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Science and Technology Issues for the 118th Congress

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SUMMARY

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Science and Technology Issues for the 118th Congress

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

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

Cross-Cutting Issues

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

Agriculture

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

Climate Change

S&T considerations permeate deliberations on climate change and may be grouped into five interrelated topics: climate change-related science and the ocean-climate nexus; climate mitigation science and technology; infrastructure and decarbonization; climate change adaptation and resilience; and carbon capture, utilization, and sequestration.

Biotechnology and Biomedical Research

Recent advances in biotechnology and biomedical research hold the promise of longer and healthier lives and more productive industry while raising policy challenges. Some issues that the 118th Congress may face include those relating to the bioeconomy; the National Institutes of Health; 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

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

Energy, 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.

Earth Sciences

Earth-science related issues that may come before the 118th Congress include the reauthorization of the National Earthquake Hazards Reduction Program; 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 science and technology, immersive technologies, blockchain (ledger) technologies, law enforcement use of information technologies and social media, and biometric technologies.

Space and Aviation

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

Telecommunications

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

Water, 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 are diffuse; there are dozens of informal congressional caucuses in areas of S&T policy such as R&D, specific S&T disciplines, and STEM education.

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

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

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

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

Cross-Cutting Issues

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

Federal Funding for Research and Development

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

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

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

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

For Further Information

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

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

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

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

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

White House Office of Science and Technology Policy

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

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

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

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

For Further Information

Emily G. Blevins, Analyst in Science and Technology Policy

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

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

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

Adequacy of the U.S. Science and Engineering Workforce

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

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

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

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

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

For Further Information

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

Jill H. Wilson, Analyst in Immigration Policy

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

Federal Efforts to Boost Regional Innovation

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

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

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

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

For Further Information

Marcy E. Gallo, Analyst in Science and Technology Policy

Julie M. Lawhorn, Analyst in Economic Development Policy

Adam G. Levin, Analyst in Economic Development Policy

Emily G. Blevins, Analyst in Science and Technology Policy

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

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

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

Federal Scientific Integrity Policies

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

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

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

Further Information

Marcy E. Gallo, Analyst in Science and Technology Policy

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

Public Access to Scientific Publications Resulting from Federally Funded Research

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

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

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

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

For Further Information

Marcy E. Gallo, Analyst in Science and Technology Policy

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

Commercializing the Results of Federal 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 intellectual property and covered inventions to be manufactured abroad. These critics argue that the ability of competitor nations to access U.S.-developed technology—especially emerging technologies—poses an economic and national security threat.

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

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

For Further Information

Emily G. Blevins, Analyst in Science and Technology Policy

Marcy E. Gallo, Analyst in Science and Technology Policy

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

Patents and Innovation Policy

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

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

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

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

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

For Further Information

Emily G. Blevins, Analyst in Science and Technology Policy

Kevin J. Hickey, Legislative Attorney

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

CRS Video WVB00518, *Patents and Innovation Policy*

CRS Report R47267, *Patents and Innovation Policy*

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

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

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

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

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

Intellectual Property Law

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

In addition to the innovation policy issues discussed above (see "Patents and Innovation Policy"), patents play a particularly important role in the pharmaceutical industry. While some stakeholders argue that robust patent rights are necessary to support costly R&D for new drugs, others argue that patents can unduly delay or deter generic competition and contribute to higher drug prices. Several bills in the 117th Congress sought to reduce drug prices by limiting certain alleged pharmaceutical patenting practices (e.g., patent "evergreening," "product hopping," "thickets," and "pay-for-delay" settlements). Other bills sought to facilitate coordination between PTO and the Food and Drug Administration (FDA) on pharmaceutical patents (S. 4430) or respond to the Biden Administration's support for a waiver of IP protections for COVID-19 vaccines under international IP treaties (e.g., H.R. 7430).

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

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

For Further Information

Kevin Hickey, Legislative Attorney

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

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

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

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

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

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

Tax Incentives for R&D Investment

Economic analysis shows that investment in research and development (R&D) is a key source of technological innovation, which in turn is a principal driver of economic and productivity growth.

Businesses are a major source of domestic R&D. According to a National Science Foundation estimate, firms financed 71% of the R&D performed in the United States in 2019. But most economists suggest that firms as a whole are likely to invest too little in R&D relative to its social welfare benefits. In general, R&D produces both returns that investing firms can capture (e.g., higher profits from using or selling new technologies) and returns that are difficult for investing firms to capture (e.g., consumer welfare gains and competitor profits from imitating new

technologies). Some estimate that the social returns from R&D are two to four times greater than the private returns to investors.

Generally, economists regard such private R&D underinvestment as a market failure that restrains productivity and economic growth over time. Many economists suggest that this failure should be remedied through government intervention in the market for new knowledge production. An option used by most national governments is tax incentives for business R&D investment. The federal government has offered one such incentive since 1981: a research tax credit under Section 41 of the Internal Revenue Code (IRC). Section 41 allows firms to claim a credit equal to (1) 20% of qualified research expenses (QREs) above a base amount linked to a firm's past ratios of research spending to business receipts, or (2) 14% of QREs above a base amount linked to a firm's recent R&D investments.

The structure of the IRC Section 41 tax credit has been of interest to policymakers for some time. One issue is the two credit options' effective rates are considerably less than their statutory rates, owing to the rules governing the use of each option. Some policymakers argue that the effective rates should be higher if the credit's incentive effect is to match the social returns to private R&D investments. Another issue is that the current research credit provides little benefit to start-up and young firms seeking to develop new and improved technologies. Some argue that the credit should be made fully refundable for such firms beginning with their early years of operation, when young small firms investing in R&D often incur operating losses that keep them from immediately benefiting from any credit they could claim.

The federal government offered another tax incentive for private R&D investment for nearly 70 years, but it was repealed starting in 2022. From 1954 to 2021, IRC Section 174(a) allowed businesses investing in qualified research to *expense* (or deduct as a current rather than capital expense) the full amount of their qualified research expenses (QREs) in the year they were paid or incurred. Expensing provides a significant tax benefit because it lowers the user cost of capital for eligible investments, boosts the short-term cash flow of firms making such investments, and simplifies their tax accounting. As a result of the Tax Cuts and Jobs Act (P.L. 115-97), QREs related to domestic research have had to be charged to a firm's capital account and amortized over five years since 2022. This change has increased the marginal effective tax rate for the returns on domestic R&D investments; according to one estimate, this rate has risen from 0% in 2021 to 8.4% in 2022-2025. The loss of QRE expensing has been a financial burden for many small firms that derive most of their income from contract research.

