The History of a
Scientific Community in
Modern America

THE PHYSICISTS

by

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XXI

The Bomb and Postwar Research Policy

In early 1939 Enrico Fermi, now a Nobel laureate and refugee from Italy, gazed thoughtfully out his office window high in the Columbia physics building. In the laboratory Fermi had been investigating the recent report of the German and Austrian scientists Otto Hahn and Lise Meitner that uranium atoms fissioned upon impact by neutrons. Now, looking toward the expanse of Manhattan beyond the pane of glass, Fermi shaped his hands into a large-sized ball. A little bomb like that, he remarked, and it would all disappear.[1]

Hahn and Meitner's startling discovery stimulated a number of physicists, native and refugee alike, to think of a nuclear explosive. In the process of fission, a large quantity of energy was released, and so were more neutrons, possibly enough to make a chain reaction. Certain that the Germans would recognize the same possibility, in the summer of 1939 the refugee physicists Eugene Wigner and Leo Szilard prevailed upon Einstein to call FDR's attention to the military implications of nuclear fission. A committee was formed, and $6,000 appropriated. But the committee members, thinking of fission as a potential source of peaceful industrial power, gave the government's uranium project little push or direction. Anxious to explore the possibilities of a nuclear weapon, Wigner and his colleagues felt as if they were "swimming in syrup."[2]

[1] Interview with George Uhlenbeck, who at the time shared the office with Fermi.

[2] Wigner, "Are We Making the Transition Wisely?" *Saturday Review of Literature*, 28 (Nov. 17, 1945), 28.

In June 1940, authority over the program was transferred to NDRC and Vannevar Bush. Mindful of maintaining balance in the defense research program—and half hoping that an atom bomb might be impossible—Bush refused to embark on a major nuclear weapons program, especially since it could prove to be a wild goose chase.[3] Chief among the numerous obstacles to the bomb was the natural occurrence of uranium as a mixture of two isotopes, U-235 and the slightly heavier U-238. The fissionable isotope was U-235, which amounted to only 1 part in 140 of ordinary uranium. An explosive chain reaction would require a still undetermined number of kilograms of nearly pure U-235, yet no one knew an obviously easy way to separate even a few grams of U-235 from the more abundant U-238.

But in mid-1941 optimistic word about the prospects of a uranium bomb came from British scientists. They estimated that the amount of uranium for a "critical mass," in the phrase used to denote the minimum material necessary for a self-sustaining chain reaction, totaled only about 10 kilograms. The British also believed that sufficient U-235 could be separated from U-238 by the method of gaseous diffusion. Already under investigation at Columbia University by Harold Urey and the physicist John Dunning, this technique took advantage of the physical fact that two gaseous substances of different weights diffuse through a porous barrier at different rates. Forced through a sufficiently long cascade of porous barriers, the lighter U-235 would eventually be separated from the heavier U-238. Adding to the encouraging news from the British, in Berkeley Ernest Lawrence had begun work on separation by electromagnetic means. Moving in a magnetic field, identically charged ions of different weights follow different trajectories. If uranium ions were sent through the magnetic field of a cyclotron, the ions of U-235 would be eased away from those of U-238 and made available for collection.

Lawrence's imagination was also fired by the results of experiments with U-238 in his cyclotron. Early in 1941, Glenn T. Seaborg, a young physical chemist at Berkeley, had demonstrated that, after bombardment with neutrons, U-238, which was element 92 in the periodic table, eventually transformed itself into a new element 94, which Seaborg christened plutonium. Furthermore, as expected on theoretical grounds, plutonium fissioned just like U-235. The striking implication: Fashioned into a chain-reacting pile, all the abundant, nonfissioning U-238 could be transformed into fissionable plutonium suitable for an atomic explosive.

During the spring and summer of 1941 Lawrence, soon joined vigorously by Arthur Holly Compton, insisted to Bush and Conant that, if only because of what the Germans might be doing, prudence required stepping up atom bomb research. In October a persuaded Bush obtained President Roosevelt's go-ahead for a major attempt to test whether a bomb could

[3] Bush to Jewett, May 2, 1940, VB, Box 55, file 1375.

actually be developed in time for use in the current war. Shortly after Pearl Harbor, his sense of urgency now acute, Compton decided that the scientific side of the question, then under investigation by geographically isolated groups, would be better explored in a concerted fashion. In January 1942 he brought various teams of physicists, including Fermi's from Columbia, to the University of Chicago and organized them into the Metallurgical Laboratory. The misleading name veiled its main immediate purpose: the achievement of a chain reaction to test the feasibility of producing plutonium in an atomic pile.

In June 1942, with the favorable scientific evidence steadily mounting, FDR gave Bush the green light for a full-scale effort to build the bomb. Aware that the operation would require an industrial effort far beyond the managerial capacities of OSRD, Bush and Conant arranged for the assignment of process development, engineering design, procurement of materials, and the selection of plant sites to a new Manhattan District of the Army Engineers. In September, command of the Manhattan Project was given to Brigadier General Leslie R. Groves, the builder of the Pentagon, brisk, efficient, supremely self-confident, and decidedly able. Under Groves, the direction of physical and chemical research for the bomb remained in the hands of three civilian program chiefs: for gaseous diffusion, Harold Urey at Columbia University; for electromagnetic separation and plutonium studies, Ernest Lawrence at Berkeley; and for weapon theory and chain reactions, Arthur Holly Compton at Chicago.

While Compton handled administration and policy at the Chicago Metallurgical Laboratory, Enrico Fermi masterminded the construction of a chain-reacting pile in a squash court under the west stands of Stagg Field, the university's unused football stadium. Physicists hand-hauled into place heavy graphite blocks—they were needed to slow the neutrons—seeded in uranium slugs, and gradually built up an arrangement resembling a flattened sphere about twenty-six feet in diameter. Finally, on December 2, 1942, almost four hundred tons of graphite were in place, together with six tons of uranium metal and fifty tons of uranium oxide. Under Fermi's direction, the reaction control rods were slowly withdrawn. The clicks of the neutron counters rose steadily, like a mounting frenzy of crickets. Fermi, raising his hand, announced that the pile had gone critical. A while later, Arthur Compton telephoned Conant at Harvard: "Jim, you'll be interested to know that the Italian navigator has just landed in the new world."[4]

Later that month, President Roosevelt approved the expenditure of $400,000,000 for uranium separation plants and a plutonium-producing pile. In 1943, moving decisively, Groves let contracts for the construction

[4] Arthur Holly Compton, *Atomic Quest: A Personal Narrative* (New York, 1956), p. 144.

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of gaseous diffusion and electromagnetic facilities at Oak Ridge, Tennessee, a 59,000-acre governmental reservation that the army had acquired for the purpose. He also ordered the construction of the plutonium works on 400,000 federal acres near the Columbia River at Hanford, Washington.

When representatives of Stone and Webster, the prime contractor for the electromagnetic plant, first visited Berkeley, they came away shaking their heads in awe at the way Lawrence's skyscraper plans rested so far on the successful separation of only a few millionths of a gram of U-235.[5] Lawrence, his gusto for the impossible intensified by the war emergency, drove his staff day and night. In a cut-and-try fashion, Berkeley physicists and engineers designed vacuum tanks, ionization apparatus, U-235 collectors, and magnets. Forced by the shortness of time to skip the pilot-plant stage, Stone and Webster went from the Berkeley designs directly to the building of the vacuum separation chambers and the huge steel magnet ovals. The chambers contained an unprecedentedly enormous volume of evacuated space; the magnet coil windings required more than 28,000,000 pounds of silver (the metal, worth $400,000,000, was borrowed from the Treasury Department). When the racetracks, as the electromagnetic system was dubbed, were first operated in late 1943, electrical shorts and vacuum leaks erupted everywhere. In 1944, after major repairs, breakdowns still plagued the system, so Lawrence brought squads of scientists and technicians from Berkeley to trouble-shoot the equipment. The racetracks would work, Lawrence assured a discouraged General Groves.[6]

Even more prodigious efforts were required for the gaseous diffusion process, the key to which was the development of a suitable diffusion barrier. The barrier had to have millions of tiny holes, be impervious to the exceptionally corrosive effects of uranium hexafluoride gas, and possess sufficient structural strength to withstand high pressures. After months of research at Columbia, Bell Telephone Laboratories, and elsewhere, Percival C. Keith, in charge of the diffusion process for the prime contractor, the Kellex Corporation, despaired that the barrier problem would ever be solved; so even did Ernest Lawrence, who urged de-emphasis of the diffusion method. But not Bush, Conant, or Groves, who boldly pushed ahead the construction of literally acres of diffusion cascades at Oak Ridge. Industrial physicists, chemists, and engineers performed prodigious feats of design and development to fabricate corrosion-resistant valves, pipes, and pumps. In the fall of 1943 Clarence A. Johnson, a young engineer working for Keith's corporation, hit upon a promising idea for the barrier, one that fused elements of the existing

[5] Stephane Groueff, *Manhattan Project: The Untold Story of the Making of the Atomic Bomb* (Boston, 1967), pp. 36–37.

