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Science and Technology Issues for the 118th Congress

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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 (R&D) 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 S&T policy issues 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, Department of Defense (DOD) 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 role of patents and other intellectual property policies, and semiconductors.

Agriculture

The federal government funds billions of dollars of agricultural research annually. The 118th Congress may consider issues related to funding this research.

Climate Change

S&T considerations permeate deliberations on climate change topics: climate-change-related science and the ocean-climate nexus, decarbonizing the railroads, and carbon capture 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 National Institutes of Health; the Office of the National Coordinator for Health Information Technology; 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 Research and Development

DOD relies on a robust R&D effort to develop new military systems and improve existing systems. Issues 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, Minerals, and Mining

S&T issues related to energy, minerals, and mining that may come before the 118th Congress include biofuels, electricity transmission, offshore energy technologies, hydrogen, hydrogen pipelines, critical minerals and materials, and various types of mining technologies.

Earth Sciences

Earth-science-related issues before the 118th Congress include changes to the National Oceanic and Atmospheric Administration's S&T activities and improvements to weather observations, modeling, and forecasting.

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

Rapid advancements in information technologies present several issues for congressional policymakers, including those related to artificial intelligence, cybersecurity, Big Tech and online platforms, social media, consumer data privacy, children on the internet, quantum information S&T, law enforcement use of information technologies and social media, and biometric technologies.

Space and Aviation

Congress has a strong interest in space policy and aviation issues. Issues before the 118th Congress include the funding and oversight of the National Aeronautics and Space Administration, the commercialization of space, Earth-observing satellites, and law enforcement use of drones.

Telecommunications

Telecommunications technologies present several issues for policymakers, 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, Accessibility, and Use

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 diffuse, but also 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 (E.O.s) 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 breakup of AT&T in the 1980s), and the admissibility of S&T-related evidence (e.g., DNA samples).

CRS experts have identified the issues below 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, and federal efforts to boost regional innovation. It also addresses issues relating to the commercialization of results of federal R&D investments, the role of patents and other intellectual property (IP) policies, 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 \$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 \$194.6 billion in FY2024. Concerns by some about the adequacy of U.S. 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. 117-167) authorized 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

Laurie Harris, Analyst in Science and Technology Policy

CRS Video WVB00700, *FY2025 Federal Research and Development (R&D) Funding*

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*

White House Office of Science and Technology Policy

Congress has a long-standing interest in the development and implementation of S&T policies across the federal government as well as the effective coordination of multiagency R&D initiatives. To ensure a permanent source of S&T-related advice and policy coordination within the White House, Congress established OSTP within the Executive Office of the President 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 E.O. 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 E.O. 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 multiagency 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 (AI) 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*

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. For example, 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 the Economic Development Administration (EDA), the Regional Innovation Engines Program at NSF, and the Regional Clean Energy Innovation Program at the Department of Energy (DOE). EDA and NSF have started making awards under their programs and initial projects and activities are beginning.

The 118th Congress may 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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CRS Report R47495, *Regional Innovation: Federal Programs and Issues for Consideration*

Commercializing the Results of Federal Research and Development 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 IP 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 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

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CRS In Focus IF12582, *March-In Rights Under the Bayh-Dole Act: Draft Guidance*

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. Bills have been introduced in the 118th Congress to change statutory eligibility standards and abrogate Supreme Court decisions (e.g., H.R. 8134, §7, and S. 2140).

In 2011, Congress created PTAB, an administrative body within USPTO, 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 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 and 118th Congresses on PTAB, and a number of bills were introduced in the 118th Congress that sought to reform or eliminate PTAB processes (e.g., S. 2140 and H.R. 8134, §5).

USPTO does not 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.

For Further Information

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CRS Report R48016, *The Patent Trial and Appeal Board and Inter Partes Review*

CRS Video WVB00690, *The Patent Trial and Appeal Board: Legal Developments and Proposed Reforms*

CRS In Focus IF12582, *March-In Rights Under the Bayh-Dole Act: Draft Guidance*

CRS In Focus IF12563, *Patent-Eligible Subject Matter Reform: An Overview*

Intellectual Property (IP) Law

IP rights, including patents and copyrights, play a critical role in encouraging innovation, creativity, and the dissemination of knowledge. Many areas of IP law may be of interest to the 118th Congress. In addition to the general innovation policy issues discussed above (see “Patents and Innovation Policy”), a key emerging area concerns the interaction between AI and IP, which is discussed separately below (“Artificial Intelligence and Intellectual Property Law”).

While patents are important to many industries, they play a particularly critical 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 118th Congress seek to reduce drug prices by limiting certain alleged pharmaceutical patenting practices, such as “product hopping,” “patent thickets,” or “pay-for-delay” settlements (e.g., H.R. 6275, H.R. 6436, S. 142, S. 150, and S. 3583). Other bills seek to facilitate coordination between USPTO and the U.S. Food and Drug Administration (FDA) on pharmaceutical patents (e.g., H.R. 1717, S. 79, and S. 2780) or increase generic drug companies’ ability to challenge patent information that may affect FDA approval of generic drugs (S. 1128).

Copyrights grant authors of original creative works (e.g., books, music, computer code, and visual art) 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. In addition to bills relating to AI (discussed separately below), copyright bills introduced in the 118th Congress include proposed reforms to copyright in technical standards incorporated by reference into law (H.R. 1631 and S. 835) and music licensing (e.g., H.R. 5576 and H.R. 7763), including whether broadcast radio should pay royalties to play sound recordings (e.g., H.Con.Res. 13, H.R. 791, S.Con.Res. 5, and S. 253).

As to trademarks—another area of federal IP—the 117th Congress saw increased efforts to combat fraudulent trademarks through USPTO regulations implementing the Trademark Modernization Act of 2020. Trademark bills in the 118th Congress include proposals to reduce the availability of counterfeit goods on online platforms (S. 2934) and strengthen the U.S. Customs and Border Protection’s authority to prevent the importation of counterfeit goods (S. 3431).

For Further Information

Kevin J. Hickey, Legislative Attorney

CRS Video WVB00567, *Introduction to Intellectual Property Law*

CRS Report R46679, *The Role of Patents and Regulatory Exclusivities in Drug Pricing*

CRS In Focus IF12700, *“Skinny Labels” for Generic Drugs Under Hatch-Waxman*

CRS In Focus IF12644, *Patent Listing in FDA’s Orange Book*

CRS In Focus IF12582, *March-In Rights Under the Bayh-Dole Act: Draft Guidance*

CRS Report R47656, *Copyright in Standards Incorporated by Reference into Law and the Pro Codes Act*

CRS Report R47642, *On the Radio: Public Performance Rights in Sound Recordings*

CRS In Focus IF12456, *An Introduction to Trademark Law in the United States*

The U.S.-China Science and Technology Cooperation Agreement

For more than 45 years, the United States has engaged with the People's Republic of China in joint R&D activities under the U.S.-China Science and Technology Cooperation Agreement (STA), the first major agreement between the United States and the People's Republic of China that was signed in 1979. The STA was a part of U.S. strategy at the time to build ties with China to counter the influence of the Soviet Union. During the 1980s and 1990s, U.S. strategy shifted and S&T ties became part of a broader U.S. effort to integrate China into the global system and influence its development trajectory and behavior. More recent efforts have focused on areas such as health, energy, and environmental technologies.

Since its inception, U.S. views and strategy toward China have been shifting to protect and advance U.S. interests vis-à-vis China as a strategic competitor. STA proponents and critics both say that the current STA does not reflect these shifts or U.S. concerns about China's S&T practices and industrial policies. Some say the STA does not address China's growing research and technological capabilities and increasingly restrictive and risky operating environment for cross-border research.

The United States has used the U.S.-China STA as a tool to deepen diplomatic ties, address global challenges, and advance science. Advocates say it guides U.S. S&T work with China without mandating activity; provides access and protections for U.S. scientists in China, including in the social sciences (where access has been more restricted); and benefits U.S. researchers by providing access to large pools of research subjects and longitudinal health studies. China's cooperation has not been consistent, however, as Beijing developed domestic S&T competencies and has sought to restrict U.S. researcher access in certain areas. STA critics say that China is an unreliable or untrustworthy research partner, citing data restrictions and a lack of forthrightness in sharing scientific results.

The STA was to be renewed every five years, subject to modification or extension by the parties. The STA was last extended on June 27, 2018, and was amended to address U.S. concerns about China's approach to technology, innovation, and practices of concern (e.g., lax IP enforcement, IP theft, and forced technology transfer). Just before the STA was to lapse on August 27, 2023, the Biden Administration said it would extend renewal for six months to determine how to proceed. On February 24, 2024, the two sides agreed to another six-month extension to negotiate renewal terms.

Congress might consider its oversight role with regard to the STA and any U.S. STA-related activities and negotiations with China. U.S. options regarding the U.S.-China STA (not mutually exclusive) include (a) renew the U.S.-China STA as is; (b) renew the STA and modify STA sub-agreements; (c) modify and renew the STA; (d) significantly rework and renegotiate the STA; (e) let the STA expire; (f) shift focus to deepen other STAs (e.g., with Europe, Japan, and others); and (g) work with allies and partners to develop a common approach to S&T work, in general and with regard to China, specifically. Experts debate the extent to which canceling the STA would affect U.S.-China S&T ties, including sub-agreements and federally funded research.

Renegotiating the STA might or might not address specific concerns that Congress could address through legislation. It could allow Washington, but also Beijing, to set new terms. Congress might consider its preferred role in overseeing the U.S.-China STA and its negotiation. The STA is not a treaty requiring Senate ratification.

For Further Information

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

CRS In Focus IF10964, *“Made in China 2025” Industrial Policies: Issues for Congress*

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, AI, information technology (IT), 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

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

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

CRS In Focus IF12473, *U.S.-China Competition in Emerging Technologies: LiDAR*

CRS In Focus IF11667, *China's Economy: Current Trends and Issues*

R&D Security

The federal government invests extensively in science and engineering 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, collaboration, and information sharing. When broadly disseminating certain research results involves releasing proprietary information or presents potential national security concerns, however, access to such results may be restricted. For example, relevant federal restrictions may include classification and the use of 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 (DOC) 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 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. Some Members have been concerned with co-optation 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

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Marcy E. Gallo, Analyst in Science and Technology Policy

Karen M. Sutter, Specialist in Asian Trade and Finance

Jill H. Wilson, Analyst in Immigration Policy

CRS In Focus IF12589, *Research Security Policies: An Overview*

CRS Infographic IG10039, *Foreign Students: Screening and Monitoring*

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 AI, 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), lowering of operating costs abroad, outsourcing of manufacturing by 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 William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (P.L. 116-283), which authorized an incentive program for building and equipping semiconductor fabs in the United States, as well as 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 (NIST) 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.

The 118th Congress may continue to oversee the implementation of these provisions to assess whether incentives awards comply with statutory requirements related to the labor policies of recipient companies and national security provisions, among others. It also may evaluate what impact, if any, these programs have had on U.S. semiconductor manufacturing and workforce development.

For Further Information

Emily Blevins, Analyst in Science and Technology Policy

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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 WVB00705, *Science and Technology Q&A: CHIPS for America: Technology or Industrial Policy?*

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

CRS Report WPD00105, *Science and Technology Q&A: CHIPS for America: Technology or Industrial Policy?*

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

Agriculture

The federal government funds billions of dollars of agricultural research annually. The 118th Congress may consider issues related to funding agriculture that is conducted at research agencies within the U.S. Department of Agriculture (USDA) or the research conducted in partnership with the land-grant institutions throughout the nation.

