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COLD WAR AND HOT PHYSICS
REFLECTIONS ON SCIENCE, SECURITY AND THE AMERICAN STATE

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ABSTRACT

The contributions of physics to the Allied victory in World War II made clear that the maintenance of national security required major public investment in scientific research and training. By the late 1940s, the United States government was spending about one billion dollars annually on research and development (R&D), mainly through the Department of Defense and the Atomic Energy Commission. The Korean War drove these expenditures permanently higher. Between 1945 and 1957, defense-related agencies formed the principal patrons of the country's civilian science. At the same time, civilian scientists became deeply engaged in advising the government upon the technologies of national security, obtaining access to the White House with the creation, in 1951, of the Science Advisory Committee, through which they helped accelerate the nation's missile development program. Under this patronage and influence, physics flourished--both high-energy particle physics and branches of physics such as quantum and micro-electronics that were directly related to national security. The result was a diversification of physics and its integration across a broad front into the R&D network of national security.

Physicists won World War II with radar and ended it with the atomic bomb, decisively eliminating the need to risk ground troops in an invasion of the Japanese Home Islands -- so the history of the war was instantly understood by physicists and policymakers in the United States. The consequences seemed clear: National security would depend, henceforth, upon technological superiority; nuclear weapons and other military technologies could offset the Soviet manpower advantage in postwar Europe. Technological superiority, in turn, needed state programs and facilities of scientific research, and state efforts to enlarge the nation's pool of people trained in relevant technical disciplines, especially physics, the practitioners of which had been in notably short supply during the war.

Some of the research could be conducted where it had traditionally been carried out -- in government laboratories -- but among the key lessons drawn from the success of the wartime mobilization under the Office of Scientific Research and Development (OSRD) was that a significant part of the work had to exploit the civilian scientific sector outside government -- that is, the laboratories of both industry and -- for the most innovative work -- of academia. Here -- at least in the view of the civilian scientific veterans of OSRD -- was where fresh thinking and activity on the frontiers of science were the norm. Here was where the ideas for radical new weapons and weapons systems would most likely originate -- especially if its knowledgeable civilian scientists were kept involved in the forging of national strategic policy. As Vannevar Bush, the head of OSRD, had argued as early as 1941, only by drawing upon scientific experts familiar with the latest laboratory products could military planners know the best way to exploit new weapons. Only by having access to the military's strategic requirements could defense scientists best understand the kinds of weapons that needed developing.[1]

By 1949/50, the eve of the Korean War, the federal government was spending some $1 billion for R&D, which was almost $300 million more than it had allocated for the purpose in 1946, the year of demobilization. Most of it -- 90% -- came about equally from the new Atomic Energy Commission (AEC) and the Department of Defense (DOD). Defense-related research loomed large everywhere in the civilian scientific sector. The military spent $350 million dollars on research in industrial laboratories, accounting for about 25% of the total dollar performance in the industrial R&D sector.[2] The Office of Naval Research (ONR) was by far the principal patron of academic science, sponsoring some 1200 research projects in almost 200 universities, including the construction and maintenance of a number of on-campus accelerators for unclassified work in nuclear and particle physics. ONR

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[1] Daniel J. Kevles, The Physicists: The History of a Scientific Community in Modern America (1987), p. 308.

[2] William T. Golden, Memo to File, "Conversation with E. U. Condon, Director, National Bureau of Standards, and Messrs. Hugh Odishaw and N.E. Golovin, Assistants to the Director," Oct. 31, 1950, p.3, William T. Golden MSS; "Research and Development in the United States, 1941-1952," table attached to Oliver Buckly to James Killian, Oct. 26, 1951, Karl T. Compton/James R. Killian MSS, MIT Archives (hereafter, C/K MSS), Box 256, folder 10; Forman, "Behind Quantum Electronics: National Security as a Basis for Physical Research in the United States, 1940-1960," HSPS: Historical Studies in the Physical and Biological Sciences, 18:1(1987), p. 211.

assisted some 2,500 science students towards their Ph.D.s., while the Atomic Energy Commission provided some 800 fellowships a year in the physical and biomedical sciences. In 1949, the Defense Department together with the AEC accounted for 96 percent of all federal dollars spent on the campuses for research in the physical sciences. For every two of those dollars spent by the AEC, the military spent at least three.[3]

