PROJECT ON SCIENCE, INDUSTRY, AND THE STATE

Recovering Science Policy

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Executive Summary

The aftermath of a global public health crisis, combined with the rise of populism at home and growing economic and security threats abroad, has persuaded a wide swath of Americans that a more interventionist state is needed to shore up, promote, or protect particular sectors of the economy. This has led commentators to declare the "return of industrial policy." These changes in the politics of industrial policy have been accompanied by distinctive and underappreciated changes in the politics of the related area of science policy. In effect, science policy—the sets of questions concerning how and to what degree the government should fund, conduct, or direct scientific research—has been eclipsed by, or, perhaps more accurately put, absorbed into, industrial policy.

This is illustrated most clearly by one of the most significant pieces of industrial policy in recent years, the CHIPS and Science Act. Passed by Congress and signed into law by President Joe Biden in 2022, the centerpiece of this law—the CHIPS part—is an effort to "re-shore" advanced manufacturing of semiconductors. Yet fused to this effort is another—the Science part—derived from a distinct legislative proposal known as the Endless Frontier Act, which sought to transform the National Science Foundation (NSF) into a massive technology directorate intended to boost American competitiveness in prespecified areas of development.

Implicit in this policy package is an instrumentalist conception of science. According to this idea, science is the raw material for technological innovation—an "input" in a process of production that begins with knowledge discovery, leads to invention, and culminates in innovation and commercialization. The state's role, accordingly, is to intervene in the "pipeline" of innovation—in the production of knowledge (science policy) or the production of the goods and services the knowledge enables (industrial policy).

The CHIPS and Science Act illustrates a broader instrumentalist trend in political discourse about science. Many recent policy proposals from across the political spectrum share a similar outlook, treating science as if it were simply an instrument among many for achieving national goals—whether competing with China, combating disease, solving climate change, or boosting gross domestic product.

Science and innovation are of course intimately linked. For this reason, the conflation of science and industrial policy might appear perfectly understandable, even desirable. Yet though related, science, technology, and industry are distinct areas of policy; they raise their own questions and concerns, and they implicate different domains of expertise, institutions, constituencies, and stakeholders—often with divergent priorities and goals. Crafting sound policy requires that policymakers be attentive to the particular contexts and goals of proposed interventions. From this perspective, the conflation of science policy and industrial policy is unfortunate, and the former ought to be reclaimed as its own distinctive area of public concern.

In fact, it was not so long ago that a non-instrumentalist idea—that the pursuit of knowledge is valuable in and of itself—still informed public discourse about science. Before and after World War II, pioneers of science policy such as Vannevar Bush, Michael Polanyi, and Edward Shils articulated the concept of scientific autonomy as an alternative to policies to "plan" science as part of a larger political project to "plan" or "rationalize" the economy and society overall. For Bush, Polanyi, and Shils, scientific autonomy was about much more than science per se or even economic policy; it provided a normative standpoint from which to defend a politically liberal conception of scientific institutions and their place in society at a moment of growing extremism at home and abroad.

This vision has much to teach us today. But to recover its insights, we need a better understanding of how and why it came to be eclipsed in the first place. This, in turn, requires grappling with our culture's underlying assumptions about the nature of science and its relationship to technological and political power—and the ways those assumptions have been contested and transformed over time.

The instrumentalist conception of science is an Enlightenment inheritance, closely connected, conceptually and historically, to the political project of

planning. Its roots are in the writings of the English jurist and philosopher Francis Bacon, often considered the father of modern science. He argued that science did not consist in the pursuit of knowledge for the sake of understanding, as the ancients and medievals had thought, but instead enabled practical power—mastery over nature. In the 19th century, thinkers such as Henri de Saint-Simon and Auguste Comte extended the Baconian goal of mastery beyond nature to society. They argued that a new social class of scientists and engineers could steer society toward rational ends.

In the American context, the most systematic expression of these ideas came in the late 19th and early 20th centuries, with the Progressive ideals of social control and economic planning. Following Saint-Simon and Comte, Progressives argued that political decisions should be delegated to technical experts who could use their knowledge to direct social and economic forces that, left to themselves, would tend toward disorder and conflict. Perhaps surprisingly, the idea of using such expertise to rationally plan *science itself* arose later. And ironically, it also met resistance from within the scientific community.

The US federal government began to take an active interest in science in the 19th century—and for practical, Baconian reasons. Beginning in the middle of the century and accelerating after Reconstruction, Congress created or expanded a number of science bureaus, such as the Geological and Coast Surveys, Weather Service, Army Signal Corps, and Department of Agriculture, to grapple with a variety of challenges the growing nation faced. This drew the federal government into supporting a wide array of scientific activities. But the emerging system of federal science faced resistance from the start.

Some members of Congress, the scientific community, and the broader public feared the creation of an "official clique" in Washington that would politicize science, undermine scientific freedom, and exceed the federal government's constitutional limits. Ultimately, however, the exigencies of war and periodic outbreaks of infectious diseases, such as yellow fever, proved too powerful. The expansion of the federal scientific establishment during the late 19th and early 20th centuries institutionalized a conception of science as a tool to be wielded by the state to wage war and "combat" disease and other societal ills.

From the eradication of yellow fever in the early 20th century to the development of mass-produced penicillin, radar, and the atomic bomb during World War II, this emergent system proved quite successful at grappling with practical problems. Inspired by wartime mobilization and spurred by competition with the Soviet Union, reformers of the postwar decades facilitated the creation or expansion of a range of different federal science agencies, further tightening the link between science and the state. In many respects, the new federal system redounded to scientists' benefit.

Between 1946 and 1970, federal research funding ballooned more than fourfold relative to total US budget outlays. In addition to increasing public funds, scientists enjoyed newfound public prestige. But science's new public role was not an unalloyed good. Science's growing dependence on the state and its priorities precipitated a popular backlash against the "military-industrial complex" and weakened scientific freedom. Contrary to their self-image as members of a self-governing community, American scientists had become embedded in a large and bureaucratic system of state-managed research and development. It was in this context that Bush, Polanyi, and Shils articulated their visions of scientific autonomy.

Bush was President Franklin D. Roosevelt's science adviser during World War II and oversaw the mobilization of science. After the war, however, Bush sought to disestablish the federal bureaucracy he had helped build. Unlike "reform liberals" such as Sen. Harley Kilgore (D-WV), Bush and his colleagues were skeptical that the state—or anyone else—could rationally plan science, and they feared the effort to do so would not serve the public interest but rather undermine the freedom of science and its institutions. They proposed instead to devolve the governance of science back to the institutions they believed were the appropriate custodians of its social obligations and enforcers of its professional norms.

According to the Hungarian-British polymath Polanyi, science is a social activity so intricate and successful that it appears to be the product of conscious design. In fact, however, science, like the market, is a "spontaneous order" that cannot be rationally planned in advance. For

Polanyi, the case for what he called "pure science" was essentially moral. A free society, he thought, depended above all on not the progress of science per se—or the utilitarian benefits it spawns—nor the freedom of individuals simply to do as they pleased but rather the freedom of institutions such as science and law to flourish.

Shils, a sociologist and founding member of the University of Chicago's Committee on Social Thought, agreed with Polanyi that pure science is the "heart of scientific work" and stressed its resistance to rational planning. But he also emphasized the multifaceted roles and functions science had come to acquire in modern society. Science, argued Shils, is irreducibly pluralistic, so its modes of organization and governance must be as well. In the context of the Cold War, he feared that the idea of scientific autonomy was threatened by those across the political spectrum who dismissed it as a selfish attempt to decouple knowledge from societal or economic utility or to empower unaccountable elites over and against the people.

For Bush, Polanyi, and Shils, science's resistance to rational planning was not a problem to be solved by the state. It was instead a clue to understanding not only science but also the free society in which they believed science flourished. Securing the conditions under which science could continue to flourish was, for these thinkers, a key aspect of a broader political project: preserving the plurality of institutions on which liberal democracy itself depends. Taking up this task today would not mean simply regurgitating these thinkers' ideas. Instead, what we need is "a reformulation," as Shils put it, of the "traditional conception of the autonomy of intellectual life" adequate to our own instrumentalist moment.

Such a reformulation would not entail severing science from the state. The federal government can and should continue to use science for practical purposes—whether for protecting the environment and public health or for military preparedness, geopolitical competitiveness, and economic growth. Besides its overtly utilitarian needs, the state also has a unique role to play in funding "pure" science, thus nurturing the conditions for scientific institutions to flourish alongside other vital institutions of democratic society.

Lastly, some areas of scientific research—such as research on potential pandemic pathogens, human subjects, and human cloning—raise ethical issues or pose potential societal harms. Especially when it is supported by the state, such research calls for democratic deliberation about risks and benefits or for outright regulation, control, or even interdiction. This is a place in which Congress can—or even should—play a more prominent role, not just in funding science, nor as a mechanism for planning it, but as a site of democratic contestation over its uses.

Yet the tradition of scientific autonomy serves as a reminder that science is ultimately more than its practical uses, whether beneficial or harmful. Recovering science policy means recognizing science as a tradition, with its own distinctive norms, goals, and standards of excellence that are valuable in their own right. The cultivation and maintenance of this tradition are essential to not just scientific and technological progress but also the institutional pluralism at the heart of free society.

Recovering Science Policy

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The aftermath of a global public health crisis, combined with the rise of populism at home and growing economic and security threats abroad, has persuaded a wide swath of Americans that a more interventionist state is needed to shore up, promote, or protect particular sectors of the economy. This has led commentators to declare the "return of industrial policy," raising anew the old specter of government "planning." Critics point to the government's inherent inability to allocate resources more efficiently than the market, while advocates claim the market alone cannot address today's challenges.[1]

Of course, the strategy of using the federal government to protect the nation's interests is not new. What we now call industrial policy has always had its supporters and detractors; arguments about it have occurred cyclically throughout American history.[2] Yet something distinctive about the resurgence of industrial policy today—although it has so far passed by almost unnoticed—is a change in the politics of the related but distinct area of *science* policy. In effect, science policy—the sets of questions concerning how and to what degree the government should fund, conduct, or direct scientific research—has been eclipsed by, or, perhaps more accurately put, absorbed into, industrial policy.[3]

This is illustrated most clearly by one of the most significant pieces of industrial policy in recent years, the CHIPS and Science Act. Passed by Congress and signed into law by President Joe Biden in 2022, the centerpiece of this law—the CHIPS part—is an effort to "re-shore" advanced manufacturing of semiconductors. Yet fused to this effort is another—the Science part—derived from a distinct legislative proposal known as the Endless Frontier Act (EFA), which sought to boost federal investment in scientific research. So intertwined were these efforts in policymakers' minds that they eventually became indistinguishable, lumped together in the same policy package.

On one level, this was quite understandable: Science and innovation are, of course, intimately linked. Yet though related, science, technology, and industry are distinct areas of policy. They raise their own questions and concerns and implicate different domains of expertise, institutions, constituencies, and stakeholders—often with divergent priorities and goals.[4] The EFA's rocky legislative history made this all too plain.[5] Moreover, the arguments for and against government intervention in each policy area are not the same or equally supported by empirical evidence and historical precedent. (Nor are they equally popular with lawmakers: In sharp contrast to the CHIPS part of the bill, the funding actually appropriated for science has fallen significantly short of what was authorized by law.)[6]

Science's absorption into industrial policy is striking for yet another reason. Modern science policy arose in the 20th century amid controversy over proposals to "plan" science. This was part of a broader debate over proposals to "plan" or "rationalize" society, famously criticized by Friedrich Hayek, among others. This historical link between science policy and the planning debates is illustrated by the document from which the EFA took its name: Vannevar Bush's 1945 *Science: The Endless Frontier*.[7] In the report—a kind of founding document of modern science policy—Bush advocated a strong, if limited, role for the state in "supporting" science without, as he said, "controlling" it.[8] This was an explicit alternative to a rival proposal, put forward by Sen. Harley Kilgore (D-WV), which, taking inspiration from the science planning movement of the 1930s, sought to steer science toward national goals.[9]

No one speaks of science planning anymore, but its echoes are still discernible in proposals to steer science toward national or even international goals—whether to combat climate change or wage war against diseases such as cancer. Even proposals to centralize all federal research still get trotted out periodically.[10] Yet perhaps the clearest example of the legacy of science planning, ironically enough, is the EFA itself.

Although its name is an allusion to *Science: The Endless Frontier*, the bill originally sought to transform the

National Science Foundation (NSF)—the agency inspired by Bush's report—into precisely the thing his report had warned against: a massive technology directorate, modeled on defense research, intended to boost American competitiveness in prespecified areas of development.[11] This proposal is consistent with the agency's new focus on "benefit[ing] society by translating knowledge into solutions"—what Director Sethuraman Panchanathan has characterized as an institutional shift to emphasizing the "outputs" of research rather than merely the "inputs."[12] (The NSF launched a directorate resembling the one proposed by the EFA even before the CHIPS and Science Act was signed into law.)[13]

Implicit in these proposals is a conception of science as the raw material for technological innovation—an "input" in a process of production that begins with knowledge discovery, leads to invention, and culminates in innovation and commercialization. Yet because scientific discovery is difficult to predict and therefore risky, the private sector "underinvests" in it; hence the federal government must step in to correct this "market failure." The only difference between science policy and industrial policy, on this view, is where in the "pipeline" of innovation the intervention focuses: on the production of knowledge (science policy) or the production of the goods and services the knowledge enables (industrial policy).

This is a fundamentally instrumentalist conception of science. And it is so pervasive in our politics today that it can be difficult even to imagine an alternative. Yet it was not so long ago that a different—much older, even classical—idea still informed public discourse about science: the idea that the pursuit of knowledge is valuable in and of itself. In the years following World War II, figures such as Bush, along with intellectuals such as Michael Polanyi and Edward Shils, developed the idea of scientific autonomy not only as an alternative to science planning policies but, more importantly, as a normative standpoint from which to defend a politically liberal conception of science and its place in society at a moment of growing extremism at home and abroad.