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 \$3.9 billion in FY2024 discretionary appropriations through the Consolidated Appropriations Act, 2024 (P.L. 118-42) 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. The 2018 farm bill expired in 2023. Congress extended it by one year through the Further Continuing Appropriations and Other Extensions Act, 2024 (P.L. 118-22). Congress extended the authorization for discretionary funding and provided mandatory funding for existing research programs by one year through the Further Continuing Appropriations and Other Extensions Act, 2024 (P.L. 118-22), until September 30, 2024. The continuing resolution for FY2025 through December 20, 2024 (P.L. 118-83), continues discretionary funding temporarily but did not extend the farm bill or its mandatory funding. Without another extension of the farm bill, authority to operate the Organic Research and Extension Initiative that has mandatory funding and future mandatory funding for three programs without baseline will expire. While the 118th Congress is considering a new multiyear farm bill reauthorization, another extension, or expiration, it may also consider establishing new REE programs or initiatives, revising existing efforts, or eliminating some programs.

For Further Information

Eleni G. Bickell, Analyst in Agricultural Policy

CRS Report R48071, *The Agricultural Cooperative Extension System: An Overview*

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 may 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* 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 genetically engineered 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). As a result, USDA is expected to revise these specific provisions while the broader labeling requirements remain in effect.

New biotechnology tools, such as gene editing technologies, updates to USDA plant biotechnology regulations, and a proposed change in the regulation of genetically engineered agricultural animals have sparked concerns among some stakeholders. In 2020, USDA finalized the SECURE Rule for the regulation of genetically engineered organisms under the Plant Protection Act (7 U.S.C. §§7701 et seq.), exempting certain engineered plants from regulation due to low plant pest risk. While some viewed this as supportive of innovation, others criticized it for lacking oversight.

USDA also has proposed transferring regulation of genetically engineered agricultural animals from FDA to USDA. In 2021, the two agencies signed a memorandum of understanding outlining collaborative regulatory frameworks, pre-market evaluations, and post-market monitoring for genetically engineered animals, with each agency having specific roles based on their authorities to ensure the safe and efficient entry of genetically engineered species into the market. Congress may consider whether to retain or revisit the 1986 framework that governs U.S. biotechnology regulation (i.e., the Coordinated Framework for the Regulation of Biotechnology), as plants and animals developed with new biotechnology tools become more common, and as federal agencies reconsider their roles and responsibilities in protecting health and the environment without impeding innovation. Congress may also examine the implementation of E.O. 14081, "Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy," intended to enhance coordination and communication between federal regulatory agencies and stakeholders to facilitate the development and commercialization of biotechnology products, including agricultural ones.

For Further Information

Eleni G. Bickell, Analyst in Agricultural Policy

CRS Report R47683, *Gene-Edited Plants: Regulation and Issues for Congress*

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

CRS Video WVB00713, *Science and Technology Q&A: Gene Editing in Agriculture*

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 National Institutes of Health (NIH); 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 AI.

National Institutes of Health (NIH) and Biomedical Research

NIH, based in the Department of Health and Human Services (HHS), is the lead federal agency for medical and health research. In FY2023, NIH used its over \$47 billion budget to support more than 300,000 scientists and research personnel working at over 2,800 institutions across the United States and abroad, as well as to conduct research at its own facilities. The agency consists of the Office of the Director, in charge of overall policy and program coordination, and 27 Institutes and Centers, each of which focuses on particular diseases or research areas in human health. NIH represents about one-fifth of total federal R&D spending, and close to half of non-DOD R&D funding.

Congress last reauthorized and comprehensively addressed NIH policy and programs through the 21st Century Cures Act of 2016 (Cures Act, P.L. 114-255). Some Cures Act NIH authorizations have since expired, for example, the Cancer Moonshot initiative authorization expired in FY2023. The Cancer Moonshot was originally established with the broad goal of making a decade's worth of scientific progress in preventing and treating cancer in just five years. In 2022, President Biden announced a "reignited" Cancer Moonshot effort focused on a broad set of health strategies in addition to research. It remains to be seen whether and how Congress might formally authorize or fund this new effort.

In the 118th Congress, some Members have focused on research security issues at NIH (e.g., NIH's support for risky research on pathogens, including "gain-of-function" research, as well as NIH's funding for research involving institutions or foreign nationals of countries of concern). The PREVENT Pandemics Act (P.L. 117-328, Division FF, Title II), enacted in December 2022, included several provisions requiring HHS and NIH to develop policies that address security risks associated with funded research. In addition, leaders in committees of jurisdiction in both the House and the Senate have published reports on potential NIH reform, with House committee leaders proposing major structural reforms at the agency.

Other NIH issues during the 118th Congress include

- the balance of NIH's research portfolio with respect to disease and health areas as well as types of research (e.g., basic, translational, and clinical),
- NIH's relationship with the new Advanced Research Projects Agency for Health (ARPA-H),
- the affordability of pharmaceutical drugs based on NIH-funded research or IP, and
- animal use in NIH-funded research and associated scientific and ethical concerns.

For Further Information

Kavya Sekar, Analyst in Health Policy

CRS Report R43341, *National Institutes of Health (NIH) Funding: FY1996-FY2025*

CRS In Focus IF12504, *The Cancer Moonshot: Overview and Issues*

CRS In Focus IF12002, *Animal Use in Federal Biomedical Research: A Policy Overview*

CRS Insight IN12173, *Expired and Expiring National Institutes of Health (NIH) Provisions*

CRS Report R47649, *PREVENT Pandemics Act (P.L. 117-328, Division FF, Title II)*

Advanced Research Projects Agency for Health (ARPA-H)

ARPA-H aims to advance high-potential, high-impact biomedical and health research that cannot be readily accomplished through traditional research or commercial activity. ARPA-H is an independent agency housed within NIH that was first funded in FY2022 and then codified as part of the Consolidated Appropriations Act, 2023 (P.L. 117-328). ARPA-H responds to concerns that traditional health research funding processes are too risk averse—favoring incremental advances over potentially transformative research.

ARPA-H is modeled after other “ARPAs” in the federal government, especially the Defense Advanced Research Projects Agency. The “ARPA model” involves an organizational structure designed to be flat and nimble, staffed by tenure-limited program managers with a high degree of autonomy to select and fund research projects using a milestone-based contract approach. There are uncertainties around how well the ARPA model will work in the health and biomedical research context.

Prior policy debates surrounding ARPA-H focused in large part on where to place the new agency within HHS and how to ensure its independence. In March 2022, the HHS Secretary chose to place ARPA-H within NIH, with the ARPA-H Director reporting directly to the HHS Secretary. ARPA-H was statutorily authorized in December 2022 through the PREVENT Pandemics Act (P.L. 117-328, Division FF, Title II), which codified this organizational structure.

ARPA-H began establishing its programs and issued its first announcement for funding proposals in 2023. Congress has thus far provided ARPA-H with over \$4 billion in multiyear appropriations. As ARPA-H continues to develop its programs, ongoing oversight issues for Congress include the following:

- Are ARPA-H’s programs and focus areas in line with congressional intent for the new agency?
- Is ARPA-H able to recruit people with the appropriate talent and expertise as program managers?
- How is ARPA-H avoiding duplication and ensuring collaboration with other agencies that fund health research?
- What processes and policies are ARPA-H putting into place to facilitate eventual broader implementation of ARPA-H-supported innovations?
- What does success look like for ARPA-H in the short, medium, and long term?

For Further Information

Kavya Sekar, Analyst in Health Policy

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

Interoperability and the Office of the National Coordinator for Health Information Technology (ONC)

Information technology (IT) takes many forms and is increasingly used in health care contexts to improve, and make more efficient, patient care. Numerous federal initiatives have facilitated and incentivized this transition, including the establishment of ONC, codified by the Health Information Technology for Economic and Clinical Health Act of 2009 (HITECH Act; P.L. 111-5). ONC is a federal staff division within HHS and is in part tasked with advancing nationwide health IT (HIT) interoperability, or essentially, the capability of different HITs to communicate with one another and meaningfully exchange and use data. Some topics in the ONC HIT sphere that may be of particular interest to the 118th Congress include AI, data protection, and efforts to extend interoperability nationwide and across different categories of health data.

ONC promotes interoperability in numerous ways. For example, ONC develops voluntary federal standards for HIT under its Health IT Certification Program (Certification Program). In December 2023, ONC operationalized the Trusted Exchange Framework and Common Agreement (TEFCA). TEFCA in part intends to facilitate the connection of different hubs, or health information exchanges (HIEs), across the country. Thus, TEFCA's operationalization is meant to continue expanding interoperability and the trusted exchange of digital health information nationwide.

As innovative HIT emerges, ONC has taken a key federal role in developing regulations for these novel technologies. On January 9, 2024, ONC published a final rule, entitled Health Data, Technology, and Interoperability: Certification Program Updates, Algorithm Transparency, and Information Sharing (HTI-1), in the *Federal Register*. Among other things, this rule further develops ONC policy regarding algorithm transparency, including as it relates to AI, in HIT contexts. Under this rule, ONC-certified health IT modules that contain AI and other predictive algorithms must provide clinical users access to consistent, baseline information, in part to better inform users' selections of appropriate tools.

For Further Information

Nora Wells, Analyst in Health Policy

CRS In Focus IF12352, *The Office of the National Coordinator for Health Information Technology (ONC)*

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 genetic engineering, 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 E.O. 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 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

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

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

CRS Report R48155, *Oversight of Laboratory Biosafety and Biosecurity: Current Policies and Options for Congress*

Regulation of Laboratory-Developed Tests (LDTs)

Regulation of LDTs—in vitro diagnostic (IVD) devices that are designed, manufactured, and used within a single laboratory—has long been debated. FDA has traditionally exercised enforcement discretion over LDTs, so most have not undergone premarket review. However, FDA has asserted authority over LDTs it considers higher risk, for example, direct-to-consumer (DTC) genetic tests. In 2014, FDA published draft guidance outlining a comprehensive risk-based regulatory framework for LDT, which was never finalized. The COVID-19 pandemic highlighted issues with FDA regulation of LDTs. Most COVID-19 LDTs were subject to premarket review during the pandemic, but in August 2020, in a now rescinded policy, HHS announced that FDA was prohibited from requiring premarket review for LDTs without first undergoing notice-and-comment rulemaking.

The VALID Act (H.R. 6102 and S. 3404), which was initially introduced in the 116th Congress, would establish a comprehensive regulatory scheme for in vitro clinical tests. The VALID Act was incorporated into the Senate user fee bill in 2022 (S. 4348) but was not included in final passed legislation. The VALID Act was again introduced in the House during the 118th Congress (H.R. 2369).

In the context of the experience with COVID-19 LDTs during the pandemic, as well as the exclusion of the VALID Act from user fee legislation, in October 2023, FDA published a proposed rule describing its intention to phase out its general enforcement discretion approach for LDTs. This rule was finalized in May 2024. The 118th Congress may be interested in revisiting the VALID Act or similar legislation in light of FDA's final rule.

For Further Information

Amanda Sarata, Specialist in Health Policy

CRS In Focus IF12628, *Regulation of Laboratory-Developed Tests: FDA's Proposed Rule*

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 with a reference from a 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 various 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 impact 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. 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. In June 2024, the White House NSTC released the *National Aquatic Environmental DNA Strategy*, which focused on eDNA analysis of aquatic biodiversity.