For Further Information

Gary Guenther, Analyst in Public Finance

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

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

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 research and development (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 science and technology (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. The extension for the agreement was set to expire on February 27, 2024. The Biden Administration may have agreed to an unannounced extension with the PRC government as both sides negotiate terms for the STA renewal.

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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Karen M. Sutter, Specialist in Asian Trade and Finance

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*

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

CRS Report R46915, *China's Recent Trade Measures and Countermeasures: 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, artificial intelligence, information technology, new materials, robotics, and semiconductors. China's military-civil fusion program seeks to leverage these *Made in China 2025* technological advancements for military development.

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

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

For Further Information

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

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

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

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

R&D Security

The federal government invests extensively in S&E R&D to achieve national objectives, including economic competitiveness and national security. Many in Congress are concerned about

security vulnerabilities in the U.S. R&D enterprise and are interested in protecting it against compromise by foreign competitors and potential military adversaries.

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

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

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

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

For Further Information

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Daniel Morgan, Specialist in Science and Technology Policy

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

Karen Sutter, Specialist in Asian Trade and Finance

Jill H. Wilson, Analyst in Immigration Policy

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

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

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

Semiconductors and the CHIPS Act

Semiconductors (also known as integrated circuits, microelectronic chips, or computer chips) are tiny electronic devices (based primarily on silicon or germanium) composed of billions of

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

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

To address these concerns, Congress enacted the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (2021 NDAA, P.L. 116-283), which authorized an incentive program for building and equipping semiconductor fabs in the United States, as well as research and development (R&D) activities to support U.S. leadership in semiconductor technology. In July 2022, Congress enacted the CHIPS and Science Act (P.L. 117-167), which President Biden signed into law in August 2022. The CHIPS Act of 2022 (Division A of P.L. 117-167) establishes and appropriates $39.0 billion to a CHIPS for America Fund to bolster semiconductor manufacturing capacity in the United States by providing financial incentives for building, expanding, and equipping domestic fabrication facilities and companies in the semiconductor supply chain. The fund also provides $11.0 billion for semiconductor R&D activities at the National Institute of Standards and Technology and in partnership with U.S. industry through a National Semiconductor Technology Center, a National Advanced Packaging Manufacturing Program, and the establishment of up to three Manufacturing USA institutes. P.L. 117-167 also provided appropriations for three additional funds that seek to bolster U.S. semiconductor capabilities for national defense, workforce development, and international cooperation. Implementation of these provisions began in 2023.

For Further Information

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

Karen Sutter, Specialist in Asian Trade and Finance

CRS Report R47508, *Semiconductors and the Semiconductor Industry*

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

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

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

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

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

Agriculture

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

Agricultural Research Funding

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

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

The most recent farm bill (P.L. 115-334), enacted in December 2018, reauthorizes many existing USDA research and education programs, and authorizes new programs, through FY2023. Congress has appropriated limited funding for some of the new programs. For example, the 2018 farm bill authorized the Agriculture Advanced Research and Development Authority (AGARDA) pilot program. AGARDA is intended to operate under the Office of the Chief Scientist to address long-term and high-risk research challenges in the agriculture and food sectors. It is modeled on federal advanced research entities such as the Defense Advanced Research Projects Agency and the Advanced Research Projects Agency—Energy. Congress authorized appropriations of $50 million annually for AGARDA from FY2019 to FY2023. Congress appropriated $2 million for AGARDA, with the program receiving $1M in both FY2022 and FY2023 for planning purposes and to hire staff.

The 118th Congress may wish to consider reviewing AGARDA and other new programs established in the 2018 farm bill that have received limited or no appropriations. The 2018 farm bill expired in 2023. Congress extended it by one year through P.L. 118-22 and plans to consider a full multiyear reauthorization in 2024. Congress may consider new programs or revisions to existing programs for the next farm bill.

For Further Information

Eleni G. Bickell, Analyst in Agricultural Policy

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

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

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

Climate Change Science at USDA

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

USDA published a progress report for the *Action Plan for Climate Adaptation and Resilience* in 2022. This plan identifies the areas of S&T where USDA believes it needs to increase its support to meet national objectives. Financial investments in climate-related agriculture practices by both Congress and USDA since 2021 have generally offered producers incentives to adopt agricultural and forestry practices that will further climate-related goals. The 118th Congress may wish to consider reviewing how investments in USDA research programs and policies align with its Action Plan.

For Further Information

Megan Stubbs, Specialist in Agricultural Conservation and Natural Resources

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

Regulation of Agricultural Biotechnology

The 118th Congress may continue to oversee USDA's implementation of regulations related to the labeling of bioengineered foods and the regulation of agricultural biotechnology. As plants and animals that are developed with new biotechnology tools become more common, Congress 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* (GE) ingredients. USDA finalized its National Bioengineered Food Disclosure Standard regulations in 2018, and mandatory compliance began in January 2022. However, in September 2022, a U.S. district court remanded two provisions in USDA's regulation that allow GE foods to be labeled only with an electronic or digital disclosure (QR code) and allow text message disclosure on packaging without requiring additional on-package labeling (7 C.F.R. §§66.106 and 66.108). Following the court's ruling, USDA is expected to revise these provisions in its labeling regulations. The case, *Natural Grocers et al. v. Perdue et al.* (3:20-cv-05151), was brought by the Center for Food Safety on behalf a coalition of nonprofits and food retailers.

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.). This rule exempts certain categories of engineered plants, including those consistent with many gene-edited plants, because they are "unlikely to pose an increased plant pest risk compared to conventionally bred plants." While some producer groups viewed the new rule as supportive of innovation, some consumer and exporter groups criticized it

as providing too little oversight and transparency. In 2020, USDA issued an Advance Notice of Proposed Rulemaking, proposing to transfer the regulation of agricultural animals produced or modified with genetic engineering from the Food and Drug Administration to USDA. In 2021, the agencies entered into a Memorandum of Understanding (MOU) establishing a collaborative framework for regulating genetically engineered animal species in agriculture. This includes species regulated by USDA under the Federal Meat Inspection Act and the Poultry Products Inspection Act. The MOU details the creation of regulatory frameworks, pre-market evaluations, and post-market monitoring, 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 Executive Order (EO) 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 R46737, *Agricultural Biotechnology: Overview, Regulation, and Selected Policy Issues*

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

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

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

Biotechnology and Biomedical Research

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

Bioeconomy

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

On September 12, 2022, President Biden issued Executive Order 14081, "Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy," which prescribes a "whole-of-government approach to advance biotechnology and biomanufacturing towards innovative solutions." According to the White House, "global industry is on the cusp of an industrial revolution powered by biotechnology. Other countries are positioning themselves to become the world's resource for biotechnology solutions and products."

