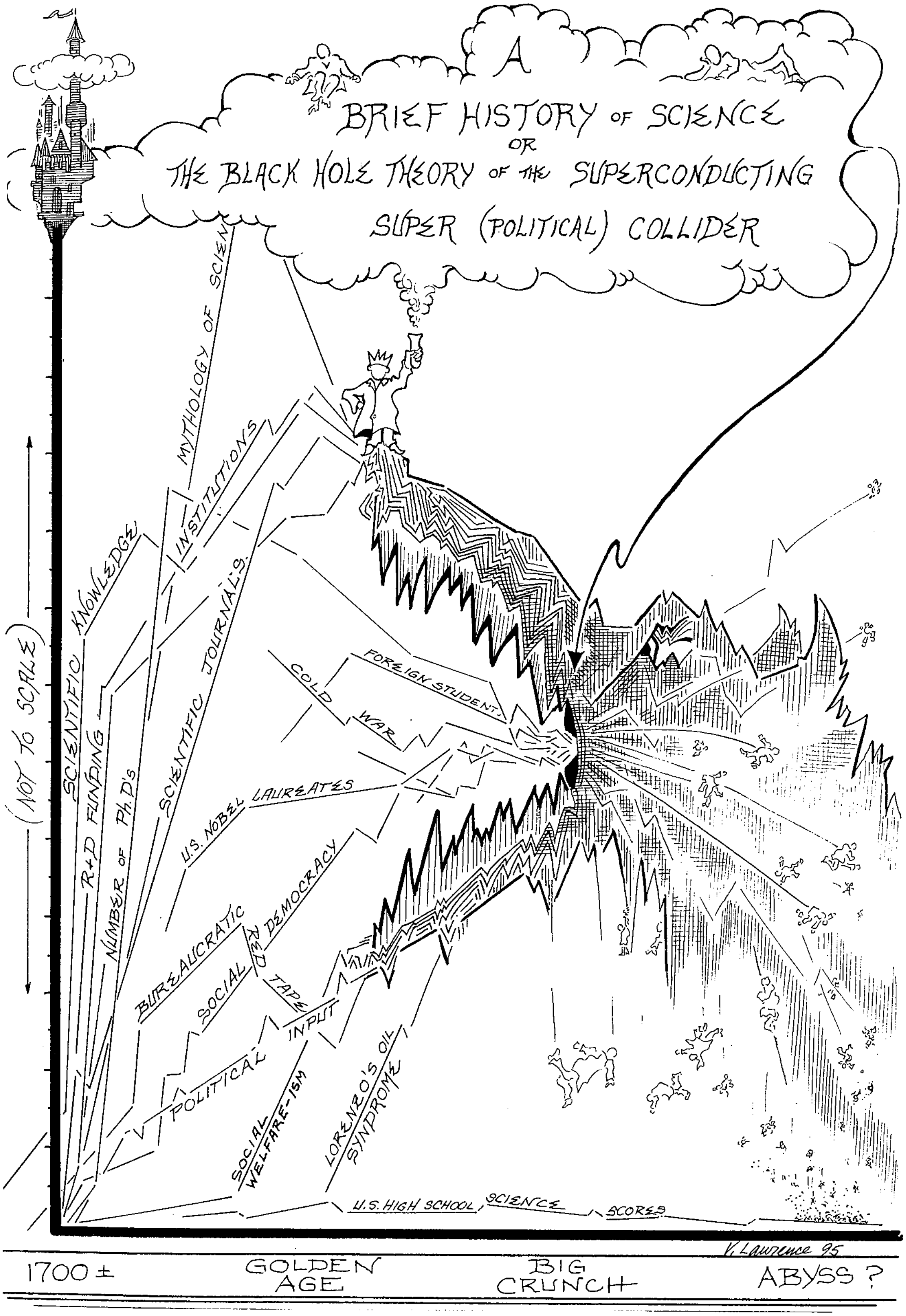
A BRIEF HISTORY of SCIENCE
OR
THE BLACK HOLE THEORY of the SUPERCONDUCTING SUPER (POLITICAL) COLLIDER
MYTHOLOGY OF SCIEN
INSTITUTIONS
SCIENTIFIC KNOWLEDGE
SCIENTIFIC JOURNALS
(NOT TO SCALE)
R+D FUNDING
NUMBER OF Ph.D's
FOREIGN STUDENT
COLD WAR
U.S. NOBEL LAUREATES
BUREAUCRATIC
RED TAPE
DEMOCRACY
SOCIAL INPUT
POLITICAL
SOCIAL WELFARE-ISM
LORENZO'S OIL SYNDROME
U.S. HIGH SCHOOL SCIENCE SCORES
V. Lawrence 95
1700 ±
GOLDEN AGE
BIG CRUNCH
ABYSS ?