[6] Herbert Childs, *An American Genius: The Life of Ernest Orlando Lawrence* (New York, 1968), p. 345.

approaches with an originality of its own. At Columbia, Urey, grown increasingly pessimistic and temperamental under the stress of the barrier project, refused to divert his laboratory to the pursuit of Johnson's idea. Keith maneuvered into control of the project the Princeton chemist Hugh Scott Taylor, who, aided by academic and industrial scientists as well as his own ingenuity and sense, inched barrier design and production successfully forward.[7]

Still, in mid-1944 the barrier problem was not yet completely solved. In desperation, Groves ordered the installation at Oak Ridge of yet another type of separator, a thermal diffusion plant. The idea of the physical chemist Philip Abelson, who had worked on it independently for three years with naval support, thermal diffusion exploited the propensity of atoms of different weights to separate when caught between hot and cold surfaces. Thermal diffusion could increase the percentage of U-235 in natural uranium by only a small amount. But the degree of enrichment might be sufficient to replace the gaseous diffusion method as the expected source of material for the electromagnetic separators.

The plutonium project required a grit and ingenuity all its own. The cyclotron at Washington University in St. Louis was enlisted to make experimental samples of the new element by bombarding U-238 with neutrons night and day. Working with mere micrograms of the material, chemists under Glenn Seaborg at the Metallurgical Laboratory devised production techniques for the chemical separation of plutonium from uranium. In 1943 physicists and chemists left Chicago for Oak Ridge, where they designed and built an experimental pile and separation facilities; at the end of the year the equipment yielded the first milligrams of plutonium. Among the Oak Ridge staff was Eugene Wigner, who came up with a basic design for the pile at Hanford which was adopted by the scientists and engineers of the prime contractor, the Du Pont Company. In 1944, the completed Hanford pile was turned on. It went critical for some minutes, then the chain reaction stopped.

Tests showed that the pile was producing an isotope of the element xenon, which poisoned the chain reaction by absorbing large quantities of neutrons. The effect had never showed up in the Oak Ridge pile because, contrary to Groves's instructions, the staff had never run it at full power. Groves was angry and, along with Compton, decidedly worried. But the young physicist John Wheeler of Princeton University, who with Bohr had written the fundamental paper on the theory of fission, had warned the Du Pont staff about the possibilities of poisoning. Over the opposition of a number of scientists at Oak Ridge and Chicago, and at the insistence

[7] Richard G. Hewlett and Oscar E. Anderson, Jr., *The New World, 1939/1946* (*A History of the United States Atomic Energy Commission*, Vol. I; University Park, Pa.: Pennsylvania State University Press, 1962), pp. 133–36; Richard G. Hewlett, "Nuclear Physics in the United States during World War II," unpublished manuscript, pp. 20–21.

of George Graves, an assistant technical adviser in the company, Du Pont engineers had designed room in the pile for excess uranium slugs. Stuffing the pile to the maximum, the Hanford staff overwhelmed the poisoning effect. Du Pont people could be forgiven their celebratory doggerel about Graves, who "with baleful glare . . . /Cried, 'Dammit, give it stuff to spare— / The longhairs may have missed.' "[8]

By early 1945 the Hanford facilities were beginning to turn out pure plutonium. By the same time, the barrier problem had been overcome at Oak Ridge. There, operating in tandem, the thermal diffusion assembly, the racetracks, and the gaseous diffusion cascades were yielding U-235 of high purity in steadily increasing quantities. But long before either plant reached full production, both had started sending their small first yields of plutonium and enriched U-235 to the apex of the Manhattan Project, the special weapons laboratory that Groves had established under J. Robert Oppenheimer at Los Alamos, New Mexico, a lonely mesa nestled 7,500 feet up in the majestic Sangre de Cristo Mountains some seventy-five miles north of Albuquerque.

From its opening in March 1943, Los Alamos absorbed physicists like a sponge. The Rad Lab was losing its best theorists to the bomb effort, Rabi complained to Bush, and if the losses continued, advanced radar research would be seriously impaired. Nevertheless, the high priority of the Manhattan Project permitted the Los Alamos scientific and technical staff to grow, by spring 1945 to well more than two thousand, including some six hundred army enlisted men assigned to the laboratory as part of a Special Engineering Detachment. The scientists ranged from first-degree apprentices—the median age of the technical staff was twenty-seven—to native, refugee, and British physicists whose names were already textbook fixtures. To Frederic de Hoffman, a new Ph.D. from Harvard, his arrival at Los Alamos seemed like "one grand final exam day, with all the senior faculty members of all the U.S and European physics faculties assembled to give . . . that final exam."[9] At the Fuller Lodge on the mesa, one could sometimes see as many as eight Nobel laureates dining at once.

The physicists at Los Alamos lived with numerous irritations, including the isolation—it was a hazardous eighty-mile round trip to Santa Fe—the jerry-built housing, and above all the army, with its pervasive security restrictions. Famous physicists played charades with pseudonyms—Niels Bohr was "Nicholas Baker"—and the birth certificates of newborn babies were inscribed "P.O. Box 1663, Sandoval County Rural." Nothing was

[8] Quoted in Compton, *Atomic Quest*, p. 193.

[9] Rabi to Bush, June 1, 1943, OSR, Entry 1, Manhattan District: Personnel Matters; Smith, "Los Alamos: Focus of an Age," in Richard S. Lewis and Jane Wilson, eds., *Alamogordo Plus Twenty-Five Years* (New York, 1971), p. 34; John H. Manley, "Organizing a Wartime Laboratory," in Jane Wilson, ed., *All in Our Time: The Reminiscences of Twelve Nuclear Pioneers* (Chicago: Bulletin of Atomic Scientists, 1975), p. 135; de Hoffman, "A Novel Apprenticeship," *ibid.*, p. 163.

permitted that might indicate to the outside world the identity of the inhabitants. In the laboratories, army engineers sometimes interfered with technical matters in which they had no competence.[1] To the physicists and their families, the army personified was General Groves, who could be infuriatingly pompous, behave as though his judgment were infallible, and take unassailable positions on matters as small as whether the Los Alamos compound should have a west gate. Still, Groves's dedicated attention to the project produced welcome results that ranged from the miracle of getting a scarce B-29 for tests to the thoughtful favor of supplying every household with an electric hotplate when he learned that the wood-burning stoves were difficult to operate. Sometimes reluctantly, Groves also eased military rigidity to accommodate the freewheeling ways of science. And on their part, the scientific staff learned to cope with the isolation, the army, the security restrictions, and each other.

Los Alamos scientists skied and hiked in the remote beauty of the surrounding mountains, gathered at intellectually stimulating social evenings, and kept the maternity ward busy. Way down in the hierarchy, a homesick army recruit from New York hung a bagel from the ceiling so that he could lie back on his bunk and admire it. The future Nobel laureate Richard P. Feynman, then in his early twenties, dealt with the strain by playing the bongo drums, challenging the censors with coded letters, or picking the combination locks of safes containing classified documents. Higher up the ladder, the moody Edward Teller, who was apt to spend his leisure in long walks, insisted at work upon pursuing his own scientific demon, a thermonuclear weapon, and drove his neighbors to distraction by rhapsodizing on the piano at odd hours of the night. Oppenheimer relaxed over writings from the Sanskrit or the poetry of John Donne.