This vision has much to teach us today. But to recover its insights—and thus reclaim science policy as its own distinctive area of public concern—we need a better understanding of what this vision was and how and why it came to be eclipsed in the first place. This, in turn, requires grappling with our culture's underlying assumptions about the nature of science and its relationship to technological and political power—and the ways those assumptions have been contested and transformed over time.[14]

The Origins of Instrumentalism

The instrumentalist conception of science is an Enlightenment inheritance, closely connected conceptually and historically to the political project of planning. Its roots are in the writings of the English jurist and philosopher Francis Bacon, often considered the father of modern science. He argued that science should be modeled on technology, or what was then called the "mechanical arts." Abandoning its traditional goal of achieving knowledge for the sake of understanding, science should strive instead to produce "useful works."[15]

The instrumentalist conception of science is an Enlightenment inheritance, closely connected conceptually and historically to the political project of planning.

Scientific knowledge, for Bacon, was valuable not because it enabled wisdom, as the ancients and medievals had thought, but rather because it enabled power—mastery over nature. He envisioned a utopia in which scientists, supported by the state, were left free to advance science for the "relief of man's estate."[16] Bacon's ideas exerted a profound influence on the self-understanding of modern science, even if his influence on the actual practice of science has sometimes been greatly exaggerated.[17]

Enlightenment philosophers such as Voltaire, the Marquis de Condorcet, and Baron d'Holbach claimed Bacon as one of their own, conveniently dispensing with his extravagant metaphysical views. Condorcet in particular found in Bacon's writings inspiration for the idea that scientific progress was the driver of material and moral

progress.[18] In the 19th century, thinkers such as Henri de Saint-Simon and Auguste Comte extended the Baconian goal of mastery beyond nature to society. They argued that a new social class of scientists and engineers could steer society toward rational ends. This was a progressivist vision of history, beginning with religious superstition and culminating in modern science, at which point a science of society would replace traditional politics with the "administration of things."[19]

In the American context, similar notions found expression in the ideals of social control and economic planning. According to American Progressives—many of them influenced by Saint-Simon and Comte—political decisions should be delegated to technical experts who could use their knowledge to direct social and economic forces that, left to themselves, would tend toward disorder and conflict.[20] Thus Walter Lippmann called for the "substitution of conscious intention for unconscious striving" in public life to "introduce plan where there has been clash, and purpose into the jungles of disordered growth."[21] The power enabled by scientific knowledge was key. As historian George H. Daniels notes, a major "part of the appeal of science to reform-minded citizens" was "explained simply by the strong Progressive sense of power, for science seemed to promise the power to control both man and nature."[22]

The idea of governance through technical expertise was given a conceptual foundation during this period by the sociologist Max Weber. He identified—with considerably more ambivalence than his American counterparts—the functional differentiation of social life, requiring increased specialization, as a characteristic of modernity. And he saw this, in turn, as part of a more comprehensive process of *rationalization*. Rationalization, for Weber, entails that instrumental rationality (i.e., matching means to ends in the most efficient manner possible) comes to supplant the traditional foundations of social order. This is illustrated by the bureaucratization of society and the retreat of traditional sources of moral and spiritual authority—with "values" cabined to the subjective sphere and apolitical technicians left to manage public affairs.[23]

A traditional critique of the political project of planning comes from libertarians, who deny either the existence of market failures (in general or in the given instances) or the possibility of effective state intervention to correct them. The federal government has no business subsidizing industry, on this view, or funding any research allegedly "undersupplied" by the private sector. Better to leave the entire life cycle of innovation to the market.[24] But while they reject planning, libertarians typically *don't* reject the underlying instrumentalist idea that science is a form of power—the power to innovate. Their argument, rather, is that this power must be left in the hands of the market, which is a more efficient mechanism for allocating resources, whether industrial, technological, or scientific.

Moreover, libertarians argue, government bureaucracies are just as self-interested as the rest of us, so if they are empowered to use science to protect the national interest, they will inevitably get captured by particular interests instead.[25] A more extreme version of this idea is evident in radical critiques of expertise. According to this view, once prominent on the anti-technocratic left but now prevalent on the populist right, the very idea of expertise is a ruse, a ploy by which self-appointed experts project disinterestedness while pursuing their own interests.[26] Here, again, knowledge is conceived of as power—not so much to innovate as to manipulate. Hence populism doesn't really abandon the instrumentalism of the technocratic vision either; it merely flips it on its head. Rather than rejecting as illusory the dream of control by scientific means, populists seek instead to wrest control of those means for themselves.[27]

Despite their differences, all sides of this debate treat science as if it were an *instrument*, which can be wielded for or against the public interest. The only real question, politically speaking, is *who* should wield it: the federal bureaucracy, the market, or the "people." The idea that science might have its own intrinsic values gets dismissed out of hand—by the left, because it amounts to a selfish attempt to decouple knowledge from societal utility; by libertarians, because it represents a misguided effort to shield knowledge from economic utility; and by the populist right, because it empowers unaccountable elites over and against the people.

Perhaps surprisingly—given that the Enlightenment tradition takes science as the paragon of rationality—the idea of rationalizing *science itself* arose only relatively recently. And ironically, it also met resistance from within the scientific community. For thinkers such as Polanyi and Shils, science's resistance to rational planning became central to their account of not only science but also the

free society in which they believed science flourished. Their vision thus provides an alternative, underexplored in our own time, to not only the political project of rational planning but also the more familiar libertarian and populist critiques of that project.

Science and the State

The federal government began to take an active interest in science in the 19th century—and for practical, Baconian reasons. Beginning in the middle of the century and accelerating after Reconstruction, Congress created or expanded a number of science bureaus, such as the Geological and Coast Surveys, Weather Service, Army Signal Corps, and Department of Agriculture, to grapple with a variety of challenges the growing nation faced. This drew the federal government into supporting a wide array of scientific activities, including research on geography, demographics, statistics, and, increasingly, medicine, physics, and chemistry.[28]

But the emerging system of federal science faced resistance from the start. Some members of Congress, the scientific community, and the broader public feared the creation of an "official clique" in Washington that would politicize science, undermine scientific freedom, and exceed the federal government's constitutional limits.[29] Though often differing in their politics, motivations, and aims, those who resisted "Washington science" nevertheless shared a broad conviction that science should remain autonomous institutionally, financially, and politically.[30]

This conviction was often expressed by scientists in the late 19th century using the language of "pure science." The ultimate aim of science, on this view, was not the practical applications of scientific knowledge to human affairs—whether in business or government—but rather ennobling the human mind and enriching our civilizational inheritance through the quest for knowledge. Science, though it enabled innovation, was not itself a form of technology but rather a proper part of the liberal arts. Rather than linking science and the state, advocates of this "ideal of pure science" sought instead to build independent institutions, notably the modern research university, for the cultivation of scientific knowledge.[31]

Advocates of federal science, by contrast, saw science as a source of practical innovation that benefited the public and thus required state intervention. For them, efforts to shield "pure" science from utility were misguided and self-interested. "We may not rest and eat lotus," declared the American physician and federal science advocate John Shaw Billings. "We may not devote our lives to our own pleasures, even though it be pleasure derived from scientific investigation. No man lives for himself alone; the scientific man should do so least of all."[32]

Rather than keeping government out of science, reformers such as Billings sought to build autonomous institutions *within* government, overseen by scientist-administrators tasked with harnessing science for the public good.[33]

The dialectical tension between those seeking to link science and the state and those who resisted such efforts would play an important role in shaping the character of modern scientific institutions, both within and outside government: their diverse and sometimes conflicting self-understandings, constituencies, and aims.

For instance, spurred by an especially deadly and disruptive epidemic of yellow fever in 1878, Congress established the National Board of Health, the nation's first federal public health bureau. Though created in response to a national crisis, the board was in fact the culmination of years of efforts by reformers who had long sought a national institution devoted to public health. But the new institution proved controversial.[34]

Its purpose was to support research and assist federal, state, and local governments in implementing public health policies. This dual mandate fostered ambiguity about whether the board should be primarily a research institution or a regulatory body, leading to conflicts with state and local authorities. These conflicts in turn were exacerbated by the fact that experts disagreed about how to control yellow fever: quarantines and travel restrictions or more targeted measures to improve hygiene and sanitation.

Politically damaged and lacking broad congressional support, the board was ultimately shuttered after only five years. But it nevertheless provided a model—and a cautionary tale—for future bureau-building efforts in the federal scientific establishment, including the launch of the Marine Hospital Service's Hygienic Laboratory only a few years later.

Yet if disease created a major impetus to federalize science—not to mention opportunities for reformers to push their agendas—war was an even more powerful force. The large-scale mobilization of society during World War I in particular suggested to many reformers a model for organizing society during peacetime. As historian Alan Brinkley put it, the Great War "provided an example of what an enlightened state could do (as Lippmann had urged) to replace 'clash' with 'plan,' and 'disorder' with 'purpose.'" And it remained an "inspiration for more than a generation . . . to those progressives who hoped to achieve in peacetime what they liked to think they had achieved in war."[35] Plans for science reform followed this same pattern.

During the war, the Marine Hospital Service—recently expanded and rebranded as the Public Health Service—and the newly formed National Research Council pioneered methods of coordinating scientific research across the country to tackle such practical problems as venereal disease among soldiers, submarine detection, and chemical warfare.[36] With the success of these voluntary efforts to organize science around practical aims, pure-science arguments against the alliance of science and the state were put on the back foot.

The interwar years saw a flowering of reform efforts aiming to coordinate research in a similar way—now for peacetime rather than wartime purposes. For instance, a 1923 report outlining a plan for a new "chemo-medical research institute" called for a "determined cooperative attack on the problems of disease and health." "May the day come," the report declared, "when the lesson of the power of cooperative scientific endeavor, so effectively utilized in the Chemical Warfare Service organization, may be applied with equal success to the solution of the problems of disease and health." This report provided the blueprint for the legislative push that culminated in the Ransdell Act of 1930, which expanded the Hygienic Laboratory and renamed it the National Institute of Health.[37]

The most ambitious plans for rationalizing science in the interwar years came from abroad: from Marxists such as Otto Neurath in Austria and J. D. Bernal in the United Kingdom. As George Reisch has shown, Neurath's project to "unify" the sciences took inspiration from his own experience with the mobilization of national resources during World War I and his brief tenure as director of the Central Planning Office for Bavaria's socialist government.[38] Bernal, for his part, looked to the Soviet Union as a model of how scientific research could be "planned" to achieve social ends.[39] In this way, science can be "consciously controlled," to use Neurath's language, and become an instrument of social and political progress.

The most ambitious plans for rationalizing science in the interwar years came from abroad.

These ideas were popularized in the American context by the prominent science writer and *New York Times* science editor Waldemar Kaempffert. A maternal first cousin of Neurath, Kaempffert was enthusiastic about planning. And though he stopped short of endorsing Soviet ideology, Kaempffert nevertheless believed the Soviet model had something important to teach the West about science in particular. What was needed, he argued, was an "all-embracing plan which embodies the best in Soviet and American systems."[40] In his 1943 article "The Case for Planned Research," Kaempffert laid out his case for the public: "Laissez-faire has been abandoned as an economic principle; it should also be abandoned, at least as a matter of government policy, in science."[41] He even made this case before Congress, catching the ear of Sen. Kilgore, a New Deal Democrat who would play an important role in the future of federal science.[42]

Rival Visions of Knowledge and Power

During World War II, science was once again mobilized, now on a far grander scale. The mass production of penicillin and the invention and deployment of proximity fuses, radar, computing, and, of course, the atomic bomb—these feats all demonstrated with unrivaled clarity the technological power of science, especially when coordinated by the state to achieve common, practical objectives. These projects were under the auspices of the newly formed National Defense Research Committee—later expanded and renamed the Office of

Scientific Research and Development (OSRD)—launched and led by Bush.[43]

Kilgore, along with other "reform liberals," argued that the mobilization of science, so successful in war, should be extended into peacetime. Much like Progressive reformers in the interwar years, Kilgore and his political allies sought to supersede the "laissez-faire" approach to scientific research that had prevailed before the war and take advantage of the wartime bureaucracy to steer science toward national goals.[44] Backed by prominent public figures such as Kaempffert and key allies in the White House, Kilgore proposed a National Science Foundation to coordinate research to meet national needs.[45] This was, in effect, a proposal to plan science, now articulated in the language of New Deal liberalism.

Yet many members of the scientific community worried about the potentially corrosive effects of continued government control. They feared that perpetuating the government's wartime bureaucratic controls into peacetime would erode scientific freedom, sapping scientific institutions of the vitality that had enabled them to serve the national interest so effectively during the war. Foremost among them was Bush, who, despite being a key architect of the federal scientific establishment, would also become one of its most penetrating critics, articulating a vision of science policy that recognized a new and important role for the state while nevertheless seeking to preserve the autonomy of science.

As an alternative to Kilgore's plan, Bush proposed a new, civilian-controlled National Research Foundation.[46] Its primary purpose would be to fund basic scientific research in the nation's colleges and universities. Crucially, the foundation would devolve decisions about how to allocate these resources to the institutions conducting the research themselves. For its advocates, Kilgore's plan was a straightforward application of the lessons gleaned from the successful mobilization of science for war. Bush, by contrast, failed to exploit "the experience gained from the OSRD," Kaempffert wrote, instead promoting "laissez-faire in research, meaning that science should follow its traditional erratic path, when, as a matter of fact, it needs organization, planning and competent direction."[47]

For his part, Bush thought Kilgore and his allies completely misunderstood the lessons of wartime mobilization. First, he pointed out that most of the fundamental discoveries that made wartime technologies possible—such as electromagnetism, binary logic, atomic physics, and penicillin—predated the war, sometimes by decades.[48] And these discoveries were generally not the result of any planned effort, governmental or other. Coordinating research can of course be successful—as the OSRD dramatically proved—but only insofar as there are deep reservoirs of knowledge that may be drawn on when the time comes. Such knowledge, Bush insisted, cannot be ordered up on demand—by the state or anyone else.