The gross features of this transformation in relationships between civilian science and the American state have been known for some time, particularly as they were manifest in the areas of nuclear and thermonuclear weapons as well as high-energy physics. However, recent historical inquiry has begun to provide a view of these matters that is at once wider in view and higher in resolution. This work permits us to probe with more concrete specificity -- and challenges us to reconsider -- how the pressures and opportunities of national security shaped the American physics enterprise in the decade or so after World War II.[4]

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[3] Forman, "Behind Quantum Electronics" (1987), pp. 156, 204, 186-7; Chart, "Research and Development Obligations of the Department of Defense," Fig.2, attached to "Science Advisory Committee, Summary, Mtg. No. 3," Sept. 18, 1951, C/K MSS, Box 256, folder 10; Kevles, The Physicists (1987), pp. 355, 359; William T. Golden, Memos to File, "Conversation with Kenneth Pitzer, Director, Research Division, AEC," Oct. 31, 1950, p. 1; "Conversation with Rear Admiral T. Solberg, Director of Office of Naval Research," Jan. 15, 1951 as of Jan. 10, 1951, p. 1, Golden MSS; S. S. Schweber, "Big Science in Context: Cornell and MIT," unpublished paper, Workshop on Big Science, Stanford University, August 1988, p. 27.

[4] I have particularly in mind the investigations of J.L. Heilbron and coworkers, which have enriched considerably our knowledge of the history of nuclear and high-energy physics at levels of both the national agencies and local institutions; and also the writings of

Among the key issues in the science-security nexus were two: What kind of research was needed to maintain the nation's technological superiority? And how was that research to be organized and advanced? To many leaders of American physics, major investment had to be made in pure science, which was commonly exemplified in the discussions of the late 1940s by the abstruse prewar nuclear explorations that had made possible the invention of the atomic bomb. Yet many physicists conceded -- and a number of them enthusiastically stressed -- that also needed was research closely related to the technologies of national security (for example, the behavior of electromagnetic radiation at the frequencies of microwave radar, or of the processes in nuclear reactors designed to produce weapons-grade fissionable material). In a world perfect for physicists, there would be resources and latitude enough for both. However, in the United States the technological had always tended to command more attention than the pure. Now that problem loomed all the larger, since the principal patron of research was to be the federal government, which in the country's practically oriented culture was more naturally an ally of the technological than of the pure. It was also an article of faith that pure research thrived on autonomy and openness, while technological projects tended to be targeted and often to operate under information restrictions. Then, too, research in even

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scholars such as Paul Forman, Stuart W. Leslie, S.S. Schweber, Peter Galison, Clayton Koppes, Allan Needell, and David Devorkin, which have brought space and missile physics as well as microelectronics into the field of historical inquiry. Much of this work has appeared in HSPS: Historical Studies in the Physical and Biological Sciences. Entry into this literature is to be found in the Bibliography appended to this essay. Specific references to items in it are, of course, contained in the notes.

esoteric areas of knowledge, now freighted with the weight of national security, was threatened with controlled direction and security restrictions.

In some areas, some of these tensions were dealt with by segregating the technological from the pure. In 1949-50, only about 9% of DOD R&D obligations went for research in universities and other non-profits. Some 54% of them were for work in industry. About 36% of DOD research dollars went to government laboratories, including such civilian facilities as the National Bureau of Standards.[5] Each of the armed services had enlisted academia in the cause of weapons technology but by arrangements -- they had originated during the war -- under which leading universities managed separate major weapons research facilities for defense agencies. University-connected laboratories under DOD sponsorship included the Jet Propulsion Laboratory at the California Institute of Technology and the Applied Physics Laboratory of The Johns Hopkins University, the former a ward of Army Ordnance, the latter of Navy Ordnance -- and both devoted to basic research related to the development of guided missiles.[6]

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[5] Paul Forman, "Behind Quantum Electronics" (1987), p. 180; James Forrestal to Karl T Compton, Sept. 30, 1948; Chart, "Research and Development Obligations of the Department of Defense," Fig.2, attached to "Science Advisory Committee, Summary, Mtg. No. 3," Sept. 18, 1951, C/K MSS, Box 245, Folder 16; Box 256, folder 10.