The Crisis of Contemporary Science

With the United States no longer engaged in war, hot or cold, American science is entering a new—and uncertain—age. The close relationship between science and government is being redefined. The exponential growth of the scientific enterprise is at an end. And science itself comes increasingly under attack. Our authors explain.

THE CHANGED PARTNERSHIP

BY DANIEL J. KEVLES

Not many years ago in the United States, the special relationship between science and government seemed as permanent as an old-fashioned marriage. Whatever one partner requested, the other was more than eager to provide.

In the early 1980s, for example, American physicists in the field of high-energy particle physics urged the Reagan administration to fund construction of a gargantuan high-energy particle accelerator—the Superconducting Super Collider, commonly called the SSC. In an underground, circular tunnel some 52 miles in circumference, two beams of protons would be accelerated in opposite directions, each to an energy of 20 trillion electron volts. The huge subterranean donut would encircle an area 160 times as great as that enclosed by the Tevatron, at the Fermi National Accelerator Laboratory in Batavia, Illinois, which is the country's flagship machine, spitting out particles at one trillion electron volts.

Enthusiasts of the SSC argued that it was essential to further progress in elementary particle physics. Not only would it guarantee the nation's strength in the field against all international competitors, but the technical innovations required to build the machine—for example, more powerful superconducting magnets—would yield industrial and medical dividends long into the future. In 1987, the project won the support of the Reagan administration, and in 1989, Congress voted decisively to fund construction of the machine—it would be located in Waxahachie, Texas, near Dallas—at a cost of $5.9 billion.

Then, astonishingly, just three years later, the partnership faltered. In June 1992, the House of Representatives voted to terminate the SSC. The margin of defeat for the project was a hefty 51 votes. Scientists who supported the Collider were stunned. Forty physicists, including 21 Nobel laureates, expressed their shock and dismay in a letter to President George Bush and House members, pointing out the SSC's importance to America's scientific prowess. The Bush administration and the Senate then came to the project's rescue. The next year, however, the House tried again, and this time it succeeded. In October 1993, the SSC died, a victim of the post–Cold War outlook. Senator Dave Durenberger (R.-Minn.) explained the change in blunt terms: "If we were engaged in a scientific competition with a global superpower like the former Soviet Union, and if this project would lead to an enhancement of our national security, then I would be willing to continue funding the project. But . . . we face no such threat."

Leading physicists were profoundly dismayed by the collider's demise. They variously declared that high-energy physics had no future in the United States, that the country was relinquishing its role as a scientific leader, and that, as Roy Schwitters, the head of the project, remonstrated, "curiosity-driven science is [now regarded as] somehow frivolous and a luxury we can no longer afford." Some scientists, with a mixture of resentment and regret, declared that the long-standing partnership between American science and the federal government had come to an end.

In fact, it hadn't. But the alliance *is* being redefined. To understand what is happening, it is necessary to go back to the partnership's beginning.

During World War II, civilian scientists working under the auspices of the Office of Scientific Research and Development (OSRD) achieved military miracles. The physicists—who produced microwave radar, proximity fuses, solid-fuel rockets, and the atomic bomb—were the most conspicuous of the scientists, but members of the OSRD Committee on Medical Research also brought off several miracles, including the development of penicillin.

With the war nearing its conclusion, it seemed evident to many policymakers and scientists that for the sake of the nation's military security, public health, and economic welfare, the federal government should support programs of basic and applied scientific research and training in academic institutions, the traditional source of new scientific knowledge and new scientists. The question was how to do so. Two fundamentally different approaches competed for acceptance.

Senator Harley M. Kilgore, a New Deal Democrat from West Virginia and a staunch ally of organized labor, favored what could be called a "social welfare" approach. Kilgore, a small-town lawyer, National Guardsman, Legionnaire, Mason, and past Exalted Ruler of an Elks lodge, was quick to admit "utter, absolute ignorance" of science and technology. However, during wartime hearings on ways of better mobilizing the nation's technological resources, he had learned a good deal about the importance of science to the national interest. Now, looking ahead to postwar America, he began to develop legislation that called for federal research activities to be planned in accordance with liberal social purposes such as aiding small business, fostering pollution control, and providing low-cost rural electrification. Kilgore also wanted at least part of the money in all scientific fields to be distributed geographically. And he urged federal support of the social sciences, then widely regarded as tools for distributing the benefits of science and technology more equitably.