The 118th Congress may consider the 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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Caitlin Keating-Bitonti, Specialist in Natural Resources Policy

Anne A. Riddle, Specialist in Natural Resources 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)*

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

As biotechnology has advanced, it has built upon advances in other fields of science and engineering, such as nanotechnology, AI, 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 AI 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?

AI technologies, methodologies, and applications can be used throughout the biological sciences and biology R&D, including in engineering biology (e.g., the application of engineering principles and the use of systematic design tools to reprogram cellular systems for a specific functional output). This has enabled R&D advances across multiple application areas and industries. For example, AI can be used to analyze genomic data (e.g., DNA sequences) to determine the genetic basis of a particular trait and potentially uncover genetic markers linked with those traits. It has also been used in combination with biological design tools to aid in characterizing proteins (e.g., 3D structure) and for designing new chemical structures that can enable specific medical applications, including for drug discovery. The convergence of AI and other technologies associated with biology can lower technical and knowledge barriers and increase the number of actors with certain capabilities. These capabilities have potential for beneficial uses while at the same time raising certain biosafety and biosecurity concerns. For example, some have argued that when AI is used for biological design, it can be repurposed or misused to potentially produce biological and chemical compounds of concern.

For federally funded research, the United States has multiple, overlapping policies that provide biosafety and biosecurity guidance and oversight for certain life sciences research, depending on factors such as the types of experiments and biological agents used. On May 9, 2024, the White House OSTP released its most recent policy update, the *United States Government Policy for Oversight of Dual Use Research of Concern and Pathogens with Enhanced Pandemic Potential*. According to the policy, it is “a unified federal oversight framework for conducting and managing certain types of federally funded life sciences research on biological agents and toxins.” It addresses oversight of research on biological agents and toxins that, when enhanced, have the potential to pose risks to public health, agriculture, food security, economic security, or national security.

In the 118th Congress, policymakers may consider whether current policies to address the convergence of biotechnology, digital data, robotics, and AI are sufficient and adequately balanced or whether new oversight authorities are needed to manage 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 WPD00077, *Science and Technology Podcast: Artificial Intelligence in the Biological Sciences*

CRS Video WVB00642, *Science and Technology Q&A: Artificial Intelligence in the Biological Sciences*

Climate Change

S&T considerations are often part of the deliberations on climate change policy. Among the S&T topics discussed are climate-change-related science and the ocean-climate nexus, decarbonizing the railroads, and carbon capture and sequestration. Legislation regarding climate change was enacted in the 117th Congress, influencing debate on related issues during the 118th Congress.

Climate-Change-Related Science and the Ocean-Climate Nexus

Congress may examine and consider recent scientific assessments—domestic and international—that strengthened and updated previous assessments. For example, in 2023 the U.S. Global Change Research Program (USGCRP) published the Fifth National Climate Assessment (NCA5), which found that human-related greenhouse gas (GHG) emissions are accumulating in the atmosphere, raising global average temperature, and increasing acidity of the global ocean. It concluded that the increase in GHG emissions is driving global land and ocean warming and other climate effects (e.g., melting ice and sea level rise). It stated that

[i]t is unequivocal that human activities have increased atmospheric levels of carbon dioxide and other greenhouse gases. It is also unequivocal that global average temperature has risen in response.

The USGCRP also coordinates U.S. participation in the Intergovernmental Panel on Climate Change (IPCC), which provides reports on climate science.

Recently the science of climate change attribution—whether, or to what degree, human influence may have contributed to extreme climate or specific extreme weather events—has received increased attention. Attributions of extreme weather to human-induced climate change may affect how policymakers, understand and manage associated risks.

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 absorption of increased levels of carbon dioxide by the ocean is contributing to *ocean acidification* thereby affecting some marine species and putting fisheries at risk. Ocean acidification is an area of ongoing research by federal science agencies. The U.S. marine economy may be positively or negatively impacted by climate change (e.g., ocean warming or acidification).

The 118th Congress may examine the role of the federal government in supporting federal climate and ocean science. Congress may monitor federal support for climate and ocean research, whether adjustment to the level of federal support is needed, and how federal funding may be allocated among federal agencies.

For Further Information

Jonathan D. Haskett, Analyst in Environmental Policy

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

CRS Report R47551, *Solar Geoengineering and Climate Change*

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

Decarbonizing the Railroads

Freight railroads, which generally do not receive federal funding, own and control most of the railroad tracks in the United States and primarily rely on fleets of diesel-powered locomotives with long service lives (approximately 25 years, longer if remanufactured). Compared to most other modes of freight and passenger transportation, railroads consume energy more efficiently and produce fewer emissions. Nevertheless, reducing emissions from U.S. railroads could be of interest to Congress as part of the nation's overall strategy to reduce air pollution and reach long-term GHG reduction targets. Congress may consider extending some of the demonstration or incentive programs in the Infrastructure Investment and Jobs Act (IIJA; P.L. 117-58) and Inflation Reduction Act (IRA; P.L. 117-169) to apply to railroads, altering project eligibilities under existing grant and loan programs, or creating new programs or freestanding legislation to promote one or more mature technologies (e.g., electric trains powered by overhead wires) or emerging ones (e.g., battery- or hydrogen-powered trains) for rail electrification or decarbonization.

The adoption of any low- or zero-emission railroad technology could present obstacles to an industry that is accustomed to operating its locomotives effectively barrier free across the entire national railway network. Large-scale electrification with overhead wires could require up-front investments in infrastructure that may be cost prohibitive and provide logistical challenges; electric locomotives would not be able to operate on unelectrified lines unless they were purpose built to do so, at additional cost. Battery-powered locomotives have practical limits to their power and range that may not be well suited to long-haul freight. Hydrogen-fueled locomotives could depend on the future development of affordable hydrogen fuel nationwide.

For Further Information

Ben Goldman, Analyst in Transportation Policy

CRS In Focus IF12707, *Options for Railroad Electrification and Decarbonization*

Carbon Capture and Sequestration

Carbon capture and sequestration (or storage)—known as CCS—seeks to capture CO₂ at its source, store it underground, or utilize it for another purpose or product. CCS is sometimes referred to as CCUS—carbon capture, utilization, and sequestration (or storage). The capturing step is the costliest and most energy-intensive step in the CCS process. CCS could reduce the amount of CO₂ emitted into the atmosphere at large stationary sources. Carbon utilization has recently gained interest as a means of converting CO₂ into potentially commercially viable products, such as chemicals, fuels, cements, and plastics. Direct air capture, a related emerging technology, removes atmospheric CO₂ directly from the atmosphere. CO₂ can also be captured from seawater in a process known as *direct ocean capture*.

Federal law and regulations specify certain requirements for CO₂ underground injection wells, which are regulated by the Environmental Protection Agency (EPA) or delegated states. Currently, 4 federal EPA-permitted geologic sequestration wells and at least 11 state-permitted wells are in operation in the United States. From FY2010 through FY2024, Congress has provided a total of \$11.5 billion (in constant 2024 dollars) in annual appropriations for the DOE research arm conducting most federal CCS research activity. Additionally, IIJA provided supplemental appropriations of \$8.5 billion for CCS for FY2022-FY2026 and \$3.6 billion for direct air capture for the same time period. IRA increased the “Section 45Q” tax credit for underground carbon sequestration, among other provisions.

Proponents of CCS and some Members of Congress have called for increased federal support for building CO₂ pipeline and storage infrastructure related to CCS. Others oppose investment in CCS and prefer to focus climate and energy policy on renewable energy exclusively. CCS technology and the extent of the federal role in development of the U.S. CCS industry may continue to be of interest in the 118th Congress.

For Further Information

Angela C. Jones, Analyst in Environmental Policy

Ashley J. Lawson, Specialist 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 R48033, *Class VI Carbon Sequestration Wells: Permitting and State Program Primacy*

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*

Defense Research and Development

S&T play an important role in national defense. DOD relies on a robust research, development, test, and evaluation (RDT&E) 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.

Department of Defense (DOD) Research, Development, Test, and Evaluation

DOD spends more than \$100 billion per year on 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. 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 various considerations, such as whether DOD has adequately justified the expenditure or the need for 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.

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 stakeholders 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 dual-use fields such as AI, 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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Kelley M. Saylor, Specialist in Advanced Technology and Global Security

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

CRS In Focus IF11105, *Defense Primer: Emerging Technologies*

CRS Report R46458, *Emerging Military Technologies: Background and Issues for Congress*

DOD Innovation Capacity

R&D is a global enterprise, with the private sector generally 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, it may examine any of several issues, such as

- the adequacy of DOD's investments in RDT&E 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

Marcy E. Gallo, Analyst in Science and Technology Policy

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

Energy, Minerals, and Mining

S&T issues related to energy, minerals and mining that may come before the 118th Congress include biofuels, electricity transmission, offshore energy technologies, hydrogen, hydrogen pipelines, critical minerals and materials, and seabed mining.

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 cost and supply, 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, including the sustainable aviation fuel credit and the biodiesel credit.

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 began a new phase in 2023 with the EPA Administrator determining the volume requirements in a multiyear rulemaking for 2023-2025. The RFS is under scrutiny for various reasons, including concerns about EPA’s lifecycle GHG emissions modeling and advanced biofuel pathway approval.

The 118th Congress may consider whether to modify 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 and commercial production of sustainable fuels for aviation, shipping, and other applications.

For Further Information

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

Electricity Transmission

The U.S. electricity transmission system (i.e., the grid) is of central importance to maintaining reliable electricity supply across the country. The grid faces several challenges that could limit its ability to deliver reliable and affordable electricity moving forward. Many transmission facilities are at or near the end of their design lifetimes. Cyberattacks and physical attacks against the grid appear to be on the rise. Extreme weather events can damage the grid or disrupt power flows through it. Much of the transmission system is not optimally built to access wind and solar energy, which are becoming a larger share of the national electricity supply.

Many of these challenges can be addressed by constructing new or replacement transmission facilities or deploying new, innovative grid technologies (or a combination of both). Choices about what kind of transmission infrastructure to build—and where to build it—are primarily made by utility companies with the approval of state and local regulators. Regulators are often balancing an interest in addressing transmission challenges with concerns about raising costs for consumers, because the costs of new transmission infrastructure are primarily borne by electricity customers.

The federal government has a role in some aspects of the grid. Mandatory reliability standards, including cybersecurity and physical security protections, apply to most components of the transmission system. Financial incentives for deploying innovative grid technologies are available in those parts of the system under the jurisdiction of the Federal Energy Regulatory Commission (FERC). FERC regulations also cover some aspects of planning new transmission facilities. IIJA (P.L. 117-58) and IRA (P.L. 117-169) established several programs at DOE to support electricity transmission development and modernization. Most of these are administered through DOE's Grid Deployment Office.

For Further Information

Ashley J. Lawson, Specialist in Energy Policy

CRS Report R47862, *Electricity Transmission: What Is the Role of the Federal Government?*

CRS Insight IN12074, *Electric Grid Physical Security: Recent Developments*

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

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 (DOI) support ocean energy research.

With respect to U.S. offshore oil and gas, one ongoing interest for developers and federal regulators is exploration of deepwater areas of the Gulf of Mexico. Industry interest in expanding deepwater activities has prompted advances in drilling technologies and steps toward automated

monitoring and maintenance. Government and industry seek to address concerns about safety and resilience, including oil spill prevention, and security, including cybersecurity. Also of interest are options 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 CCS, 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 DOI undertake and fund Arctic energy R&D, including through DOE's Arctic Energy Office.