[6] Clayton R. Koppes, JPL and the American Space Program: A History of the Jet Propulsion Laboratory (1982), pp. 18-34; Michael Aaron Dennis, "No Fixed Position: University Laboratories and Military Patronage at Johns Hopkins and MIT, 1944-46," unpublished paper (1987). Army Ordnance's sponsorship of JPL expressed sharply the change in the military's attitude toward civilian science. The footsoldier's Army had long been the most backward of the services with respect to scientific research. Ordnance, which received about two thirds of Army R&D funds,

The Atomic Energy Commission managed the tension, as Robert Seidel has told us, by differentiating its installations into "laboratories primarily devoted to programmatic research with limited basic research programs, and laboratories primarily devoted to basic research with limited applied research programs." To a considerable extent, the commitment to a basic research program had been brought about by Ernest Lawrence, whose Berkeley Radiation Laboratory was replete with ambitious plans for new accelerators and had been left well funded to begin realizing them by General Leslie R. Groves, the head of the terminating Manhattan Project. In 1947, the AEC fixed upon a policy of supporting fundamental research, a policy that led to bonanzas for Lawrence's Laboratory and its new east coast counterpart, the Brookhaven National Laboratory, on Long Island, New York.[7]]

In 1949, AEC Commissioner Henry Smyth, himself a physicist, reflected to a group of laboratory representatives that the Commission's strategy for its technological installations gave the AEC

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had traditionally been prone to rely on its own laboratories, such as the Aberdeen Proving Grounds, and to distrust civilian establishments. William T. Golden, Memo to File, "Meeting with Roger W. Jones, Assistant Director in Charge of Legislative Reference, Bureau of the Budget," Oct. 11, 1950, Golden MSS. See the comments on contract-operated government laboratories in Oliver Buckley to the President, May 1, 1952, attached to Science Advisory Committee, "Summary, Meeting No. 11," May 9, 1952, C/K MSS, Box 256, folder 12.

[7] J. L. Heilbron, Robert W. Seidel, and Bruce R. Wheaton, _Lawrence and His Laboratory: Nuclear Science at Berkeley, 1931-1961_ (Berkeley, CA: Office for History of Science and Technology, University of California, Berkeley, 1981), pp. 49, 60-62; Robert W. Seidel, "Acclerating Science: The Postwar Transformation of the Lawrence Radiation Laboratory," _HSPS: Historical Studies in the Physical and Biological Sciences_, 13:2(1983), 375-400.

"secrecy, and big groups of scientists who will take orders, and big equipment."[8] Still, the Commission's best known technologically oriented installation -- the Los Alamos Weapons Laboratory -- was, of course, operated for the AEC by the University of California, a connection which, like DOD's arrangement with various universities, no doubt helped obscure the Lab's order-taking characteristics, added legitimacy to its claims of academic tone, and aided in the recruitment of high-quality staff. (Whatever the advantages of the UC connection, J. Robert Oppenheimer was moved to remark, in 1949, that "it is a great liberal university that is the only place in the world, as far as I know, that manufactures, under contract with the United States governmnent, atomic bombs." He added, "I have sometimes asked myself whether we can find any analogy to this situation in the practice of the monastic orders that devote a part of their attention and derive part of their sustenance from the making of their private liquers."[9])

However, on a number of campuses, the pure and the technological were not always sharply segregated. While the Department of Defense provided a good deal of money for projects in pure science free of most restrictions, security or otherwise, many of its subventions were for basic research recognized, to quote a later Defense Department directive, "as an integral part of programmed

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[8] Seidel, "A Home for Big Science: The Atomic Energy Commission's Laboratory System," HSPS: Historical Studies in the Physical and Biological Sciences, 16:1(1986), 144, 148-9.

[9] Seidel, "A Home for Big Science" (1986), p. 150; J. Robert Oppenheimer, Uncommon Sense, eds., N. Metropolis, Gian-Carlo Rota, and David Sharp (1984), p. 30.

research commited to specific military aims." [10]

The leading case in point was MIT, which had a strong tradition of emphasis on engineering and had been the home of the wartime Radiation Laboratory. At the end of the war, mainly at the initiative of the physicist John C. Slater, MIT created the Research Laboratory in Electronics, which was to extend the basic microwave research of the Rad Lab, obtained a good deal of its valuable equipment, and enjoyed a subvention from the three armed services that soon reached $1.5 million annually. A joint venture of the physics and engineering departments at MIT, the Laboratory was to accelerate the transfer of advanced atomic, molecular, solid state, and microwave physics to engineering practice, while employing the theories and devices its staff developed in basic physics research. In the late 1940s, 85% of the MIT research budget came from the military and the AEC.[11]

The armed services sustained not only the MIT Research Laboratory in Electronics but similar installations at Harvard and

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[10] Daniel J. Kevles, "K_1S_2: Korea, Science, and the State," California Institute of Technology, Humanities Working Paper 134, July 1988, p. 8.