Opposing Kilgore's social welfare notions were Vannevar Bush, head of OSRD, and most of America's high-level research scientists. The Massachusetts-born son of a minis-

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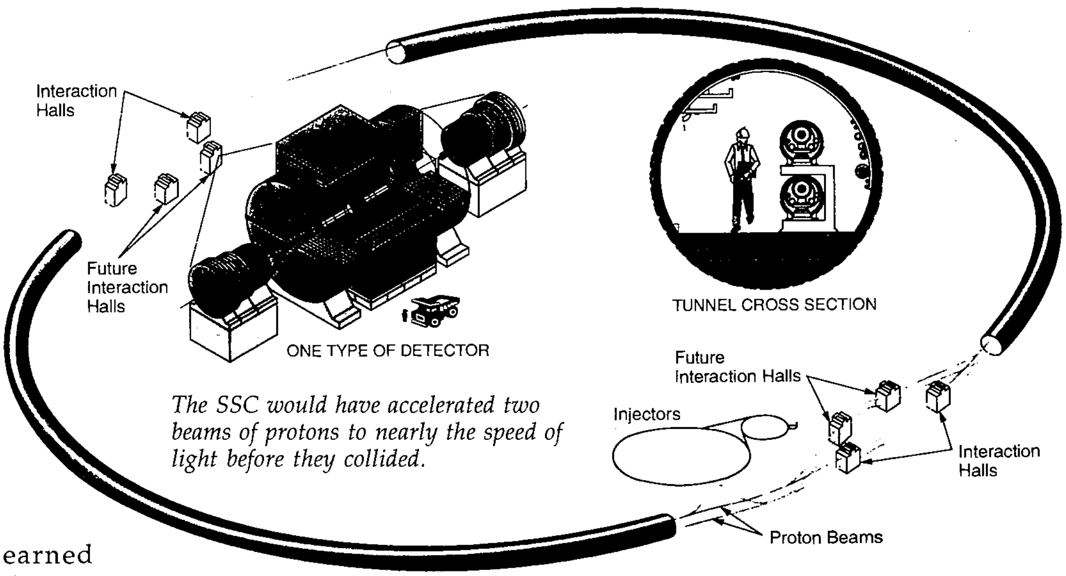
ter, Bush (1890–1974) was a no-nonsense electrical engineer with a strong sense of public service. He had spent most of his prewar career on the faculty of the Massachusetts Institute of Technology, where the electrical engineering curriculum emphasized training in the basic sciences and the department stressed research. During his MIT years, he earned distinction for his own research, especially for the invention and development of the differential analyzer, an early type of computer. He also played an influential role in transforming MIT into a research-oriented institution at the vanguard of both high-tech engineering and basic science.

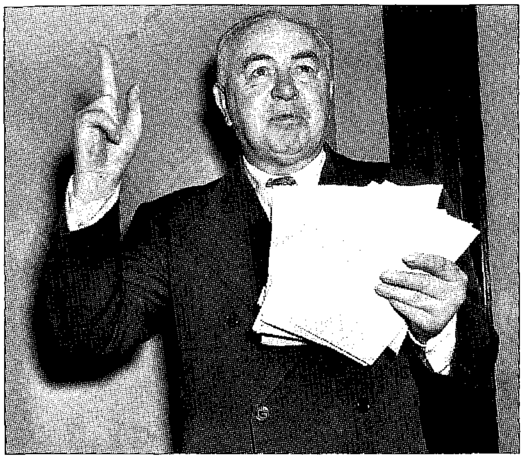
Bush fully recognized the powerful inclination in America's "practical" culture to foster the applications of knowledge rather than the advancement of knowledge as such. From the war effort, he also knew that advances in esoteric, seemingly impractical fields such as nuclear physics and microbiology could lead to the creation of powerful new weapons and medical agents. In his view, the wartime production of such technological miracles as the atomic bomb and penicillin had drawn heavily on the capital of basic science, and by doing so had retarded the growth of fundamental knowledge and depleted the supply of trained men and women able to generate it. The welfare of the nation demanded the replenishment and enlargement of its scientific investment. But this had to be done in the right way—and that way, he was sure, was not Kilgore's.



The SSC would have accelerated two beams of protons to nearly the speed of light before they collided.

Partly to head off the senator, Bush persuaded President Franklin D. Roosevelt to ask him to prepare a report on postwar science policy. Bush delivered the report to President Harry S Truman in July 1945, outlining a policy that, in its essentials, would ultimately prevail.

Bush's approach in *Science—the Endless Frontier*, as the report was called, could not have been more different from Kilgore's. Unlike the senator, Bush gave no consideration to the social sciences, which he regarded as intellectually shoddy, little more, indeed, than political propaganda masquerading as science. His report also made no mention of the geographical distribution of research funds; Bush believed that funding should be distributed among the best investigators, wherever they were located.