Among renewable ocean energy sources, only wind energy has advanced to the point of commercial application in U.S. waters. The Biden Administration announced a national goal to deploy 30 gigawatts of offshore wind by 2030 and a related goal to deploy 15 gigawatts of floating offshore wind by 2035. Wind energy resources have been identified in the Atlantic region, the Pacific region, and offshore of the Gulf Coast. Other potential resources are offshore of Alaska and in the Great Lakes. Identified priorities for offshore wind R&D include (1) technology advancement for offshore wind plant; (2) improvements of resource and physical site characterization; (3) environmental impact assessment and siting to reduce radar interference; and (4) technology improvements in installation, electricity transmission and onshore grid integration, 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. Another focus is building the domestic supply chain for offshore wind development, including port infrastructure and manufacturing capabilities for turbine components and installation and support vessels. As interest in offshore wind grows in the United States, some stakeholders have expressed concerns about offshore wind projects' potential impacts on the marine ecosystem and associated species, including marine mammals, birds, and fishes. Congress may continue to consider whether—and, if so, how—to support or incentivize development of offshore wind and other ocean renewables, as well as how to assess the potential impacts these technologies may have on the ocean ecosystem.

For Further Information

Laura B. Comay, Specialist in Natural Resources Policy

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

CRS Report R46970, *U.S. Offshore Wind Energy Development: Overview and Issues for the 118th Congress*

CRS Report R47894, *Potential Impacts of Offshore Wind on the Marine Ecosystem and Associated Species: Background and Issues for Congress*

CRS In Focus IF12491, *Vessel Construction for Offshore Wind Power Generation*

Hydrogen

A future “hydrogen economy” using hydrogen as an energy carrier and fuel could offer an alternative to today's economy with its prevalent combustion of fossil fuels. Initially thought of as a new technology for personal mobility services (e.g., cars) and high-value applications such as provision of electric power during space flight, hydrogen now is receiving attention for industrial

processes, heavy vehicles, forklifts, portable power, and buffering and balancing of electric power.

Except for its use as an established industrial chemical (e.g., petroleum refining, ammonia manufacture), the scope and scale of hydrogen for energy applications is limited to demonstration scale or early deployment activities. IIJA (P.L. 117-58) authorized and funded the Regional Clean Hydrogen Hubs—envisaged networks of hydrogen producers, consumers and infrastructure in a common geography. DOE announced seven finalists for \$7 billion in grants for Regional Clean Hydrogen Hubs in October 2023. DOE announced a further \$1 billion for a Demand-side Support Initiative on July 5, 2023.

The 117th Congress incentivized hydrogen production that meets certain criteria. IRA (P.L. 117-169) created a new tax credit for the production of “clean hydrogen.” The amount of the hydrogen production tax credit (Internal Revenue Code Section 45V) can be up to \$3 per kilogram hydrogen, provided GHG emissions limits and wage and apprenticeship requirements are met. The Department of the Treasury and Internal Revenue Service (IRS) published a notice of proposed rulemaking on the implementation of the 45V tax credit on December 26, 2023.

Congress may consider the coordination and simplification of hydrogen and fuel cell programs. Questions surround the implementation and oversight of the 45V credit, including how to determine if the energy inputs used to manufacture the hydrogen will be counted as “clean,” how to balance concerns about GHG emissions from electricity generation against the goal of accelerating the development of hydrogen fuel and technology, and whether the uptake of the production tax credits will be sufficient to support the development of Regional Clean Hydrogen Hubs.

For Further Information

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CRS Report R48196, *Hydrogen Production: Overview and Issues for Congress*

CRS Report R47487, *The Hydrogen Economy: Putting the Pieces Together*

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

CRS In Focus IF12514, *DOE Appropriations for Its Hydrogen Program: FY2024*

CRS Video WVB00579, *Science and Technology Q&A: The Outlook for Hydrogen Fuel*

CRS Video WVB00607, *The Hydrogen Economy*

Hydrogen Pipelines

IIJA (P.L. 117-58, §40315) 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 (R&D). For example, the chairman of the Senate Energy and Natural Resources Committee made the following statement 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.

In the 117th Congress, the Senate Committee on Appropriations (H.Rept. 117-394) encouraged DOE to include hydrogen pipeline-related R&D in its plans for transitioning segments of the economy to low-carbon fuels.

IJIA 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, including H.R. 6494, H.R. 6510, H.R. 7655, H.R. 9323, and S. 4983, would mandate studies to examine the potential for, and challenges associated with, repurposing existing natural gas infrastructure to carry pure hydrogen or hydrogen blends. H.R. 7200 and S. 649 would mandate studies to synthesize the results from research, development, and demonstration projects on materials for transporting hydrogen and hydrogen blends and to determine outstanding research questions. H.R. 7073 would support technology demonstration projects involving the pipeline transportation of hydrogen and hydrogen blends.

Executive agencies, such as the Department of Transportation's (DOT's) Pipeline and Hazardous Materials Safety Administration, 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 R44201, *DOT's Federal Pipeline Safety Program: Background and Issues for Congress*

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 GHG 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), a fusion energy research and demonstration facility under construction in France. ITER is an international collaboration involving the United States, China, India, Japan, South Korea, Russia, and the European intergovernmental organization Euratom. 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 (1) 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; (2) 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 in order to bring fusion to commercial viability; and (3) 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

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CRS In Focus IF12411, *Fusion Energy*

CRS In Focus IF12692, *Department of Energy (DOE) Office of Science*

Critical Minerals and Materials

The Energy Act of 2020 (Division Z of P.L. 116-260) amended national minerals and materials policy and directed various federal agencies to engage in R&D, analysis and forecast, education and workforce development, and other activities to ensure critical minerals and materials supply to meet demand. IIJA (P.L. 117-58) amended or added directives and provided some supplemental appropriations for federal agencies to advance critical minerals and materials initiatives. Additional laws, including the CHIPS and Science Act (P.L. 117-167) and IRA (P.L. 117-169) included provisions that may increase demand for these critical minerals and materials.

Critical minerals are essential for the U.S. economy and national security, and are susceptible to vulnerable supply chains. The U.S. Geological Survey (USGS) published a 2022 Critical Minerals List of 50 minerals that were deemed critical based on past production and consumption, and began prioritizing research and assessment of potential domestic critical mineral resources. The USGS Earth Mapping Resources Initiative (EarthMRI) established and funded by IIJA is working to complete a national assessment of critical mineral resources by 2031.

DOE published a 2023 Critical Materials List that forecast which materials would be critical for energy technologies in the medium term (2025-2035). DOE categorized and considered these energy technologies in developing the DOE list: vehicles, stationary storage, hydrogen electrolyzers, solar energy, wind energy, nuclear energy, electric grid, solid state lighting, and microchips. DOE is working on critical material initiatives across the department that focus on research, development, and demonstration, as well as domestic production of these materials.

Congress may consider whether critical minerals and materials policy and initiatives by federal agencies are sufficient to ensure sustainable supply chains in the future. Legislation introduced in the 118th Congress would amend policy, programs, and appropriations for critical minerals and materials initiatives.

For Further Information

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

Emma Kaboli, Analyst in Energy Policy

CRS Report R47982, *Critical Mineral Resources: National Policy and Critical Minerals List*

CRS Report R48005, *Critical Mineral Resources: The U.S. Geological Survey (USGS) Role in Research and Analysis*

CRS Report R48149, *Critical Minerals and Materials for Selected Energy Technologies*

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

Land-Based Mining and Mineral Processing

Two main types of land-based mining are surface and underground mining, used for accessing mineral lodes at different depths and the type of minerals being extracted. Advances in mining technology, such as by using advanced mapping technologies and virtually recreating mine sites, have increased efficiency. Also, autonomous vehicles and drones have been deployed for both

surveillance of mine sites and “exploration” of mineral resources. AI has also been deployed to run predictive analytics for mineral ore “location,” as well as in predictive maintenance systems to monitor equipment health and maintenance schedules on expensive mining equipment.

Mineral processing and recycling technologies have also advanced in recent decades, with a particular focus on critical minerals. New mineral extraction technologies allow for the possibility of processing older mine sites to extract critical minerals and rare earth elements. In addition, domestic recycling capacity for many minerals has potential for expansion to meet increased demand. For some technologies, such as electric vehicles, research into the recycling of their components and batteries seeks to separate and reuse valuable mineral components.

Federal support of land-based mining and processing R&D is spread across multiple agencies and departments. These include DOE, DOI, DOD, and others. The 117th Congress provided authority in Section 10359 of the CHIPS and Science Act (P.L. 117-167) for the Director of NSF to make grants for basic research to accelerate innovation to advance critical minerals and mining strategies and technologies for improving domestic supply resilience.

For Further Information

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CRS Video WVB00699, *Critical Minerals for Energy: Recycling and Alternatives*

CRS Report R48149, *Critical Minerals and Materials for Selected Energy Technologies*

Seabed Mining

The transition to alternative 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. 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. In tension with the apparent concentration of such minerals is the technological challenge of extracting resources from such remote locations and the debate about the impact of these techniques. The emergence of the seabed mining industry 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.

The 118th Congress may continue to consider whether additional authorities or funding may be useful in researching and identifying seabed mineral resources on the U.S. outer continental shelf as well as better understanding potential marine ecosystem impacts from future deep-seabed mining in domestic or international waters. In the 118th Congress, some Members proposed a moratorium on seabed mining until its potential impacts on the marine ecosystem are fully understood and an international regulatory regime is in place. U.S. ocean mapping campaigns may provide a baseline for understanding whether—and to what degree—deep-sea life is vulnerable or resilient to human disturbance (e.g., seabed mining). Efforts in the 118th Congress may also include oversight of the rate at which federal agencies are mapping, exploring, and characterizing certain areas of the U.S. seafloor and how these mapping efforts may contribute to the identification of mineral resources that would serve U.S. national security interests.

For Further Information

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CRS In Focus IF12608, *U.S. Interest in Seabed Mining in Areas Beyond National Jurisdiction: Brief Background and Recent Developments*

CRS Infographic IG10053, *Seabed Mining in the Clarion-Clipperton Zone*

CRS Report R47623, *Frequently Asked Questions: Mapping of U.S. Ocean and Coastal Waters*

CRS Report R47912, *Outer Limits of the U.S. Extended Continental Shelf: Background and Issues for Congress*

Earth Sciences

Earth-science-related S&T issues before the 118th Congress include changes to the National Oceanic and Atmospheric Administration's (NOAA's) R&D activities and improvements to weather observations, modeling, and forecasting.

National Oceanic and Atmospheric Administration (NOAA) Organic Act and S&T Activities

NOAA was established via an executive reorganization plan in 1970; a combination of existing agencies and programs in the Departments of Commerce, the Interior, Navy, and Transportation, and NSF. Congress has since shaped NOAA's responsibilities through numerous statutes, which are codified in various titles of the *U.S. Code*. NOAA's S&T activities span the agency, and include satellite systems; living marine resource conservation and management; ocean and coastal science and management; monitoring and prediction of the atmosphere and environment; underlying R&D; and operation and maintenance of ships and aircraft.