Oppenheimer, the director, his hair cropped efficiently short, mediated between Groves and the scientific staff, easing army regulations, housing problems, and personal crises. At times overwhelmed to the point of despair by the administrative burden, he depended heavily on the hardheaded executive talents of his division leaders and his early assistant John H. Manley, who had helped drive him to an acrimonious outburst one night in Berkeley by nagging about the need for an organizational plan at Los Alamos. Later on, Samuel K. Allison, the Chicago physicist and former head of the Metallurgical Laboratory, became Oppenheimer's associate director and kept track of the numerous details involved in the fabrication of a weapon. But the scientific tone at Los Alamos was shaped principally by Oppenheimer. Despite Groves's vigorous objections at the hazard to security, Oppenheimer refused to compartmentalize the laboratory; he insisted upon holding a weekly progress review open to everyone who wore the white badge that signified an academic degree. "Here

[1] Lansing Lamont, *Day of Trinity* (New York, 1965), pp. 54–55; Robert R. Wilson, "A Recruit for Los Alamos," in Wilson, ed., *All in Our Time*, p. 157.

we have assembled the greatest bunch of prima donnas ever seen in one place," Groves remarked.[2] Through some combination of tough judgment, mystique, and a melancholic sense of the laboratory's terrible goal, Oppenheimer dampened the scientific factionalism, persuaded both apprentices and prima donnas to feel privileged to be cooped up on the mesa, and inspired the entire staff to remarkable feats of research and technical ingenuity.

Much of the technical challenge centered on finding out how a critical mass of U-235 or plutonium would behave in the microsecond between the start of the chain reaction and the explosion. An experimental physics division under Robert F. Bacher laboriously used accelerators as neutron sources to measure the fission properties of the two elements. Exploiting their expertise in the electronic techniques of microwave radar, they devised sensitive equipment to determine the reaction speeds at different neutron energies. Shaping the experimental data into a prediction of critical mass behavior was the task of the theoretical division under Hans Bethe. With his formidable theoretical powers, Bethe, in the observation of Feynman, resembled a battleship surrounded by an escort of smaller vessels, the younger theorists, moving majestically forward through the ocean of the unknown.[3]

Both experimentalists and theorists pondered the key problem of bomb design. To obtain a powerful explosion, sufficient fissionable material to form a critical mass had to be brought together quickly, then kept together long enough to release a lot of energy. The most direct assembly method consisted of using a gun to fire one subcritical mass of fissionable material into another with the speed and force of an artillery shell. But while experiments suggested strongly that the gun method would work for U-235, they also indicated by spring 1944 that it would not work for plutonium.

The trouble was that plutonium emitted many more neutrons spontaneously than did U-235, enough possibly to predetonate the bomb assembly before it could release more than a minute fraction of its potentially explosive energy. But an alternative to the gun method had been proposed in April 1943 by the young Caltech physicist Seth Neddermeyer. Called implosion, this approach relied upon surrounding a mass of subcritical plutonium with high explosives which, when fired, would produce a spherically symmetrical shock wave traveling inward toward the center of the bomb. The shock wave would compress the plutonium into a critical mass and, keeping it compressed while a rapid chain reaction developed, would maximize the energy released. The great speed of compression would also eliminate the danger of predetonation. At first re-

[2] Robert F. Bacher, "Robert Oppenheimer," *Proceedings of the American Philosophical Society*, 116 (Aug. 1972), 281–82; Groves is quoted in Groueff, *Manhattan Project*, p. 204.

[3] Stanislaw M. Ulam, *Adventures of a Mathematician* (New York, 1976), p. 150.

jected as too difficult by most, and scoffed at by some, Neddermeyer's idea acquired increasing luster at Los Alamos as the dangers of a plutonium fizzle became more apparent.

But the array of imploding explosives around the plutonium core would have to yield a spherical shock wave of absolute uniformity. The slightest nonuniformity, and the plutonium would tend to squirt away, halting the chain reaction. In February 1944, Oppenheimer brought in the physical chemist George Kistiakowsky to head a new implosion effort at the laboratory. In early March, Kistiakowsky drew up a day-by-day chart of desirable progress. His final entry, projected for the end of the year: "The test of the gadget failed. Project staff resumes frantic work. Kistiakowsky goes nuts and is locked up!"[4] The pressure on Kistiakowsky's people rose even more after it became clear that, because of the likelihood of spontaneous fission, a plutonium bomb could not be set off by the gun method; it would have to be detonated by implosion.

Mainly to meet the challenge of implosion, Oppenheimer reorganized the laboratory in mid-1944, shifting its emphasis from research to the design and fabrication of both a U-235 and, especially, a plutonium bomb. When Hanford and Oak Ridge began sending production quantities of plutonium and U-235, the tension on the mesa rose precipitously. In January 1945, aware that the cost of the project was close to $2 billion, Groves warned his aides that if the Manhattan Project failed, "each of you can look forward to a lifetime of testifying before Congressional committees."[5]

By early March, the design of the implosion bomb was set in principle, and Oppenheimer appointed a Cowpuncher Committee to ride herd on the final development of the system. By mid-April, Kistiakowsky had overcome the critical problem of the asymmetrical shock wave. In early July, the laboratory moved ahead toward the assembly of the U-235 gun bomb for shipment to the 509th Composite Air Group, a specially trained B-29 unit in the South Pacific. No precombat explosive test of the uranium bomb, code-named Little Boy, appeared necessary; the Los Alamos scientists had high confidence in the gun method. But a trial of the implosion weapon had long seemed imperative. The Cowpunchers worked frantically to ready a plutonium bomb for detonation in the desert near Alamogordo, New Mexico.

On July 16, in the dark before morning, the plutonium gadget rested atop a lone tower in a sheet-metal shack three hundred feet above the desert floor. Outside a ten-thousand-yard radius, scores of men waited, tense, nervous, apprehensive. Oppenheimer, standing in the doorway of the South-10,000 bunker, seemed to totter on the verge of nervous collapse. Kistiakowsky had bet him a month's salary against ten dollars that

[4] Quoted in Hewlett and Anderson, *The New World*, p. 248.
[5] Quoted in Lamont, *Day of Trinity*, p. 76.

the implosion device would work. Samuel Allison brought the countdown to zero with a scream. A spot of light burst through the darkness, then boiled upward, exploding into a rainbow of fire that colored the desert wastes and dazzled the mountain ranges in the distance. Moments later the shock wave blasted through with the roar of twenty thousand tons of TNT. After the first exhilarating cheers of success, there was an awesome silence. Through Oppenheimer's mind flashed a line from the Bhagavad-Gita: "I am become Death, The shatterer of worlds."[6]

Twenty-one days later, at 2:45 A.M. August 6, 1945, three B-29s belonging to the 509th rose from the island of Tinian in the Marianas and headed for Japan fifteen hundred miles to the north. In the belly of the lead plane, the *Enola Gay*, was the uranium bomb, Little Boy. By 7:30 A.M. Navy Captain William S. Parsons, the head of the ordnance division at Los Alamos, had completed arming the bomb. Fifteen minutes later the plane was over the Japanese mainland. "It is 8:50," Captain Robert A. Lewis, who had been jotting a log of the flight, soon noted. "Not long now, folks. . . . There will be a short intermission while we bomb our target." The plane lurched upward when the five-ton bomb fell away toward its detonation point two thousand feet above the city. A few moments later Captain Lewis exclaimed: "My God!"[7] Hiroshima was covered with a great swirling column of smoke that reached thirty thousand feet in less than three minutes and could still be seen when the *Enola Gay* was four hundred miles away.

In the United States later that day, the White House released the news: "Sixteen hours ago an American airplane dropped one bomb on Hiroshima. . . . That bomb had more power than 20,000 tons of TNT. . . . It is a harnessing of the basic power of the universe."[8] Three days later, August 9, 1945, another B-29 from the 509th dropped an implosive plutonium bomb, code-named Fat Man, on Nagasaki.

Within weeks Americans knew fully the grim results of the atomic bombings—from the pictures of Hiroshima and Nagasaki devastated beneath the towering mushroom clouds, from the cold statistics of fire, blast, destruction, and death, from the prompt surrender of Japan. Here and there, notably in liberal religious circles, the atomic bombings of Japan were publicly denounced on moral grounds as cause, in the phrase of *Commonweal*, for "American guilt and shame." Among most people, the nuclear end of the war provoked a jumble of ambivalent feelings, not only joy and relief but doubt, and fear that perhaps science had finally gone too far. There was no comfort to be found in Oppenheimer's flat response to a reporter's query about nuclear weapons: "If you ask: 'Can

[6] Quoted *ibid.*, p. 235.