Senator Harley Kilgore: a "social welfare" approach

(He maintained, with considerable justification, that most of the significant progress in a scientific field is generated by the most capable practitioners, a relatively small group.) And his report rejected the idea of targeting research to particular social or economic purposes. Above all, Bush held that the social and economic benefits of basic scientific research and training were best realized not by the directives of politicians but by the mechanisms of the free market, by private initiative. Federal science policy, his report stressed, should be insulated from political control.

Bush proposed creation of a "National Science Foundation" to serve as the flagship agency of basic research and training in all the major areas of science, including those related to medicine and the military. He staunchly opposed military domination of science in peacetime, in part because he believed that military influence in American life ought to be limited, but also because he thought that civilian scientists who were independent of military control (as they had been under OSRD) were better able to produce worthwhile innovations, even for military purposes.

Released to the public on July 19, 1945, Bush's report became, as an OSRD staff member remarked, "an instant smash hit," applauded in scores of editorials across the ideological, partisan, and geographical spectrum. *Science—the Endless Frontier* became the charter for a science-government partnership that was to last for almost a half-century.

Still, not everything went according to Bush's plan. By the time the National Science Foundation (NSF) was established in 1950, it had already been pre-empted in the medical area by the National Institutes of Health (NIH), which had been set up in 1948 as an "umbrella" to cover the National Cancer Institute and the new National Heart Institute, and which now comprised five more research institutes, for a total of seven. In the military area, too, the National Science Foundation was vastly overshadowed.

In his postwar science blueprint, Bush had not anticipated that the peace that followed World War II would soon turn into the Cold War with the Soviet Union and communism. But he soon found that the imperatives of that struggle would make national security the predominant focus of federal policy for scientific research and development (R&D). Contrary to his plan, some 90 percent of federal R&D funding would come not from the National Science Foundation but from the armed services, which were consolidated in the Department of Defense in 1947, and from the Atomic Energy Commission, which Congress established in 1946. (Although a civilian agency, the commission devoted its research efforts overwhelmingly to the military uses of atomic energy, especially the development of nuclear, and then thermonuclear, weapons.)

With the outbreak of the Korean War in 1950, the defense R&D budget more than quadrupled, to $3.1 billion in fiscal 1953. Some of it was spent on "basic" research, which, while seemingly impractical, might unexpectedly pay enormous practical dividends (as research into the atomic nucleus had, in the form of the atomic bomb). Another portion went to basic defense research, that is, research into phenomena closely related to military technologies. A larger amount of the money was devoted to "applied" research, intended to produce a specific technology (such as an airplane). And the lion's share of the R&D funds went for "development"—

turning a technological prototype into a finished piece of hardware.

The terminology was loose; one sort of research could easily shade into another. But whatever the labels, a lot more R&D was undertaken. By 1957, the demands of high-tech national security—nuclear warheads, rockets and missiles, antisubmarine warfare and continental defense systems, and scientific manpower—had increased federal R&D expenditures another 10 percent in constant dollars. High-tech industrial research increasingly became a ward of national security, with defense projects supplying an ever-larger fraction—the portion crossed the 50 percent mark in 1956—of total expenditures for industrial research.

The military gave lavish sums to large research universities, supplying them with roughly one-third of all their federal R&D funds. Most of the rest came from the Atomic Energy Commission and, to lesser extents, from the National Science Foundation, NIH, and the Department of Agriculture. A sizable fraction of the military support went to basic research, which, to quote a later Defense Department directive, was recognized "as an integral part of programmed research committed to specific military aims."

Typical of such activity was the Research Laboratory in Electronics at MIT, created to extend the basic microwave research that had been conducted there during the war. Supported by the three armed services, the work was intended to accelerate the transfer of advanced atomic, molecular, solid-state, and microwave physics to engineering practice. The military also became the principal supporter of basic scientific research as such, particularly via the Office of Naval Research (ONR), which before the NSF was established had moved quickly to support the work of astronomers, chemists, physiologists, botanists, logicians, psychologists, computer scientists, and nuclear physicists, among others.

Washington's nondefense R&D budget for science and technology rose with the tide, reaching $16 million in 1956. The NSF supplied a small but significant supplement to the enormous patronage that the Defense Department and the Atomic Energy Commission gave to the nation's universities for research and graduate training in physics, electronics, aeronautics, computers, and myriad other branches of the physical and biological sciences and engineering. In 1955, the NIH budget totaled $81 million and was climbing. Part of the money went to NIH laboratories in the Washington, D.C., area, but at least one-third of it was devoted to research fellowships for promising young biomedical scientists and for basic and applied biomedical research conducted in universities and medical schools.