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

For Further Information

Todd Kuiken, Analyst in Science and Technology Policy

Marcy E. Gallo, Analyst in Science and Technology Policy

CRS Report R46881, *The Bioeconomy: A Primer*

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

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

National Institutes of Health (NIH) and Biomedical Research

The National Institutes of Health (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 2,500 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. For example, there has been increased attention on NIH's funding and oversight of so-called "gain-of-function" research, which can make a virus more transmissible or pathogenic. In addition, concerns have been raised around foreign interference in NIH research, particularly where NIH-funded researchers have had undisclosed foreign conflicts of interest and commitment (e.g., duplicate research funding). 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.

Other NIH issues during the 118th Congress include:

- The newly appointed NIH Director's strategy and decisions, particularly with respect to research priorities.
- 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 intellectual property.
- 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-FY2024*

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)

Through FY2022 appropriations (P.L. 117-103), Congress provided $1 billion to establish the Advanced Research Projects Agency for Health at HHS. ARPA-H advances "high-potential, high-impact biomedical and health research that cannot be readily accomplished through traditional research or commercial activity." 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 modelled 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 Director reporting directly to the HHS Secretary. ARPA-H was formally 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 $2.5 billion in multiyear

appropriations. As ARPA-H continues to develop its programs, ongoing oversight issues for Congress include:

- 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

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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 the Office of the National Coordinator for Health Information Technology (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 the U.S. Department of Health and Human Services 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 artificial intelligence (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. Notably, 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

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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 GE, genome engineering, and biotechnology. Engineering biology may find use in multiple sectors, including biomanufacturing, medicine, consumer products, agriculture, smart materials, energy generation, adaption to and mitigation of climate change, environmental conservation, pollution remediation, and others. On September 12, 2022, President Biden issued Executive Order 14081, "Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy." An accompanying White House press release stated that "global industry is on the cusp of an industrial revolution powered by biotechnology" and that "other countries are positioning themselves to become the world's resource for biotechnology solutions and products."

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

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

For Further Information

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

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

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

Regulation of Laboratory-Developed Tests (LDTs)

Regulation of LDTs, in vitro diagnostic (IVD) devices that are designed, manufactured, and used within a single laboratory, has long been debated. The Food and Drug Administration (FDA) has traditionally exercised enforcement discretion over LDTs, so most have not undergone premarket review; regardless, 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 LDTs. This guidance was never finalized, although FDA published a 2017 discussion paper presenting a modified proposed framework for LDT oversight.

The COVID-19 pandemic highlighted issues around FDA regulation of LDTs. Although FDA generally exercises enforcement discretion over LDTs, most COVID-19 LDTs were subject to premarket review (Emergency Use Authorization (EUA)) during the pandemic. In August 2020, HHS announced that FDA was prohibited from requiring premarket review for LDTs without first undergoing notice-and-comment rulemaking. After this announcement, FDA temporarily halted review of COVID-19 LDT EUA submissions; HHS rescinded the policy in November 2021.

Two bills addressing LDT regulation were introduced early in 2020: the VALID Act (H.R. 6102, S. 3404), to establish a comprehensive regulatory scheme for in vitro clinical tests, and the VITAL Act (S. 3512), to exclude LDTs from regulation by the FDA. The VALID Act was incorporated into the Senate user fee bill in 2022 (S. 4348), but was not included in the final passed legislation and was again introduced in the House during the 118th Congress (H.R. 2369).

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

For Further Information

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

CRS Report R46261, *Early Development and Regulation of Diagnostic Testing for COVID-19: Frequently Asked Questions*

DNA as Data

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

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

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

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

For Further Information

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

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

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

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

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

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

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

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

For Further Information

Todd Kuiken, Analyst in Science and Technology Policy

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

CRS Report 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*

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

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

Climate Change

S&T considerations are often part of the deliberations of climate change policy and may be grouped into five interrelated topics:

1. climate-change-related science and the ocean-climate nexus;
2. climate mitigation science and technology;
3. infrastructure and decarbonization;
4. climate change adaptation and resilience; and
5. carbon capture, utilization, and sequestration.

Legislation regarding climate change and water policy 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 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:

> It 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), that provides reports on climate science, including mitigation solutions that some might consider controversial, such as solar geoengineering.

Recently the science of climate change attribution—whether, or to what degree, human influence may have contributed to extreme climate or 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 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 wish to examine the role of the federal government in supporting federal climate and ocean science. Congress may wish to monitor federal support for climate and ocean research, whether additional support for is needed, and how it may be allocated among federal agencies.

For Further Information

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

CRS Report R47172, *Geoengineering: Ocean Iron Fertilization*

CRS Report R47551, *Solar Geoengineering and Climate Change*

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

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

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

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

Climate Mitigation Science and Technology

A large majority of federal climate-change-related expenditures are aimed at advancing technologies and practices that reduce GHG emissions from energy, agriculture, industry, and additional sectors. For example, these might include advanced fossil fuels, renewable energy, biofuels, energy efficiency, energy storage, vehicles and their fuels, nuclear energy, and electricity grid innovation, among others. Mitigation of human-related GHGs may also occur through the decarbonization of industrial processes such as the manufacture of low-carbon-intensity aluminum and steel.

Congress may consider the magnitude of federal expenditures for climate change mitigation technologies, the performance of federally supported programs, and priorities for policy tools and technologies. These may be topics for Congress to evaluate regarding their role in incentivizing or de-incentivizing mitigation technologies.