[7] Quoted in William L. Laurence, *Dawn over Zero: The Story of the Atomic Bomb* (New York, 1946), p. 221.

[8] *Public Papers of the Presidents . . . Harry S Truman, 1945* (Washington, D.C., 1961), p. 197.

we make them more terrible?' the answer is yes. If you ask: 'Can we make a lot of them?' the answer is yes. If you ask: 'Can we make them terribly more terrible?' the answer is probably."[9] Yet pollsters reported that the public backed the use of the atomic bombs against Japan overwhelmingly because it brought the war to a speedy end. And whatever ambivalence the bomb provoked, it sealed a consensus, rapidly emerging even before Hiroshima, about the future requirements of national security.

Vannevar Bush himself publicly attested that, if the enemy's early technological superiority had been slightly greater or more diverse, "Nazi Germany would not now be prostrate." The United States, defense analysts said, managed to surpass German military technology only because the grace period before Pearl Harbor had allowed the nation sufficient time to mobilize her civilian scientific resources. After Hiroshima—as well as the German V-1s and V-2s, those harbingers of intercontinental missiles—it was widely said that there would be no grace period again. The White House had called the atomic bomb the "greatest achievement of organized science in history."[1] Now military officials, civilian analysts, congressmen, and thoughtful observers across the partisan and ideological spectrum agreed: In the atomic age, the United States could not do without a national policy of scientific, especially nuclear, research.

Americans debated the shape of that policy with special attention to the opinions of a newly influential group: the generation of atomic scientists—the Los Alamos generation—that Hiroshima and Nagasaki had brought to the center of the public stage. From the days of John Wesley Powell to those of Robert Millikan, American scientists had scarcely been concealed from public notice. But unlike any of its predecessors, this generation was dominated by physicists who seemed to wear the "tunic of Superman," in the phrase of a *Life* reporter, and stood in the spotlight of a thousand suns.[2]

Long before the glare of publicity, the role of martial superman had provoked a certain queasiness among the atomic scientists. I. I. Rabi had refused to take a full-time post at Los Alamos—was this to be the "culmination of three centuries of physics"?—and in the spring of 1945 he warned: "If we take the stand that our object is merely to see that the next war is bigger and better, we will ultimately lose the respect of

[9] *Commonweal*, 42 (Aug. 24, 1945), 443; Oppenheimer is quoted in *Time*, 46 (Oct. 29, 1945), 30. It is interesting to note that, speaking for the Federal Council of Churches, John Foster Dulles declared of Hiroshima and Nagasaki: "If we, a professedly Christian nation, feel morally free to use atomic energy in that way . . . the stage will be set for the sudden and final destruction of mankind." Quoted in *Time*, 46 (Aug. 20, 1945), 36.

[1] Bush testimony, U.S. Congress, House Committee on Military Affairs, *Hearings, Research and Development*, 79th Cong., 1st Sess., May 1945, p. 4; *Public Papers of . . . Harry S Truman, 1945*, p. 198.

[2] Francis Sill Wickware, "Manhattan Project," *Life*, 19 (Aug. 20, 1945), 100.

the public. In popular demagogy we [will] become the unpaid servants of the 'munitions makers' and mere technicians rather than the self-sacrificing public-spirited citizens which we feel ourselves to be." After the test explosion at Alamogordo, Kenneth T. Bainbridge, the chief of the operation and a shrewd, sensitive human being, turned to Oppenheimer: "Now we're all sons of bitches."[3] Hoping to maintain their scientific, political, and moral integrity, the Los Alamos generation on the whole declared with the Manhattan Project group under the leadership of the Nobel laureate James Franck that scientists could "no longer disclaim direct responsibility for the use to which mankind . . . put their disinterested discoveries."[4]

The Franck group was located at the University of Chicago Metallurgical Laboratory, where in the spring of 1945 the staff, its work for the bomb finished earlier than at other sites, had debated the use of the weapon in the war. Some of the Chicago scientists sided with Leo Szilard, the mercurial, effusive, perceptive Hungarian refugee, who was already appalled at the mass bombings of civilian populations. Sure that atomic bombs were "primarily a means for the ruthless annihilation of cities," Szilard opposed the atomic bombing of Japan on the moral ground that it would open the door "to an era of devastation on an unimaginable scale."[5] Many Metallurgical Laboratory scientists endorsed the earlier, more pragmatic report drawn up by the small group—Szilard among them—under Franck. If the United States were to release this new means of "indiscriminate destruction" without warning, the Franck Report argued eloquently, she would sacrifice her moral position in the world, precipitate a nuclear arms race, and "prejudice the possibility of reaching an international agreement on the future control of such weapons." Better, the report concluded, to warn the Japanese of what they faced, and to reveal this awful weapon to the world, "by a demonstration in an . . . uninhabited area."[6]

[3] Rabi is quoted in Oppenheimer to Rabi, Feb. 26, 1943, JRO, Box 59, Rabi file; Rabi to the Research Board for National Security, April 3, 1945, OV, Box 33; Bainbridge is quoted in Lamont, *Day of Trinity*, p. 242.

[4] James Franck et al., "A Report to the Secretary of War, June 1945," in Morton Grodzins and Eugene Rabinowitch, eds., *The Atomic Age: Scientists in National and World Affairs* (New York, 1963), pp. 19–20.

[5] Leo Szilard, "A Petition to the President of the United States, July 3, 1945," appended to Szilard, "Reminiscences," in Donald Fleming and Bernard Bailyn, eds., *The Intellectual Migration* (Cambridge, Mass., 1969), pp. 150–51; Szilard, "A Petition to the President of the United States, July 17, 1945," Grodzins and Rabinowitch, eds., *The Atomic Age*, pp. 28–29. Szilard told Oppenheimer that from the "point of view of the standing of the scientists in the eyes of the general public one or two years from now it is a good thing that a minority of scientists should have gone on record in favor of giving greater weight to moral arguments" than to pragmatic ones. Quoted in Martin J. Sherwin, *A World Destroyed: The Atomic Bomb and the Grand Alliance* (New York, 1975), p. 217.

[6] Franck et al., "A Report to the Secretary of War, June 1945," Grodzins and Rabinowitch, eds., *The Atomic Age*, p. 27.

But not all Manhattan Project scientists, at Chicago or elsewhere, agreed with the Franck Report. Particularly important were the high-level scientists giving advice on nuclear policy to Secretary of War Stimson, who had become accustomed to taking seriously the opinions of scientists on strategic matters. A scientific panel consisting of Oppenheimer, Arthur Compton, Enrico Fermi, and Ernest Lawrence concluded in mid-June 1945: "We can propose no technical demonstration likely to bring an end to the war; we can see no acceptable alternative to direct military use."[7] Neither could Bush, Conant, or Karl Compton, who, at an advisory level closer to Stimson, had already joined in a recommendation that the bomb should be dropped without warning upon a military installation surrounded by workers' housing. Stimson and his scientific advisers expected that using the bomb in this manner would most likely achieve their primary aim of bringing the war to a speedy end. Some also believed that such a course might further, not impair, the prospects of postwar amity, since the indisputable proof of the bomb's destructiveness would force the world to recognize the imperativeness of peace.

Whatever their differences, even before Hiroshima the scientists who supported the Franck Report and those who sided with Stimson's advisers did agree on two points: The postwar peace would hinge on the establishment of some system of international control of nuclear energy, and reaching that goal would require the cooperation of the Allied powers, especially the Soviet Union. The two points commanded all the more unity among the Los Alamos generation after Hiroshima, when many of the nation's atomic scientists seemed to regard themselves, in the phrase of *Time*, as the "world's guilty men."[8] Guilty or not, World War II physicists knew, contrary to what various outspoken laymen claimed, that there was no "secret" of the bomb; the laws of nature were available to anyone. Since the technology to exploit those laws could be developed sooner or later by a scientifically capable nation, the current Anglo-American monopoly of the atomic bomb was no guarantee of long-term American security, certainly not against the Soviet Union.