Second, Bush argued, though it coordinated research, the OSRD was hardly a paragon of central planning. On the contrary, he and his colleagues had pioneered a distinctive mode of organization that relied on a decentralized decision-making process in which civilian scientists were tasked with coordinating and assessing research projects designed to meet military needs. In other words, the OSRD devolved authority over research decisions as much as was practically possible. The goal, according to historian A. Hunter Dupree, was to preserve the universities and industrial research laboratories in which wartime research was conducted "as institutions even while their social role was temporarily but radically changed."[49]

To be sure, World War II meant an unprecedented degree of government coordination and control of science. Bush was among the first to recognize the need for such organizational innovations in the lead-up to America's entry into the war. The "new situation," he wrote, "demanded a closer linkage among military men, scientists, and industrialists than had ever before been required."[50] But this was, so to speak, a necessary—and temporary—evil. "If a modern scientific war must be fought," Bush said in 1945, "the most effective way in which to fight it is under the temporary rigid controls which a continuing democracy voluntarily imposes upon itself as it girds for combat."[51]

Thus, while Bush and his allies sought to demobilize science, maintaining a fundamental distinction between peacetime and the emergency conditions of war, Kilgore and his allies sought to take advantage of the exigencies of war to push through peacetime reforms. For them, wartime mobilization proved what the state was capable of, when there are but funds enough and political will.[52]

This debate is sometimes framed by scholars as one between "science" and "democracy."[53] Bush and his allies are on one side, promoting an elitist system in which scientists control science for their own ends with little or no accountability; Kilgore and his allies are on the other side, seeking to bring science under the aegis of democracy rather than that of a self-interested scientific elite. But it would be more accurate to say that the two groups disagreed about *which* elites should be charged with governing science—and, indeed, what such governance should amount to.

Kilgore and his allies wanted political elites, understood to be representative of the popular will, to have ultimate responsibility over the nation's scientific resources, directing them toward socially and economically progressive ends. Reform liberals were generally more optimistic than their political opponents about the capacity of the state, especially the newly expanded executive branch, to rationally plan science according to national needs.[54] And they feared that left to themselves, scientists could not be trusted to place science in the service of the public interest.[55]

Even civilian research on atomic energy and space was shaped indirectly by the military priorities of the Cold War.

By contrast, in trying to disestablish the wartime bureaucracy he had helped build, Bush sought to devolve the governance of science back to the institutions he believed were the appropriate custodians of its social obligations and enforcers of its professional norms.[56] Demobilizing science did not mean keeping science institutionally separate from the state, as the "pure science" reformers of the 19th century had wished. But Bush and his scientific colleagues were skeptical that the state—or anyone else—could rationally plan science. And they feared the effort to do so would not serve the public interest but rather undermine the freedom of science and its institutions.

The postwar debate over federal science policy, therefore, was not just about the most effective way to organize science. At stake were rival visions of scientific knowledge and political power—and the consequences of wartime mobilization for both.

Instrumentalism Ascendant

After five years of debate and one presidential veto, Congress finally passed and President Harry S. Truman signed the National Science Foundation Act of 1950. In addition to using Kilgore's name, the law also empowered the president, rather than an independent board of scientists and lay citizens, to appoint the director of the new agency, just as Kilgore and his allies wanted. In other respects, the bill was a victory for Bush's side. To this day, the primary mission of the NSF is to fund basic science conducted in universities and colleges on a largely meritocratic basis. But while Bush and his allies could in this sense be said to have won the battle over the NSF, they nevertheless lost the war over federal science.

The postwar years saw the creation or expansion of a range of different federal science agencies, spurred especially by the Soviet Union's successful launch of Sputnik 1, the first artificial Earth satellite, in 1957.[57] As a result, the NSF did not turn out to resemble anything close to the nation's premier research institute. It emerged instead as one relatively minor agency in an alphabet soup of federal science—a "puny partner," as Daniel Kevles once put it, "in an institutionally pluralist federal research establishment."[58]

Unsurprisingly, perhaps, the lion's share of federal research funding—then, as now—went not to basic science, as Bush had hoped, but to applied research and especially "development," particularly in connection to the space program. Even when it came to the comparatively small percentage of federal funding dedicated to basic science, the NSF could not lay claim to being the biggest player. That honor would instead go to new agencies such as the Office of Naval Research and the Atomic Energy Commission, as well as the ever-expanding National Institutes of Health.[59]

Moreover, rather than a system of civilian control of federal science, as Bush and his scientific colleagues had sought, the newly created Department of Defense became the primary source of federal science funding. Even civilian research on atomic energy and space was

shaped indirectly by the military priorities of the Cold War.[60] Scientists chafed against the increasing security protocols required for research deemed vulnerable to Soviet espionage.[61] This tightening link between federal science and the military would have political consequences that rippled out into the postwar decades.

In many respects, the new federal system redounded to scientists' benefit. For instance, between 1946 and 1970, federal R&D funding grew from $918 million to about $16 billion—a more than fourfold increase relative to total US budget outlays.[62] In addition to increasing public funds, scientists enjoyed newfound public prestige. As historian Clarence G. Lasby puts it, the image of scientists that emerged after World War II was "that of 'miracle workers,'" a "prestigious image [that] has been translated into heightened political power and representation at the highest levels in government."[63] But science's new social standing was not an unalloyed good.

Increasing anxiety over the alliance of science and the state, exacerbated by the Vietnam War, fueled the New Left's protests in the late 1960s. Student activists, resisting what they saw as the technocratic lurch of an increasingly "administered society," protested the co-optation of American universities by an imperialist war machine, staging sit-ins and pressuring administrators to "divest" from defense research contracts.[64] Some scientists joined the fray, calling for the "disestablishment of science" and urging fellow scientists to "reject any contract, grant or project that comes to him from a military department."[65] This was a stark contrast to the "reform liberals" of the previous generation.

Rather than seeking to utilize the state's wartime bureaucracy to plan science toward national goals, this new generation attacked the fusion of science and state power as such. They professed not the rationalization of science by allegedly apolitical technocrats but rather the "re-politicization" of science through "participatory democracy." Whatever one makes of these criticisms, they did reflect—albeit in politically charged and often illiberal forms that obscured more than they revealed—science's new social standing. Contrary to their self-image as members of a self-governing community, American scientists were increasingly embedded in a large and bureaucratic system of state-managed research and development.[66]

Although no one could plausibly describe this system as the triumph of a socialist vision of central planning, it was a far cry from laissez-faire. Nor was it the realization of Bush's vision of state-supported science, with the "free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for exploration of the unknown."[67] It was instead a hybrid system, in which the state had responsibility for funding and managing the nation's scientific resources for a variety of civilian and military purposes, while leaving much of the day-to-day operations of research to scientists in both public and private institutions.

In addition to pulling scientists into the political maelstrom of the Vietnam War era, the new arrangement also weakened scientific freedom—albeit more subtly than Bush and his allies had initially imagined. To be sure, national security protocols aside, individual scientists were generally free to pursue research without external constraint and amply funded to do so. At the same time, however, scientific institutions now lacked the freedom of self-determination that had come from independence. They had become instead utterly dependent on the state and its priorities. Scientists had, in effect, traded institutional autonomy for the financial and political benefits accruing from the mutual dependence of science and the state.

Several years before the New Left backlash against the "bureaucratic" society, President Dwight D. Eisenhower had captured the ambivalent and politically precarious nature of science's emerging public role. In his 1961 farewell address, he famously cautioned "against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex," and with it, the "danger that public policy could itself become the captive of a scientific-technological elite."[68] He saw that democracies had come to depend on science for military and economic advantage to a degree previously unimaginable—and that this posed a danger to democracy in the form of a newly empowered technical elite.

Less remembered today, however, is that Eisenhower also recognized that the new social standing of science threatened science itself, which risked becoming a mere instrument of the state. With the integration of science and the state, he warned, research becomes "more formalized, complex, and costly," and a "government

contract" can become "virtually a substitute for intellectual curiosity." This bureaucratization of research not only threatens scientific progress but also weakens the very foundation of higher education—"historically the fountainhead of free ideas and scientific discovery."[69]

Just as a free society must guard against the unwarranted influence of the new scientific-technological elite, Eisenhower urged, so too must it guard against the potential "domination of the nation's scholars by Federal employment, project allocations, and the power of money."[70] Kilgore *and* Bush, in other words, had put their fingers on genuine—and enduring—challenges posed by the system of federal science that emerged in the wake of World War II. These would become central themes in the postwar writings of intellectuals such as Polanyi and Shils.

The Fate of Pure Science

The rise of the federal scientific establishment in the mid-20th century transformed, but did not resolve, the long-standing dispute between planning advocates and their critics. Some, such as the Hungarian-British polymath Polanyi, continued to defend the "pure" science ideal. "The most vital service we [scientists] owe to the world to-day," he wrote in 1945, "is to restore our own scientific ideals which have fallen into discredit. . . . We must reassert that the essence of science is the love of knowledge and that the utility of knowledge does not concern us primarily."[71] Polanyi saw this non-instrumentalist conception of science as threatened by two distinct philosophical viewpoints.

The first was a reductive materialism, according to which pure science is merely bourgeois ideology—a "screen" for "selfish interests hiding behind" it.[72] Polanyi had encountered this view in its most extreme form on his visit to the Soviet Union in the 1930s, which spurred his activism on behalf of pure science. The Communist Party official Nikolai Bukharin had informed him that the distinction between "pure" and "applied" science was an ideological illusion that was inapplicable there. All science in the USSR ultimately served the practical ends of the party's five-year plan.[73] This materialist critique of pure science can be found in nascent form in Karl Marx. Almost a century earlier, Marx had written that "even . . . 'pure' natural science receives its purpose as well as its substance through trade and industry."[74]

Bukharin's view had been taken up enthusiastically and promoted in a Western idiom by Bernal and his allies during the 1930s and '40s. But the predominant view of science in Western democracies after the war was not Marxist. It was instead the more familiar Baconian idea that the purpose of science is to alleviate human suffering—and hence that the pursuit of science merely for the sake of understanding is not only fruitless but also selfish.[75] "Scientists," especially insofar as they are supported by the state, "are morally reproached for pursuing science for the mere love of knowledge," Polanyi observed, and he urged instead to "turn their eyes to the misery which fills the world" and use their "gifts" to bring "relief" to it.[76]

However distinct, the Soviet and Baconian conceptions of science converged on the same conclusion: that science has social value only insofar as it contributes directly to material progress. "Do we still believe," Polanyi asked rhetorically in 1945, "that it is proper for a scientist to spend public funds for the pursuit of studies . . . which, though perhaps not lacking in some remote possibility of practical usefulness, are at any rate as unlikely to yield a material dividend as any human activity within the realms of sanity?"[77] It is only a short step from the view that only socially useful science is valuable to the view that science must therefore be *directed* to such purposes—"planned" by public authorities.

But this is impossible, according to Polanyi. Science, he said, is a social activity, so intricate and successful that, like the "evolution of a polycellular organism from the fertilized cell," it appears to be the product of conscious design.[78] In reality, however, science is *not* the product of rational planning—nor could it ever be. Science is not a mechanical procedure that can be routinized; it instead rests on what Polanyi called tacit knowledge—the kind of savoir faire that can be acquired and honed only through experience and cannot be explicitly articulated.[79] Like the market, science is the result of a "spontaneous mutual adjustment" between its practitioners, rather than an external agency intervening to bring a preconceived plan into existence.[80]

Yet although he likened the "spontaneous order" of science to that of the market, Polanyi was not arguing that the former was reducible to the latter. Instead, like

the legal tradition of common law, science is an exemplary instance of what Polanyi called an *intellectual* spontaneous order.[81] Such systems are akin to the market in that they cannot be planned. But their practitioners are not fundamentally driven by the profit motive, for their "intellectual products cannot in general be valued by what they fetch on the market."[82] To reduce the scientist to *Homo economicus* would be to accept the premise of Bukharin's materialism—namely that, as Polanyi put it, "there can be nothing higher than the longing for material benefits—so that to talk about higher missions is just foolishness or deceit."[83]

Polanyi's friend Shils was also a fierce critic of Soviet Communism who saw the autonomy of science and scholarship as a vital bulwark against its reductive materialism. A sociologist and founding member of the University of Chicago's Committee on Social Thought, Shils, too, emphasized science's resistance to rational planning.[84] At the same time, he recognized that what he called the "governmentalisation of science" in Western democracies had changed the game.[85] The debate was no longer simply between central planners on one side and political liberals on the other. "Far-reaching governmentalisation," Shils wrote in 1962, "is generally accepted on all sides," even if unadulterated central planning had few explicit adherents left.[86]

The state-managed system that had emerged after World War II, with its burgeoning national security apparatus, could not be easily identified with either side of the prewar debates. Critics argued that Polanyi's view was no longer workable, nor was Soviet-style planning the only or most pressing rival.[87] Shils didn't go quite so far. He too wished to "affirm the traditional conception of the autonomy of intellectual life." But he also recognized

> at the same time that this traditional conception, valid though it is in principle, requires a reformulation which does justice to the new multifariousness of the relations between governments on the one hand and science, scholarship and higher education on the other.[88]

Shils still believed, with Polanyi, that "pure science is the heart of scientific work and that the university is its proper place."[89] But his was a more capacious—and perhaps more realistic—understanding of the multifaceted roles and functions science had come to acquire in modern society. There can be no "single goal nor a unitary set of goals toward which science as a whole can be planned," Shils wrote, hence "no single institutional arrangement that is equally appropriate to the development of all its parts."[90] Pure science, in other words, may be the heart of scientific work, but it is by no means the whole of it. Science is like the free society in which it thrives: irreducibly pluralistic, so its modes of organization and governance must be as well.

This prejudice against intellectual elites, and scientists in particular, found expression in the paranoid politics of the McCarthy era.