Stakeholders and some Members of Congress have proposed codifying NOAA's existing functions, restructuring the agency, or dividing its functions among multiple federal agencies (e.g., DOI). Legislation that would serve as NOAA's organic act, or legislation that forms the foundation of an organization, was introduced in the 118th Congress, having also been introduced in various forms in the past decades.

For instance, in the 118th Congress, H.R. 3980 would establish NOAA as a "scientific research and development agency with an overarching statutory framework that focuses on Earth system science." The bill would also establish NOAA as an independent agency, outside the DOC. Other proposals may direct NOAA to focus on other activities, including its current living marine resource activities, while retaining it in DOC or moving it to another department.

Congress may consider whether changing the agency's research activities necessitates changes in which House and Senate Committees have jurisdiction over NOAA. Congress could also deliberate whether changing the agency's activities, including S&T activities, would require alterations to the funding levels NOAA receives.

For Further Information

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CRS Report R47636, *National Oceanic and Atmospheric Administration (NOAA): Overview and Issues for Congress*

Weather-Related Science and Technology

Weather and climate-related disasters impact millions of people in the United States each year and can cost billions of dollars (e.g., according to NOAA, 28 such events with losses exceeding \$1 billion each occurred in 2023). In the United States, weather information is developed by a mix of academia, the public sector, and the private sector (i.e., commercial weather forecast providers). The federal public sector includes a variety of federal agencies that engage in weather-related activities or research, have a major need for weather services, or set policy and direction for such services and research. Congress has indicated its interest in improving various aspects of weather forecasting, most recently passing the Weather Research and Forecasting Innovation Act in 2017 (P.L. 115-25). The act directed NOAA, the primary U.S. civilian weather forecasting agency, to prioritize weather research and forecasting, subseasonal and seasonal forecasting, weather satellite and data, and federal weather coordination.

Various stakeholders and practitioners have recommended additional improvements to the weather enterprise and weather research. For example, in 2022, NOAA's Science Advisory Board, a federal advisory committee charged with advising the NOAA Administrator, recommended actions to improve NOAA's weather-related observations, data use, forecasting, information delivery, and science, among other topics.

Members of Congress introduced legislation in the 118th Congress regarding weather research, focused on several of the same topics as in the Weather Research and Forecasting Innovation Act (e.g., H.R. 6093) but also wildfire forecasting (e.g., H.R. 550), fire weather forecasting (e.g., H.R. 4866), and weather modeling (e.g., S. 3642), among other topics. Congress may consider options that direct NOAA and other federal agencies to concentrate research activities on other types of extreme weather events or technological advancements with weather applications (e.g., AI), among other topics, in addition to its oversight role.

For Further Information

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CRS In Focus IF12695, *Tornadoes: Background and Forecasting*

CRS In Focus IF12671, *NOAA's Commercial Data Program: Background and Considerations for Congress*

CRS Insight IN12094, *Atmospheric Rivers: Background and Forecasting*

CRS Report R44838, *The Weather Research and Forecasting Innovation Act of 2017: Congressional Direction to NOAA in P.L. 115-25*

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

CRS Report R48212, *Hurricane Rapid Intensification: In Brief*

CRS Report WPD00045, *CRS Science and Technology Podcast: Atmospheric Rivers*

CRS Video WVB00599, *Drought in the United States: Science, Policy, and Authorities*

Financial Technology, or “Fintech”

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

Cryptocurrency

Cryptocurrencies are designed to function as payment and value storage systems; they resemble “electronic cash protected through cryptographic mechanisms instead of a central repository or authority.” Cryptocurrencies are typically exchanged across and cleared on public blockchains (ledgers). 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 tenant is trust, with one that is trustless and *permissionless*. For example, a variety of safeguards built into the traditional financial system seek to foster trust and inspire confidence, including regulation and government backstops, among others. Cryptocurrency, on the other hand, relies on a series of separate but concurrent incentives for network participants, such as block 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 network—or in intermediated transactions with platforms such as cryptocurrency exchanges and payments companies.

The system, which emerged as a payment tool, has gained traction as a speculative investment. The two most prevalent cryptocurrencies are Bitcoin and Ethereum, which combined represent roughly 70% of the entire crypto market. According to industry websites that track data, there are thousands of cryptocurrencies with a total market capitalization of approximately \$2.5 trillion. The industry has been characterized by rapid growth and enthusiasm, as well as volatility, accusations of its prominence in illicit finance, and high-profile frauds. Industry and regulators debate how digital assets should be regulated—as securities, commodities, payment products, or some alternative. Over the past year, Congress has considered various bills that would overhaul how digital assets are regulated, including H.R. 4763, which the House passed in May 2024, and S. 2281, among others.

For Further Information

Paul Tierno, Analyst in Financial Economics

Jay B. Sykes, Legislative Attorney

CRS Report R47425, *Cryptocurrency: Selected Policy Issues*

CRS Insight IN12223, *An Overview of H.R. 4763, Financial Innovation and Technology for the 21st Century Act*

CRS Insight IN12249, *An Overview of H.R. 4766, Clarity for Payment Stablecoins Act*

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. IJIA (P.L. 117-58) defines a 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 digital assets meet the legal definition for 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 for 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.

Some aspects of the existing regulation of digital assets 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. For example, in January 2024, the SEC approved a batch of spot Bitcoin exchange-traded product (ETP) applications, broadening retail and institutional investor access to Bitcoin. Bitcoin ETP proponents argue that the funds provide a familiar and convenient way for investors to invest in digital assets, enabling them to partake in potential financial gains. Opponents worry that the associated risks, such as fraud, manipulation, and valuation and trading risks, could generate investor protection challenges.

Another development is that new technologies 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 continues to research and conduct potential rulemaking 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). The SEC proposed a rule in July 2023 to address certain conflicts of interest associated with the use of predictive data analytics in investor interactions.

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CRS In Focus IF12573, *SEC Approves Bitcoin Exchange-Traded Products (ETPs)*

Consumer Products

Beyond the retail investment activities, 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 AI—have been used to create new fintech products for consumers. Some recent fintech products include “peer to peer” (P2P) payments, digital wallets, consumer data aggregation services, marketplace lending, and “Buy Now, Pay Later” (BNPL) financing.

New technology could potentially improve consumer experiences, lower the cost of providing financial products, and expand access to underserved consumers. 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.

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. Fintech innovations may also have impacts on market competition, such as potentially creating systemic risks. Moreover, consumer loan underwriting models using alternative data and AI 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.

For Further Information

Karl E. Schneider, Analyst in Financial Economics

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

CRS Report R47475, *Consumer Finance and Financial Technology (Fintech)*

Artificial Intelligence and Machine Learning in Finance

Technological advances in computer hardware, capacity, and data storage—which permit the collection, storage, and analysis of data—helped fuel the development and use of AI and machine learning (AI/ML) technologies in finance. Unlike older algorithms that automated human coded rules, new AI models can “learn” by themselves and make inferences and recommendations not identified by modelers in advance. This shift in technology has also enabled the use of new types of data, including alternative data (not traditionally used by the consumer credit bureaus), unstructured data (e.g., images, social media posts), and unlabeled information data, which extends the technologies’ uses to new financial services or products.

Different parts of the financial services industry have adopted AI technology to varying degrees and for various purposes. Some uses of AI/ML include powering chatbots in customer service functions; identifying investment opportunities and/or executing trades; and augmenting lending models or (more sparingly) making lending decisions. Whether, and the extent to which, a sector or firm uses the technology reflects certain priorities—involving questions such as the following: Do firms have the financial capability to fund internal development of models? How comfortable are such firms with the regulatory ramifications that may accompany their use?

The increased use of AI/ML to deliver financial services has attracted attention and led to numerous policy issues and subsequent policy actions. Such policy actions culminated in (1) E.O. 14110 on the “Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence” and (2) the establishment of an AI working group in the House Committee on Financial Services. The evolving legislative and regulatory framework regarding AI/ML use in finance is likely, at least in part, to influence the development of AI/ML financial services applications. Various financial regulators have indicated that regulated entities are subject to the full range of laws and regulations regardless of the technology used. Additionally, some regulators have identified regulations and issued guidance of particular relevance to financial firms employing AI/ML technologies.

Beyond the regulatory framework, various policy considerations accompany the financial services industry’s use of AI/ML. Some considerations are (1) the potential for the technology to introduce or exacerbate bias in the provision of financial services; (2) the lack of “explainability” that stems from increasing model complexity, potentially introducing risk to the financial system; (3) the ability to encourage herd-like behavior, leading to financial stability concerns; (4) data security and privacy issues; (5) the potential to promote market manipulation; and (6) the evolving role of Big Tech’s position at the intersection of data, AI/ML, and financial services.

For Further Information

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CRS Report R47997, *Artificial Intelligence and Machine Learning in Financial Services*

CRS In Focus IF12399, *Automation, Artificial Intelligence, and Machine Learning in Consumer Lending*

Information Technology and Social Media

Rapid advancements in information technologies present several issues for congressional policymakers, including those related to AI, cybersecurity, Big Tech and online platforms, social media, consumer data privacy, children on the internet, law enforcement use of information technologies and social media, and biometric technologies.

Artificial Intelligence

The Biden Administration and Congress have been increasingly engaged in supporting AI R&D and working to address policy concerns arising from AI development and use. Congressional activities focused on AI in the 116th and 117th Congresses included multiple committee hearings in the House and Senate, the introduction of numerous AI-focused bills, and the passage of AI provisions in legislation. Such 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); provisions focused on AI activities at NSF, DOE, and NIST within the CHIPS and Science Act (P.L. 117-167); the AI Training Act (P.L. 117-207); and the Advancing American AI Act within the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 (P.L. 117-263).

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 starting in 2022 of software (i.e., ChatGPT) that can (1) respond to questions and (2) draft prose documents may represent a sentinel event in popular use of AI.

Several broad concerns relate to AI, spanning multiple sectors, and could be considered in the 118th Congress. These include questions regarding

- 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 if so 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.

Congress may address additional national security concerns about the potential use of AI technologies, such as the potential for “deepfakes” 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

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

CRS Video WVB00685, *Science and Technology Q&A: Regulating Artificial Intelligence*

CRS Video WVB00650, *Current Issues in Artificial Intelligence*

CRS Video WVB00708, *Disruptive Technology Series: Internet Policy in the Artificial Intelligence Era*

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 Legal Sidebar LSB11097, *Section 230 Immunity and Generative Artificial Intelligence*

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*

Artificial Intelligence and Intellectual Property Law

Congress, the executive branch, and courts have begun to confront several questions regarding how IP law should apply to AI.

In the field of copyright law, the U.S. Copyright Office has denied applications to register copyrights for artworks created by inputting text prompts into generative AI programs on the basis that they lack human authorship. In March 2023, the office issued guidance stating that human beings do not have sufficient “creative control” over such works to be considered authors. For works containing materials created by both humans and AI programs, the Copyright Office guidance states that copyright protects only the human-authored aspects and requires the author to disclaim any AI-generated portions.

Some argue that AI can be used to infringe existing copyrights, either by training AI models on copyrighted works or by generating outputs that are substantially similar to those works. In 2023 and 2024, authors, news companies, music labels, and other plaintiffs filed dozens of lawsuits alleging copyright infringement by AI companies. In response, these companies argue that using copyrighted works to train their models constitutes fair use and that generative AI programs are unlikely to reproduce copyrighted works in their outputs. Congress has also introduced various bills concerning copyright and AI (e.g., H.R. 6881 and H.R. 7913).