For years scientific visitors to the USSR had all returned with the same report: Russian science was on the march. The second five-year plan had called for considerable investments in research—$200,000,000 a year according to congressional testimony in 1936—and the Russian government paid its physicists well, provided them with well-stocked libraries, ample research facilities, and even rest houses by the sea or in the country. During the war, the Soviet government had maintained a high level of pure research; it had also husbanded its scientific manpower, keeping young men in school and producing, an observer remarked, "a

[7] Quoted in Alice Kimball Smith, *A Peril and a Hope: The Scientists' Movement in America, 1945–1947* (Chicago, 1965), p. 50.

[8] *Time*, 46 (Nov. 5, 1945), 27.

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veritable army of young physicists."[9] In mid-June 1945 Soviet planes brought hundreds of foreign scientists, including a dozen Americans, to Russia to celebrate the two-hundred-twentieth anniversary of the Soviet Academy of Sciences. The itinerary included technical conferences and laboratory inspections and climaxed in an enormous banquet in the Great Hall of the Kremlin, where Kalinin, Molotov, and Stalin himself toasted Russian scientists for their contributions to the national defense and designated thirteen of them Heroes of the Socialist Order. Irving Langmuir, a member of the American delegation and not inclined to admire anything Communist, returned home convinced: The Russians would be "capable within a very few years of constructing atomic bombs."[1]

The mushroom clouds had hardly cleared over Hiroshima and Nagasaki before atomic scientists started publicly, passionately, and persistently to plead for the international control of atomic energy. Many of them expected that their Soviet brethren, aware that there could be no adequate defense against nuclear weapons, might help bring about an international accord, and make it work. On the world level, Austin M. Brues, a Manhattan Project veteran, maintained, scientists "see that nationalism means war and nothing else; that wishful thinking along the old pattern can destroy us." Yet now that science was so obviously an instrument of national power, it was even more inseparable than after World War I from the politics of national interest.[2] Most Los Alamos generation scientists tacitly treated it as such. So, quite explicitly, did the leadership of OSRD, in their policy toward former Axis scientists, international scientific affairs generally, and particularly the international control of atomic energy.

Unlike Hale's contemporaries, the leaders of World War II research neither condemned nor sought to ostracize Axis scientists on grounds of war guilt. They may have empathized with the plea of Hugo R. Kruyt, the Dutch president of the successor agency to Hale's ill-fated Inter-

[9] Testimony of Lyman J. Briggs, Subcommittee of the House Committee on Appropriations, *Hearings, Department of Commerce Appropriations Bill for 1937*, 74th Cong., 2d Sess., p. 141; Caryl P. Haskins, "Cooperative Research," *The American Scholar*, 13 (April 1944), 218.

[1] Langmuir to Robert M. Hutchins, Sept. 10, 1945, IL, Box 5.

[2] Brues is quoted in Smith, *A Peril and a Hope*, pp. 180–81. The theologian Reinhold Niebuhr declared: "There is . . . no 'scientific method' which could guarantee that statesmen who must deal with the social and political consequences of atomic energy could arrive at the kind of 'universal mind' which operated in the discovery of atomic energy. Statesmen who deal with this problem will betray 'British,' 'American,' or 'Russian' bias, not because they are less intelligent than the scientists but because they are forced to approach the issue in terms of their responsibility to their respective nations." Niebuhr, "A Faith to Live By . . .," *The Nation*, 164 (Feb. 22, 1947), 204. What Niebuhr said of statesmen tended, of course, to be true of scientists, too.

national Research Council: "keep politics as far from science as possible."[3] But they found their seemingly apolitical posture toward Axis scientists convenient to take, in part because they deemed some of them not guilty. A number of German academics had deeply resented the Nazi perversion of the universities. They and most leading Japanese physicists had contributed nothing to the Axis war machine. Matters of justice aside, the leadership of OSRD was sure, any attempt to suppress basic research in Germany or Japan would provoke a spirit of retaliation and revenge. The national interest of the United States, they insisted, called for encouraging democratically inclined Axis scientists to do basic research, publish their results, and contribute to the economic and political rehabilitation of their countries.[4]

On a more global level, during the war Joseph Needham, the British scientific liaison in Chungking, had proposed the establishment of an international scientific corps to help disseminate, independent of national and commercial interests, advanced scientific knowledge to the less industrialized nations of the East. Anton J. Carlson, the politically liberal president of the American Association for the Advancement of Science, pronounced the scheme "purely wishful thinking," because the great powers, the military services, and even the scientific members of the proposed corps would behave in just as nationalist a fashion as everyone else. Bush, who liked the thrust of the idea, transformed it into a recommendation to FDR for the inclusion of an international scientific section in the charter of the United Nations. The section would, among other duties, police the scientific activities of aggressor nations to the end that no nation should have cause to fear the scientific activities of another.[5] That aim also colored strongly the American plan for the international control of nuclear energy which took shape during the spring of 1946 with contributions of major significance from Bush, Conant, and especially Oppenheimer.

In this program, a world authority established under the United

[3] *The Fourth General Assembly of the International Council of Scientific Unions, Held at London, July 22nd to 24th, 1946, Reports of Proceedings* (Cambridge, England, 1946), p. 3.

[4] *Study of the National Academy of Sciences . . . on the Treatment of German Scientific Research and Engineering from the Standpoint of International Security*, July 2, 1945, OSR, Entry 1, Control of Germany file. Arguing to Bush that German atomic scientists should not be treated as dangerous persons, Oppenheimer declared: "You and I both know that it is not primarily men of science who are dangerous, but the policies of Governments which lead to aggression and to war. You and I both know that if the German scientists are treated as enemies of society, the scientists of this country will soon come to be so regarded." Oppenheimer to Bush, Dec. 11, 1945, *ibid.* The outraged response of Lee DuBridge to the destruction of the Japanese cyclotrons in the fall of 1945 was not atypical. DuBridge, "Recommendation on the Japanese Cyclotrons," [fall 1945], LAD.

[5] Needham, "Memorandum on an International Science Cooperation Service," attached to Needham to Bush, July 25, 1944; A. J. Carlson to Ross T. Harrison, Sept. 25, 1944; Bush to the President, Feb. 22, 1945, OSR, Entry 1, Postwar Planning, Needham Plan.

Nations would eventually control the production and use of all fissionable materials and oversee research and development in atomic energy for peaceful purposes only. But there would have to be a period of transition, Bush and Conant believed, between the signing of the agreement and the full operation of the authority, between 1946, when the United States commanded a nuclear monopoly, and the point in the distant future when no nation would possess a nuclear arsenal. In this transition period, they argued, the agreement would have to go into effect by stages, each accompanied by a quid pro quo from the Soviet Union. On the side of the United States, the stages might proceed from sharing of information about basic nuclear science, then to the release of material concerning the practical, industrial uses of nuclear energy. On the side of the Soviet Union the quid pro quo for each such stage would necessarily be the opening up of Russian basic research laboratories to free, unlimited access by foreign scientists, then acceptance of international inspection of all her nuclear facilities. Only after the inspection system was successfully in force would the United States turn its bombs into power plants.

Whatever the particular stages, Bush, Conant, and Oppenheimer recognized, any international control agreement had from start to finish to protect American security. To that end, Bernard Baruch, whom President Truman appointed to carry the American plan to the United Nations, insisted that the arrangement must include sanctions against violators, sanctions which must not be thwarted in the Security Council. Truman agreed. On June 14, 1946, in a portentous speech, Baruch presented the American plan—the Baruch Plan, it was quickly dubbed—to the newly created United Nations Atomic Energy Commission. "There must be no veto," he stressed, "to protect those who violate their solemn agreements not to develop or use atomic energy for destructive purposes."[6]

Three days later, June 19, Andrei Gromyko declared that the Soviet Union flatly rejected any tampering with the veto power. Otherwise ignoring the Baruch Plan, Gromyko proposed instead an international convention that would ban the bomb, of course meaning the American bomb, almost immediately. Over the next six months, in meetings of scientists and diplomats, the United States and Russia negotiated; the negotiations deadlocked over the issue of the veto. By January 1947 the Baruch Plan was a dead issue.