As much as the federal government was spending on science and technology—$3.9 billion in fiscal 1957, or some five percent of the federal budget—widespread fears soon developed that it was not enough. On October 5, 1957, Americans were shocked to learn that the Soviet Union had launched the world's first artificial Earth satellite, a 184-pound capsule called *Sputnik I*. Then, 29 days later, *Sputnik II*, weighing more than 1,120 pounds, was sent aloft, packed with a maze of scientific instruments and a live dog. The two Sputniks revealed that the Soviets possessed impressive rocket, guidance, and life-support capabilities. After December 6, when

Vannevar Bush: a no-nonsense federal science policy the U.S. attempt to launch a satellite from Cape Canaveral fizzled in a cloud of brownish-black smoke, American alarm at the Soviet achievements increased. Much hand-wringing and self-flagellation ensued. The American character was said to be materialistic and flabby, and America was said to be lagging behind the Soviet Union in science and technology. "Ten years from now the best scientists in the world will be found in Russia," the physicist Edward Teller warned.

The Eisenhower administration promptly established a new White House post of special assistant to the president for science and technology, and MIT president James R. Killian, Jr., was named to fill it. The federal government undertook crash programs to improve high school science facilities and to assist college students in critical scientific fields. In 1958, the National Aeronautics and Space Administration (NASA) was established to oversee the nation's nonmilitary activities in space research and development. "How much money would you need to . . . make us even with Russia . . . and probably leap-frog them?" Representative James G. Fulton (R.-Penn.), asked NASA chief T. Keith Glennan. "I want to be firstest with the mostest in space, and I just don't want to wait for years."

That goal was not achieved overnight, but it didn't take long for federal R&D expenditures to skyrocket. Between 1957 and 1967 they quadrupled, to some $16.5 billion a year—about 11 percent of the federal budget—including more than $2 billion for basic research. In part because of the high priority given to the space program and to biomedical research (the NIH budget reached $400 million in 1960 and $1.4 billion in 1967), the defense-related share of total federal R&D fell from three-fourths to a bit less than one-half.

The Cold War competition kept the federal dollars flowing for scientific projects that were deemed significant. In 1958, an advisory panel of physicists pointed out that the Soviet Union proposed to build a 50-billion-volt synchrotron, a machine that would speed up protons to an energy twice that of the most powerful proton accelerator in the U.S. budget. At the time, a proposal from Stanford University was pending at the Atomic Energy Commission for a 10-billion-volt linear accelerator that would send electrons down a two-mile tunnel through the hills near Palo Alto; it would cost $100 million and be the most powerful electron accelerator in the world. In May 1959, President Eisenhower announced that he would ask Congress for the money, declaring that progress in this field was vitally important to the nation.

It was not the intellectual content of the field that was so critical. The more energetic the physical processes that were investigated, the less they had to do with the world of nuclear or thermonuclear processes. As the physicist Robert Wilson said when he testified in favor of constructing the original Fermilab accelerator in the mid-1960s, particle accelerators have nothing to do *directly* with national defense. But the technologies involved in building and operating accelerators—such as high-speed electronics and data analysis—paid real-world dividends. Most important, in terms of the Cold War, the pursuit of high-energy physics provided national prestige and an insurance policy: if something important to national security unexpectedly emerged from the work, the United States would have that knowledge ahead of the Soviet Union.

For academic scientists, the quarter-century after World War II was a golden era. Not only was federal money freely available, but their own professional judgment was given great weight in determining how it was spent. The partnership between science and government might have been dominated by the concerns and agencies of national security, with the NSF given only a minor role to play, but the system still worked pretty much as Bush had proposed. The Department of Defense paid attention to what leading academic scientists and engineers said was worth studying, and grants and contracts went to the scientists and engineers, and the colleges and universities, that were adjudged most capable—regardless of the resulting geographical and institutional concentration of federal dollars. Without overt political control, the system produced basic scientific and technological knowledge, as well as trained technical manpower.