[11] Department of Defense Directive, "Policy on Basic Research," June 19, 1952, C/K MSS, Box 256, folder 13;Schweber, "Big Science in Context" (1988), pp. 3, 18, 25, 26; Stuart W. Leslie, "Playing the Education Game to Win: The Military and Interdisciplinary Research at Stanford," HSPS: Historical Studies in the Physical and Biological Sciences, 18:1(1987), 65-66; Forman, "Behind Quantum Electronics" (1987), pp. 156, 204, 186-7. A move to bring engineering and physics closer together was also evident at Cornell and elsewhere (see Schweber, pp. 23-24), a phenomenon with precedent in the late nineteenth and early twentieth centuries, when physics, having produced a body of method and theory for power and electronic circuitry and devices, spun off electrical engineering as a new branch of engineering.

Columbia universities.[12] The MIT model inspired ambitious leaders at Stanford University to develop the Stanford Electronics Research Laboratories, also a cooperative activity of physics and electrical engineering, organized around the subject of microwaves and concerned with its applications in basic physics and practical technology, and handsomely funded -- at almost half a million dollars annually, in 1950 -- by the three armed services. Stanford Provost Frederic Terman proclaimed: "After the Massachusetts Institute of Technology, Stanford is now the most important center of electronics among American universities. Although we cannot match M.I.T. in size, we concede nothing to them in quality and productiveness in proportion to money expended by sponsoring agencies."[13]

Physicists, along with other scientists, were also, of course, involved in policy-making for the technology of national security. Some of the involvement took the form of consultantships and summer studies, like that begun in late 1949 by the MIT physicist Jerrold R. Zacharias, who agreed to head an investigation for ONR on ocean transport and antisubmarine warfare. (The study, conducted during the summer of 1950, was dubbed Project Hartwell, because the civilian scientists who carried it out dined frequently at the Hartwell Farms Restaurant, which was near the MIT field station in Lexington, Massachusetts, where they

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[12] Forman, "Behind Quantum Electronics" (1987), pp. 156, 204, 186-7.

[13] Leslie, "Playing the Education Game to Win" (1987), pp. 62, 67-69.

did the work.)[14] Some of the involvement consisted of participation in analytical cadres in the armed services -- for example, the Weapons Systems Evaluation Group that was attached to the Joint Chiefs of Staff -- for planning and evaluating weapons systems. More general policy influence came from participation in key standing scientific advisory committees to each of the armed services and, in the most portentous area, the General Advisory Committee of the AEC.[15]

Yet while physicists were influential in the making of military technology policy, they were rather less so in the formation of grand policy for national security. The armed services had by no means made them -- or any other civilian scientists -- full partners in strategic planning. While the AEC General Advisory Committee's noble, if ill-fated, attempt in late 1949 to head off a crash program for a hydrogen bomb has been taken to symbolize the participation of physicists in

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[14] Hartwell ran formally from March through December 1950 and cost $124,000, much of which went to pay the summer salaries of the 21 civilian scientists responsible for the study. T. J. Crane to James R. Killian, July 23, 1954, C/K MSS, Box 257, folder 18; Jerrold R. Zacharias, with Myles Gordon, "Military Technology: One of the Lives of J.R. Zacharias," ms of a draft autobiography (1986), chapter I.