In the context of the Cold War, Shils saw the threats to the autonomy of intellectual life as emanating from not only the far left and the Baconian middle but also increasingly the "hyperpatriotism" of the far right.[91] What he called "populism" was a mirror image of Soviet Marxism: It, too, derided "the interest in pure science . . . as self-indulgence and a sign of inadequate appreciation of the needs of the people." And it "assailed" the "ivory tower" as "morally suspect."[92] This prejudice against intellectual elites, and scientists in particular, found expression in the paranoid politics of the McCarthy era—the subject of one of Shils's first books. (The excesses of American security policies hit close to home, hampering Shils's efforts to secure a permanent appointment at the University of Chicago for, of all people, Polanyi.)[93]

Polanyi and Shils, together with broadly like-minded colleagues, mobilized their ideas in various practical efforts. Polanyi helped organize the Society for Freedom in Science during World War II to promote the "causes of pure science and of freedom in science"; Shils founded the journal *Minerva*, which aimed "to contribute to the protection of the creative powers of science . . . by describing and defining the conditions of their vitality . . . in contemporary society."[94] These efforts came to be connected with the anti-Communist Congress for Cultural Freedom, which promoted

a variety of intellectual and cultural initiatives in the 1960s (including *Encounter* magazine, founded and edited by Irving Kristol).[95]

These intellectual and political projects should not be dismissed as mere artifacts of the ideological contest of the Cold War, as some scholars have recently suggested.[96] In resisting the instrumentalist pull of postwar science policy, Polanyi, Shils, and their collaborators were drawing on and advancing long-standing philosophical and political traditions, which had been vital to the establishment of modern scientific institutions, and adapting them to the peculiar circumstances of the Cold War era. The continued predominance of instrumentalism today is reason enough to reconsider, and perhaps even recover, these traditions.

Scientific Autonomy and Its Critics

The idea of scientific autonomy has always appeared vulnerable to several interrelated criticisms. The first—and longest-standing—attacks the implied distinction between "pure" science and its "applications."[97] Some critics, echoing the old Marxist line, blame a "powerful reactionary ideology" for constructing an artificial "dichotomy between pure and applied science" that serves the interests of scientific or professional elites.[98] This was central to Kaempffert's criticism of Bush and has been repeated by countless scholars since.[99] Some critics take issue with the implication that engineering, medicine, and technology generally are mere "applications" of scientific theory. Other scholars go much further and deny that there can be any meaningful distinctions between these fields whatsoever, preferring instead to speak only of "technoscience."[100]

It is true that, as a matter of historical fact, science has become harder to distinguish from its practical uses in such fields as engineering and medicine. In some fields, such as artificial intelligence and genetic engineering, the distinction between science and technology is well-nigh meaningless. But it is a sophistic fallacy to infer that because a boundary is blurry there is therefore no boundary at all.[101] Rather than trying to provide logically sufficient criteria for demarcating science from other practices, the ideal of pure science should be understood as just that: an ideal.[102] That is to say, pure science provides a normative vision of what science is, or rather what it should strive to be.

As Bush put it to the graduating class of his alma mater, the Massachusetts Institute of Technology, in 1953, in a passage highly redolent of the 19th-century pure-science ideal:

> Science has a simple faith, which transcends utility. Nearly all men of science, all men of learning for that matter, and men of simple ways too, have it in some form and in some degree. It is the faith that it is the privilege of man to learn to understand and that this is his mission.
>
> If we abandon that mission under stress, we shall abandon it forever, for stress will not cease. Knowledge for the sake of understanding, not merely to prevail—that is the essence of our being.[103]

This vision has played—and continues to play—an important role in shaping the character and self-understanding of modern scientific institutions, even if individual scientists do not always adhere to it. Understood this way, pure science could be considered what Harry Collins and Robert Evans refer to as a "formative aspiration," part of what makes science as a social practice a distinctive "form of life."[104]

To be sure, practical fields such as engineering and medicine are much more than—and are not helpfully described as—mere "applications" of scientific theory. But recognizing science as a distinctive form of life need not entail denigrating these other types of practice or subordinating them to science. This point was particularly important to Bush, who, far from exhibiting scientific chauvinism, was not himself a scientist, but rather an engineer, inventor, and entrepreneur—something he liked to point out—who spent a considerable amount of time and energy advocating for the engineering profession.[105] He often complained that engineers tended to be treated as "a kind of second-class citizen compared to the scientist," especially in the context of wartime mobilization.[106]

As Bush pointed out, it was in fact the indiscriminate use of the word "science" that was elitist, blotting out the genuine accomplishments of other forms of expertise. As he noted wryly years later, because during the war

the military tended to hold scientists in higher esteem than engineers,

> all O.S.R.D. personnel promptly became scientists. . . . The business of elevating the scientist to a pedestal probably started with this move, and it has certainly persisted. . . . Even recently when we sent the first astronauts to the moon, the press hailed it as a great scientific achievement. Of course it was nothing of the sort; it was a marvelous skillful engineering job.[107]

Arguably, recognizing the distinctiveness of science is a precondition for respecting the integrity of other related but distinct practices such as engineering and medicine, which have their own histories, achievements, institutions, and professional standards.

A related criticism of scientific autonomy is that it presupposes the widely discredited "linear model" of innovation.[108] According to this idea, innovation is a unidirectional process, moving like a conveyor belt from "pure" or "basic" scientific discovery to technological "application" to commercial development.[109] This is indeed a cartoonish picture of the processes of discovery and invention, its continued prevalence in policy circles notwithstanding. Indeed, an entire subfield of historical scholarship has arisen to try to explain how such an implausible idea ever took hold.[110] Certainly, neither Polanyi nor Shils subscribed to it.

Some incautiously worded passages from *Science: The Endless Frontier* do seem to support it. There is no question that in trying to sell basic science's contribution to the public interest, Bush overemphasized the link between science and innovation, imprudently implying that technologies may freely flow from the pursuit of science purely for the sake of curiosity.[111] But a more holistic assessment of his ideas reveals a rather different picture.[112] In fact, Bush believed the process of discovery and invention was highly collaborative, from the scientists who discovered new knowledge and the tinkerers who invented new devices to the technicians and laborers who supplied necessary materials and built new things to even the humanists who could give these new creations meaning.[113]

Together with Polanyi and Shils, Bush actually provides good reasons for skepticism about the pipeline model of science and innovation encouraged by the postwar system of state-managed science. This admittedly runs counter to a stereotype, prevalent in the scholarly literature. Even in its own time, *Science: The Endless Frontier* was caricatured by Harold Smith, director of the Bureau of the Budget, as *Science: The Endless Expenditure*.[114] And to this day, Bush's report is credited with or blamed for establishing the rationale for "no limits on the pursuit of knowledge."[115] In fact, however, Bush heaped scorn on the "fallacy"—encouraged, he thought, by OSRD's success—that "any problem can be solved by gathering enough scientists and giving them enough money."[116]

Already in the early 1950s, Bush expressed concerns about the "ambiguous effects on the quality of research of increased accessibility to government funds."[117] And he remained uneasy about the ever-expanding size of federal research budgets long after the war. For instance, testifying to Congress in 1963, he stated:

> After the war, and as a result of the success of our scientific programs in developing new weapons, this country plunged into a broad program of government support of research. . . . It is well that this occurred. . . . Those of us who recommended the program recognized the dangers but felt they could be avoided. . . . But the American people seldom do things moderately. The program has been over-extended and it is still rapidly growing. . . .
>
> If the country pours enough money into research, it will inevitably support the trivial and mediocre. The supply of scientific manpower is not unlimited.[118]

Bush did believe the quest for knowledge was endless. But "endless expenditure" was no part of his plan.

The association of scientific autonomy with the discredited linear model is closely related to another line of criticism: that by trying to cabin science off from the rest of society, its advocates fail to appreciate the social contexts in which science operates. But this criticism misses its mark. Although Polanyi and Shils stressed the irreducibility of science to social, political, or economic determinants—unlike the Marxist accounts of Bukharin, Bernal, and their successors—they not only recognized but *emphasized* the social and political contexts conducive to scientific flourishing. Recent scholars have gone

so far as to argue that Polanyi in particular helped inaugurate the "social turn" in the history, philosophy, and sociology of science.[119]

Often bound up with such criticisms is a concern that scientific autonomy somehow absolves scientists of any moral responsibility for the uses to which their knowledge is put—a concern that took on renewed force after Hiroshima and Nagasaki.[120] As Heather Douglas and T. Y. Branch recently put it, the ideal of scientific autonomy gets used to grant scientists a "special dispensation to be freed from this basic general moral responsibility" for the "foreseeable impacts of their work."[121] But this criticism doesn't stand up under scrutiny either.

Bush emphasized the indispensability to a free society of "professional classes" motivated by "public zeal and altruism" and "complete devotion to the public welfare."[122] One of his principal reservations about the postwar scientific establishment was that this ethic of social "responsibility" would get supplanted by mere "subservience" to the state.[123] He knew as well as anybody that the power enabled by scientific knowledge can "provide tools for good and evil."[124] But, he observed, this was hardly unique to the natural sciences:

> We would not stop our progress in the social sciences because better understanding of mass psychology, for example, is one of the most powerful tools of a dictator, any more than we would stop progress in the natural sciences because of an atomic bomb. We pursue both because of the faith that the acquisition of knowledge, while dangerous, is worth the risk.[125]

What was required was a "conscious effort to control the course of evolution," to prevent the misuse of scientific knowledge. "We either proceed down [that] path," he wrote, "or we quit the game."[126]

For his part, Shils—a founder of, and frequent contributor to, the *Bulletin of the Atomic Scientists*—was highly cognizant of these moral and political responsibilities. At the University of Chicago, he came to know many veterans of the Manhattan Project. And together with them, Shils became active in the politics of nuclear weapons. Arguably his first foray into science policy was a 1948 pamphlet, *The Atomic Bomb in World Politics*, which grappled with the challenges of arms control.[127] A principal focus of his work on science policy during the 1960s and 1970s concerned what he called the "new sense of responsibility which answers to the new responsibilities which scientists have accepted" in the postwar era.[128]

Polanyi certainly insisted on a distinction between pure science and its technological "applications." Compared with Bush and Shils, he arguably placed the least weight on scientists' social responsibilities, at least in the conventional sense.[129] But this was hardly because he wanted to denude science of moral values.[130] On the contrary, Polanyi's case for pure science was *essentially* moral—what he called the "social message of pure science."[131] A free society, he thought, depended above all not on the freedom of individuals simply to do as they pleased but rather on the freedom of institutions such as science and law to flourish.

Polanyi's case for pure science was *essentially* moral—what he called the "social message of pure science."

Far from advocating "freedom from responsibility," Polanyi roundly rejected the purely private conception of freedom.[132] Neither scientists nor anyone else for that matter had the right to pursue their own private interests without restraint. "This individualist or self-assertive conception of freedom," Polanyi wrote, can "be used to justify all kinds of objectionable behaviour."[133] Moreover, "its fundamental opposition to all restraint can easily be turned into nihilism," which "prepares the mind for submission to public despotism."[134] Hence, Polanyi insisted, private freedom must be counterbalanced by a more fundamental *public* freedom.[135]

This is where institutions such as science and the law come in: They bring into productive tension individual freedom—to pursue disruptive new ideas or challenge accepted beliefs—and submission to the shared standards and norms of a collective practice handed down by tradition.[136] "A free society," Polanyi wrote, "is characterized by the range of public liberties through which individualism performs a social function, and not by the scope of socially ineffective personal liberties."[137]

Scientific autonomy thus does not entail that scientists are shielded from social responsibilities. Rather it is through participation in autonomous institutions that scientists serve society.

The tradition of scientific autonomy serves as a salutary reminder that discharging social responsibilities is not the same as merely following bureaucratic injunctions. In fact, state bureaucracies can sometimes even be antithetical to the ethical practice of science. Historically, some of the most morally controversial uses of science in modern times—including eugenicist programs for social control, chemical warfare research, experimentation on prison populations, the Tuskegee syphilis study, and the development of nuclear weapons—were not the "spontaneous" result of scientists pursuing their own lines of inquiry. These were instead the coordinated—one might say "planned"—efforts of scientific experts working actively with federal bureaucracies.[138]

Consider one telling, if lesser known, example. During World War II, a medical research subsidiary of the OSRD persuaded leadership that clinical trials were needed to test the effectiveness of treatments for gonorrhea, a common affliction among soldiers.[139] But because the Army was unwilling, on practical and ethical grounds, to subject its soldiers to "deliberate experimentation," prison volunteers were used instead.[140] Yet, as Harry M. Marks records, "the engineers and physicists in charge were less comfortable than their medical associates with the idea of deliberately inflicting gonorrhea."[141]

The physicist Frank Jewett—the president of the National Academy of Sciences and a staunch advocate of scientific autonomy—was skeptical that such an experiment conducted on prison volunteers could in fact be truly voluntary.[142] He also questioned whether the medical experts who recommended the study had the requisite competence. Because the proposal raised ethical and even political issues, he reasoned, it was, in effect, a matter of public policy and not just science. And though the "scientific opinion" of his medical colleagues "might be the most authoritative in the world," their "opinion on a matter of public policy had no more value than that of any similar group of intelligent laymen."[143]

Episodes such as this should remind us that we can no more assume that the state's instrumentalization of science inevitably yields morally desirable outcomes than we can assume that left to its own devices, science inevitably produces socially useful research. History suggests that the fusion of science and the state is an ambivalent proposition, ripe with potential to exploit scientific knowledge for beneficent or pernicious ends, and thus with potential benefits and harms to both science and society. The roles scientists have come to acquire in modern society are similarly multifaceted, as are the ethical obligations that attend them.

Autonomy Against Technocracy and Populism

However misguided, the criticisms of scientific autonomy share a sense that its advocates are insufficiently attentive to the ways scientific knowledge has become intertwined with power. In the extreme, defending scientific autonomy is seen as tantamount to defending the power of expert elites over and against the people. Given its resonance with today's populist attitudes, this critique deserves more careful consideration.

There is no doubt that the vision of science propounded by the likes of Bush, Polanyi, and Shils is elitist, at least insofar as it recognizes the legitimate authority that derives from acquired competence.[144] Not everyone is or can be a scientist—just as not everyone is or can be a physician, a sharpshooter, or a pilot. Indeed, Bush, Polanyi, and Shils saw science as something distinctive and even noble—an "example of the good life," as Polanyi put it.[145] Shils was even more explicit: "Scientific activity is the activity of free men—not of all free men, but of those who have special gifts and qualifications—and its community is the epitome of the free society."[146] This vision certainly contrasts with the more participatory currents of the New Left as well as more recent calls to "democratize" science.[147]

Yet recognizing that science is in this sense an elite activity is quite different from seeking to invest scientific experts with political power.[148] The concept of scientific autonomy should not be confused with technocracy or the jejune scientism of those who today rally behind the banner of "follow the science."[149] To defend scientific autonomy is not to defend scientists' ability to make or influence political decisions with scant accountability. It is, on the contrary, to insist on a separation—imperfect,

partial, even aspirational—between science and politics, seeing them as distinct but mutually dependent spheres of our common life.[150] Maintaining this distinction requires that both spheres strive to respect their proper goals, obligations, and limits.