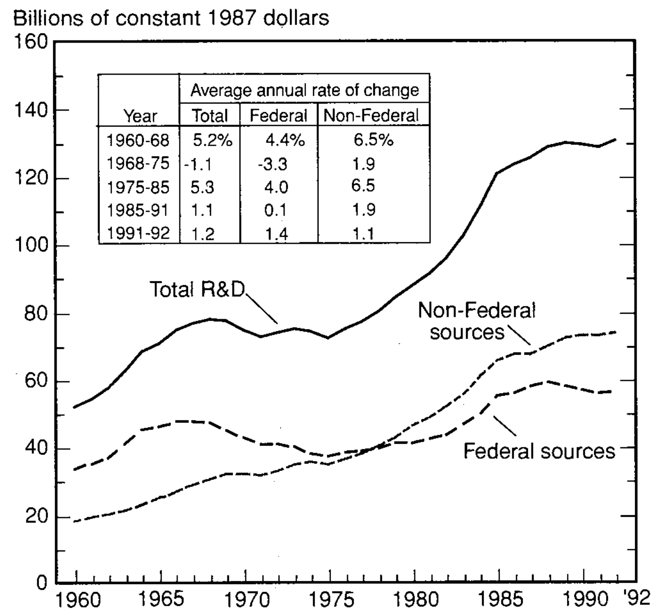
The system proved highly fruitful, to say the least. It yielded not only nuclear weapons and intercontinental missiles but jet planes, computers, silicon chips, nuclear reactors, and Earth satellites for communications and surveillance; chemotherapies for cancer and other medical marvels; advances in molecular genetics, particle physics, and planetary science; and the landing of men on the moon, not to mention myriad consumer items and, indirectly, millions of jobs. American scientists in this golden age received more than three dozen Nobel Prizes, and the United States became the world's leading scientific and technological nation, a mighty and dominant producer of scientific knowledge and high-tech goods.

Yet for all that, the system was, in truth, not as free of "politics" as it seemed. The decision to make national security the paramount consideration in research policy, the decision to allow scientists and engineers wide latitude in their choice of research programs, and the decision to leave it up to the free market to determine what to do with the resulting social and economic benefits—all these were, in reality, *political* decisions and, as such, subject to change.

In 1965, Harvard University political scientist Don K. Price, a respected analyst of science policy, remarked that Senator Kilgore's "central notions are slipping up on us again."

As the nation became more concerned with poverty, racial inequality, and urban decay, left-of-center critics turned a skeptical eye on federally supported science, particularly its unresponsiveness to social problems and its insulation from political scrutiny and control. As U.S. involvement in the Vietnam War escalated, the criticism turned into searing attacks on universities for allowing the Defense Department to play so large a role in academic research and training, and on science and scientists for their close relationship with the military.

National R&D Funding



Year	Average annual rate of change: Total	Federal	Non-Federal
1960-68	5.2%	4.4%	6.5%
1968-75	-1.1	-3.3	1.9
1975-85	5.3	4.0	6.5
1985-91	1.1	0.1	1.9
1991-92	1.2	1.4	1.1

Source: National Science Foundation, *National Patterns of R&D Resources: 1992*

Since 1985, growth in the nation's total (inflation-adjusted) expenditures on R&D has been slow, with federal funding declining in the early '90s.

The left-of-center critics had allies among fiscal conservatives distressed by the federal scientific enterprise's increasing absorption of tax dollars. While the federal budget had grown elevenfold since 1940, the R&D budget had exploded some two-hundredfold, a relative growth rate that was bound to draw the attention of budget hawks sooner or later. By the late 1960s, a coalition of liberal and conservative critics had succeeded in bringing the geometric growth of federal spending for science to a halt. On college campuses and in the halls of Congress, the pressure grew to limit the military's role in academic research and the scientific establishment's role in public policy, and, above all, to subject the federal scientific system to greater control in the interest of social welfare. Liberals worked to shift R&D funds into areas they considered more socially useful, such as pollution control, and also sought to bring about a more equitable social, institutional, and geographical distribution of R&D dollars.

President Lyndon B. Johnson, who was intent on waging a "war" on poverty as well as the war in Vietnam, kept asking his science advisers what science had done for "grandma." He instructed the managers of federal science to share the wealth and see about applying all the scientific knowledge already accumulated. LBJ's successor, President Richard M. Nixon, also stressed the seemingly practical. He favored technology—the supersonic transport, the fast-breeder reactor, and antiballistic missiles—over science, and considered the "war" on cancer more important than the advancement of fundamental biology.

By the mid-1970s, the federal R&D budget had, in constant dollars, become 20 percent smaller than what it had been in 1967. Moreover, environmental, energy, and health research commanded a larger proportion of the total outlay, while the space program's share had been cut by half and the defense-related proportion had edged down further, to 46 percent. In 1969, Senator Mike Mansfield (D.-Mont.), a former professor of history and political science who was eager to reduce the military's influence in academic life, had slipped a section into the military authorization bill prohibiting the Pentagon from financing any research not directly related to a specific military purpose. Although the Mansfield amendment was dropped from the military authorization bill the next year, the Pentagon took it lastingly to heart.

Despite the inroads made by Kilgore-style social welfare-ism, the U.S. government remained committed to the hard core of Bush's vision—to federal responsibility for basic scientific research and training, to the involvement of academic and industrial scientists in the policy process, and to the awarding of research funds only to the better investigators. Science policymakers and advisers often managed to interpret mandates for "practical" research programs in such a way that basic investigations were funded. For example, war-on-cancer money paid for basic research into the mechanisms that transform healthy cells into malignant ones, and so sustained the work that led J. Michael Bishop and Harold Varmus, at the University of California, San Francisco, to their Nobel Prize–winning discovery of oncogenes.