The 117th Congress passed legislation that aims to support a range of climate mitigation approaches and technologies. The 118th Congress may continue monitoring the progress and implementation of these provisions. Legislation enacted that supports mitigation technologies and objectives includes:

- P.L. 117-58, the Infrastructure Investment and Jobs Act (IIJA) provides funding for multiple technology demonstration programs, including hydrogen, energy storage, carbon removal, and advanced nuclear energy. Other provisions support infrastructure projects that are generally considered necessary to enable increased development of GHG mitigation technologies.
- P.L. 117-167, commonly known as the CHIPS and Science Act of 2022, includes funding for a low-emissions steel manufacturing research program and a regional technology and innovation hub program, among other provisions.
- P.L. 117-169, commonly known as the Inflation Reduction Act of 2022 (IRA), includes tax incentives for deployment of a range of GHG mitigation technologies, including grants and rebates for specific energy technologies, and provisions for demonstration projects under an advanced industrial facilities deployment program, among other provisions.

For Further Information

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

CRS Report 46945, *Greenhouse Gas Emission Reduction Pledges by Selected Countries: Nationally Determined Contributions and Net-Zero Legislation*

CRS Report R45706, *Advanced Nuclear Reactors: Technology Overview and Current Issues*

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

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

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

CRS Report R47294, *U.S. Aluminum Manufacturing: Industry Trends and Sustainability*

CRS Video WVB00630, *Science and Technology Q&A: Green Steel*

CRS In Focus IF12526, *Cement: Background and Low-Carbon Production*

Infrastructure and Decarbonization

Current infrastructure investment decisions may influence future GHG emissions. Congress may wish to consider the merits of funding for federal R&D activities that support infrastructure that would reduce GHG emissions. For example, the National Initiative to Advance Building Codes calls for federal building performance standards developed by some federal agencies and departments to include a net-zero emissions building portfolio by 2045. In addition, a number of the recently enacted federal climate policies would require substantial investment and support for infrastructure to achieve their objectives.

Infrastructure's influence on future emissions is particularly strong for energy supply, transportation, industry, buildings, and communities. For example, IRA (P.L. 117-169) authorized and funded a direct loan program for some electricity transmission projects that include the use of renewable energy sources. Additionally, IIJA (P.L. 117-58) includes some infrastructure provisions that might help reduce GHG emissions, such as increasing the use of public transportation and intercity passenger rail by providing more public funding.

In the 118th Congress, policymakers may consider (1) the extent to which climate change objectives are included during debates about infrastructure investments, and (2) the role of infrastructure as the Administration implements various climate-related provisions in the IIJA (P.L. 117-58) and the IRA (P.L. 117-169).

For Further Information

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CRS Report R47665, *Building Codes, Standards, and Regulations: Frequently Asked Questions*

CRS Report R47666, *Infrastructure Codes, Standards, and Regulations: Frequently Asked Questions*

CRS Report R46719, *Green Building Overview and Issues*

CRS Insight IN12193, *The Federal Flood Risk Management Standard (FFRMS)*

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

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

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

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

Climate Change Adaptation and Resilience

Climate adaptation and resilience generally refers to processes of adjustment to actual or expected climate and its effects. For example, infrastructure resilience relates both to avoiding damages and to maintaining and recovering functionality from extreme weather events that may change with a warming climate in frequency and intensity in some U.S. regions. Congress may choose to consider how the results of scientific research inform weather-related technical specifications and guidelines for infrastructure and the choice of protective measures (including the role of natural or nature-based features in infrastructure design and investment evaluations).

Congress may wish to review federal programs and funding to support adaptation or resilience to observed and projected climate change. Examples of adaptation programs which have received additional funding from the IIJA (P.L. 117-58) include three of the Federal Emergency Management Agency's (FEMA) Hazard Mitigation Assistance (HMA) programs: the Building Resilient Infrastructure and Communities (BRIC) program, the Flood Mitigation Assistance Grant Program (FMA), and the Safeguarding Tomorrow Revolving Loan Fund Program (STRLF). FEMA uses the term *mitigation* rather than adaptation, defining mitigation as "any sustained action to reduce or eliminate long-term risk to people and property from natural hazards and their effects." The IRA (P.L. 117-169) also included provisions related to contingency planning for climate-related effects on weather events that could affect the electricity grid. The IIJA (P.L. 117-

58) provided federal funding for protective features designed to reduce the risk of infrastructure damage from extreme weather events.

In addition, Congress may wish to address the federal role in supporting decision making on adaptation and resilience to climate change. This may include increasing public access to scientific research, climate and seasonal projections, impact assessments, and adaptation decision tools. Congress may also review federal efforts to incorporate projections of the effects of climate change into federal agency management of federal personnel, lands and waters, infrastructure, and operations.

For Further Information

Jonathan Haskett, Analyst in Environmental Policy

CRS Report R46989, *FEMA Hazard Mitigation: A First Step Toward Climate Adaptation*

CRS In Focus 12307, *Understanding Linked Climate and Weather Hazards and the Challenges to Federal Emergency Management*

CRS Report R47612, *Building Resilience: FEMA's Building Codes Policies and Considerations for Congress*

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

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

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

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

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

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

CRS In Focus IF11878, *Climate and Security in the Middle East and North Africa*

Carbon Capture, Utilization, and Sequestration

Carbon capture, utilization and sequestration (or storage)—known as CCUS—seeks to capture CO_2 at its source, store it underground, or utilize it for another purpose or product. (CCUS is sometimes referred to as CCS—carbon capture and storage.) The capturing step is the costliest and most energy-intensive step in the CCUS process. CCUS could reduce the amount of CO_2 emitted into the atmosphere at large stationary sources. Carbon utilization has recently gained interest as a means of converting CO_2 into potentially commercially viable products, such as chemicals, fuels, cements, and plastics. Direct air capture, a related emerging technology, removes atmospheric CO_2 directly from the atmosphere.

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

Since FY2010, Congress has provided a total of $10.5 billion (in constant 2023 dollars) in annual appropriations for the DOE research arm conducting most federal CCUS research activity.

Additionally, IIJA (P.L. 117-58) provided supplemental appropriations of $8.5 billion for CCUS for FY2022-FY2026 and $3.6 billion for direct air capture for the same time period. IRA (P.L. 117-169) increased the "Section 45Q" tax credit for underground carbon sequestration, among other provisions.