It is precisely by insisting on the distinction between knowledge and power that advocates of scientific autonomy hoped to counter the political program of what Shils called "total rationalization."[151] This political program—and not the sheer existence of science as an authoritative social practice—was the real threat to free society, even after the threat of Soviet-style planning had receded. The concept of scientific autonomy was in fact intended as a bulwark against it. The "traditionality" of science, Shils argued, "is an indication of the ineluctability of tradition" itself—and thus an obstacle to that political program which, appealing to science, strives to rationalize all of society.[152]

Scientific autonomy also contrasts with the populist counterreaction to technocracy, which echoes Soviet Marxism in seeing science as little more than ideological cover for economic or political interests. One way to describe the project of Bush, Polanyi, Shils, and other advocates of scientific autonomy is that they were trying to identify and protect the conditions under which science as a tradition could thrive and serve the wider society. Far from being guaranteed, they saw these conditions as under strain from an instrumentalism that found expression in ideological movements across the political spectrum, on the far left, the far right, and the soft, technocratic middle.

Securing the conditions under which science could flourish was a key component of what Shils called a "permanent task": preserving the plurality of institutions on which a free society depends.[153] Taking up this task today would not mean simply regurgitating these thinkers' ideas. Even if they could be said to form a single, flawless, and coherent whole, uncritically embracing those ideas would be both undesirable and infeasible, given all that has changed since their time. Instead, we should see these figures as adherents of a particular tradition that has fallen out of favor but that nevertheless offers resources for us today. What is needed is "a reformulation," as Shils put it, of the "traditional conception of the autonomy of intellectual life" adequate to our own instrumentalist moment.[154]

Recovering the Case for Scientific Autonomy

Recovering the case for scientific autonomy today would not entail severing science from the state, as in the more extreme forms of libertarianism. Bush, Polanyi, and Shils all recognized that the link between science and the state was inextricable and in many respects a good thing. (Shils referred to the movement to disestablish science as "childish prattle.")[155] These were hardly the anti-government "neoliberals" of left-wing caricature. They rightly acknowledged that the state can and should use science for common purposes—whether developing military technologies or vaccines, collecting demographic information, or measuring meteorological events—as it long has.

Bush, Polanyi, and Shils also recognized that, in principle at least, the state has a unique role to play in supporting science without undue rationalization—without excessive "control."[156] Besides its overtly utilitarian needs, such as building weapons and vaccines, the state can and should fund science—including "pure" science—not to correct alleged "market failures" but rather to nurture the conditions for scientific institutions to flourish alongside other vital institutions of democratic society. The state's reasons for doing so, of course, may ultimately be utilitarian. Paradoxically, however, those utilitarian ends are sometimes best served by keeping such utilitarianism in abeyance.

Of course, some areas or applications of scientific research—such as research on potential pandemic pathogens, human subjects, and human cloning—unavoidably raise ethical issues or pose potential societal harms.[157] Whether and how to pursue such research are questions that call for democratic deliberation about risks and benefits or for outright regulation, control, or even interdiction—all the more so when such research is funded or conducted by the state. This is a place in which Congress can—or at least should—play a more prominent role, not just in funding science, nor as a mechanism for planning it, but as a site of democratic contestation over its uses.[158]

The idea that the national legislature might act constructively in this way is not something that Bush, Polanyi, or Shils (or Kilgore or Kaempffert, for that matter) seemed to have seriously considered.[159] Yet reasserting

Congress's role in science policy should be central to any reformulation of the traditional conception of scientific autonomy today. This might entail a larger role for "lay" citizens and their political representatives in the governance of science than Bush, Polanyi, or Shils would have been comfortable with. But it would nevertheless do justice to the inherent pluralism of science and its uses, to which Shils rightly drew our attention.[160]

We of course need the instrumental goods of science—for protecting the environment and public health and for military preparedness, geopolitical competitiveness, and economic growth. Instrumentalism is an important—indeed ineliminable—aspect of the modern scientific enterprise, not to mention the primary reason the state supports science in the first place.[161] This is just as true today, in the context of our new cold war, as it was when Bush, Polanyi, and Shils rearticulated the concept of scientific autonomy in the context of theirs.[162] But science is ultimately more than its uses.

Recovering science policy means recognizing that science is "far from being only an instrument to be operated for increasing military power or for contributing to economic well-being," as Shils wrote.[163] It is, more fundamentally, a tradition—responsive to the social, economic, and political contexts from which it is inseparable but nevertheless possessing its own distinctive norms, goals, and standards of excellence that are valuable in their own right. Bush, Polanyi, and Shils remind us that the cultivation and maintenance of this tradition is essential to the future of not just science but also the institutional pluralism at the heart of free society.

About the Author

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Notes

1. For commentary on the return of industrial policy, see Anshu Siripurapu and Noah Berman, "Is Industrial Policy Making a Comeback?," Council on Foreign Relations, September 18, 2023, https://www.cfr.org/backgrounder/industrial-policy-making-comeback; and Ira Kalish and Michael Wolf, "The Return of Industrial Policy," Deloitte Insights, June 12, 2023, https://www2.deloitte.com/us/en/insights/economy/industrial-policy-us.html. For a critical assessment, see Michael R. Strain, "Why Industrial Policy Fails," Project Syndicate, August 15, 2023, https://www.project-syndicate.org/commentary/industrial-policy-why-it-fails-biden-subsidies-trump-tariffs-by-michael-r-strain-2023-08. For a center-right perspective more favorable to industrial policy, see Marco Rubio, "Industrial Policy, Right and Wrong," *National Affairs*, Spring 2024, https://www.nationalaffairs.com/publications/detail/industrial-policy-right-and-wrong.

2. For a sense of just how cyclical such arguments can often be, see Claude E. Barfield and William A. Schambra, eds., *The Politics of Industrial Policy* (Washington, DC: AEI Press, 1986), https://www.aei.org/wp-content/uploads/2014/07/-politics-of-industrial-policy_114213281403.pdf. Many of these insightful contributions read as if they were written today.

3. For some, this conflation is a feature and not a bug. See, for instance, David Adler and William B. Bonvillian, "America's Advanced Manufacturing Problem—and How to Fix It," *American Affairs* 7, no. 3 (Fall 2023), https://americanaffairsjournal.org/2023/08/americas-advanced-manufacturing-problem-and-how-to-fix-it.

4. See Richard R. Nelson and Richard N. Langlois, "Industrial Innovation Policy: Lessons from American History," *Science* 219, no. 4586 (February 18, 1983): 814–18, https://www.science.org/doi/10.1126/science.219.4586.814. For a reflection on the importance for policy of the differences among the various aspects of science, see Richard R. Nelson, "The Sciences Are Different and the Differences Matter," *Research Policy* 45, no. 9 (November 2016): 1692–701, https://www.sciencedirect.com/science/article/abs/pii/S0048733316300981.

5. See M. Anthony Mills and Ian R. Banks, "Enthusiasm for the CHIPS and Science Act Is Overblown," RealClearScience, August 11, 2022, https://www.realclearscience.com/articles/2022/08/11/enthusiasm_for_the_chips_and_science_act_is_overblown_847350.html. For a different perspective on the legislative history of the Endless Frontier Act, which also emphasizes the frustrated ambitions of the original bill, see Samuel Hammond, "How Congress Ruined the Endless Frontier Act," Niskanen Center, May 20, 2021, https://www.niskanencenter.org/how-congress-ruined-the-endless-frontier-act.

6. Chris Miller, "The Chips Act Has Been Surprisingly Successful So Far," *Financial Times*, April 25, 2024, https://www.ft.com/content/26756186-99e5-448f-a451-f5e307b13723; and Christine Mui, "How Congress Defanged Biden's Big Science Push," *Politico*, March 9, 2024, https://www.politico.com/news/2024/03/09/biden-touted-science-funding-but-congress-hollowed-out-his-promise-00146065.

7. Vannevar Bush, *Science: The Endless Frontier* (Washington, DC: US Government Printing Office, 1945), https://www.nsf.gov/about/history/EndlessFrontier_w.pdf.

8. Vannevar Bush to Bernard Baruch, October 24, 1945, quoted in Daniel J. Kevles, *The Physicists: The History of a Scientific Community in Modern America* (Cambridge, MA: Harvard University Press, 1978), 347.

9. On the history of the Bush-Kilgore debates, see Rexmond C. Cochrane, *The National Academy of Sciences: The First Hundred Years: 1863–1963* (Washington, DC: National Academy of Sciences, 1978), https://www.ncbi.nlm.nih.gov/books/NBK217886; Daniel J. Kevles, "The National Science Foundation and the Debate over Postwar Research Policy, 1942–1945: A Political Interpretation of *Science—The Endless Frontier*," *Isis* 68, no. 1 (March 1977): 5–26, http://www.jstor.org/stable/230370; Kevles, *The Physicists*, 51; Daniel Lee Kleinman, *Politics on the Endless Frontier: Postwar Research Policy in the United States* (Durham, NC: Duke University Press, 1995); William A. Blanpied, "Inventing US Science Policy," *Physics Today* 51, no. 2 (February 1998): 34–40, https://www.nsf.gov/about/history/nsf50/science_policy.jsp; William Blanpied and Neal Lane, *A History of Federal Science Policy from the New Deal to the Present*, Rice University, 2010, 56–57, https://hdl.handle.net/1911/112314; Claude E. Barfield, ed., *Science for the Twenty-First Century: The Bush Report Revisited* (Washington, DC: AEI Press, 1997); and G. Pascal Zachary, *Endless Frontier: Vannevar Bush, Engineer of the American Century* (Cambridge, MA: MIT Press, 1999). For the connection between the Bush-Kilgore debate and the science planning movement, see George A. Reisch, "Planning Science: Otto Neurath and the *International Encyclopedia of Unified Science*," *British Journal for the History of Science* 27, no. 2 (June 1994): 153–75; and George A. Reisch, "What a Difference a Decade Makes: The Planning Debates and the Fate of the Unity of Science Movement," in *Neurath Reconsidered: New Sources and Perspectives*, ed. Adam Tuboly and Jordi Cat (Cham, Switzerland: Springer, 2019), https://philpapers.org/rec/REIWAD-4. For the relevance of the Bush-Kilgore debate to present-day disputes about science and technology policy, see M. Anthony Mills and Mark P. Mills, "The Science Before the War," *New Atlantis*, Winter 2020, 19–34, https://www.thenewatlantis.com/publications/the-science-before-the-war; and M. Anthony Mills, "To Reshape Federal Science Funding, Lawmakers Should Look to the Past," RealClearScience, April 15, 2021, https://www.realclearscience.com/articles/2021/04/15/is_federal_science_funding_about_to_be_reshaped_772779.html.

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12. See National Science Foundation, *Leading the World in Discovery and Innovation, STEM Talent Development and the Delivery of Benefits from Research: NSF Strategic Plan for Fiscal Years 2022–2026*, 2022, https://www.nsf.gov/pubs/2022/nsf22068/nsf22068.pdf; and National Science Board, "National Science Board (NSB) 483rd Meeting—Day 1," YouTube, February 15, 2023, https://www.youtube.com/live/RlRJkqrLIjU?si=eLv6yIHTDZr0uUHG.

13. National Science Foundation, "NSF Establishes New Directorate for Technology, Innovation and Partnerships," March 16, 2022, https://new.nsf.gov/news/nsf-establishes-new-directorate-technology.

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22. George H. Daniels, *Science in American Society: A Social History* (New York: Alfred A. Knopf, 1971).

23. On Weber's distinction between types of rationality, see Max Weber, *Economy and Society: An Outline of Interpretive Sociology*, ed. Guenther Roth and Claus Wittich (Berkeley, CA: University of California Press, 1978), 1:24. For a classic account of the process of rationalization, see Max Weber, *The Protestant Ethic and the Spirit of Capitalism*, trans. Stephen Kalberg (London: Routledge, 2001). For Weber's account of bureaucracy, see Max Weber, "Bureaucracy," in *From Max Weber: Essays in Sociology*, trans. and ed. H. H. Gerth and C. Wright Mills (New York: Oxford University Press, 1946). For recent scholarship on Weber's concept of rationalization, see Jon Elster, "Rationality, Economy, and Society," in *The Cambridge Companion to Weber*, ed. Stephen Turner (Cambridge, UK: Cambridge University Press, 2000), 21–41; and Alan Sica, "Rationalization and Culture," in Turner, *The Cambridge Companion to Weber*, 42–58. See also Edward Shils, "Tradition and the Rationalization of Societies," in *Tradition* (Chicago: University of Chicago Press, 1981). For a helpful discussion of instrumental reason in the context of Weber's theory of rationalization and its epigones, see Jürgen Habermas, *The Theory of Communicative Action, Volume One: Reason and the Rationalization of Society*, trans. Thomas McCarthy (Boston, MA: Beacon Press, 1981), especially chap. 2 and chap. 4. For a recent discussion of the centrality of critiques of instrumental reason to 20th-century political theory, see M. Anthony Mills, "Saving Liberalism from Itself," The Dispatch, October 22, 2022, https://thedispatch.com/article/saving-liberalism-from-itself.

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25. This is the core insight of public choice theory. (The classic sources are James M. Buchanan, Mancur Olson, Anthony Downs, and William Niskanen.) For a libertarian-leaning critique of the CHIPS and Science Act drawing on public choice theory, see Scott Lincicome, "The 'Endless Frontier' and American Industrial Policy," The Dispatch, May 26, 2021, https://www.cato.org/commentary/endless-frontier-american-industrial-policy. See also Kealey, *The Economic Laws of Scientific Research*.