Nevertheless, the disturbing trends in federal R&D policy during the 1970s set off various alarms. Some defense specialists contended that the reductions in Pentagon spending, including that for R&D, were making the United States militarily vulnerable. Other worried analysts pointed to the increasingly vigorous foreign competition, especially from Japan, that the United States faced in technological markets not only abroad but at home. Corporate and academic leaders claimed that excessive government regulation was choking industrial and academic science, perhaps even threatening freedom of scientific and intellectual inquiry.

By the late '70s, more and more people were arguing that American military and economic security required an enlarged investment in R&D and a revival of scientific autonomy. The latter would be accomplished by loosening the government's controls on research it funded and by increasing the money

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obtained from alternative sources, particularly industry. "Our engineering and scientific base is disappearing," House Armed Services Committee chairman Melvin Price (D.-Ill.) warned. In the view of many experts, *Business Week* reported, "the future health of the nation's economy . . . requires a much more benign environment for industrial R&D than has existed over the past decade."

As a result of the growing concerns, federal research expenditures grew during the Carter administration and further increased under President Reagan. By the time work began on the Superconducting Super Collider, federal R&D expenditures (in constant dollars) were 20 percent higher than they had been at the predownturn peak, in 1967. The largest share of the increase went to the Department of Defense, whose research programs included semiconductors, optics, lasers, and integrated circuits. These were things that could yield gratifying economic results as well as military ones. Similarly, between 1981 and 1990, the NIH budget (in constant dollars) rose about 50 percent, two-thirds more than the increase in total federal outlays. And at the end of the 1980s, the government established the Human Genome Project, which was estimated to cost $3 billion over 15 years. Designed to map and sequence all the genes in the human genome, the project would not only accelerate biomedical research but enlarge the nation's capacity in biotechnology.

Policymakers and biotechnologists considered biomedical research an important means of strengthening the nation's high-tech competitiveness. The emerging biotechnology industry was founded on basic research that the NIH had supported, particularly the invention of the technique of recombinant DNA during the 1970s by Herbert Boyer and Stanley Cohen, of the University of California, San Francisco, and Stanford University, respectively. With recombinant DNA, a gene from one organism—say, a human being—could be snipped from its native genome and inserted into that of another organism—for example, a bacterium or a mouse—where the function of the gene could be studied, or a valuable protein could be produced. Stanford and the University of California jointly obtained a patent on the technique, which they licensed to biotechnology companies. Among the first to make use of it was Genentech, which enjoyed a spectacular success on the stock market when it went public in 1980.

University patenting of the products of basic research and their licensing into the marketplace appeared to be advantageous to academic institutions, new high-tech businesses, and America's economic competitiveness. In academia, however, there was widespread apprehension that professorial involvements with commercial firms would lead to unsavory exploitation of university resources and students, and might drive out research that had no market promise. Despite all the worries, the incentives pulling academic biologists and their universities toward commercialization—big hits such as Genentech—were too strong to resist.

In the interest of generalizing the policies and practices that fostered the biotechnology industry, the federal government moved to encourage closer collaboration between industry and researchers. In 1980, Congress passed legislation to promote commercial use of inventions arising from federally sponsored R&D at nonprofit institutions. The new patent law made uniform across all government agencies what had been the practice in some, including NIH—namely, to grant property rights in such inventions to institutions that would seek patents on them and license the rights in the market economy. Six years later, Congress passed a law to encourage the commercial use of technologies devised in federal laboratories by, among other things, authorizing government agencies or their employees to license patents on such technologies to private industry.

Industry responded to the incentives for academic collaboration, which were strengthened by university promises of often exclusive patent-licensing arrangements with corporations that supported campus research. Between 1977 and 1986, industry patronage of academic research grew more than fourfold, increasing its share of expenditures for university R&D from around three percent to almost six percent.

In some respects, the shift in R&D policy during the 1980s represented a revival of the fuller vision advanced in *Science—the Endless Frontier*. Vannevar Bush would have been pleased by the resumption of vigorous support for basic research, the marked retreat from the socially purposeful R&D of the 1970s, and the renewed reliance on market mechanisms as the primary means of translating scientific progress into public benefits. Federal R&D funds continued to be allocated mainly to the better-qualified investigators and institutions rather than according to any principle of equity in geographical or institutional distribution. And while the Pentagon's involvement in basic research had increased considerably, in the late 1980s the military supplied only about half the proportion that it did in the mid-1950s and about the same that it did in 1967.