The veto quarrel doubtless clouded the real reason for the failure of the Baruch Plan. The Soviet Union, keenly aware it was a nonnuclear power, sought to neutralize the American advantage. The Russians preferred either to see the American nuclear arsenal destroyed forthwith, or to develop their own atomic bombs as quickly as possible, or both. Whatever the Soviet reasoning, the United States, its armies swiftly demobilizing, knew that massive Russian forces were poised on the borders of

[6] Quoted in Hewlett and Anderson, *The New World*, p. 578.

eastern Europe. Under such conditions, America would scarcely agree to immediate outlawing of the atomic bomb, the principal deterrent to Russian expansion.[7]

Like Bush and Conant, the Los Alamos generation at large generally endorsed a staged international atomic energy agreement because in the postwar era they emphatically agreed with its premise—that American security had to be protected. As citizens, the majority of atomic scientists read the lessons of the 1930s in the same way as the majority of their fellow Americans: Isolationism was perilous. As scientists, they were particularly sensitive to an argument that had first emerged in response to the repressions of the Nazis, then gathered force during the war. Science, the argument ran, needed freedom to survive, and so did freedom need science. Now, in the immediate postwar years, the Soviet scientific capability not only contributed to the plea for the international control of nuclear energy; it also helped etch deeper the belief that there was another side to the social responsibility of science—that scientists, in the words of Ernest Lawrence's old friend Merle Tuve, had a "definite, irreducible and nontransferable responsibility" to help maintain the national defense.[8]

Like Tuve, the head of the OSRD section that developed the proximity fuze, most of the nation's atomic scientists did not want to fulfill that responsibility as subordinates to the military. They insisted upon a degree of autonomy in peacetime defense research similar to what they had enjoyed under OSRD. But restless under the centralized direction of research, few wanted to remain in anything resembling OSRD itself.[9] While some intended to stay in such civilian-oriented laboratories as Los Alamos, the vast majority preferred to contribute to the national defense from the independent havens of campuses. There they would be free of excessive red tape and unreasonable or, most hoped, any security restrictions. There they could contribute to defense research on a part-time

[7] *Ibid.*, pp. 598, 619; Barton J. Bernstein, "The Quest for Security: American Foreign Policy and International Control of Atomic Energy, 1942–1946," *Journal of American History*, LX (March 1974), 1023–24, 1030, 1032, 1039.

[8] Tuve, "Notes for First Meeting of Committee on Planning for Army and Navy Research," June 22, 1944, and "Addendum to Minutes of Meeting, June 22, 1944," attached to Tuve to Bush, June 27, 1944, OSR, Entry 1, Cooperation: Postwar Military Research Committee.

[9] Bush told a congressional committee that in postwar defense research military officers and civilian scientists "must be equals and independent in authority, prestige, and in funds." U.S. Congress, House, Select Committee on Postwar Military Policy, *Hearings, Surplus Material—Research and Development*, 78th Cong., 2d Sess., Nov. 1944–Jan. 1945, pp. 248–49. Jewett to Bush, Sept. 2, 1943, OSR, Entry 1, Cooperation: Kilgore Committee; Conant, "Science and Society in the Post-War World," *Vital Speeches*, 9 (April 15, 1943), 396–97; Frank Jewett testified in May 1945: "The whole thing is repugnant to the ordinary civilian-life ways of scientists—the restrictions under which they have to operate and the cellular structure. The uniform experience in talking to all of the men who have given a lot of time and effort, to OSRD, is that they want to get out of this thing and get back to their work as soon as possible." *Hearings, Research and Development*, May 1945, p. 58.

basis, through advisory committees or actual research contracts. And there they could foster what virtually all of them considered essential to the maintenance of national security—the training of new scientists and the advancement of science as such.

In James B. Conant's estimate, the war, including the draft, had cost science some 17,000 advanced and 150,000 first degree graduates. The production of scientific doctorates was not expected to reach normal levels again until the mid-1950s. Manpower analysts studied the wartime halt in the prewar growth rates and predicted that by 1953 there would be a deficit of two thousand Ph.D.'s in physics, a sizable figure measured against demands for physicists in industry alone.[1] Besides, the nation was commonly said to have drawn heavily during the war upon its balance in the bank of pure science, and it no longer could expect substantial replenishment from Europe.

In the past, scientific training and research had been paid for by private wealth, but now private wealth, Karl Compton typically reemphasized, could no longer manage the task. The war effort had given professors the heady taste of doing research with few financial restraints. Typically, the young physicists at the Rad Lab had grown accustomed merely to signing an order for a new instrument whose purchase might have required a major faculty debate before the war. University administrators doubted that able scientists would be satisfied to return to the routine of heavy teaching loads, limited equipment budgets, and low salaries. In the wake of this physicists' war, the Los Alamos generation insisted that if it was the responsibility of the civilian scientist to contribute his expertise to defense research, it was also the responsibility of the federal government to finance the basic research and training on which the nation's security ultimately depended.

During the war the average annual federal investment in scientific research and development had shot up from $48,000,000 to $500,000,000, from 18 percent to 83 percent of the total public and private expenditure for the purpose.[2] The bulk of the increase had naturally gone to the military. Like the leaders of the Los Alamos generation, thoughtful Americans, especially those of a liberal political persuasion, were bothered about the degree to which defense research had come to overshadow basic research and training, and they were bothered by a good deal more in the legacy of wartime science, especially by the specter of monopoly.

Even the probusiness *Fortune* Magazine had concluded that dollar-a-

[1] Vannevar Bush, *Science—The Endless Frontier . . . July 1945* (Washington, D.C.: National Science Foundation, 1960), p. 158.

[2] The President's Scientific Research Board, *Science and Public Policy: A Report to the President, 1947* (5 vols.; Washington, D.C., 1947), I, 10. Part of the material in the rest of this chapter previously appeared in *Isis*, copyright © 1977 by *Isis*, and is reprinted here in different form with the permission of the editor.

year men in the war agencies sometimes rejected the suggestions of small businessmen and inventors for the self-interested purpose of protecting the market positions of their own corporations. Speeches, articles, and advertisements had frequently celebrated, in the language of *Collier's*, "the amazing new world . . . in the making in the plants and laboratories . . . devoted to war."[3] But liberals wondered who would control this amazing new world and its technological marvels. They found disturbing that some 66 percent of wartime contract dollars for research and development went to only sixty-eight corporations, some 40 percent to only ten. OSRD spent about 90 percent of its funds for principal academic contractors at only eight institutions, about 35 percent at the MIT Radiation Laboratory alone. And more than nine out of ten of the contracts from OSRD and the military granted the ownership of the patents deriving from this publicly funded research to the contractors, not to the public.[4]

Critics called the patent practice an unwarranted and dangerous giveaway. Before the war giant American firms had entered into patent agreements with foreign, including German, cartels. These contracts, it was alleged, had kept the United States from developing sufficient supplies of such strategic raw materials as beryllium, magnesium, optical glass, chemicals, and above all, synthetic rubber. Besides, the Temporary National Economic Committee had concluded that big business tended to use the patent system "to control whole industries, to suppress competition, to restrict output, to enhance prices, to suppress inventions, and to discourage inventiveness."[5] Assistant Attorney General Thurman Arnold, the administration's chief trustbuster and a central figure in the wartime patent controversies, explained to a congressional committee: If science and technology were to serve the public interest, it was necessary to do more than just break up patent pools. Something had to be done about the concentrated private control of the underlying knowledge and know-how from which patent pools germinated.[6]

[3] "The Bottleneck in Ideas," *Fortune*, 27 (May 1943), 82–85, 177–86; *Collier's*, 111 (May 8, 1943), 40.

[4] Carroll W. Pursell, Jr., ed., *The Military-Industrial Complex* (New York, 1972), pp. 165, 168–69; James Phinney Baxter, *Scientists Against Time* (Cambridge, Mass., 1968), p. 456.

[5] For salient aspects of the controversy surrounding the relationship between the control of patents and shortages of critical materials, especially synthetic rubber, see *The New York Times*, February 23, 1942, p. 30; March 26, 1942, pp. 1, 16; March 29, 1942, p. 9; April 12, 1942, p. 48; April 15, 1942, pp. 1, 7; April 18, 1942, p. 32. U.S. Senate, *Investigation of Concentration of Economic Power: Final Report and Recommendations of the Temporary National Economic Committee*, 77th Cong., 1st Sess., Sen. Doc. No. 35, 1941, p. 36. Assistant Attorney General Wendell Berge cast doubt on the academic use of patents when he attacked the Wisconsin Alumni Research Foundation for a wide range of abuses in the administration of the Steenbock vitamin D patent. U.S. Senate, Subcommittee of the Committee on Military Affairs, *Hearings, Scientific and Technological Mobilization*, 78th Cong., 1st Sess., 1943, pp. 741–42.