26. For classic treatments along these lines, which often take inspiration from Michel Foucault, see Thomas L. Haskell, ed., *The Authority of Experts: Studies in History and Theory* (Bloomington, IN: Indiana University Press, 1984), especially Eliot Freidson, "Are Professions Necessary?," 3–27; and Magali Sarfatti Larson, "The Production of Expertise and the Constitution of Expert Power," 28–80. Larson makes the Nietzschean overtones of this account of expertise explicit by appealing to Foucault's genealogical critique. Larson, "The Production of Expertise and the Constitution of Expert Power," 34–36. On this theme, see, more recently, Thomas F. Gieryn, "Boundaries of Science," in *Handbook of Science and Technology Studies*, rev. ed., ed. Sheila Jasanoff et al. (Thousand Oaks, CA: Sage Publications, 1995), 393–443. For a critique of these anti-realist approaches to expertise from within the field of science and technology studies, see Harry Collins and Robert Evans, *Rethinking Expertise* (Chicago: University of Chicago Press, 2007). For a different critique of Foucauldian accounts of expertise from within science and technology studies, see Stephen Turner, "What Is the Problem with Experts?," *Social Studies of Science* 31, no. 1 (February 2001): 123–49, http://www.jstor.org/stable/285821; and Stephen Turner, "The Significance of Shils," *Sociological Theory* 17, no. 2 (July 1999): 125–45, http://www.jstor.org/stable/202094. For the recent appropriation by the New Right of Foucault and other left-wing critiques of expertise, see especially Christopher Caldwell, "Meet the Philosopher Who Is Trying to Explain the Pandemic," *New York Times*, August 21, 2020, https://www.nytimes.com/2020/08/21/opinion/sunday/giorgio-agamben-philosophy-coronavirus.html; Edward Feser, "Scientism: America's State Religion," American Mind, August 25, 2020, https://americanmind.org/salvo/scientism-americas-state-religion; Geoff Shullenberger, "Theorycels in Trumpworld," Outsider Theory, January 5, 2021, https://outsidertheory.com/theorycels-in-trumpworld; Geoff Shullenberger "How We Forgot Foucault," *American Affairs* 5, no. 2 (Summer 2021), https://americanaffairsjournal.org/2021/05/how-we-forgot-foucault; Ross Douthat, "How Michel Foucault Lost the Left and Won the Right,"

New York Times, May 25, 2021, https://www.nytimes.com/2021/05/25/opinion/michel-foucault.html; Blake Smith, "The Unwoke Foucault," *Washington Examiner*, March 5, 2021, https://www.washingtonexaminer.com/magazine-life-arts/2227707/the-unwoke-foucault; and Blake Smith, "An Unlikely Intellectual Convergence," *City Journal*, October 20, 2021, https://www.city-journal.org/article/an-unlikely-intellectual-convergence.

27. This may be why, despite its disdain for the "expert class," today's "New Right" often winds up mirroring the Old Left's proposals for an emboldened administrative state. For a prominent example of Old Left–New Right alignment on administrative law, see Cass R. Sunstein and Adrian Vermeule, *Law & Leviathan: Redeeming the Administrative State* (Cambridge, MA: Belknap Press, 2020).

28. See A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities*, rev. ed. (Baltimore, MD: Johns Hopkins University Press, 1986); and A. Hunter Dupree, "Central Scientific Organisation in the United States Government," *Minerva* 1, no. 4 (Summer 1963): 453–69, http://www.jstor.org/stable/41821587.

29. See Howard S. Miller, *Dollars for Research: Science and Its Patrons in Nineteenth-Century America* (Seattle, WA: University of Washington Press, 1970), 146. The growth of the federal scientific establishment in the late 19th century was significant enough to prompt a congressional inquiry known as the Allison Commission. As Daniel J. Kevles puts it: "By the mid-1880s, federal science had accumulated sufficient prominence and power to warrant that telltale hallmark of arrival in the capital: the scrutiny of a lengthy congressional investigation." Daniel J. Kevles, "Not a Hundred Millionaires: The National Academy and the Expansion of Federal Science in the Gilded Age," *Issues in Science & Technology* 29, no. 2 (Winter 2013): 37–46, https://issues.org/daniel. On the Allison Commission, see also Kevles, *The Physicists*; Dupree, *Science in the Federal Government*; Dupree, "Central Scientific Organisation in the United States Government"; and, especially, David H. Guston, "Congressmen and Scientists in the Making of Science Policy: The Allison Commission, 1884–1886," *Minerva* 32, no. 1 (March 1994): 25–52. On the United States Geological Survey—which took center stage during the Allison Commission—see also Thomas G. Manning, *Government in Science: The U.S. Geological Survey, 1867–1894* (Lexington, KY: University of Kentucky Press, 1967); and Stephen Turner, "The Survey in Nineteenth-Century American Geology: The Evolution of a Form of Patronage," *Minerva* 25, no. 3 (September 1987): 282–330, http://www.jstor.org/stable/41820691.

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32. Dupree, *Science in the Federal Government*, 230.

33. On this theme, see Dupree, *Science in the Federal Government*; Dupree, "Central Scientific Organisation in the United States Government"; Kevles, *The Physicists*; Kevles, "Not a Hundred Millionaires"; Guston, "Congressmen and Scientists in the Making of Science Policy"; and Turner, "The Survey in Nineteenth-Century American Geology."

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www.ncbi.nlm.nih.gov/pmc/articles/PMC3001811/pdf/phr126000123a.pdf. See also M. Anthony Mills, "No One Is in Control," *Commonweal*, March 17, 2023, https://www.commonwealmagazine.org/yellow-fever-coronavirus-covid-epidemics-experts-science.

35. Alan Brinkley, *Liberalism and Its Discontents* (Cambridge, MA: Harvard University Press, 2000), 80–81.

36. For wartime accounts of the Public Health Service, see Laurence F. Schmeckebier, *The Public Health Service: Its History, Activities and Organization* (Baltimore, MD: Johns Hopkins Press, 1923); Bess Furman, *A Profile of the United States Public Health Service: 1798–1948* (Washington, DC: US Government Printing Office, 1973); James A. Tobey, *The National Government and Public Health* (Baltimore, MD: Johns Hopkins Press, 1926); Harden, *Inventing the NIH*; Duffy, *The Sanitarians*; and Dupree, *Science in the Federal Government*. For the Hygienic Laboratory in particular, see Victor Kramer, *The National Institute of Health: A Study in Public Administration* (New Haven, CT: Quinnipiack Press, 1937). For the history of the Chemical Warfare Service, see Leo P. Brophy, Wyndham D. Miles, and Rexmond C. Cochrane, *The Chemical Warfare Service: From Laboratory to Field* (Washington, DC: US Army Center of Military History, 1959); Leo P. Brophy, "Origins of the Chemical Corps," *Military Affairs* 20, no. 4 (Winter 1956): 217–26, https://www.jstor.org/stable/1983705; Joel A. Vilensky, *Dew of Death: The Story of Lewisite, America's World War I Weapon of Mass Destruction* (Bloomington, IN: Indiana University Press, 2005); Daniel P. Jones, "Chemical Warfare Research During World War I: A Model of Cooperative Research," in *Chemistry and Modern Society: Historical Essays in Honor of Aaron J. Ihde*, ed. John Parascandola and James C. Whorton (Washington, DC: American Chemical Society, 1983); Hugh R. Slotten, "Humane Chemistry or Scientific Barbarism? American Responses to World War I Poison Gas, 1915–1930," *Journal of American History* 77, no. 2 (September 1990): 476–98, https://www.jstor.org/stable/pdf/2079180.pdf; and Gilbert F. Whittemore Jr., "World War I, Poison Gas Research, and the Ideals of American Chemists," *Social Studies of Science* 5, no. 2 (May 1975): 135–63, https://journals.sagepub.com/doi/10.1177/030631277500500202. For a more recent history of military research during World War I, with particular reference to submarine technology, see Katherine C. Epstein, *Torpedo: Inventing the Military-Industrial Complex in the United States and Great Britain* (Cambridge, MA: Harvard University Press, 2014).

37. John J. Abel et al., *The Future Independence and Progress of American Medicine in the Age of Chemistry* (New York: Chemical Foundation, 1923). On this history, see Harden, *Inventing the NIH*. On the role of chemical warfare research in pioneering methods of cooperative research, see especially Jones, "Chemical Warfare Research During World War I."

38. On Neurath, see Reisch, "Planning Science"; and Reisch, "What a Difference a Decade Makes."

39. See J. D. Bernal, *The Social Function of Science* (London: George Routledge & Sons, 1939). For a 21st-century retrospective on Bernal, see Roger Pielke Jr., "In Retrospect: *The Social Function of Science*," *Nature* 507 (2014): 427–28, https://www.nature.com/articles/507427a. Bernal's influence is also considered and assessed in Mary Jo Nye, *Michael Polanyi and His Generation: Origins of the Social Construction of Science* (Chicago: University of Chicago Press, 2011), https://press.uchicago.edu/ucp/books/book/chicago/M/bo11669941.html; and Turner, "The Social Study of Science Before Kuhn." See also Elena Aronova, *Scientific History: Experiments in History and Politics from the Bolshevik Revolution to the End of the Cold War* (Chicago: University of Chicago Press, 2021).

40. Waldemar Kaempffert, "Dr. Bush Outlines a Plan for the Creation of a National Research Foundation," *New York Times*, July 22, 1945, https://nyti.ms/4bV7m0b.

41. Waldemar Kaempffert, "The Case for Planned Research," *American Mercury*, October 1943, 445, quoted in Kevles, "The National Science Foundation and the Debate over Postwar Research Policy, 1942–1945." On Kaempffert and his relationship to the science planning debates, see Reisch, "Planning Science"; and Reisch, "What a Difference a Decade Makes."

42. See Kevles, "The National Science Foundation and the Debate over Postwar Research Policy."

43. The definitive history of the Office of Scientific Research and Development (OSRD) is Irvin Stewart, *Organizing Scientific Research for War: The Administrative History of the Office of Scientific Research and Development* (Boston, MA: Little, Brown and Company, 1948). See also Cochrane, *The National Academy of Sciences*; and Mills and Mills, "The Science Before the War."

44. On the role of reform liberals in the debates over control of postwar federal research policy, see, especially, David M. Hart, *Forged Consensus: Science, Technology, and Economic Policy in the United States, 1921–1953* (Princeton, NJ: Princeton University Press, 1998).

45. See Blanpied, "Inventing US Science Policy"; and Zachary, *Endless Frontier*.

46. Kevles, "The National Science Foundation and the Debate over Postwar Research Policy."

47. Kaempffert, "Dr. Bush Outlines a Plan for the Creation of a National Research Foundation"; and Waldemar Kaepmffert, "For a Hierarchy of Scientists," *New York Times*, March 17, 1946, https://nyti.ms/3wR4UsL.

48. Bush, *Science: The Endless Frontier*. Bush was not wrong in so arguing. See Mills and Mills, "The Science Before the War."

49. A. Hunter Dupree, "The Great Instauration of 1940: The Organization of Scientific Research for War," in *The Twentieth-Century Sciences*, ed. Gerald Holton (New York: W. W. Norton, 1970).

50. Vannevar Bush, *The Essential Writings of Vannevar Bush*, ed. G. Pascal Zachary (New York: Columbia University Press, 2022), 145.

51. Bush, *The Essential Writings of Vannevar Bush*, 105.

52. On this theme, see Mills, "Is It Time for a U.S. Department of Science?"; and Dupree, "Central Scientific Organisation in the United States Government." See also Hart, *Forged Consensus*.

53. Kevles, "The National Science Foundation and the Debate over Postwar Research Policy"; and Kevles, *The Physicists*.

54. See Hart, *Forged Consensus*; and Kleinman, *Politics on the Endless Frontier*.

55. On this theme, see Kevles, *The Physicists*; and Kevles, "The National Science Foundation and the Debate over Postwar Research Policy."

56. See Mills, "Is It Time for a U.S. Department of Science?"; and Dupree, "Central Scientific Organisation in the United States Government." Dupree points out that the decision to dismantle OSRD was "one of the most unusual decisions in all of American political history. . . . For any group to possess such power and to display such skill in using it and then to declare as an article of faith that the whole system they had made to work could not possibly continue is by any standard remarkable."

57. Roger L. Geiger, "What Happened After Sputnik? Shaping University Research in the United States," *Minerva* 35, no. 4 (Winter 1997): 349–67, http://www.jstor.org/stable/41821079.

58. Kevles, *The Physicists*, 358.

59. Kevles, *The Physicists*, 359. On the growth of the postwar federal scientific establishment, see Geiger, "What Happened After Sputnik?" On the expansion of the National Institutes of Health in this period, see Stephen P. Strickland, *Politics, Science, and Dread Disease: A Short History of United States Medical Research Policy* (Cambridge, MA: Harvard University Press, 1972); and Blanpied, *A History of Federal Science Policy*.

60. See Paul Forman, "Behind Quantum Electronics: National Security as Basis for Physical Research in the United States, 1940–1960," *Historical Studies in the Physical and Biological Sciences* 18, no, 1 (January 1987): 149–229, https://online.ucpress.edu/hsns/article-abstract/18/1/149/47533/Behind-Quantum-Electronics-National-Security-as; and Naomi Oreskes and John Krige, eds., *Science and Technology in the Global Cold War* (Cambridge, MA: MIT Press, 2014), http://www.jstor.org/stable/j.ctt9qf6k8.

61. The classic treatment of this dynamic is Edward A. Shils, *The Torment of Secrecy: The Background and Consequences of American Security Policies* (Glencoe, IL: Free Press, 1956; Chicago: Elephant Paperback, 1996).

62. Daniel Bell, *The Coming of Post-Industrial Society: A Venture in Social Forecasting* (Harmondsworth, UK: Penguin, 1976), 260.

63. Clarence G. Lasby, "Science and the Military," in *Science and Society in the United States*, ed. David D. Van Tassel and Michael G. Hall (Homewood, IL: Dorsey Press, 1966), 276.

64. For the student movement and the "military-industrial complex," see Roger Geiger, *American Higher Education Since World War II: A History* (Princeton, NJ: Princeton University Press, 2019), 166.

65. J. Bronowski, "The Disestablishment of Science: I," *New York Times*, October 18, 1971, https://www.nytimes.com/1971/10/18/archives/the-disestablishment-of-science-i.html; and J. Bronowski, "The Disestablishment of Science: II," *New York Times*, October 19, 1971, https://www.nytimes.com/1971/10/19/archives/the-disestablishment-of-science-ii.html.