The potential for AI to replicate real people’s voices and likenesses also raises questions regarding the right of publicity, or name-image-likeness (NIL) rights. The right of publicity is mainly protected by state laws, although federal trademark law provides overlapping protection in some cases. Some stakeholders have called for Congress to supplement or replace state right-of-publicity laws with federal legislation. Several bills have been introduced into the 118th Congress that would, for example, create a federal cause of action for victims of “deepfakes” or commercial “digital depictions” of people that may be created by AI (e.g., H.R. 5586 and H.R. 6943).

AI also raises patent law questions. Limitations on patentable subject matter (see “Patents and Innovation Policy”) may cast doubt on whether some innovations in the field of AI are patentable. In addition, it is uncertain whether innovations made with varying levels of AI assistance may be patented. In 2023, the Supreme Court declined to review a decision by the U.S. Court of Appeals for the Federal Circuit holding that an invention made “autonomously” by AI was unpatentable because it lacked a human inventor. In 2024, USPTO issued new guidance on when inventions made by humans with assistance from AI are patentable, which depends on the significance of the human contribution to the invention.

For Further Information

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Kevin J. Hickey, Legislative Attorney

CRS Legal Sidebar LSB10922, *Generative Artificial Intelligence and Copyright Law*

CRS Legal Sidebar LSB11052, *Artificial Intelligence Prompts Renewed Consideration of a Federal Right of Publicity*

CRS Video WVB00580, *Copyright Law and Generative Artificial Intelligence*

CRS Report WPD00052, *Copyright for AI-Generated Works*

CRS Video WVB00696, *The Right of Publicity and Artificial Intelligence*

CRS Video WVB00650, *Current Issues in Artificial Intelligence*

Cybersecurity

Cybersecurity is not an end state. Rather, it is a risk management process that 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, Congress has

- 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;
- enacted cybersecurity incident reporting requirements as a way to better understand and mitigate events (like ransomware attacks) that compromise the availability of data and systems;

- funded federal agencies to transition to the zero-trust architecture (i.e., the continuous authentication of a user in a system) and state and local governments to improve their cybersecurity posture; and
- authorized programs to address cybersecurity education, improve cybersecurity at schools, and increase federal information sharing and technical assistance to state and local governments.

One area of ongoing congressional interest is the relationship between the private sector and the federal government.

For Further Information

Chris Jaikaran, Specialist in Cybersecurity Policy

CRS Report R48025, *CIRCLIA: Notice of Proposed Rule Making: In Brief*

CRS Insight IN12211, *Harmonic Dissonance—Synching Up Cybersecurity Regulations*

CRS Insight IN12123, *The National Cybersecurity Strategy—Going Where No Strategy Has Gone Before*

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*

Big Tech and Online Platforms

Technological developments have allowed companies to offer various products and services through online platforms, transforming existing industries and creating new markets. 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 whether the companies use anticompetitive methods to obtain and maintain market dominance, how the companies collect and use consumer data (see “Consumer Data Privacy”), and whether to implement additional protections for content accessed by minors (see “Children on the Internet”). In P.L. 117-328, Congress enacted Division BB, Title III, Inform Consumers, which created requirements for online marketplaces, and Division GG, the Merger Filing Fee Modernization Act, which adjusted fees paid by merging firms.

Some Members of Congress have introduced multiple bills (e.g., H.R. 4624, S. 2325, H.R. 2635, S. 1094) and held hearings to examine online platforms. Some of the bills focus on specific types of online platforms, such as social media platforms (see “Social Media Platforms”). Others focus on online platforms that meet a specific size threshold, often measured by the number of monthly active users, revenue, and/or market capitalization.

For Further Information

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Jay B. Sykes, Legislative Attorney

Chris D. Linebaugh, Legislative Attorney

CRS Report R47662, *Defining and Regulating Online Platforms*

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

CRS Report R46875, *Antitrust Reform and Big Tech Firms*

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

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

Social Media Platforms

Scrutiny of social media platforms—such as Facebook, Twitter, TikTok, and YouTube—has focused on content moderation, 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 content created by another person or entity. In some instances, Section 230 also protects interactive computer service providers and their users from restricting access to third-party content.

States have adopted various laws regulating social media platforms' content moderation activity. Legal challenges to some of these laws are pending.

Some Members of Congress have also expressed interest in other aspects of social media platforms. These include the use of algorithms to amplify or remove content, 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 enacted legislation to ban TikTok from certain government devices (P.L. 117-328). The 118th Congress enacted legislation to prohibit app stores and internet hosting services from supporting TikTok and other “foreign adversary controlled applications” (P.L. 118-50). On May 7, 2024, ByteDance filed a petition for review in the D.C. Circuit Court to challenge the constitutionality of the legislation; the case is ongoing.

Some Members of Congress have introduced multiple bills (e.g., H.R. 7239, H.R. 573, S. 147, S. 1525) and held hearings related to social media platforms. Some bills would amend 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 require increased transparency for social media platforms' content moderation practices or impose requirements unrelated to content moderation.

For Further Information

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CRS Report R48023, *TikTok: Frequently Asked Questions and Issues for Congress*

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 In Focus IF12584, *Section 230: A Brief Overview*

CRS Report R46751, *Section 230: An Overview*

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

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

Consumer Data Privacy

Some companies collect, process, and analyze large amounts of consumer data, such as users' behavior on the platform and personally identifiable information, through online platforms. These 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 whether existing data privacy laws are sufficient. The 118th Congress enacted legislation prohibiting data brokers from selling, licensing, or otherwise making available personally identifiable sensitive data of an individual residing in the United States to a foreign adversary or an entity controlled by a foreign adversary (P.L. 118-50).

Some Members of Congress have introduced bills—such as the American Privacy Rights Act of 2024 (H.R. 8818), the Data Care Act of 2023 (S. 744), and the Online Privacy Act of 2023 (H.R. 2701)—that would create a comprehensive data privacy law, and several states have enacted comprehensive data privacy laws. Some of these federal bills and state laws would provide consumers with certain rights, such as the right to access and delete their data, and create requirements for companies, such as providing notice about their data collection practices.

For Further Information

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Clare Y. Cho, Specialist in Industrial Organization and Business Policy

CRS Legal Sidebar LSB11161, *The American Privacy Rights Act*

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

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

Children on the Internet

Since at least the 1990s, policymakers have enacted legislation seeking to protect minors online. Concerns about potential harms to minors using the internet, particularly social media platforms, have grown over the last few years. Some policymakers are considering increasing protections for minors on the internet, including by implementing additional requirements for online platforms.

Some Members of Congress have introduced bills during the 118th Congress seeking to protect minors online (e.g., H.R. 7239, H.R. 573, S. 147, S. 1525). Some of these bills would create additional requirements for operators of websites, online platforms, and online services. Some of these bills also would require or likely incentivize operators to use different age verification

methods by, for example, creating requirements specific to minors. Some of these bills also may raise constitutional concerns.

For Further Information

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Peter Benson, Legislative Attorney

CRS Report R47884, *Identifying Minors Online*

CRS Legal Sidebar LSB11071, *NetChoice v. Bonta and First Amendment Limits on Protecting Children Online*

CRS Legal Sidebar LSB11020, *Online Age Verification (Part I): Current Context*

CRS Legal Sidebar LSB11021, *Online Age Verification (Part II): Constitutional Background*

CRS Legal Sidebar LSB11022, *Online Age Verification (Part III): Select Constitutional Issues*

Quantum Information Science and Technology

The National Quantum Initiative Act (NQI Act; P.L. 115-368; codified at 15 U.S.C. §§8801 et seq.) was enacted in December 2018 to accelerate R&D into quantum information science and its technology applications to support the continued U.S. leadership in quantum information science and its technology applications. The law defines the term *quantum information science* as “the use of the laws of quantum physics for the storage, transmission, manipulation, computing, or measurement of information.” The interagency National Quantum Initiative—established by the NQI Act—used the term *quantum information science and technology* (QIST) to refer to the understanding and applications of quantum information science to design new types of computers, networks, and sensors that “enable new speed, precision, or functionality.”

Since the enactment of the NQI Act, researchers have made progress in R&D for QIST. One notable area is quantum computing. In the Quantum Computing Cybersecurity Preparedness Act (P.L. 117-260), the term *quantum computer* means a computer that uses the collective quantum properties to perform calculations. Researchers have demonstrated the potential for quantum computers to solve complex computing problems in areas such as cryptography, ML, and scientific and engineering research. However, practical implementation challenges lead to uncertainty about whether, and, if so, when, quantum computing could be broadly deployed and applied. The NQI Act directs the Director of NIST, the Director of NSF, and the Secretary of Energy, respectively, to allocate up to specified amounts of funding from appropriations or funds otherwise made available to them to carry out certain federal R&D activities under the law. The authorization for allocating such funding expired in September 2023.

Members in the 118th Congress have considered QIST policy issues, such as (1) reauthorizing federal R&D activities and support under the NQI Act; (2) ensuring continued U.S. leadership through accelerating near-term applications, developing a robust supply chain, and facilitating workforce development; and (3) assessing and protecting national security interests by addressing risks associated with advances in quantum computing, such as the anticipated compromise of current cryptographic systems.

The NQI Reauthorization Act (H.R. 6213) was introduced in the 118th Congress. It would reauthorize federal R&D activities under the NQI Act and expand federal agency activities in quantum information science, engineering, and technology, among other changes.

For Further Information

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CRS Report R47685, *Quantum Computing: Concepts, Current State, and Considerations for Congress*

CRS Video WVB00612, *CRS Science and Technology Series: Quantum Computing*

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. Yet others have urged technology companies to maintain strong encryption to protect privacy. The 118th Congress may consider possible legislation that would address law enforcement’s concerns and customer privacy issues involving access to communications and data.

For Further Information

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CRS In Focus IF11769, *Law Enforcement and Technology: The “Lawful Access” Debate*

Federal Law Enforcement Use of Facial Recognition Technology

In the course of carrying out their law enforcement duties, various federal law enforcement agencies may use facial recognition technology (FRT) for a variety of purposes. This can include generating investigative leads, identifying victims of crimes, helping sort faces in photos that are part of forensic evidence, and helping verify the identity of inmates before they are released from prison. For instance, the Federal Bureau of Investigation (FBI) operates two programs that support law enforcement use of FRT: (1) the Next Generation Identification–Interstate Photo System (NGI-IPS), which largely supports state and local law enforcement, and (2) the Facial Analysis, Comparison, and Evaluation (FACE) Services Unit, which supports FBI investigations. In addition, border enforcement officials use FRT for identity verification purposes. For example, U.S. Customs and Border Protection is using FRT to confirm travelers’ identities as part of its biometric entry and exit control system for noncitizen travelers into and out of the country.

There are currently no federal laws specifically governing law enforcement’s use of FRT. Guidelines and recommendations regarding law enforcement’s use of FRT have been produced by the Facial Identification Scientific Working Group (FISWG). FISWG is one of the various scientific working groups that support the Organization of Scientific Area Committees for Forensic Science (administered by NIST), which facilitates standards development, including for FRT. FISWG has published a number of FRT-related guidelines and recommendations for forensic science practitioners. In addition, the FBI maintains a Policy and Implementation Guide for the use of NGI-IPS. Authorized users of NGI-IPS are required to follow these policies as well as certain FISWG standards.