[6] U.S. Senate, Subcommittee of the Committee on Military Affairs, *Hearings, Scientific and Technological Mobilization*, 1943, pp. 11, 25.

In the increasingly powerful Bureau of the Budget, where Director Harold Smith had set a small staff group to work analyzing plans for postwar federal research, young James L. Sundquist pondered the effect of private control upon the public interest in science. In the private sector, if profit was not immediately apparent, Sundquist asserted, new fields of research languished, including smoke control, stream pollution control, low-cost housing, low-cost rural electrification, and the uses of substitute materials. In the governmental sector, established research programs tended to fare better than such new socially purposeful projects. The trouble was, Sundquist argued, that the federal research budget reflected not the "*national need*" but the "national *pressures*" for research. He found the principal pressures arising from economic interest groups and the government's own research agencies.[7] He might have added the increasingly insistent pressures from scientists who were interested in areas of research determined not by social standards of national need but by professional criteria of scientific significance. To balance the emphasis on economically and, now, militarily useful research, liberals like Harold Smith and his staff considered it in the national interest for the government to respond to the mounting demand for federal investment in basic research and training. They also regarded it as equally essential for the government to identify and invest in such areas of research as pollution control for which no pressure groups existed but which would likely pay a high social return.[8]

In the Congress the liberal concern with the control and purpose of national research found a spokesman in Senator Harley M. Kilgore of West Virginia. A small-town lawyer, National Guardsman, Legionnaire, Mason, and past Exalted Ruler of the Elks Lodge, Kilgore was quick to admit "utter, absolute ignorance" of science and technology. The son of a wildcat oil prospector, he was equally quick to discourse on the power of big business, including its power to deprive ordinary people of a fair chance. While a judge of the county criminal court, Kilgore won a reputation for his willingness to help juvenile offenders get a new start. In 1940 the pro-Roosevelt faction in the bitterly divided West Virginia Democratic Party found him a natural, if last-minute, choice for the senatorial nomination. Kilgore squeaked through a three-way primary with less than 40 percent of the vote, winning mainly because of the support of the CIO.[9] Handily elected on FDR's coattails, he went to Washington a down-the-line New Dealer eager to do all he could for the plain folks back home, especially the prolabor folks who had put him into office.

[7] James L. Sundquist to Arnold Miles, Feb. 16, 1945, BOB, series 39.33, file 91.

[8] Smith testimony, U.S. Congress, Senate, Subcommittee of the Committee on Military Affairs, *Hearings on Science Legislation*, 79th Cong., 1st Sess., Oct. 1945, p. 97.

[9] Kilgore, speech, May 10, 1943, copy in OSR, Entry 1, Cooperation: Kilgore Committee; *New York Times*, May 16, 1940, p. 24.

His suits wrinkled, his pockets crammed with papers, pencils, and a good luck horse chestnut, Kilgore soon established himself as an outspoken member of the Truman Committee, decrying the rubber shortage, patent abuses, and the power of dollar-a-year men. In 1942, at the urging of Herbert Schimmel, a congressional staffer who had a Ph.D. in physics, Kilgore introduced a bill for the better mobilization of the nation's technological resources.[1] In the course of extended hearings, Kilgore gradually learned about the critical importance of civilian science to national defense, the concentration of contracts for research and development, the pro-contractor patent policy of the armed services and OSRD. Moving steadily away from the problems of war mobilization, by the end of 1945 Kilgore had put together a full legislative program for peacetime science.

In Kilgore's program, the federal government was to finance basic research and training in the major fields of science, including a civilian-controlled effort in fundamental defense research. Kilgore called for the evaluation and, in the form of recommendations to the President, planning of all federal research activities to good social purpose. He also urged federal support of the social sciences, insisted that at least part of the money in all fields be distributed on a geographical basis, and proposed that the ownership of patents arising from federally sponsored research normally go to the government. In exceptional cases the contractor might be awarded ownership of the patent, but the government would always receive a royalty-free license for its use. To carry out his program, Kilgore proposed the establishment of a new federal agency, a National Science Foundation, which would of course be a regular part of the executive branch under the direct control of the President.[2]

In a way, Kilgore aimed de facto to extend the social reformism pioneered by John Wesley Powell to virtually the whole of federally sponsored science. In part his program responded to the long-standing demands of public colleges and to the professional self-interest of social scientists; in part it drew upon the preference for national planning of current Budget Bureau staffers, not to mention the pleas in the 1930s of Delano, Merriam, and Mitchell; in part it reflected the issues raised by the wartime mobilization of research. Whatever the roots of its specific elements, Kilgore's package added up to a major liberal initiative for peacetime science.

But while Kilgore's program was evolving, some armed service officers and the National Association of Manufacturers denounced it as a threat to socialize all of science in the United States. Both the army and navy objected to the patent provisions on grounds that they would raise the

[1] Henry H. Collins, Jr. and Herbert Schimmel to Senator Kilgore, Aug. 14, 1942, HMK, file A & M 967, series 1; Schimmel to the author, Oct. 3, 1973.

[2] U.S. Senate, Subcommittee of the Committee on Military Affairs, Report No. 7, *Preliminary Report [on Science Legislation]*, [Dec. 1945], 79th Cong., 1st Sess., copy in OWMR, Box 275, Legislation . . . Scientific Research file.

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cost of, if not make impossible, industrial contracts for military research and development.[3] Like their employers, industrial scientists vociferously attacked Kilgore's patent policy, too, but the chief scientific opposition to his overall program came from the leadership of OSRD, especially Vannevar Bush.

Unlike many industrial scientists, Bush endorsed governmental curbs on the domination of markets by large industrial combinations through patents or any other device.[4] He had a variety of proposals in mind to prevent large firms from using the patent system to bar the entry of small firms into lucrative new technological markets; none of his ideas included the measures in Kilgore's program, especially not the stipulation that patents arising from federally sponsored research should belong to the government.[5] To Kilgore's call for the geographical distribution of some fraction of federal research funds, Bush advanced the traditional best-science objection: All the money should be awarded to the best investigators, wherever they were located. Kilgore's proposal to foster the social sciences antagonized the conservative Bush; he did not respect them intellectually and regarded them for the most part as just so much political propaganda masquerading as science. Besides, the OSRD staff worried that their inclusion might place the natural science program in jeopardy. Irvin Stewart, one of Bush's closest aides, advised a dean in Texas: Any provision for the support of the social sciences would be "dynamite."

[3] *Hearings, Scientific and Technological Mobilization*, 1943, pp. 309, 240–41, 245, 271; Walter S. Landis [Vice-President of American Cyanamid Co.], *What's Wrong with the Kilgore Bill* (privately printed, October 1943); *Legislation . . . That Could Radically Change Our Whole Economic Structure* (Commerce and Industry Association of New York, November 1943), copy in HMK, file A & M 967; Julius A. Furer, "Memo for Files," March 26, 1943, and Ralph Bard to Chairman, Senate Committee on Military Affairs, June 2, 1943, NCONR, Kilgore bill file; Harvey H. Bundy to Colonel Ege, April 3, 1943, and attached documents, OSW, Entry 82, Box 73, Technological Mobilization bill.

[4] At the end of World War I Bush's fledgling Raytheon Corporation had almost been forced out of business when General Electric, RCA, Westinghouse, and AT&T formed an exclusive patent pool and marketing agreement for vacuum tubes. In the coming postwar period, he believed, the nation's prosperity would depend to a considerable extent upon the appearance of similar small businesses applying new knowledge in a useful manner. Bush to Oliver E. Buckley, July 25, 1945, OSR, Entry 2, Report to the President, #3; Bush, *Pieces of the Action* (New York, 1970), pp. 198–99.

