The Development of Federal Science Policy, 1787-1957

Americans have always sought to explore new frontiers. Vannevar Bush, one of the architects of federal science policy, stated in 1945 that the expansion and prosperity of the United States has been through "the product of three factors – the free play of initiative of a vigorous people under democracy, the heritage of great natural wealth, and the advance of science and its applications." In his report, *Science—The Endless Frontier*, Bush affirmed the fact that without scientific progress, "no amount of achievement in other directions can ensure our health, prosperity, and security as a nation in the modern world."

Federal government involvement in science, technology, and the advancement of knowledge began with the Continental Congress, in the Northwest Ordinances of 1785 and 1787. Congress ordained that the Northwest Territory be explored and surveyed into townships, with one section reserved to endow public schools. Since the 18th century, the relationship between science, technology, research, and development has been a close one, as Americans created a decentralized system for the advancement of scientific and technological innovation, combining federal government backing with university and privately funded research. The House Committee on Science and Technology is heir to a long history of federal support for exploration, developing technical standards, and energy and environmental research.

In Article I, section 8 of the Constitution, the Founding Fathers granted Congress the power "to promote the Progress of Science and the useful Arts," initially through granting limited times for "Authors and Inventors the exclusive Right to their respective Writings and discoveries," along with the power to "fix the Standard of Weights and Measures." Congress also was given power to "regulate Commerce," and to make all laws "necessary and proper for carrying into Execution the foregoing Powers."

Congress quickly assumed its role in encouraging science and technology, passing the first patent and copyright laws in the spring of 1790. Two years later, the Second Congress authorized the first U.S. Mint to set standards of weight for U.S. coinage. In addition to such regulatory legislation, Congress adopted most of Treasury Secretary Alexander Hamilton's recommendations in his *Report on Manufactures,* December 1791, which proposed that it should be U.S. policy to encourage manufacturing and domestic industries through a system of tariff protection and subsidy to industry. Although most federal policy was designed to protect private innovation, Congress did

subsidize two military arsenals, at Springfield, Massachusetts, and Harpers Ferry, Virginia. It was under this federal sponsorship that the first practical system of interchangeable parts for manufacturing was developed.

The "commerce clause" was the rationale for the most significant scientific study of the early national period, the Lewis and Clark Expedition. After gaining a $2,500 appropriation from Congress for exploration, President Thomas Jefferson instructed his secretary, Meriwether Lewis, to not only find a passage to the Pacific, but also to make systematic scientific observations of regional geography, soils, animals, mineral production, and record as much as possible about the Indian tribes encountered. With these instructions, the Corps of Discovery was practical and also scientific, revealing the wide range of federal interest during the period.

Federal science policy also encouraged the relation between commerce, science, technological development, and exploration. On March 30-31, 1824, Speaker of the House Henry Clay proposed the adoption of a "genuine American system" that would expand markets and lessen dependence upon foreign trade, providing protective tariffs to safeguard domestic manufacturing and a government sponsored system of internal improvements. In the General Survey Act of 1824, Congress authorized "necessary surveys, plans, and estimates" of roads and canals of national importance for commercial, military, or postal uses.

Although most federal legislation created the broad conditions conducive to technological innovation, Congress occasionally sponsored large, capital-intensive projects. On March 3, 1843, Congress appropriated $30,000 "for testing the capacity and usefulness of the system of electro-magnetic telegraphs invented by Samuel F. B. Morse," and for constructing a telegraph line for government use. By May 1844, Morse had completed his telegraph line between the U.S. Capitol and the Baltimore and Ohio Railroad's Mt. Clare Station near Baltimore, Maryland. On May 24, he made his first public demonstration from the Capitol by sending the message, "What Hath God Wrought."

In 1829, British scientist James Smithson died and left his entire estate to the United States, to endow "an establishment for the increase and diffusion of knowledge among men." Congress accepted this unprecedented gift in 1836, and, after much debate, created the Smithsonian Institution in 1846 as a trust administered by a board of regents and a secretary. This private gift to the whole nation provided one model for the support of scientific research and now has grown to become the world's largest museum complex. Attempts to establish a

national university, however, failed. Americans held a deep suspicion of any single national institution of higher learning and preferred a decentralized, entrepreneurial model for education and research.

President Abraham Lincoln and the 37th Congress (1861-63) enacted two critical pieces of legislation during the Civil War that helped develop the institutions for scientific and technological research. Lincoln signed into law the Land-Grant College Act on July 2, 1862, which Congressman Justin Morrill of Vermont introduced that granted states public lands to endow a college dedicated to the teaching of "agriculture and the mechanic arts." This federal effort to support state institutions developed into a network of land-grant universities that emphasized practical, scientific research. On March 3, 1863, Congress passed a second piece of legislation which chartered the National Academy of Sciences. Established as a self-perpetuating organization, the academy comprised 50 of the nation's top scientists named "to investigate, examine, experiment, and report upon any subject of science," for the federal government. While the scholars served without compensation, Congress authorized appropriations for expenses, which was an early form of contract research. Anticipating the nation's involvement in World War I, President Woodrow Wilson requested that the Academy establish the National Research Council in 1916 to recruit scientists and technicians, which continued to expand after the war under executive order. Since its chartering, the National Academy of Sciences has expanded several times through peer selection of individuals distinguished in their fields as well as through the establishment of the National Academy of Engineering in 1965 and the Institute of Medicine in 1970.