66. On this theme, see Jean-Jacques Salomon, *Science and Politics* (London: Macmillan, 1973); and Bell, *The Coming of Post-Industrial Society*, 385.

67. Bush, *Science: The Endless Frontier*.

68. Dwight D. Eisenhower, "President Dwight D. Eisenhower's Farewell Address" (speech, White House, Washington, DC, January 17, 1961), https://www.archives.gov/milestone-documents/president-dwight-d-eisenhowers-farewell-address.

69. Eisenhower, "President Dwight D. Eisenhower's Farewell Address."

70. Eisenhower, "President Dwight D. Eisenhower's Farewell Address."

71. Michael Polanyi, *The Logic of Liberty: Reflections and Rejoinders* (Chicago: University of Chicago Press, 1951; Indianapolis, IN: Liberty Fund, 1998), 7.

72. Polanyi, *The Logic of Liberty*, 6.

73. See Polanyi, *The Contempt of Freedom: The Russian Experiment and After* (London: Watts & Co., 1940). On Polanyi and Bukharin, see Nye, *Michael Polanyi and His Generation*, 194; Stephen Turner, "Polanyi Defanged," *Social Studies of Science* 42, no. 6 (December 2012): 945–53, https://journals.sagepub.com/doi/10.1177/0306312712458479; and Stephen Turner, "Polanyi's Social Theory: Was There One, and What Was It?," *Tradition and Discovery: The Polanyi Society Periodical* 47, no. 1 (February 2021): 11–16, http://polanyisociety.org/TAD%20WEB%20ARCHIVE/TAD47-1/Turner-tad-47-1-pg11-16.pdf. For a recent analysis more favorable to the views of Bukharin, Bernal, and other prominent Soviet-friendly planners, see Aronova, *Scientific History*.

74. Karl Marx and Friedrich Engels, *Die Deutsche Ideologie* [The German Ideology] (Moscow, Soviet Union: Marx-Engels-Lenin-Institut, 1932). The translation is by the author. For a complete English translation, see Karl Marx and Friedrich Engels, *The German Ideology*, ed. C. J. Arthur (New York: International Publishers, 1970). This is, to my knowledge, the first appearance of the term "pure" science in something like its modern—albeit here pejorative—sense. This suggests the chronology given by Robert Bud should be modified. (See Bud, "Applied Science.") Bud argues that before 1850, "pure science" referred not to natural science but rather to a priori metaphysics. It is notable in this connection that Marx's deployment of the term—in the 1840s, when *The German Ideology* was written—occurs in the midst of his critique of German idealism, in which context the term "pure" (*reine*) would likely have been understood to evoke Immanuel Kant's concept of the a priori. It therefore seems plausible that Marx—who places the term in quotation marks—is here deliberately repurposing a familiar Kantian term. (I'm grateful to Don Howard for the latter suggestion.)

75. As Shils put it in a piece for *Minerva* on the occasion of Polanyi's death: "The recession of the desire to 'plan' science on the model of the Soviet Union was not followed by the restoration of the belief in the intrinsic value of the understanding of nature. A less revolutionary but equally utilitarian justification for the support of science replaced it." Edward Shils, "A Great Citizen of the Republic of Science: Michael Polanyi, 1892–1976," *Minerva* 14, no. 1 (Spring 1976): 1–5, https://www.jstor.org/stable/41820262.

76. Polanyi, *The Logic of Liberty*, 4–5.

77. Polanyi, *The Logic of Liberty*, 3–4.

78. Polanyi, *The Logic of Liberty*, 191–92.

79. On tacit knowledge, see Polanyi, *The Tacit Dimension* (Garden City, NY: Doubleday and Company, 1966; Chicago: University of Chicago Press, 2009). For more recent work on the subject, see Harry Collins, *Tacit and Explicit Knowledge* (Chicago: University of Chicago Press, 2010).

80. Polanyi, *The Logic of Liberty*, 191.

81. See Polanyi, *The Logic of Liberty*, 195–203.

82. Polanyi, *The Logic of Liberty*, 205.

83. Polanyi, *The Logic of Liberty*, 6. This point seems utterly missed by Philip Mirowski in his otherwise informative paper, Philip Mirowski, "On Playing the Economics Trump Card in the Philosophy of Science: Why It Did Not Work for Michael Polanyi," in "Proceedings of the 1996 Biennial Meetings of the Philosophy of Science Association: Part II: Symposia Papers," ed. Lindley Darden, supplement, *Philosophy of Science* 64, no. S4 (December 1997): S127–38, https://www.jstor.org/stable/188396. He characterizes Polanyi's comparison of science to the market as "an initially plausible invisible hand argument [that] ended up as crude propaganda for the uniquely privileged social support of science."

84. For Shils's biographical and intellectual background, see Roy MacLeod, "Consensus, Civility, and Community: The Origins of *Minerva* and the Vision of Edward Shils," *Minerva* 54 (2016): 255–92, https://link.springer.com/article/10.1007/s11024-016-9305-x; Stephen Turner, "The Significance of Shils," *Sociological Theory* 17, no. 2 (July 1999): 125–45, http://www.jstor.org/stable/202094; and Christopher Adair-Toteff and Stephen Turner, eds., *The Calling of Social Thought: Rediscovering the Work of Edward Shils* (Manchester, UK: Manchester University Press, 2019).

85. "Minerva," *Minerva* 1, no. 1 (Autumn 1962): 5–17, https://www.jstor.org/stable/41821546.

86. Edward Shils, "*Minerva*: The Past Decade and the Next," *Minerva* 10, no. 1 (January 1972), 2, http://www.jstor.org/stable/41822127. "Only a few ignorant nuts . . . still talk about the 'planning of science' in the way in which those characters used to speak about it," Shils wrote in 1965 (quoted in MacLeod, "Consensus, Civility, and Community"). On this theme, see also Edward Shils, "Introduction," in *Criteria for Scientific Development: Public Policy and National Goals: A Selection of Articles from* Minerva, ed. Edward Shils (Cambridge, MA: MIT Press, 1968), v–xiv.

87. For a friendly critique of Polanyi's position, see Alvin M. Weinberg, "Criteria for Scientific Choice," in Shils, *Criteria for Scientific Development*, 21–33.
88. "Minerva," 10.
89. "Minerva," 15.
90. Shils, "Introduction."
91. Shils, *The Torment of Secrecy*, 77.
92. Shils, *The Torment of Secrecy*, 181.
93. See Nye, *Michael Polanyi and His Generation*.
94. "Society for Freedom in Science," *Nature* 154 (July 8, 1944): 48, https://www.nature.com/articles/154048a0; and "Minerva," 5. On the Society for Freedom in Science, see William McGucken, "On Freedom and Planning in Science: The Society for Freedom in Science, 1940–46," *Minerva* 16, no. 1 (Spring 1978): 42–72, https://www.jstor.org/stable/41827223. On *Minerva*, see MacLeod, "Consensus, Civility, and Community."
95. On the connection between *Minerva* and the Congress for Cultural Freedom, see Elena Aronova, "The Congress for Cultural Freedom, *Minerva*, and the Quest for Instituting 'Science Studies' in the Age of Cold War," *Minerva* 50, no. 3 (September 2012): 307–37, http://www.jstor.org/stable/43548587. For a classic (and critical) take on the Congress for Cultural Freedom, especially its notorious link to the CIA, see Frances Stonor Saunders, *Who Paid the Piper? The CIA and the Cultural Cold War* (London: Granta Books, 2000).
96. See Aronova, "The Congress for Cultural Freedom, *Minerva*, and the Quest for Instituting 'Science Studies' in the Age of Cold War."
97. For recent scholarship on these themes, see Ronald Kline, "Construing 'Technology' as 'Applied Science': Public Rhetoric of Scientists and Engineers in the United States, 1880–1945," *Isis* 86, no. 2 (June 1995), 194–221, https://www.journals.uchicago.edu/doi/abs/10.1086/357153; Paul Forman, "The Primacy of Science in Modernity, of Technology in Postmodernity, and of Ideology in the History of Technology," *History and Technology* 23, no. 1–2 (March–June 2007), 1–152; Roger Pielke Jr., "'Basic Research' as a Political Symbol," *Minerva* 50, no. 3 (September 2012), 339–61, https://www.jstor.org/stable/43548588; Schauz, "What Is Basic Research?"; Bud, "Applied Science"; Schatzberg, "From Art to Applied Science"; Gooday, "Vague and Artificial"; Alexander, "Thinking Again About Science in Technology"; Lucier, "The Origins of Pure and Applied Science in Gilded Age America"; and Kaldewey and Schauz, "Transforming Pure Science into Basic Research."
98. Hounshell, "Edison and the Pure Science Ideal in 19th-Century America," 612. Similarly, George H. Daniels refers to the "development" in the 1870s of a "generally shared ideology, of the notion of science for science's sake." George H. Daniels, "The Pure-Science Ideal and Democratic Culture," *Science* 156, no. 3783 (June 30, 1967): 1699–705, https://www.jstor.org/stable/1722253. The self-serving nature of such "boundary work" is a central theme in much scholarly literature critical of the concepts of expertise and professionalism. See, for instance, Larson, "The Production of Expertise and the Constitution of Expert Power." For a helpful discussion of these themes, see Gieryn, "Boundaries of Science."
99. For recent examples of this trope, see Bud, "'Applied Science'"; Gooday, "Vague and Artificial"; and Heather Douglas and T. Y. Branch, "The Social Contract for Science and the Value-Free Ideal," *Synthese* 203 (2024): 1–20, https://link.springer.com/article/10.1007/s11229-023-04477-9.
100. See Bruno Latour, *Science in Action: How to Follow Scientists and Engineers Through Society* (Cambridge, MA: Harvard University Press, 1988). The term is due to Gilbert Hottois, *Le signe et la technique: La philosophie à l'épreuve de la technique* (Paris, France: Aubier, 1984). For recent debates over the concept of "technoscience," see Bensaude-Vincent et al., "Matters of Interest: The Objects of Research in Science and Technoscience," *Journal for General Philosophy of Science* 42, no. 2 (November 2011): 365–83, https://www.jstor.org/stable/41478313; Bernadette Bensaude-Vincent, "Technoscience and Convergence: A Transmutation of Values?" (paper, Summerschool on Ethics of Converging Technologies, Romrod, Germany, September 21–26, 2008), https://shs.hal.science/halshs-00350804/document; Alfred Nordmann, "Collapse of Distance: Epistemic Strategies of Science and Technoscience," *Danish Yearbook of Philosophy* 41 (2006): 7–34, https://brill.com/view/journals/dyp/41/1/article-p7_7.xml; Martin Carrier and Alfred Nordmann, eds., *Science in the Context of Application* (Dordrecht, Netherlands: Springer, 2010); and Alfred Nordmann, Hans Radder, and Gregor Schiemann, eds., *Science Transformed? Debating Claims of an Epochal Break* (Pittsburgh, PA: University of Pittsburgh Press, 2011). See also Mills, "The Case Against STEM." The emphasis in recent decades on the interpenetration of science and technology—and the related repudiation of "pure science"—is connected to, and may partly be explained by, the eclipse of "internalist" methods in the history of science. On this theme, see especially Arnold Thackray, "Science: Has Its Present Past a Future?," *Historical and Philosophical Perspectives of Science* (Minneapolis, MN: University of Minnesota Press, 1970), 112–33; and Steven Shapin, "Discipline and Bounding: The History and Sociology of Science as Seen Through the Externalism-Internalism Debate," *History of Science* 30 (1992): 333–69, https://journals.sagepub.com/doi/10.1177/007327539203000401. See also Forman, "The Primacy of Science in Modernity."
101. On the relevance of this fallacy for the concept of "boundary work" in science and technology studies, see Harry Collins, "Performances and Arguments," *Metascience* 21, no. 2 (July 2012): 409–18, https://link.springer.com/article/10.1007/s11016-011-9562-0.
102. As David Kaldewey and Désirée Schauz rightly note, it would be both unfair and inaccurate to "reduce the pure science ideal to this kind of boundary work." Kaldewey and Schauz, "Transforming Pure Science into Basic Research," 115, https://www.berghahnbooks.com/downloads/OpenAccess/KaldeweyBasic/9781785338113_OA.pdf#page=129.
103. Bush, *The Essential Writings of Vannevar Bush*, 222. Also published as Vannevar Bush, "The Search for Understanding," *American Scientist* 56, no. 3 (Autumn 1968): 298–302, http://www.jstor.org/stable/27828193.
104. Harry Collins and Robert Evans, *Why Democracies Need Science* (Cambridge, UK: Polity, 2017), 33–34. For background on this concept, see Harry Collins and Martin Kusch, *The Shape of Actions: What Humans and Machines Can Do* (Cambridge, MA: MIT Press, 1998).
105. See Kevles, *The Physicists*, 293. For general background, see Zachary, *Endless Frontier*.
106. Vannevar Bush, *Pieces of the Action* (New York: William Morrow and Company, 1970), 54, quoted in M. Granger Morgan, *Theory and Practice in Policy Analysis: Including Applications in Science and Technology* (Cambridge, UK: Cambridge University Press, 2017), 505.
107. Bush, *Pieces of the Action*, 54.
108. For a recent version of this critique, see Douglas and Branch, "The Social Contract for Science and the Value-Free Ideal."
109. On the difference between "pure" and "basic" science, frequently overlooked by advocates and critics alike, see Schauz, "What Is Basic Research?"; and Kaldewey and Schauz, "Transforming Pure Science into Basic Research."
110. David Edgerton, "'The 'Linear Model' Did Not Exist: Reflections on the History and Historiography of Science and Research in Industry in the Twentieth Century," in *The Science-Industry Nexus: History, Policy, Implications*, ed. Karl Grandin, Nina Wormbs, and Sven Widmalm (Saga-

more Beach, MA: Science History Publications, 2004), https://www.researchgate.net/publication/313772710_%27The_Linear_Model%27_Did_Not_Exist_Reflections_on_the_History_and_Historiography_of_Science_and_Research_in_Industry_in_the_Twentieth_Century; and Benoît Godin, "The Linear Model of Innovation: The Historical Construction of an Analytical Framework Science," *Technology and Human Values* 31, no. 6 (November 2006): 639–67, https://journals.sagepub.com/doi/abs/10.1177/0162243906291865.