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

For Further Information

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

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

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

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

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

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

Defense Research and Development

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

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

DOD spends more than $100 billion per year on research, development, testing, and evaluation (RDT&E). In FY2022, enacted RDT&E funding was $119.3 billion. Roughly 80%-85% of this is spent on the design, development, and testing of specific military systems. Examples of such systems include large integrated combat platforms such as aircraft carriers, fighter jets, and tanks, among others. They also include much smaller systems such as blast gauge sensors worn by individual soldiers. The other 15%-20% of the RDT&E funding is spent on what is referred to as DOD's Science and Technology Program. The Program includes activities ranging from basic science to demonstrations of new technologies in the field. The goal of DOD's RDT&E spending is to provide the knowledge and technological advances necessary to maintain U.S. military superiority.

DOD's RDT&E budget contains hundreds of individual line items. Congress provides oversight of the program, making adjustments to the amount of funding requested for any number of line

items. These changes are based on considerations such as whether DOD has adequately justified the expenditure or the need to accommodate larger budgetary adjustments.

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

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

For Further Information

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

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

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

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

impact of these reforms and their effectiveness, there are several issues it may wish to examine in the 118th Congress, such as

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

For Further Information

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

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

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

Energy, 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 multi-year rulemaking for 2023-2025. The RFS is under scrutiny for various reasons, including concerns about EPA's lifecycle greenhouse gas emissions modeling and advanced biofuel pathway approval.

The 118th Congress may wish to 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*

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

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

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

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 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 does have 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. The Infrastructure Investment and Jobs Act (P.L. 117-58) and the Inflation Reduction Act (P.L. 117-169) established several programs at the Department of Energy (DOE) to support electricity transmission development and modernization. Most of these are administered through DOE's Grid Deployment Office.

For Further Information

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CRS In Focus IF12253, *Introduction to Electricity Transmission*

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 support ocean energy research.

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

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

For Further Information

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

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), the scope and scale of hydrogen for energy applications is limited to demonstration scale or early deployment activities. The Infrastructure Investment and Jobs Act (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. The Department of Energy (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. P.L. 117-169, known as the Inflation Reduction Act of 2022, 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 greenhouse gas emissions limits and wage and apprenticeship requirements are met. The Treasury Department 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 across DOE offices, permitting reform and safety. There are questions surrounding 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 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 Hydrogen and Fuel Cell Activities: FY2024*

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

CRS Video WVB00607, *The Hydrogen Economy*

Hydrogen Pipelines

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

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

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

> We will certainly need to build some new infrastructure dedicated solely to transporting and storing hydrogen. There is also potential to adapt our country's extensive natural gas delivery network in the near-term to support a blend of hydrogen and natural gas.... More work is needed to look at the safety and feasibility of these modifications.

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

The IIJA directs the Secretary of Energy to advance the safe and efficient delivery of hydrogen or hydrogen-carrier fuels in pipelines, including by retrofitting existing natural gas pipelines (§40313). Other legislative proposals, such as H.R. 6494, H.R. 6510, and S. 649 in the 118th Congress, would mandate studies to examine technical challenges with repurposing existing natural gas infrastructure to carry pure hydrogen or hydrogen blends; to synthesize the results from research, development, and demonstration projects on materials and metallurgy for transporting hydrogen and hydrogen blends; and to determine outstanding research questions regarding the transport of hydrogen and hydrogen blends.

Executive agencies, such as the Department of Transportation's Pipeline and Hazardous Materials Safety Administration, currently 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

Paul W. Parfomak, Specialist in Energy and Infrastructure Policy

CRS Report R44201, *DOT's Federal Pipeline Safety Program: Background and Issues for Congress*

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

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

Fusion Energy

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

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

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

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

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

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

Congress has taken several legislative actions regarding fusion energy in recent years, such as defining the term *advanced nuclear reactor* to include fusion reactors, which made fusion R&D

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

For Further Information

Daniel Morgan, Specialist in Science and Technology Policy

CRS In Focus IF12411, *Fusion Energy*

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 research and development, analysis and forecast, education and workforce development, and other activities to ensure critical minerals and materials supply to meet demand. The Infrastructure Investment and Jobs Act (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 P.L. 117-167 (commonly known as the CHIPS and Science Act) and P.L. P.L. 117-169 (commonly known as the Inflation Reduction Act of 2022) 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 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.

The U.S. Department of Energy (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 agency that focus on research and development, 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 first session of 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 Policy

Emma E. Kaboli, Analyst in Energy and Minerals Policy

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

CRS In Focus IF12358, The U.S. Geological Survey (USGS): Background and FY2024 Appropriations

CRS Report R47124, *2022 Invocation of the Defense Production Act for Large-Capacity Batteries: In Brief*

CRS In Focus IF11284, *U.S.-China Trade Relations*

CRS In Focus IF12517, *U.S.-Japan Critical Minerals Agreement*

CRS Insight IN12145, *Critical Minerals: A U.S.-EU Free Trade Agreement?*

Seabed Mining

The transition to low emissions 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.

Private industry and governments have been exploring areas of the ocean for the purposes of seabed mining. Although not directly related to seabed mining activities, the United States National Ocean Mapping, Exploration, and Characterization (NOMEC) Strategy aims to map and better understand the terrain beneath certain ocean and coastal areas by 2030 and 2040, respectively. As of January 2023, 50% of U.S. ocean and coastal areas are mapped. These U.S. ocean mapping efforts may support the exploration and characterization of the seafloor for seabed minerals.

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. In 1980, Congress directed NOAA to assess the effects on the deep-sea environment from seabed mineral exploration and commercial recovery activities. For more than two decades, U.S. agencies have studied the recovery of deep-sea benthic organisms (i.e., those living on or in the seafloor sediment) from sediment disturbance as a means of assessing the potential impacts of seabed mining activities. These studies focused primarily on the potential ecosystem impacts of collecting and removing polymetallic nodules from the seafloor.

The 118th Congress may continue to consider whether additional authorities or funding may be useful in 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 in U.S. waters, or by U.S. companies in international waters, 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

Caitlin Keating-Bitonti, Analyst in Natural Resources Policy

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

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

Earth Sciences

Earth-science related issues that may come before the 118th Congress include reauthorization of the National Earthquake Hazards Reduction Program; changes to the National Oceanic and Atmospheric Administration's research and development activities; and improvements to weather observations, modeling, and forecasting.

The National Earthquake Hazards Risk Reduction Program

According to the 2023 USGS National Seismic Hazard Model (NSHM), nearly 75% of the area of the conterminous United States, Alaska, and Hawaii could experience damaging earthquake shaking. According to the USGS, the congressionally requested NSHM update utilized the latest techniques and technologies and incorporated more data to identify nearly 500 additional faults in the United States. The USGS considers the NSHM an essential tool to help engineers and others mitigate the impact of earthquake hazards on people and property.