Law enforcement use of FRT has been the subject of ongoing congressional attention. Some of the concerns raised revolve around the accuracy of the technology, including potential race-, gender-, and age-related biases; the process of collecting, retaining, and securing facial images; public notification of the use of facial recognition and other image-capturing technology; and policies or standards governing law enforcement agencies’ use of the technology. Some of these concerns have manifested in actions such as federal, state, and city efforts to prohibit or restrict law enforcement agencies’ use of FRT. In addition, some companies producing facial recognition software have placed new barriers to law enforcement using their technologies.

For Further Information

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CRS Insight IN12289, *Law Enforcement Use of Artificial Intelligence and Directives in the 2023 Executive Order*

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*

Immigration: Biometric Entry-Exit System

The U.S. entry-exit system aids in immigration enforcement, national security, and travel facilitation. In 1996, Congress mandated the development of an entry-exit system to collect the records of noncitizen arrivals and departures. Congress later added a biometric requirement in 2001. The completion of a comprehensive entry-exit system has been a persistent subject of congressional concern. The biographic and biometric *entry* components are complete and operational at all U.S. air, sea, and land ports of entry. However, the *exit* component is in varying degrees of completion depending on mode of travel (air, land, or sea) and the type of information gathered (i.e., biographic vs. biometric data).

After piloting various biometric technologies (e.g., fingerprints, facial recognition, iris scans), U.S. Customs and Border Protection determined FRT to be the best fit operationally. The U.S. Customs and Border Protection, in partnership with the Transportation Security Administration (TSA), uses the Traveler Verification Service (TVS), a facial recognition matching technology to help verify travelers' identities. TVS is a public-private partnership between the federal government and private airlines, airports, and cruise lines.

TVS can perform two types of matching. One-to-many matching compares a *live photograph*, typically taken by a gate agent, to a gallery of photographs, to see if there is a potential match. The gallery varies by situation and could, for example, consist of photos of all individuals listed on a flight manifest. One-to-one matching compares a person's live photo to the photo in their travel document. Both types of matching can aid in verifying travelers' identities.

Congress has long been interested in the completion of the exit component of the system. In addition, some policymakers are concerned about the accuracy of FRT and the security of biometric data, including data storage and the auditing of private partners and contractors who collect these data. Further, though U.S. citizens can opt out of biometric data collection at ports of entry, some policymakers have expressed interest in how this is communicated to the public.

For Further Information

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CRS Report R47541, *Immigration: The U.S. Entry-Exit System*

Web Accessibility

The Americans with Disabilities Act of 1990 (ADA; P.L. 101-336) requires businesses open to the public to accommodate people with disabilities. To comply, businesses must work to remove physical barriers and modify policies that limit access. The Department of Justice (DOJ), charged with enforcing the relevant provisions of the ADA, has issued guidance on web accessibility. The guidance offers some suggestions about how websites can comply with the ADA. It does not present a detailed, uniform web accessibility standard. Without binding regulations defining ADA compliance, web developers, litigants, and courts have often turned to the Web Accessibility Initiative's Web Content Accessibility Guidelines (WCAG), a set of private web accessibility standards. The federal government has modeled rules for its own web content on these industry standards, and DOJ has proposed incorporating these standards as it creates regulations for state and local government websites. In addition, the shift from static to interactive websites and from traditional web browsers to mobile apps may also increase their technical complexity, bringing new challenges for applying ADA requirements. Some commentators have asserted that such standards should be made legally binding, while others see value in permitting website owners to select among possible accessibility options.

Web accessibility presents many issues for Congress. Congress may consider whether to wait for agency action, engage in oversight, or enact legislation. Options for legislation include clarifying ADA applicability to websites and mandating specific accessibility standards such as WCAG—in whole, in part, or not at all. In formulating any legislative measures, Congress could consider crafting different requirements depending on a website's scale (in terms of resources or traffic) or purpose (whether it is for-profit, nonprofit, or governmental). Bills on this topic introduced in the 118th Congress include the Websites and Software Applications Accessibility Act of 2023 (S. 2984/H.R. 5813). The legislation would establish “uniform accessibility standards for websites and applications.”

For Further Information

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Ling Zhu, Analyst in Telecommunications Policy

CRS Report R48104, *The Americans with Disabilities Act (ADA) and Public Accommodations in Web Services*

Space and Aviation

Congress has historically had interest in space policy and aviation issues. Issues that may come before the 118th Congress include the funding and oversight of NASA, the commercialization of space, Earth-observing satellites, and law enforcement use of drones.

NASA

Spaceflight has attracted 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 through its Commercial Crew program. 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 conducted a flight test in summer 2024 but is not yet operational.

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 2025. 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 human operations in Earth orbit, which NASA has proposed to transition to a combination of public-private partnerships and commercial service contracts by 2030, when the ISS is expected to be discontinued.

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

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Bryan Adkins, Legislative Attorney

CRS Report R47891, *National Aeronautics and Space Administration (NASA): A Primer*

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

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

CRS Video WVB00712, *NASA: Selected Topics for Congress*

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 Federal Communications Commission (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 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 scheduled to expire in January 2025. The 118th Congress may examine the potential implementation of these regulatory changes and consider whether additional legislation is required, potentially including renewal of the moratorium. Related ongoing efforts, such as the proposed reorganization of space offices in the DOC, the creation of a new Space Bureau at the FCC, and the shift of space situational awareness (e.g., issuing alerts when orbiting satellites may be about to collide) from DOD to civil responsibility are also likely to attract congressional attention. Both the Biden Administration and the House Committee on Science, Space, and Technology released legislative proposals in 2023 regarding mission authorization (i.e., authorities for regulation of emerging commercial space activities not covered by the current licensing regimes), and additional legislative proposals may follow.

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 similar programs, the National Security Space Launch and Rocket System Launch programs, in which commercial companies provide launch services to the agency. 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

Rachel Lindbergh, Analyst in Science and Technology Policy

Bryan Adkins, Legislative Attorney

CRS Report R48050, *Regulation of Commercial Human Spaceflight Safety: Overview and Issues for Congress*

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

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

CRS In Focus IF12671, *NOAA's Commercial Data Program: Background and Considerations for Congress*

Civil Earth-Observing Satellites

U.S. government Earth-observing satellites collect a wide range of observations and data. 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 daily atmospheric measurements that enable weather forecasts and storm prediction. Satellite observations contribute to a wide range of activities and products including short-term seasonal forecasts, which are valuable to U.S. agriculture and commodity interests; wildfire detection and monitoring, which can assist firefighting and mitigation; and global climate modeling.

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, 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 improve satellite capabilities and keep to budgets and schedules.

Congressional interest in NOAA in the 118th Congress has focused on the ongoing development of the Geostationary Operational Environmental Satellites (GOES) and Joint Polar Satellite System (JPSS) weather satellites and plans for future satellites (Geostationary Extended Observations [GeoXO] and additional JPSS satellites). 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 also may conduct oversight of NOAA's partnerships with NASA, including NASA's Joint Agency Satellite Division, other agencies, and the commercial sector.

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. In 2022, the agencies presented initial details about the next proposed launch in the series, Landsat Next, which is expected to collect about 15 times more data than Landsat 9. Landsat Next is to be a constellation of three satellites sent into orbit on the same launch vehicle in 2030. Congress may debate the amount and timing of Landsat Next funding and may provide oversight of mission administration and progress.

For Further Information

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Anna E. Normand, Specialist in Natural Resources Policy

Rachel Lindbergh, Analyst in Science and Technology Policy

Caitlin Keating-Bitonti, Specialist in Natural Resources Policy

CRS In Focus IF12667, *National Oceanic and Atmospheric Administration (NOAA) FY2025 Budget Request and Appropriations*

CRS In Focus IF12406, *National Oceanic and Atmospheric Administration (NOAA) FY2024 Budget Request and Appropriations*

CRS Insight IN12281, *Landsat Next on the Horizon*

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

CRS Report R47021, *Federal Involvement in Ocean-Based Research and Development*

CRS In Focus IF12671, *NOAA's Commercial Data Program: Background and Considerations for Congress*

Law Enforcement Use of Unmanned Aircraft Systems

Alongside growth in the use of unmanned aircraft systems (UAS), commonly referred to as *drones*, for both commercial and recreational purposes, law enforcement agencies' use of this technology has been increasing. Agencies use drones for a variety of purposes from gathering intelligence and evidence to providing for remote communication and operational support.

No specific legislative framework governs federal law enforcement use of drones. Generally, federal law does not direct or prohibit specific tools and technologies—such as UAS—used by federal law enforcement agencies. Rather, federal laws and policies broadly govern law enforcement investigations and intelligence gathering. Additionally, policies and pertinent guidance resources direct the use of drones by federal agencies, including law enforcement. Such documents include the 2015 presidential memorandum, “Promoting Economic Competitiveness While Safeguarding Privacy, Civil Rights, and Civil Liberties in Domestic Use of Unmanned Aircraft Systems,” which placed certain requirements on executive departments and agencies—including law enforcement agencies—that use UAS.

Some observers have raised concerns that law enforcement use of drones could infringe upon individuals' privacy or could chill free speech—such as in situations where law enforcement may fly drones over First Amendment-protected activities. Others argue that drone use can enhance public safety and national security—including their use by first responders. Policymakers may debate potential trade-offs as they conduct oversight or legislate on law enforcement use of UAS. For example, in conducting oversight of federal law enforcement use of UAS, key considerations policymakers may examine include the extent to which agencies adhere to the 2015 presidential memorandum on UAS or to their department- or agency-specific policy guidance. With respect to legislating on law enforcement use of UAS, while Congress can legislate directly on federal law enforcement agencies' use of the technology, policymakers may seek to influence the use of UAS at the state, local, and tribal law enforcement levels through other means, such as the provision or withholding of federal grant funding.

For Further Information

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CRS Report R47660, *Law Enforcement and Technology: Use of Unmanned Aircraft Systems*

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 National Telecommunications and Information Administration (NTIA) spectrum programs.

5G Telecommunications Technologies

Wireless telecommunication service providers are continuing to upgrade to fifth-generation (5G) technologies. Congress is weighing the values inherent in accelerating 5G development and deployment to advance U.S. competitiveness, ensuring security of U.S. networks, and monitoring the impact any restrictions may have on the U.S. network operators and equipment makers.

The 118th Congress may continue to assist in the development and deployment of 5G and future technologies by DOD with a goal of enhancing U.S. military operations and readiness, ensuring U.S. competitiveness with China, and bolstering U.S. leadership in the global telecommunications market. Congress has funded 5G demonstration projects in selected DOD facilities and directed the expanded 5G use to other bases and facilities.

Congress has addressed the security of federal telecommunications networks and systems in a number of ways. Congress has restricted federal agencies from purchasing telecommunications and video surveillance equipment and services from certain entities (e.g., Huawei, ZTE), citing national and cybersecurity concerns; restricted U.S. agencies from doing business with companies that use such equipment; and restricted use of federal grant and loan funds for such equipment. Some Members have sought to expand the list of entities and to secure further the information and communications technology (ICT) supply chain. Elimination of entities and equipment from the ICT supply chain can be costly and complex. In the 118th Congress, S. 4651 would require agencies to purchase ICT products from original equipment manufacturers and authorized resellers to avoid counterfeit supplies. H.R. 2864 would add certain China-based companies to the list of restricted entities.

