water treatment plants and in distribution systems (e.g., real-time monitoring, treatment to minimize disinfection byproducts, and lead pipe corrosion control); and
- innovative technologies and practices to protect or improve water quality (e.g., green infrastructure, watershed management, and nonpoint source pollution management), including methods for increasing resilience of drinking water systems against natural events and disasters.

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CRS Report R45998, *Contaminants of Emerging Concern Under the Clean Water Act*

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