Yet federal science policy—starting in the 1960s with the reappearance of the Kilgore approach of social welfare-ism—had also departed from Bush's vision in important respects. It had become overtly politicized, not in the sense that what might be thought or published was subject to political test, but in the sense that—beginning with the Nixon administration—the views of candidates for appointive advisory and administrative posts on such controversial issues as antiballistic missile policy, the Vietnam War, and the Strategic Defense Inititative were taken into account. The Reagan administration applied tests of political allegiance to candidates for appointment to scientific advisory panels, especially in the regulatory agencies. In the early years of the administration of President Bush, similar tests on issues such as abortion reportedly played a role in appointments to the National Institutes of Health.

Science policy had also become politicized in a more profound sense: the allocation of resources for R&D had been incorporated into the open, conventional political process and become subject to the play of competing interest groups, especially in Congress. Before the late 1960s, the president and the federal bureaucracy had held the upper hand in most areas of science and technology policymaking. They controlled the making of the budget, and they could marshal enormous technical expertise to back up their policy choices.

But they lost that monopoly of power when Congress became more assertive and acquired its own arsenal of expertise on science and technology (beyond the special subject of atomic energy). Legislators hired capable staff members who were knowledgeable in such areas as space, the environment, health, and defense, and over time, individual lawmakers developed their own expertise in particular subjects. Senators and House members also could turn to the Congressional Budget Office for budgetary analyses and to the Office of Technology Assessment for reports on topics ranging from biotechnology to the effects of nuclear war.

As the power to set science policy has become diffused, more and more interest groups, such as environmentalists, feminists, and AIDS activists, have become involved. For federal R&D, that has meant reduced attention to science for its own sake and more to science for social purposes, technological innovation, regional development, and regulation. Thanks to the enactment of laws to strengthen environmental protection, occupational health and safety, public health and medicine, and consumer protection, scientific research has become more integral than ever to regulatory policymaking. Congress also has been challenging the concentrated distribution of federal R&D funds, responding sympathetically to moves by have-not or have-less institutions to circumvent the peer review process by legislating direct grants for the development of laboratory facilities to particular universities.

While scientists continue to enjoy intellectual freedom, the new, open politicization of science policy has meant that the previously most powerful branches of the scientific community—high-energy physics, for example—can no longer decisively determine which inquiries federal monies will stress.

The Superconducting Super Collider was largely done in by the shift to a greater sharing of power between the executive and the legislature in the making of science policy. Made vulnerable by the end of the Cold War, the SSC was forced to stand or fall on its domestic political muscle. On that basis, its strength did not compare with the space station's, which, with a price tag more than twice that of the collider, had commitments of some $8 billion in foreign financing, the heavyweight support of the aerospace industry, and the reported creation of 75,000 jobs to its credit. The vast majority of SSC procurement contracts had gone to only five states, including Texas, where some four times as much money was spent as in second-ranked California. Representative Sherwood Boehlert (R.-N.Y.), an unrelenting enemy of the collider, summarized with only slight exaggeration the political dynamic: "My colleagues will notice that the proponents of the SSC are from Texas, Texas, Texas, Texas, and Louisiana, and maybe someone from California. But my colleagues will also notice that the opponents are . . . from all across the country."

The death of the SSC signified not the end of the partnership between science and government but rather a redirection of its aims and a revision of its operating rules. Now, Senator Kilgore's social welfare approach, as much as Vannevar Bush's vision, is reflected in the partnership's purpose: the advancement of knowledge not only for its own sake but for the sake of specific socioeconomic purposes ranging from industrial competitiveness to environmental management to the battle against particular diseases. And the revised rules of operation make science subject to "normal" political constraints, not the least of them being the pressure to curb federal spending.

In the years ahead, private patrons—both industrial and philanthropic—may well come to shoulder more of the cost of scientific research and training, as they did before World War II. The Howard Hughes Medical Institute, for example, currently supports roughly 10 percent of the basic biomedical research in the United States.

Still, the federal government remains the country's most generous single patron of science, providing in fiscal 1995 roughly $70 billion for R&D, including 60 percent of all monies spent on academic research. If such largesse is spent wisely—that is, if a reasonable portion is devoted to basic research by the most capable scientists—the quality and vitality of American science will not necessarily suffer. But the more it is recognized that the era of sustained exponential growth in science is over, the more difficult it may become for wisdom to prevail. In the SSC controversy, physicists outside the field of high-energy particle physics became involved and helped to kill the project. As the competition for federal research dollars becomes more intense, scientists in all fields, as well as their host institutions, are likely to get involved in political battles in the same way.

With the end of the Cold War, American science is no longer sacrosanct. Science is in the open political arena and scientists can no longer remain above the fray. Instead, they will have to fight for federal tax dollars, like any other interest group. For them, and for science, it is a new era.