Congress has funded 5G R&D programs in DOD, NIST, and NSF, as well as NTIA. The Public Wireless Supply Chain Innovation Fund, established in the CHIPS and Science Act (P.L. 117-167) and administered by NTIA, intends to develop open and interoperable network solutions, also known as Open Radio Access Network (ORAN). ORAN aims to allow network operators to move away from a one-vendor solution and to mix and match network equipment from different vendors. The National Defense Authorization Act for Fiscal Year 2024 (P.L. 118-31, Title XV, Subtitle C, Section 1526) directs the Secretary of Defense to develop and implement a strategy for deploying private 5G networks and ORAN technologies to military installations and facilities. The 118th Congress may support additional ORAN deployments at military and other federal facilities, for example, to develop ORAN use cases and showcase U.S. technologies.

Congress has also supported elimination of untrusted equipment in commercial networks. In P.L. 116-124, Congress restricted use of FCC subsidies to obtain communications equipment or services from a company that poses a national security risk to U.S. communications networks and established the Secure and Trusted Communications Networks Reimbursement Program. The

program is to supply small communications providers with funds to offset the cost of removing prohibited equipment or services from their networks and replacing it with more secure equipment or services. While Congress appropriated \$1.9 billion for the program in 2020 (P.L. 116-260, Division FF, Title IX, Section 906), the actual cost of replacement exceeded appropriated amounts by \$3.08 billion. The 118th Congress has considered bills using different approaches to fully fund the program and close the estimated \$3.08 billion shortfall (e.g., S. 4207, S. 4317, S. 1245, S. 4049). Without funding, providers have warned that they may not meet mandated timelines for completion, which could result in disruption of services, including in rural regions.

The 118th Congress has shown interest in promoting 5G availability in rural regions. In 2020, the FCC established the 5G Fund for Rural America and allocated \$8 billion in Universal Service Fund (USF) funding for the program. The FCC is relying on its mapping efforts to identify areas lacking services and has not released funding from the 5G Fund program. Some Members have questioned whether \$8 billion allocated by the FCC to the 5G Fund is sufficient to extend 5G to remote and rural regions.

For Further Information

Jill C. Gallagher, Specialist in Telecommunications Policy

Peter Benson, Legislative Attorney

CRS In Focus IF12465, *5G Fund for Rural America: Current Status and Issues*

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. While broadband deployment continues to progress throughout the United States, some communities 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 termed the “digital divide.” 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 single largest federal broadband grant program is the Broadband Equity, Access, and Deployment (BEAD) program under IIJA. This program is to provide \$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 IIJA. NTIA has awarded grants under many of these programs and approved most states’ initial proposals to request access to a portion of the BEAD funding. Congress may continue to monitor the implementation of these broadband grant programs.

The 118th Congress may consider a range of broadband-related issues related to the digital divide. These include ongoing funding decisions regarding the broadband programs of USDA’s Rural Utilities Service, the future of the FCC’s long-standing USF broadband programs and the Affordable Connectivity Program, oversight of broadband investments under IIJA, adequacy of the established benchmark broadband speed, sufficiency of federal broadband mapping efforts pursuant to the Broadband Deployment Accuracy and Technological Availability Act (P.L. 116-

130), consideration of broadband deployment regulation, potential broadband workforce challenges, the potential capabilities of new broadband technologies, and the role of municipalities as broadband providers.

In the 118th Congress, multiple bills have been introduced to address various broadband-related issues. For example, the Accurate Map for Broadband Investment Act of 2023 (S. 1162) would amend IJA and require NTIA to recalculate the BEAD funding allocated to states and territories “based on the most current versions of the broadband DATA maps.” H.R. 3362 would direct that NTIA publish “the data collected from grant recipients and subgrantees under the [BEAD] Program that is related to the diversity, equity, inclusion, and accessibility elements of the Program.”

For Further Information

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CRS Report R47883, *Federal Funding for Broadband Deployment: Agencies and Considerations for Congress*

CRS In Focus IF12041, *Farm Bill Primer: Rural Broadband Provisions*

CRS Report R47621, *The Future of the Universal Service Fund and Related Broadband Programs*

CRS In Focus IF12429, *Broadband Equity, Access, and Deployment (BEAD) Program: Issues and Congressional Considerations*

CRS In Focus IF12559, *Legacy Lead-Sheathed Telecommunications Cables: Status and Issues for Congress*

CRS Report WPD00062, *Science and Technology Podcast: Broadband Equity, Access, and Deployment (BEAD) Program*

CRS Video WVB00600, *Science and Technology Q&A: Broadband Equity, Access, and Deployment (BEAD) Program*

CRS Report R47506, *The Persistent Digital Divide: Selected Broadband Deployment Issues and Policy Considerations*

CRS In Focus IF12441, *Fixed Technologies Used to Deliver Broadband Service: A Primer and Considerations for 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 natural hazard and security incidents involving cables have raised concern among U.S. officials.

The U.S. government has supported deployment of undersea fiber optic cables to strengthen domestic and international communication links and to enhance resiliency and redundancies of the U.S. and global undersea cable network. 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.

Congress remains engaged in policy discussions related to facilitating deployment of trusted undersea cables in the United States and abroad, and policies that hinder deployment of cables with untrusted owners and untrusted equipment. The Undersea Cable Control Act (H.R. 1189) seeks to prevent foreign adversaries (e.g., China) from acquiring goods and technologies capable of supporting the construction, maintenance, or operation of undersea cable projects.

For Further Information

Jill C. Gallagher, Specialist in Telecommunications Policy

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

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. The agency 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. Federal agencies also rely on spectrum for mission-essential functions (e.g., military communications, radionavigation, air traffic control). NTIA, an agency of DOC, manages federal use of radio spectrum, assigning frequencies to federal agencies and representing federal agency needs in spectrum discussions with the FCC. Together, the two agencies manage use of the nation's spectrum.

Since much of the radio spectrum is in use by federal and nonfederal users, finding spectrum for new wireless technologies is challenging. The FCC and NTIA work together to identify potential bands for reallocation or sharing to enable new technologies while also protecting incumbent systems and avoiding interference between users. The FCC has taken action to allocate spectrum for 5G wireless communications, identifying spectrum for 5G use, working with the NTIA and commercial users to free spectrum for 5G and other emerging technologies, and auctioning licenses to the highest bidders to support development and deployment of new technologies. In some instances, incumbent users, including federal agencies, have raised concerns that loss of spectrum resources would impact existing systems and capabilities or cause interference with mission-essential functions in the band or in nearby bands. Congress has pressed for greater coordination between the FCC and NTIA to identify bands for emerging technologies, balance federal and commercial needs, and avoid interference between users.

A key issue of concern to Congress is the FCC's auction authority, which expired on March 9, 2023. In the 118th Congress, Members have introduced single-issue bills (e.g., H.R. 1108) to renew the FCC's auction authority and comprehensive spectrum legislation that includes several spectrum-related provisions, including an extension of the FCC's auction authority. S. 4207 would promote interagency cooperation on spectrum issues, invest in spectrum-sharing technologies and research, restore the FCC's auction authority, identify a pipeline of spectrum

bands for future auction, and designate spectrum auction proceeds for public interest programs. S. 3909 would extend the FCC's auction authority, direct NTIA to identify spectrum that could be made available for commercial use, direct the FCC to auction spectrum, and expand allowable upgrades to federal systems.

With increasing demand for spectrum from commercial and federal users, and a lack of free and available spectrum for new technologies, Congress may focus on improving processes for identifying potential spectrum for new wireless uses, developing spectrum-sharing technologies and interference measurement methods to avoid conflicts and accommodate all users, and restoring the FCC's auction authority.

For Further Information

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Peter Benson, Legislative Attorney

CRS In Focus IF12766, *4.9 GHz Public Safety Band: Competing Views on Use*

CRS In Focus IF12350, *Repurposing 3.1-3.55 GHz Spectrum: Issues for Congress*

CRS In Focus IF12552, *The National Spectrum Strategy for Wireless Technologies: Priorities, Objectives, and Congressional Considerations*

CRS Insight IN12023, *National Academies of Sciences, Engineering, and Medicine Report on Ligado Networks and the Interference Debate*

CRS Video WVB00639, *Science and Technology Series: FCC Spectrum Auction Authority*

CRS Report R47578, *The Federal Communications Commission's Spectrum Auction Authority: History and Options for Reinstatement*

NTIA Federal Spectrum Issues

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 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.

In the 118th Congress, multiple bills have been introduced to address federal spectrum issues. For example, the Spectrum and National Security Act of 2024 (S. 4207) would direct NTIA to (1) establish “a national testbed for dynamic spectrum sharing,” (2) improve federal interagency coordination and spectrum management, and (3) create a “spectrum pipeline” making spectrum available for nonfederal use or shared federal and nonfederal use. The Commerce Spectrum Coordination Act of 2023 (H.R. 4513) would codify the Commerce Spectrum Management Advisory Committee within NTIA—with members from nonfederal entities—to advise NTIA on developing spectrum management policies.

For Further Information

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CRS In Focus IF12552, *The National Spectrum Strategy for Wireless Technologies: Priorities, Objectives, and Congressional Considerations*

Water Availability, Accessibility, and Use

Water in sufficient quantities and of appropriate quality supports the U.S. population and economy, including public and ecosystem health, agriculture, and industry (e.g., energy production, fisheries, manufacturing, and navigation). 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). Federal water research activities and facilities span numerous agencies and laboratories and include both cooperative agreements with and grants to nonfederal researchers. 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

- 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 ML 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 (e.g., see the section “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, including utilization of eDNA technology;
- standardization, access, dissemination, and use of water data; and
- coordination of water science and research.

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CRS Report R47440, *Water Resource Issues in the 118th Congress*

CRS Report R48148, *Coastal Blue Carbon as a Carbon Dioxide Removal Approach: Selected Issues for Congress*

CRS Report R47021, *Federal Involvement in Ocean-Based Research and Development*

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

CRS Insight IN12094, *Atmospheric Rivers: Background and Forecasting*

CRS Report WPD00045, *CRS Science and Technology Podcast: Atmospheric Rivers*

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, and updates accounting for climate change to national probable maximum precipitation studies, which are used for regulation and design of water resource infrastructure;
- resilience of infrastructure to droughts, floods, hurricanes, and other natural hazards through gray (i.e., traditional infrastructure) and green technologies;
- technologies to secure water infrastructure against cybersecurity threats, natural hazards, and other threats, 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 R47878, *Drinking Water Infrastructure Needs: Background and Issues for Congress*

CRS Report R47440, *Water Resource Issues in the 118th Congress*

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

CRS Report R45981, *Dam Safety Overview and the Federal Role*

CRS Insight IN12378, *Desalination: Converting Saline Water into a Municipal Water Source*

CRS Video WVB00599, *Drought in the United States: Science, Policy, and Authorities*

CRS Report WPD00069, *Science and Technology Podcast: Saltwater Intrusion in the Lower Mississippi River*

Water Quality

Quality of drinking water, surface water, groundwater, and marine water is important for public health, environmental protection, food security, and other purposes. Research on technologies for preventing contamination and for identifying and treating existing contamination is ongoing within 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.

For Further Information

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CRS Report R46652, *Regulating Contaminants Under the Safe Drinking Water Act (SDWA)*

CRS In Focus IF12367, *Safe Drinking Water Act: Proposed National Primary Drinking Water Regulation for Specified PFAS*

CRS In Focus IF12341, *Limiting Lead in Public Water Supplies: An Overview of the U.S. Environmental Protection Agency's Regulatory Actions*

CRS In Focus IF11666, *U.S. Army Corps of Engineers Nuisance Species Efforts*

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