The NSHM will benefit the USGS-led ShakeAlert, an earthquake early warning (EEW) system operating in California, Oregon, and Washington by providing more information about faults and potential shaking intensity. People and automated systems receive an EEW before potential strong ground shaking reaches their locations after detecting an earthquake. Upon receiving the alerts, people can protect themselves and automated systems can protect property from the impending shaking. EEW is among the most challenging types of emergency communications, in part because earthquakes cannot be predicted and occur suddenly. In addition, mass notification to high-risk areas must occur within seconds of earthquake detection to be effective.

In 2021, EEWs sent via the Federal Emergency Management Agency (FEMA) communication pathways often did not arrive before intense shaking occurred. EEWs sent in 2021 via cell phone applications over Wi-Fi or cellular networks were typically faster, and most alerts arrived before intense shaking occurred. Congress may be interested in how to improve emergency communications, especially for mass notifications, using FEMA communication pathways or the First Responder Network so that alerts arrive before the shaking occurs.

The 118th Congress may be interested in the strengths, weaknesses, opportunities, and threats to the continued development of NSHM, ShakeAlert, and related earthquake hazards risk reduction products and services. The NSHM and ShakeAlert products and services under the National Earthquake Hazards Reduction Program (NEHRP, established in 1977). Congress may consider the effectiveness of NEHRP products and services and whether to reauthorize appropriations beyond FY2023 for the four coordinating federal agencies (authorization of appropriations expires on DATE), the USGS, NIST, FEMA, and NSF. Congress may consider other amendments to the National Earthquake Hazards Reduction Program Reauthorization Act of 2018 (P.L. 115-307). On January 17, 2024, a bill to reauthorize NEHRP and for other purposes (S. 3606) was introduced for congressional consideration. In particular, the measure would authorize $10.6 million for FEMA, $5.9 million for NIST, $58 million for NSF, and $100.9 million for USGS per year from FY 2024 to 2028.

For Further Information

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

CRS Report R43141, *The National Earthquake Hazards Reduction Program (NEHRP): Overview and Issues for Congress*

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

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

CRS Video WVB00613, *Building Codes and Resilience to Natural Hazards*

CRS Report R47665, *Building Codes, Standards, and Regulations: Frequently Asked Questions*

CRS Video WVB00596, *Geologic Hazards: Earthquakes, Volcanoes, Landslides, and Tsunamis*

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 research and development; 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., Department of the Interior). 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.

Introduced bills could change the agency's research and development activities. For instance, in the 118th Congress, one bill 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 Department of Commerce (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

Eva Lipiec, Specialist in Natural Resources Policy

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, there were 28 such events with losses exceeding $1 billion each in 2023). In the United States, weather information is developed by the

weather enterprise, 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 Forecast Innovation Act in 2017. 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 others.

There is legislation introduced during the 118th Congress regarding weather research, focused on several of the same topics as in the Weather Research and Forecast Innovation Act, but also aviation, atmospheric rivers, hazard communication, and weather for agriculture and water management, 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 activities.

For Further Information

Eva Lipiec, Specialist in Natural Resources Policy

CRS In Focus IF12307, *Understanding Linked Climate and Weather Hazards and the Challenges to Federal Emergency Management*

CRS Insight IN11826, *Tornadoes: Background and Forecasting*

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

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

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 artificial intelligence 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, there are a variety of safeguards built into the traditional financial system that seek to foster trust and inspire confidence including, among others, regulation and government backstops. Cryptocurrency, on the other hand, relies on a series of separate but concurrent incentives for network participants, such as 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 emerged as a payment tool, but its attractiveness as a speculative investment soon eclipsed that use. The two most prevalent cryptocurrencies are Bitcoin and Ethereum, which combined represent more than 60% of the entire crypto market. According to industry websites that track data, there are thousands of cryptocurrencies with a total market capitalization of approximately $1.5 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.

For Further Information

Paul Tierno, Analyst in Financial Economics

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*

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

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

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

Investment Activities

In recent years, financial innovation in capital markets has fostered a new asset class—called *digital assets*, which include cryptocurrencies—and introduced new forms of fundraising, trading, and other investment activities. The Infrastructure Investment and Jobs Act (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 is soliciting public input on how broker-dealers and investment advisers, including robo advisers, mitigate conflict of interest concerns. Specifically, the SEC is concerned about how the DEPs' profit optimization designs may encourage investors to invest in ways that would prioritize the profitability of the firms (as opposed to their retail investor clients). 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.

For Further Information

Eva Su, Specialist in Financial Economics

CRS Report R46208, *Digital Assets and SEC Regulation*

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

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

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

New technologies could pose certain consumer protection and data security risks, raising questions over what consumer information is appropriate to collect and use. Policymakers designed many of the financial laws and regulations before the most recent technological changes. This raises questions concerning whether the existing legal and regulatory frameworks, when applied to fintech, effectively mitigate risks without unduly hindering the development of beneficial technologies. In addition, fintech products often access sensitive consumer financial

data, which may introduce privacy and cybersecurity concerns. Fintech innovations may also have impacts on market competition, such as potentially creating systemic risks. Moreover, consumer loan underwriting models using alternative data and artificial intelligence could introduce fair lending risks due to biases in data or model development. The Consumer Financial Protection Bureau (CFPB) is the primary consumer protection regulator for consumer financial products and services.

For Further Information

Cheryl Cooper, Analyst in Financial Economics

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

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

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

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

CRS Insight IN11745, *Open Banking, Data Sharing, and the CFPB's 1033 Rulemaking*

CRS Report R44614, *Marketplace Lending: Fintech in Consumer and Small-Business Lending*,

CRS Insight IN11784, *Rapidly Growing "Buy Now, Pay Later" (BNPL) Financing: Market Developments and Policy Issues*

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 artificial intelligence and machine learning (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 execute 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: 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) Executive Order 14110 on the *Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence*, and (2) the establishment of an artificial intelligence 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/M. 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

Cheryl R. Cooper, Analyst in Financial Economics

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 artificial intelligence, cybersecurity, big tech and online platforms, social media, consumer data privacy, children on the internet, immersive technologies, blockchain technologies, law enforcement use of information technologies and social media, and biometric technologies.