[15] Kevles, The Physicists (1987), p. 355; Herbert York and Alan Greb, "Military Research and Development: A Postwar History," Bulletin of the Atomic Scientists, 33(1977), 16-17; William C. Foster to John Stennis, April 23, 1952, C/K MSS, Box 256, folder 12; William T. Golden, who was surveying defense research, noted, "Advisory committees are becoming increasingly fashionable." Golden, Memos to File, "Conversation with Brigadier General L.E. Simon and Major General A.C. McAuliffe," March 1, 1951 as of Feb. 28, 1951, p. 3; File, "Conversation with H.P. Robertson, Deputy Director, WSEG; Dr. Louis Ridenour, Special Adviser to the Secretary of the Air Force and to the Director of Research and Development of the Air Force; and Professor Marshall Stone," Dec. 8, 1950, pp. 1-2; "Conversation with Lt. General Hull and Dr. Robertston, Director and Deputy Director of the Weapons System Evaluation Group," Nov. 21, 1950 as of Nov. 15, 1950, p.1, Golden MSS.

grand strategy-making, the fact of the matter was that for the most part the GAC dealt mainly with technical and research issues.[16] In the postwar United States, physicists had become more the creatures than the makers of national security policy -- a policy made largely by others. Rather than distracting them as research scientists, the policy served them. In return, most willingly served the overall policy, while successfully constructing a system of institutional arrangements that served it, too. On the eve of the Korean War, radical new weapons -- the hydrogen bomb, certain types of guided missiles, and a variety of other hardware innovations -- were aborning, in the Atomic Energy Commission facilities, the Applied Physics Laboratory, the Jet Propulsion Laboratory, and elsewhere, not as the result of major scientific breakthroughs in basic research but from the success of the new institutional arrangements that tied civilian scientists to the military while keeping them relatively free of its close control.

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With the outbreak of the Korean War, in June 1950, the defense R&D budget followed the overall defense budget into the stratosphere, doubling to slightly more than $1.3 billion in fiscal 1951, and rising still higher, to about $1.6 billion in fiscal 1952. Scientists wondered

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16 William T. Golden, Memos to Files, "Conversation with Dr. Lawrence Hafstad, Director, Reactor Development Division, Atomic Energy Commission," Nov. 8, 1950, p. 2; "Telephone Conversation with Dr. H.P. Robertson," Jan. 25, 1951, Golden MSS; remarks of Robert Seidel, Workshop on Big Science, Stanford University, August 1988.

how to make themselves useful in the war emergency. Some ruminated over the possibility of creating a new OSRD, but such a move was ultimately deemed unnecessary.[17]] The war emergency could be handled by the defense R&D system already in place, including its contigents on the nation's campuses.

Nevertheless, the Korean War did provoke a series of important policy moves in saliently critical areas of military technology. In 1950, Secretary of Defense George C. Marshall established an Office of the Director of Guided Missiles in the Defense Department and appointed as head of it the industrialist K.T. Keller, who quickly became known as the "missile czar." In March 1950, the Air Force was given exclusive jurisdiction over the development of long-range strategic missiles. In the meantime, the Army and Navy accelerated their short-range missile programs. The Army transferred a team of missile engineers to the Huntsville Arsenal, in Huntsville, Alabama, where, under Wehrner von Braun, work commenced on the development of a tactical ballistic missile. In Pasadena, California, the Jet Propulsion Laboratory obtained authorization from Army Ordnance to move beyond basic research into the development of the Corporal guided missile, which would be designed for tactical use carrying atomic warheads in the European theater. Between 1950 and 1953, the JPL budget more than doubled, to

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[17] Allan Needell, "Preparing for the Space Age: University-Based Research, 1946-1957," <u>HSPS: Historical Studies in the Physical and Biological Sciences</u>, 18:1(1987), 97-98, 101-105; Daniel J. Kevles, "K_1S_2" (1988).

$11 million a year, and its staff similarly multiplied.[18]

The Korean War also reinforced the air of emergency that had settled over the Atomic Energy Commission after the detection, in September 1949, of the first explosion of a Soviet atomic bomb. ("How do we get the boys away from their mesons and back into the military salt mines?" the Berkeley physicist Luis Alvarez had asked.) Like leading members of his staff, Ernest Lawrence was ready to march back to war, and he was instrumental in obtaining the establishment, in June 1952, of the Livermore Weapons Laboratory -- which was to provide "healthy competition" for Los Alamos, Edward Teller said, and, like it, to operate under the egis of the University of California. The war stimulated pressure everwhere in the AEC laboratory complex -- even at pure-science oriented Brookhaven -- for activity in research directly relevant to national security.[19]