111. As he put it in one of the more notorious passages from *Science: The Endless Frontier*: "As long as . . . scientists are free to pursue the truth wherever it may lead, there will be a flow of new scientific knowledge to those who can apply it to practical problems in Government, in industry, or elsewhere." Bush, *Science: The Endless Frontier*, 9. Such passages suggest that, far from exaggerating the differences between "basic" science and its technological applications, as many of his critics have suggested, Bush if anything greatly exaggerated how closely linked science and technology really are. (On this theme, see Layton, "Mirror-Image Twins.") Yet as the above quotation from his address to the Massachusetts Institute of Technology illustrates, Bush in fact disavowed the crude utilitarianism on which the postwar scientific establishment came to be based.

112. Most historians now agree that ascribing the "linear model" to Bush's ideas is a highly partial and misleading interpretation. Key sources for the revisionist account of Bush are Nathan Reingold, "Vannevar Bush's New Deal for Research: Or the Triumph of the Old Order," *Historical Studies in the Physical and Biological Sciences* 17, no. 2 (January 1987), 299–344, https://online.ucpress.edu/hsns/article-abstract/17/2/299/47707/Vannevar-Bush-s-New-Deal-for-Research-Or-the; Larry Owens, "The Counterproductive Management of Science in the Second World War: Vannevar Bush and the Office of Scientific Research and Development," *Business History Review* 68, no. 4 (Winter 1994): 515–76, https://www.cambridge.org/core/journals/business-history-review/article/abs/counterproductive-management-of-science-in-the-second-world-war-vannevar-bush-and-the-office-of-scientific-research-and-development/864F261BE1D539FA648E52CC89D59B19; and especially Zachary, *Endless Frontier*. See also Edgerton, "The 'Linear Model' Did Not Exist." Still, some critics persist in repeating this canard (including, most recently, Douglas and Branch, "The Social Contract for Science and the Value-Free Ideal").

113. See Vannevar Bush, "The Builders," in *The Essential Writings of Vannevar Bush*, 100.

114. Quoted in Barfield, *Science for the Twenty-First Century*, 4.

115. Daniel Sarewitz, "Normal Science and Limits on Knowledge: What We Seek to Know, What We Choose Not to Know, What We Don't Bother Knowing," *Social Research* 77, no. 3 (Fall 2010): 997–1010, https://www.jstor.org/stable/40972304.

116. Bush, *The Essential Writings of Vannevar Bush*, 309–10.

117. Reingold, "Vannevar Bush's New Deal for Research," 342.

118. Bush, *The Essential Writings of Vannevar Bush*, 307–8.

119. See Nye, *Michael Polanyi and His Generation*. For a more critical take on this idea, see Turner, "Polanyi Defanged."

120. The most recent and forceful version of this critique is Douglas and Branch, "The Social Contract for Science and the Value-Free Ideal."

121. Douglas and Branch, "The Social Contract for Science and the Value-Free Ideal," 12.

122. Bush, *The Essential Writings of Vannevar Bush*, 41, 52.

123. Quoted in Owens, "The Counterproductive Management of Science in the Second World War," 525.

124. Reingold, "Vannevar Bush's New Deal for Research," 335.

125. Reingold, "Vannevar Bush's New Deal for Research," 335.

126. Quoted in Reingold, "Vannevar Bush's New Deal for Research," 335.

127. Edward Shils, *The Atomic Bomb in World Politics* (London: National Peace Council, 1948). See MacLeod, "Consensus, Civility, and Community."

128. "Minerva," 9–10.

129. As Shils himself put it: "I myself would perhaps lay greater weight than Michael Polanyi on the obligations which scientists and scholars and scientific and academic institutions have for the well-being of their societies. . . . I would not attribute less importance than he would to the uncompromisable obligation of original and important discovery and the consequent enrichment of our traditions." Shils, "A Great Citizen of the Republic of Science," 4.

130. For a clear argument for why the ideal of scientific autonomy cannot be value neutral (but which takes a rather different tack from the one taken here), see Dan Hicks, "On the Ideal of Autonomous Science," *Philosophy of Science* 78, no. 5 (December 2011): 1235–48, https://www.cambridge.org/core/journals/philosophy-of-science/article/abs/on-the-ideal-of-autonomous-science/28052036091DD61FA55132CCDB793BCE.

131. See Polanyi, *The Logic of Liberty*, 3–8.

132. Douglas and Branch draw a tight connection between the concept of scientific autonomy, the linear model, the idea of "freedom from responsibility," and the so-called value-free ideal. Douglas and Branch, "The Social Contract for Science and the Value-Free Ideal."

133. "At some time or other," Polanyi observed, "it has been invoked in protection of the worst forms of exploitation, including even the keeping of slaves." Polanyi, *The Logic of Liberty*, 40.

134. Polanyi, *The Logic of Liberty*, 40, 194.

135. See Polanyi, *The Logic of Liberty*, 193–94, 237–46.

136. On Polanyi's distinction between public and private liberty, see Polanyi, *The Logic of Liberty,* 39–58, 193–94, 237–46.

137. Polanyi, *The Logic of Liberty*, 194.

138. On the Public Health Service's involvement in the Tuskegee experiment and other ethically compromised clinical studies, see note 139. The Public Health Service was also involved in a range of eugenicist and other morally problematic forms of social control in the early decades of the 20th century. For instance, a World War I–era law charged the Public Health Service with conducting medical inspections of immigrants to exclude "idiots, imbeciles, feeble-minded persons" and "persons not comprehended within any of the foregoing excluded classes who are found to be and are certified by the examining surgeon as being mentally or physically defective." (Quoted in Schmeckebier, *The Public Health Service*, 43.) Another law from that era, the notorious Chamberlain-Kahn Act, called for the establishment of the ominously named Interdepartmental Social Hygiene Board, which launched overtly paternalistic programs of sexual regulation that have since become the object of intense critical scrutiny by scholars, especially for discriminatory impacts on women. On the Interdepartmental Social Hygiene Board, see Tobey, *The National Government and Public Health*, 111–12; and "The Social Hygiene Movement," editorial, *American Journal of Public Health* 3, no. 11 (November 1913): 1154–57, https://ajph.aphapublications.org/doi/pdf/10.2105/AJPH.3.11.1154. For critical scholarship, see Kristin Luker, "Sex, Social Hygiene, and the State: The

Double-Edged Sword of Social Reform," *Theory and Society* 27, no. 5 (October 1998): 601–34; and Scott W. Stern, *The Trials of Nina McCall: Sex, Surveillance, and the Decades-Long Government Plan to Imprison "Promiscuous" Women* (Boston, MA: Beacon Press, 2018).

139. For an account of this episode, see Harry M. Marks, *The Progress of Experiment: Science and Therapeutic Reform in the United States, 1900–1990* (Cambridge, UK: Cambridge University Press, 1997), 101–4. On the ethical issues raised by this study and its influence on other ethically problematic clinical studies—such as syphilis research in Guatemala after the war and the notorious Tuskegee experiment—see Presidential Commission for the Study of Bioethical Issues, "'Ethically Impossible': STD Research in Guatemala from 1946 to 1948," September 2011, https://law.stanford.edu/wp-content/uploads/2011/09/EthicallyImpossible_PCSBI_110913.pdf; David J. Rothman, "Ethics and Human Experimentation," *New England Journal of Medicine* 317, no. 19 (November 5, 1987); and David J. Rothman, *Strangers at the Bedside: A History of How Law and Bioethics Transformed Medical Decision Making* (New York: Basic Books, 1992).

140. Marks, *The Progress of Experiment*, 101.

141. Marks, *The Progress of Experiment*, 103.

142. Marks, *The Progress of Experiment*, 104.

143. Marks, *The Progress of Experiment*, 103.

144. On this theme, see M. Anthony Mills, "Manufacturing Consensus," *New Atlantis*, Fall 2021, 30–46, https://www.thenewatlantis.com/publications/manufacturing-consensus.

145. Polanyi, *The Logic of Liberty*, 7.

146. Shils, *The Torment of Secrecy*, 190.

147. On democratizing science, see, for instance, David Guston, "Democratizing Science: Ends, Means, Outcomes," in *The Rightful Place of Science: Politics*, ed. G. Pascal Zachary (Tempe, AZ: Consortium for Science, Policy and Outcomes, 2013), 39–47. "Democratizing science" has become a major theme in science and technology studies in recent decades, but it, too, has a longer prehistory, dating especially to the postwar decades. For sources on the democratization of science, see, for example, Sabine Maasen and Peter Weingart, eds., *Democratization of Expertise? Exploring Novel Forms of Scientific Advice in Political Decision-Making* (Dordrecht, Netherlands: Springer, 2005). For the postwar history of efforts to democratize science and technology, see M. Anthony Mills, *Reviving Technology Assessment: Learning from the Founding and Early History of Congress' Office of Technology Assessment*, American Enterprise Institute, May 24, 2021, https://www.aei.org/research-products/report/reviving-technology-assessment-learning-from-the-founding-and-early-history-of-congress-office-of-technology-assessment.

148. On this distinction, see Collins and Evans, *Why Democracies Need Science*. See also Harry Collins and M. Anthony Mills, "Science as Craftwork with Integrity," *New Atlantis*, Winter 2022, 53–70.

149. For analysis of how the allure of scientism warped discussions about the role of scientific expertise in policymaking during the COVID-19 pandemic, see M. Anthony Mills, "Unmasking Scientific Expertise," *Issues in Science and Technology* 37, no. 4 (Summer 2021), 84–88, https://issues.org/unmasking-scientific-expertise-covid-mills; and M. Anthony Mills, "The Masking Debate We Didn't Have," *New Atlantis*, Summer 2023, 108–127, https://www.thenewatlantis.com/publications/the-masking-debate-we-didnt-have.

150. On the aspirational nature of this distinction, see Collins and Mills, "Science as Craftwork with Integrity."

151. Shils, *Tradition*, 319.

152. Shils, *Tradition*, 311.

153. Shils, *Tradition*, 323. For Shils's views on political pluralism, see Shils, *The Torment of Secrecy*, 225–38.

154. "Minerva," 10.

155. Shils, "*Minerva*: The Past Decade and the Next."

156. The question of degree here is important. Bush, we saw, believed there was an important, if limited (and sometimes temporary), role for organization in scientific and technological research. But neither Shils nor Polanyi opposed all planning or rationalization either. As Shils put it, "a fully rational policy is unattainable," since an algorithm or "code" for scientific choice likely "cannot in the nature of things be attained." Yet a "more rational discussion of the alternatives of policy is attainable." He saw *Minerva* as making "contributions to the movement in that direction." Shils, "Introduction," xiii. On the circumscribed but nevertheless important role of planning (especially in "applied" science) recognized by advocates of scientific autonomy, including Polanyi, see McGucken, "On Freedom and Planning in Science."

157. On the ethical responsibilities entailed by dual-use research, see Heather Douglas, "Scientific Freedom and Social Responsibility," in *Science, Freedom, Democracy*, ed. Péter Hartl and Adam Tamas Tuboly (New York: Routledge, 2021).

158. Here we can take inspiration from past efforts to build the legislative capacity to respond to the complex challenges and opportunities posed by science and its uses—as in the 1960s and 1970s, when Congress created the Office of Technology Assessment for precisely this purpose. M. Anthony Mills, *The Role of Judgment and Deliberation in Science-Based Policy*, American Enterprise Institute, June 4, 2021, https://www.aei.org/research-products/report/the-role-of-judgment-and-deliberation-in-science-based-policy; and Mills, *Reviving Technology Assessment*.

159. Bush later observed that "there were those who protested that the action of setting up [the National Defense Research Committee] was an end run, a grab by which a small company of scientists and engineers, acting outside established channels, got hold of the authority and money for the program of developing new weapons. That, in fact, is exactly what it was." Bush, *Pieces of the Action*, 31–32. For an extended discussion of the role of the legislature vis-à-vis bureaucrats, scientists, and the "intelligentsia," see Edward A. Shils, "The Strain of Politics," in *The Torment of Secrecy*, 105–49. Arguably, Congress's role in science and technology policy also gets short shrift by many present-day advocates of "participatory" approaches to the governance of science and technology, who generally focus on increasing citizen participation outside the traditional mechanisms for political representation and deliberation. On participatory methods, see especially Richard Sclove, *Reinventing Technology Assessment: A 21st Century Model*, Woodrow Wilson International Center for Scholars, Science and Technology Innovation Program, April 2010, https://www.wilsoncenter.org/sites/default/files/media/documents/publication/ReinventingTechnologyAssessment1.pdf; and Leah R. Kaplan et al., "Designing Participatory Technology Assessments: A Reflexive Method for Advancing the Public Role in Science Policy Decision-Making," *Technological Forecasting and Social Change* 171 (October 2021), https://www.sciencedirect.com/science/article/abs/pii/S0040162521004066. On the role of Congress, in particular, see Mills, *Reviving Technology Assessment*.

160. The inherent pluralism of science and technology—and thus the modes of governance called for in different circumstances—was a prominent feature in public discussions of science and technology policy during the 1960s and 1970s. Consider, for instance, how a National Academy of

Sciences report from that era describes the scope of "technology assessment": Its "concern . . . is not with the effects of science—what man knows or hypothesizes about his world—but with the effects of technology—what man can do and chooses to do with what he knows." National Academy of Sciences, Committee on Science and Astronautics, "Technology: Process of Assessment and Choice," July 1969, 24. Nowadays, discussions of democratizing science, including discussions of technology assessment and participatory technology assessment, tend to reject or at least ignore the distinction between science and technology.

161. On the ineliminable, though not essential, nature of instrumentalism in modern science, see Peter Dear, *The Intelligibility of Nature: How Science Makes Sense of the World* (Chicago: University of Chicago Press, 2006).

162. Hal Brands and John Lewis Gaddis, "The New Cold War: America, China, and the Echoes of History," *Foreign Affairs*, October 19, 2021, https://www.foreignaffairs.com/articles/united-states/2021-10-19/new-cold-war.

163. Shils, *The Torment of Secrecy*, 190.

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