In the late 19th century, Congress continued its sponsorship of scientific exploration. On March 3, 1879, it authorized the creation of the U.S. Geological Survey as a bureau in the Interior Department with responsibility to examine "the geological structure, mineral resources and products of the national domain." In the Hatch Experiment Station Act of 1887, Congress supported the development of scientific research in agriculture. Administered by land-grant colleges, these research stations promoted "scientific investigation and experiment respecting the principles and applications of agricultural science." Although under the jurisdiction of congressional agricultural committees, the Hatch Station Act furthered the principle of direct federal support of scientific research, a precedent that would later be extended to other scientific fields.

The development of standard time zones provided an excellent example of the essential technical initiatives that benefited both private enterprise and public institutions. The British Royal Observatory had

first established Greenwich Mean Time in 1675, but this was only a voluntary standard. Americans initially relied on local sun time to indicate the time of the day, but with the expansion of railroads and the quick movement of people and freight, a national standard was necessary. Meeting privately in Chicago in the fall of 1883, American and Canadian railroad executives standardized four time zones across North America. Congress formally adopted this as a national standard during World War I with the Daily Standard Time Act of March 19, 1918. While daylight saving time proved controversial at the time and was repealed in 1919, standard time zones have remained the law.

Building upon the complexity of rapid industrialization and the expansion of engineering demands, Congress created the National Bureau of Standards (NBS) on March 3, 1901. The federal government invested in it the responsibility for comparing the "standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted by the Government." NBS established the first federal government physical science research laboratory with authority to develop precision instruments to set standards on length, mass, temperature, time, electrical power, as well as develop safety standards for commerce and industry. Within a few years, NBS acquired experimental factories to test manufacturing processes on product quality, which became especially useful during World War I, and also performed the first government studies of aerodynamics.

Although the federal government provided standardization and some encouragement to technological innovation, most scientific research was conducted by private industries and in research universities. In the late 19th century, the dynamic element in higher education shifted from liberal arts colleges to research universities dedicated to the advancement of knowledge. Johns Hopkins University took a leadership role in this approach. Other institutions, such as the University of Chicago, Cornell, Harvard, Columbia, and University of Michigan, soon followed and began to emphasize basic research in the sciences. New philanthropic foundations, such as those created by Andrew Carnegie and John D. Rockefeller, funded much of the growth in basic research in the theoretical sciences, medicine, and the social sciences.

The rise and development of research universities and large philanthropic foundations created the research infrastructure necessary for scientific advances, producing not only graduate training programs, but also incubating basic research. By the early 20th century, a tacit division of labor emerged where basic research belonged in private research universities while the federal government sponsored applied

research, with technical and land grant institutions such as Massachusetts Institute of Technology and University of Illinois occupying a middle ground. The new universities emphasized basic research and graduate instruction for those seeking advanced degrees and those who would work for government agencies. These three institutions, government bureaus, private foundations, and research universities, created a dynamic that strengthened each component and encouraged new avenues of research. The funding of basic scientific investigation in universities by private foundations insulated such research from democratic pressures, allowing the federal government to focus generally on the application and dissemination of knowledge.

The impact of World War I on research and development increased the coordination among universities, government bureaus, and foundations. Wartime necessity accelerated the pace of adaptation of laboratory results into production, not only increasing the scale, but also enabling coordination of scientific effort across disciplinary lines. The war effort also enhanced the research capacities of private industry, such as Bell Labs, which made significant advancements in applied industrial research.

The conclusion of World War I and America's growing apprehension of the realities of the militarization of science, such as the development of poison gas, led to the rapid dismantling of federal government control of scientific research. The military virtually abandoned research and focused almost exclusively on procurement of standard types of weapons and material. During the 1920s, Secretary of Commerce Herbert Hoover, who had made his fortune as a mining engineer, created a voluntary system to encourage "pure and applied scientific research as the foundation of genuine labor-saving devices, better processes, and sounder methods." Utilizing the expertise of NBS, Hoover encouraged cooperative scientific enterprises and trade associations to increase industrial research. Hoover also tried to shift business and especially government agencies to fund basic research, attempting to reverse the trend toward applications. However, with the onset of the Great Depression, most of the support for basic research was left to private universities and philanthropic foundations, as governmental resources were focused on dealing with the immediate economic crisis.