Responding to the needs of ONR, and the offer of considerable additional funding, Stanford University expanded its microwave work into applied (and classified) areas, while laying plans to build a

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[18] York and Greb, "Military Research and Development: A Postwar History" (1977), pp. 17-18; Michael Armacost, The Politics of Weapons Innovation (1969), pp. 26-27; Ernest J. Yanarella, The Missile Defense Controversy (1977), pp. 37-38; William T. Golden, Memos to File, "Conversation with Mr. William A. Burden and Henry Loomis," Jan. 30, 1951; "Conversation with . . . Burden," Feb. 27, 1951 as of Feb. 18, 1951, Golden MSS; Koppes, JPL and the American Space Program (1982), pp. 43-48.

[19] Seidel, "A Home for Big Science" (1986), pp. 152-54; Heilbron, Seidel, and Wheaton, Lawrence and His Laboratory, pp. 63-65, 72, 75.

microwave-powered high-energy accelerator with AEC money.[20]

Before the war, the Bell Telephone Laboratories had declined an Army Signal Corps contract offer for research on the transistor. After the war broke out, the Bell Labs attitude changed and by 1953 50% of its transistor work was being supported by the military.[21] By late 1951, it was estimated that DOD and AEC contracts accounted for nearly 40 percent of all industrial and academic research effort. Defense research was estimated to be occupying some two thirds of the nation's scientists and engineers. At the American Physical Society meeting earlier that year, perhaps the principal non-technical topic of conversation was the wholesale and high-powered recruiting of scientists by defense agencies, especially the Air Force. Planners were once again concerned with shortages of technical manpower, and the draft status of young scientists, particularly in such critical fields as nuclear physics and electronics, was once again a matter of policy debate.[22]

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20 Leslie, "Playing the Education Game to Win" (1987), pp. 69-71; Peter Galison et al, "Controlling the Monster: Stanford and the Control of Physics Research, 1935-1962," unpublished paper, Workshop on the History of Big Science, Stanford University, August 1988, pp. 19-20.

21 Thomas J. Misa, "Military Needs . . . ," in Merritt Roe Smith, ed., <u>Military Enterprise and Technological Change</u> (Cambridge, Mass.: MIT Press, 1985), pp.

22 Oliver E. Buckley, "An Appraisal of Some Indicated Needs of Defense Research . . . ," Dec. 31, 1951, attached to "Science Advisory Committee, Summary of Meeting No. 6," Dec. 11, 1951; Karl T. Compton, "The Research and Development Budget of the Department of Defense," Oct. 30, 1950, attached to Compton to E. O. Lawrence, Oct. 31, 1950, C/K MSS, Box 256, folder 11; Box 245, folder 19; William T. Golden, Memo to File, "Conversation with Dr. Robert F. Bacher," Feb. 6, 1951 as of Feb. 3, 1951, p. 2, Golden MSS; Forman, "Behind Quantum Electronics" (1987), p. 167, n. 32.

In the end, the Korean War fostered a series of subtle -- and not so subtle -- changes in the relationship between civilian science and the American state. Unlike World War II, the scientific mobilization during Korea produced no miraculous new weapons. Combined with the Soviet's becoming a nuclear power, however, it generated a pervasive psychology of permanent mobilization, a commitment to an expansive technological readiness.[23] Even during the war, the military's outlook had struck James B. Conant, as he told the National War College, as "something like the old religious phenomenon of conversion." Conant continued, "The military, if anything, have become vastly too much impressed with the abilities of research and development. They are no longer the conservatives. . . at times they seem to be fanatics in their belief of what the scientists and the technologists can do."[24]

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[23] George Kolstad, of the AEC's Division of Research, said, in January 1951, in a draft round-robin letter to university physicists: "We must . . . keep in mind that we are not at war and that the nature of the emergency is one of recurring crises and is such that we may expect it to last for a considerable length of time, perhaps ten or twenty years." Needell, "Preparing for the Space Age" (1987), pp. 102-3.