Artificial Intelligence

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

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

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

- the impact of AI and AI-driven automation on the workforce, including potential job losses and the need for worker retraining;
- the challenges of educating students in AI, from teaching foundational concepts at the K-12 level to supporting doctoral-level training to meet increasing demand for AI expertise;
- the balance of federal and private sector funding for AI;

- whether and how to increase access to public datasets to train AI systems for use in the public and private sectors;
- the development of standards and testing protocols and algorithmic auditing capabilities for AI systems;
- the need for and effectiveness of federal and international coordination efforts in AI, as well as concerns over international competition in AI R&D and deployment; and
- the incorporation of ethics, privacy, security, transparency, and accountability considerations in AI systems, including such applications as facial recognition technologies.

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

For Further Information

Laurie A. Harris, Analyst in Science and Technology Policy

Kristen Busch, Analyst in Science and Technology Policy

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

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

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

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

CRS 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 intellectual property law should apply to artificial intelligence.

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, authors and other plaintiffs filed several 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.

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.

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.

For Further Information

Christopher T. Zirpoli, Legislative Attorney

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 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*

Cybersecurity

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

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

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

- explored policy options to ensure the *confidentiality* of internet-based communications (i.e., data security and privacy) by enacting national privacy legislation;
- investigated ways that nation-state actors compromised the *integrity* of IT vendors' products in order to compromise their customers; and

- considered cybersecurity incident reporting requirements as a way to better understand and mitigate ransomware attacks that attack the *availability* of data and systems.

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

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

For Further Information

Chris Jaikaran, Specialist in Cybersecurity Policy

CRS 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*

CRS In Focus IF10559, *Cybersecurity: A Primer*

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

CRS Report R47011, *Cybersecurity: Deterrence Policy*

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").

Some Members of Congress have introduced multiple bills 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. The INFORM Consumers Act (created requirements for online marketplaces) and the Merger Filing Fee Modernization Act (adjusted fees paid by merging firms) were enacted in the 117th Congress (P.L. 117-328).

For Further Information

Clare Cho, Analyst in Industrial Organization and Business

Kristen Busch, Analyst in Science and Technology Policy

Jay Sykes, Legislative Attorney

Chris Linebaugh, Legislative Attorney

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*, by Jay B. Sykes

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

CRS In Focus IF12246, *What Hides in the Shadows: Deceptive Design of Dark Patterns*, by Kristen E. Busch

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. Significantly, the Supreme Court is set to hear challenges to Texas and Florida laws that limit social media platforms' ability to moderate content in the Court's 2023–2024 term.

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).

Some Members of Congress have introduced multiple bills 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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Valerie Brannon, Legislative Attorney

Chris Linebaugh, Legislative Attorney

Stephen P. Mulligan, Legislative Attorney

CRS Report R47753, *Liability for Algorithmic Recommendations*

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

CRS Video WVB00562, *Social Media Content Moderation*

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

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

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

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

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

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

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

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

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

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

Consumer Data Privacy

Some companies are able to 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.

Some Members of Congress have introduced bills that would create a comprehensive data privacy law, and several states have enacted comprehensive data privacy laws. Some of these federal bills and all of the 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

Kristen Busch, Analyst in Science and Technology Policy

Chris Linebaugh, Legislative Attorney

Clare Cho, Analyst in Industrial Organization and Business

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

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

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

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

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

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

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 by creating additional requirements for operators of websites, online platforms, and online services. Some of these bills would require or likely incentivize operators to use different age verification methods by, for example, creating requirements specific to minors. Some of these bills might also raise constitutional concerns.

For Further Information

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Peter Benson, Legislative Attorney

Kristen Busch, Analyst in Science and Technology Policy

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*

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

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 quantum research and development (R&D) to ensure 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 quantum R&D. 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, machine learning, and scientific and engineering research. However, there are practical implementation challenges leading to uncertainty about whether and when quantum computing could be broadly deployed and applied. The authorization of funding for several federal R&D activities under the NQI Act expired in September 2023.

The 118th Congress may opt to consider 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.

For Further Information

Ling Zhu, Analyst in Telecommunications Policy

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

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

Metaverse and Immersive Technologies

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

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

activities and programs in those focus areas to support research and technology transfer and increase capabilities to enhance the competitive advantage and leadership of the United States in the global economy.

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

For Further Information

Ling Zhu, Analyst in Telecommunications Policy

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

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

Blockchain and Distributed Ledger Technologies

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

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

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

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

For Further Information

Kristen Busch, Analyst in Science and Technology Policy

CRS Report R47064, *Blockchain: Novel Provenance Applications*

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

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

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

Evolving Technology and the Debate over "Lawful Access"

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

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

The debate over lawful access to information originally focused on data in motion, or law enforcement's ability to intercept real-time communications. More recent technology advances have affected law enforcement's capacity to access not only real-time communications but stored content, or data at rest. Some officials have urged the technology community to develop a means to assist law enforcement in lawfully accessing certain data. At the same time, law enforcement entities have taken their own steps to bolster their technology capabilities. The 118th Congress may wish to consider possible legislation that would address law enforcement's concerns and customer privacy issues involving access to communications and data.

For Further Information

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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 (CBP) 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 the National Institute of Standards and Technology), 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 Video WVB00328, *Law Enforcement Use of Facial Recognition Technology*

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 (POEs). 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 facial recognition technology (FRT) to be the best fit operationally. CBP, 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.

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 POEs, 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*

Space and Aviation

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

NASA

Spaceflight has attracted strong congressional interest since the establishment of NASA in 1958. Issues facing the 118th Congress include the goals and strategy of NASA's human spaceflight program, the relationship between NASA and the commercial space sector, and implementation of the NASA Authorization Act of 2022 (Division B, Title VII, of P.L. 117-167, the CHIPS and Science Act). Congress may address these and other topics through oversight hearings, NASA reauthorization legislation, and the annual appropriations process.