Scientific research was significantly disrupted during the early years of the 1930s, as government, industry and universities dramatically cut back research funding. By 1935, however, the immediate emergency had passed, and the Roosevelt administration was able to concentrate more on long term solutions. The Works Project Administration, initially designed for emergency relief, began

to fund technicians, scientists, and engineers to assist in state university research projects under faculty supervision. President Roosevelt called upon the National Academy of Sciences to help coordinate federal research policy, which led to the creation of a National Resources Board and their support of both the physical and social sciences. In 1937, the board published *Research–A National Resource*, the first comprehensive study of the federal research establishment, which looked not only at federal bureaus and the military, but also placed federal scientific programs in the context of the entire research community, seeing scientific research as a "national resource."

As the world situation became significantly more threatening in the late 1930s, the American scientific community welcomed a large number of refugee scientists from Europe. These refugees, many funded by private foundations, entered the American university system with the latest European scientific research methodology. In August 1939, at the urging of Leo Szilard, Albert Einstein wrote to President Roosevelt informing him of German research on nuclear fission and uranium and urged the president to begin a federal program to fund experiments in atomic energy. Scientific mobilization continued, and on June 28, 1941, President Roosevelt created by executive order the Office of Scientific Research and Development (OSRD), naming MIT president Vannevar Bush as director. OSRD was to "serve as a center for mobilization of the scientific personnel and resources of the Nation" and to develop and apply "the results of scientific research to defense purposes." OSRD supervised a massive increase in government research funding, with total expenditures growing from approximately $100 million in 1940, to $1.6 billion in 1945. The most important program was the Manhattan Project and the development of the atomic bomb, but numerous other critical research activities led to the creation of additional weapons that helped defeat the Axis Powers.

World War II transformed the relationship between the federal government and the scientific community. The war convinced most individuals of the vast powers of science and technology, and the American people continued to support and willingly financed federal programs. However, military control, secrecy, and security clashed with the scientific principle of the free exchange of ideas. OSRD was a temporary wartime measure, and its continued existence ran counter to civilian scientific research efforts. President Roosevelt asked Vannevar Bush in November 1944 to address this issue. Bush presented his report, *Science—The Endless Frontier*, on July 5, 1945, calling for the creation of a centralized National Research Foundation, which would award grants, contracts, and fellowships for training and basic research in the natural and medical sciences, along with military research.

Due in part to the enormous expanse and centralization of the organization Bush proposed, the creation of the National Science Foundation (NSF) took five years of political compromises. The military, unlike in the aftermath of World War I, realized the utility of research and set up its own infrastructure, such as the Office of Naval Research, authorized in 1946, and the privately contracted Rand Corporation. Also in 1946, Congress reestablished the principle of civilian control, transferring all aspects of atomic energy research from the War Department to the new Atomic Energy Commission (AEC). The president appointed AEC commissioners with oversight provided by the congressional Joint Committee on Atomic Energy, comprised of nine senators and nine representatives. In an effort to retain the scientific infrastructure created during the war, Congress also authorized the establishment of numerous laboratories, such as Brookhaven and Argonne National Laboratories, which operated in cooperation with universities under federal contracts.

Although Bush's vision had included medical research, the separate and competing tradition for federal funding for medical research originated in the late 1880s as part of the Public Health Service. In 1902 Congress established the Hygienic Laboratory as a medical research center. It expanded dramatically during World War I, and in 1930 Congress changed its name to the National Institute of Health (NIH). During World War II, NIH concentrated on war-related medical issues through its own labs and expanded its efforts after the war by providing grants for university based researchers. Congress authorized numerous other institutes dealing with specific diseases and consolidated them into the National Institutes of Health in 1948. NIH has expanded in the last 60 years to include approximately 30 separate institutes and centers.

On May 10, 1950, five years after it was originally proposed, President Truman signed the National Science Foundation Act. The act was to encourage "a national policy for the promotion of basic research and education in the sciences . . . [and] to initiate and support basic scientific research in the mathematical, physical, medical, biological, engineering, and other sciences" through contracts and grants. NSF was also required to support research and development activities with the Department of Defense (DOD), maintain a register of scientific and technical personnel, and coordinate private and public research projects. NSF was granted only limited funding in its early years, but it provided the support structure for later growth in federal funding for basic scientific research.

By the mid 1950s, federal support for scientific and technological research had been institutionalized in a wide range of government

agencies, such as NSF, NIH, DOD, and AEC. In the decade after 1957, the total federal research budget would almost quadruple, much of it going to the newly created National Aeronautics and Space Administration (NASA). While most federal research dollars were still focused on applied research for the military during the Cold War, by 1960 the decentralized system of public and private institutions created over the previous century provided the foundation for the United States to become the world's leader in science and technology. As Thomas Jefferson stated, "Liberty . . . is the great parent of science and of virtue; and . . . a nation will be great in both always in proportion as it is free."