[5] Bush thought that the government might make it less expensive for small firms to defend a patent by supporting the firm's case in court. The law might also be modified to help small firms to defend themselves against infringement suits by big firms. It would be a valid defense to show that, by exchange of patent rights in combination with others, the big firm had acquired more than a reasonable fraction of the market; if the plaintiff won, he would be awarded only royalties, not an order to cease and desist. Bush was even willing to go so far as to compel the licensing of patents held by large producers who were found to be participants in an exclusive cross-licensing agreement. Bush to Conway P. Coe, November 4, 1943, VB, Box 24, file 567; Bush to John T. Tate, February 8, 1945; Bush to Delos G. Haynes, February 21, 1945; Bush to Robert E. Wilson, March 10, 1945, OSR, Entry 2, Report to the President.

Social scientists could not easily convince Congress to spend federal funds "for studies designed to alleviate [the] conditions of the Negroes in the South or to ascertain the influence of the Catholic Church on the political situation in Massachusetts."[6]

Nothing in Kilgore's program disturbed Bush more than its direct control by the President, especially since the control was to be exercised in conjunction with planning for socially purposeful research. Here was not so much a threat of political interference with intellectual freedom as a prospect of permitting the political system to determine the kind of research to be encouraged. Homer W. Smith, the director of the physiology laboratory at New York University School of Medicine and an adviser to Bush on postwar policy for science, warned: We stand in danger of losing our intellectual heritage "not to personal dictators, anti-scientific prejudices or other antiquated tyrants, but to an as yet unnamed horror of [a] national policy wherein men will be 'requested' . . . to devote their lives to artificial and imposed intellectual interests." Of course, Smith implied, the scientist need not heed the requests, but he would be "forced" to do so through the "pressures of personal and professional financial needs, advancement, security and scientific opportunity." What the scientist required was the opportunity for "free" research, which meant "the intellectual and physical freedom to work on whatever he damned well pleases."[7]

Smith's analysis recalled Alexander Agassiz's assault on John Wesley Powell—and it merited something akin to Powell's response. Without Kilgore's program, were not scientists subject to personal pressures, financial and otherwise? Did they not worry about advancement, security, and scientific opportunity? Did not professional pressures help to determine their research topics? And was not the trend, in other disciplines as well as physics, toward group efforts, in which junior scientists scarcely enjoyed the same latitude as their seniors? Under these circumstances scientists were hardly as "free" as Smith claimed. They were free only from any government encouragement to invest their talents in one field or another. They were free only to operate within a framework defined by private decisions.

Kilgore's program rested on James Sundquist's fundamental assumption: Science had become too important to leave the formation of national scientific policy entirely to the haphazard play of interest groups, scientific or otherwise. Like Kilgore, Bush, too, saw a need for the planning and

[6] Bush to Isaiah Bowman, Jan. 7, 1946, OSR, Entry 1, NSF: Public Interest, Committee for the Bush Report; Bush to D. C. Josephs, Sept. 12, 1946, VB, Box 60, file 1416; U.S. Congress, House, Subcommittee of the Committee on Interstate and Foreign Commerce, *Hearings, National Science Foundation Act*, 79th Cong., 2d Sess., 1946, p. 53; Stewart to A. P. Brogan, Sept. 24, 1945, OSR, Entry 1, Postwar Planning.

[7] Smith to Bush, Aug. 29, 1945, OSR, Entry 1, NSF: Public Interest, Educational Institutions.

evaluation of the national research program. But Bush objected to vesting control over much of the nation's science in a centralized federal bureaucracy, and not without justification. Policy decisions could all too easily favor the bureaucratic over the scientific or even the national interest. Of course, more than in the private arena, public decisions would be open to scrutiny and debate. Nevertheless, while Kilgore aimed to subject the shaping of federal scientific policy to the political process, Bush, a political elitist, wanted the immediate determination of that policy left essentially in private hands, even if its execution involved the expenditure of public funds. "Powerful writing," he exclaimed of Smith's fusillade.[8]

During the fall of 1944, ready to seize the initiative from Kilgore, Bush successfully maneuvered to obtain a letter from FDR requesting a report to the President on postwar policy for science, and in July 1945 he sent the completed document to President Truman under the title *Science—The Endless Frontier*.[9] Like Kilgore, Bush called for a program of federal aid to basic scientific research and training, along with a civilian-controlled effort in fundamental defense research. Unlike the senator, he proposed no remedy for what he acknowledged were "uncertainties" and "abuses" in the patent system, omitted the social sciences from consideration, and made no mention of distributing the funds in his program in accord with either a geographical scheme or the planning of socially purposeful research. Bush conceded that his program had to be responsible—but, in a politically elitist fashion, not responsive—to the President and Congress. Stressing the importance of insulating it from political control, he proposed to operate his program through a new federal agency, which, unlike Kilgore's National Science Foundation, would, in the apt summary of an OSRD staff aide, be "a new social invention—of government sanction and support but professional guidance and administration."[1]

Bush's report, in the remark of an OSRD staff member, was "an instant smash hit."[2] But while applauded in scores of editorials across the partisan and geographical spectrum, it was no smash hit with the *New Republic*, which commented: "Research needs to be coordinated carefully and the projects should be selected in terms of our national necessities, and not the accidental interests of various scientific groups." The politically insular posture of Bush's program was certainly not a smash hit in the

[8] Bush to Carroll L. Wilson, n.d., attached to Smith to Bush, Aug. 29, 1945, *ibid.* To Bush, the primary question was "whether science in this country is going to be supported or whether it is also going to be controlled." Bush to Bernard Baruch, Oct. 24, 1945, OSR, Entry 1, NSF Legislation.

[9] Daniel J. Kevles, "FDR's Science Policy," *Science*, 183 (March 1, 1974), 798–800; Diary of Oscar S. Cox, Oct. 24, 1944, OSC; "News Stories and Editorial Comment on the President's Letter . . .," FDR, OF 4482.

[1] Bush, *Science—The Endless Frontier*, pp. 32–40, 21–22, 38; Laurence K. Frank, "Comments on Bush Report . . .," OSR, Entry 2, Misc.

[2] Lyman Chalkley to Carroll L. Wilson, July 20, 1945, OSR, Entry 2, Distribution; "News Stories and Editorial Comment on the Postwar Program for Scientific Research," OSR, Entry 1, Postwar Planning Reports.

Budget Bureau or with Maury Maverick, the former mayor of San Antonio, Texas, and the head of the Smaller War Plants Administration, who recognized the degree of concentration of defense research contracts and who in October 1945 exploded to a congressional committee: "I get a little tired of these hired hands of the monopolies and some of the professors . . . piously abrogating [sic] to themselves all the patriotism. . . . I'm not sure but that the office holder has been, and is, more conscious of the public welfare than many scientists. . . . Let us all bear in mind that we have a political Government and that our Constitution is a political instrument. The political character of our Government guarantees democracy and freedom, in which the people, through their Government, decide what they want."[3]

At the opening of the atomic age, the revolutionary needs of national security had joined the older requirements of economic development to force an end to what had long been, de facto, a federal policy of laissez-faire in physics. Bush was willing to endorse that end insofar as he was willing to put the government into the business of funding academic scientific research outside of agriculture. But if Kilgore's program was directed at mobilizing scientific research in a fashion politically responsive to the nation's best needs, Bush's aimed to enlist the nation's resources, through a politically elitist mechanism, to satisfy the scientific community's traditional goal of advancing the best science. Like George Ellery Hale at the end of World War I, Bush may have thought that his program disinterestedly sought the apolitical national interest. Set against Kilgore, Bush insisted upon a politically conservative interpretation of what the end of laissez-faire was to mean in postwar America for the Los Alamos generation and its science.

[3] "A National Science Program," *New Republic*, 113 (July 30, 1945), 116; *Hearings on Science Legislation, 1945*, pp. 368–69. In the administratively sensitive Budget Bureau, Harold Smith, who wondered, only half puckishly, whether the "Endless Frontier" implied the "Endless Expenditure," declared most scientists had "learned to accept governmental funds with ease, and . . . they can adapt themselves to governmental organization with equal ease." Smith to Carroll L. Wilson, July 18, 1945, BOB, series 39.27, Box 82, OSRD file; Smith to Julius A. Furer, June 14, 1945, JAF, Research and Development file. Budget staff members found Bush "pompous" and the research policy area filled with "prima donnas." Donald Stone, "Notes Relating to Meeting of Vannevar Bush . . ., Jan. 1945"; Donald Miles to Stone, Feb. 12, 1945, BOB, series 39.32, files E8—21/44.1 and E8–20/45.1.