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

Second, for human exploration beyond Earth orbit, NASA is developing a crew capsule called Orion and a heavy-lift rocket called the Space Launch System (SLS). These are key elements of the Artemis program for human exploration of the moon and eventually Mars. The first test flight of Orion and the SLS occurred in late 2022, and the first test flight with a crew on board is expected in 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

Daniel Morgan, Specialist in Science and Technology Policy

Rachel Lindbergh, Analyst in Science and Technology Policy

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

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

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

Commercial Space

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

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

Multiple federal agencies regulate the commercial space industry, based on statutory authorities that were enacted separately and have evolved over time. The Federal Aviation Administration (FAA) licenses commercial launch and reentry vehicles (i.e., rockets and spaceplanes) as well as commercial spaceports. NOAA licenses commercial Earth remote sensing satellites. The FCC licenses commercial satellite communications. The Departments of Commerce and State license exports of space technology. In the past few years, several of these agencies have made significant changes in their regulations affecting commercial space, and additional regulatory action is underway or expected on topics such as orbital debris and in-space servicing, assembly, and manufacturing. In addition, a statutory moratorium on FAA regulations to protect the health and safety of humans aboard commercial spacecraft is scheduled to expire in 2024. The 118th Congress may wish to 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 Commerce Department, the creation of a new Space Bureau at the FCC, and the shift from DOD to civil responsibility for space situational awareness (e.g., issuing alerts when orbiting satellites may be about to collide) are also likely to attract congressional attention. 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 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

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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 is likely to focus 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 may also wish to provide 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. Landsat 9 was essentially a rebuild of Landsat 8. Together, they acquire around 1,500 images of Earth per day, with a repeat visit every 8 days, on average. In December 2022, NASA and the USGS presented initial details about Landsat Next, the next proposed launch in the Landsat series. Landsat Next is planned to be a constellation of three observatories, to be sent into orbit on the same launch vehicle in late 2030. The constellation is to collectively improve the temporal, spatial, and spectral resolutions by two to three times compared to Landsat 8 and 9, while maintaining radiometric resolution. Congress may debate the sufficient amount and timing of funding for both agencies to support the Landsat series. Congress also may consider conducting oversight of mission progress to ensure Landsat Next meets user needs and requirements and the desired launch date.

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CRS In Focus IF12156, *National Oceanic and Atmospheric Administration (NOAA) FY2023 Budget Request and Appropriations*

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Advanced Air Mobility

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

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

A number of companies are engaged in R&D of marketable passenger-carrying AAM vehicles capable of carrying from two to about eight people. The end goal of these projects is to develop uncrewed and largely autonomous AAM vehicles and supporting infrastructure, although initially

flights will be piloted. Future AAM concepts for passenger-carrying operations are envisioned to function in a manner similar to concepts being developed for self-driving vehicles deployed in taxi fleets and ride-share systems: A passenger would simply input an origin and a destination into an application interface, and AI built into a connected reservation system and integrated with computers onboard the vehicle would handle scheduling, logistics, navigation, and flight guidance.

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

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

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

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.

There is currently no specific legislative framework that 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, there are federal laws and policies broadly governing law enforcement investigations and intelligence gathering. Additionally, there are policies directing the use of drones by federal agencies, including law enforcement, and pertinent guidance resources such as the 2015 presidential memorandum, *Promoting Economic Competitiveness While Safeguarding Privacy, Civil Rights, and Civil Liberties in Domestic Use of Unmanned Aircraft Systems*, that 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 greatly enhance public safety and national security—including using them as first responders. Policymakers may debate the tradeoffs 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 means such as the provision or withholding of federal grant funding.

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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 NTIA spectrum programs.

5G Telecommunications Technologies

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

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

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

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

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

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

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

Broadband Deployment and the Digital Divide

Broadband internet service is delivered through a variety of technologies and allows users to send and receive data at volumes and speeds that support a wide range of applications. Broadband technologies are being deployed throughout the United States. While broadband deployment continues to progress, there are communities that lack broadband services entirely or lack affordable broadband service options. These communities are typically in rural and tribal areas but may also be in urban areas. The gap between those who have access to broadband internet services and those who do not is termed the "digital divide." The 117th Congress passed two bills—the American Rescue Plan Act of 2021 (P.L. 117-2) and Infrastructure Investment and Jobs Act (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 the IIJA. This program provides $42.45 billion to states and territories for broadband deployment, connectivity, mapping, and adoption projects. The BEAD program is among a total of $48 billion broadband grants administered by National Telecommunications and Information Administration (NTIA) under the IIJA. The calendar year of 2024 will be a critical implementation window for many of these grants, as NTIA will review applications and distribute significant portions of the funding.

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

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

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

Undersea Telecommunication Cables

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

interest of cables landing in the United States, denied approval of a license application for a cable connecting the United States to China, restricted the use of untrusted equipment in undersea cables, established an outage reporting system for cables, and expanded its cable repair fleet.

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

For Further Information

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CRS Report R47237, *Undersea Telecommunication Cables: Technology Overview and 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. It grants licenses to nonfederal entities to use specific frequencies within those bands and sets terms and conditions on use to serve the public interest, avoid interference between users, and promote the most efficient use of spectrum. NTIA, an agency of the Department of Commerce, manages federal use of radio spectrum. Together, the two agencies manage use of the nation's spectrum.

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

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

mitigation methods, and upgrades to federal receivers and systems to avoid interference from 5G systems in neighboring bands.

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

CRS In Focus IF12046, *National Spectrum Policy: Interference Issues in the 5G Context*

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

NTIA Federal Spectrum Issues

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

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

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

repurposing federal spectrum for commercial services and their coordination in addressing disputes of frequency allocation and interference; and (3) oversight and assessment of federal resources and efforts invested in spectrum-related R&D, particularly in dynamic spectrum sharing and advanced wireless communications technologies.

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CRS Report R47075, *The National Telecommunications and Information Administration (NTIA): Current Roles and Programs*

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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 the following:

- Water monitoring infrastructure and science programs (e.g., programs for drought, groundwater and streamflow, evapotranspiration, and water quality);
- Next-generation water observing systems, modeling frameworks and machine learning for informing predictions;
- Water-related weather, climate, and Earth system science, including hurricane, rainfall, and associated in situ and remote sensing monitoring and data collection (see, for example, “Civil Earth-Observing Satellites”);
- Monitoring and modeling ocean and coastal changes (e.g., warming, acidification, loss of oxygen, relative sea-level rise rates);
- Monitoring and management of aquatic invasive species and harmful algal blooms, 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 R47021, *Federal Involvement in Ocean-Based Research and Development*

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

CRS In Focus IF10719, *Forecasting Tropical Cyclones: NOAA's Role*

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*

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

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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.

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

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