[24] Conant, "The Problem of Evaluation of Scientific Research and Development for Military Planning," speech to the National War College, Feb. 1, 1952, quoted in James G. Hershberg, "'Over My Dead Body': James B. Conant and the Hydrogen Bomb," unpublished ms (1987), forthcoming, p. 50. Conant suggested to a meeting of the Science Advisory Committee that, in order to get better control of military research, at key levels every proposal for a new defense R&D project should have at least one designated naysayer to make a case against it. Science Advisory Committee, "Summary, Meeting No. 7," Jan. 11, 1952, C/K MSS, Box 256, folder 12. Louis Ridenour, a physicist who was special adviser to the Secretary of the Air Force, told William Golden that any kind of project, no matter how far-fetched, could count on finding support in some branch of the military. Golden, Memo to File, "Conversation with H.P. Robertson . . .; Louis Ridenour. . .," Dec. 8, 1950, Golden MSS.

On the side of civilian science, the psychological sea change was typically manifest in the conclusions of Project Hartwell. Though Korea had no direct bearing on the content of the project, Zacharias recalled, the conflict "heightened our sense of purpose and underlined the relevance and the urgency of the task -- what it takes to fight half way around the world." The thick, two-volume Hartwell report dealt with what the Navy should do to protect shipping against Soviet forces in a war with theaters that spread from Europe and Latin America to India, Southeast Asia, and Japan. It assumed that the Soviets would be well armed and prepared to use all their weapons.[25]]

The Hartwell analyses, which ranged from technologies for the destruction as well as for the detection of submarines, paid particular attention to nuclear weapons. Zacharias recalled, "We wanted the military to start thinking about how to integrate atomic weapons into the battle plan of 'a conventional war,' a protracted affair, in which both sides would have ample opportunity and time to gear up, get prepared, and deploy forces -- <u>without devastating destruction on both sides.</u>" The report sought to destroy certain myths about nuclear weapons, starting with the myth that all were big bombs deliverable only from big high-flying aircraft. Hartwell stressed that they could be built small, in both size and explosive power, and that they would be appropriate for use against submarines and their bases by a variety of small aircraft, including helicopters. Project Hartwell did not think it unreasonable for the United States to seek to equip itself

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[25] Zacharias, with Myles Gordon, "Military Technology: One of the Lives of J.R. Zacharias" (1986), chapter I.

soon with 10,000 such atomic weapons.[26] Hartwell decidedly influenced Navy R&D as well as its antisubmarine doctrine (though the impact on the latter has been difficult to measure because of security restrictions). Suffice it to say that years later, naval officers treasured the Hartwell report as the bible of antisubmarine warfare.[27]

The change in administrations -- and, for the first time in twenty years, the change in political parties -- brought fresh players, fresh arrangements, and fresh doctrines into the defense policy game. The salient fresh doctrine was the "New Look," which emphasized economies of dollar cost and troop commitments in national defense in favor of relying on technological advantage to counter the perceived Soviet threat. In short order, civilian enthusiasts of technological advantage, newly arrived in the office of the Secretary of Defense, began to prevail upon the Air Force to step up its intercontinental ballistic missile program, the feasibility of which seemed all the higher as a result of the early hydrogen bomb tests, which suggested that a megaton of explosive could be delivered to the Soviet Union via a missile less powerful than had previously been assumed.[28]

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26 Ibid.

27 Ibid.

28 See, for example, York and Greb, "Military Research and Development" (1977), pp. 20-21; Armacost, The Politics of Weapons Innovation (1969), pp. 28-31, 56-58. Insightful observations upon the Air Force's reluctance to move rapidly into an ICBM program are advanced in Robert L. Perry, "Commentary," in Monte D. Wright and Lawrence J. Paszek, eds., Science, Technology, and Warfare (1969), pp. 119-21.

The change in administration also led to a more intimate relationship of civilian scientists to high policymaking. During the Korean War, on April 19, 1951, Truman had established a Science Advisory Committee in the Office of Defense Mobilization to provide advice not only to the director of the Office but to the president on scientific matters, particularly in connection with national defense. In June 1952, Lee DuBridge, the head of the MIT Radiation Laboratory during the war, became chairman of the group, whose other members also represented key veterans -- many of them physicists -- of the wartime scientific mobilization and key players in the postwar military advisory system.[29] The establishment of the Science Advisory Committee had put scientists institutionally within reach of the White House; Eisenhower took them inside of it. The committee was kept apprised of relevant discussions in the National Security Council by its chairman, Robert Cutler, and, eventually, by its own executive secretary, David Beckler, who sat in on NSC meetings.[30]

The committee, much impressed by Project Hartwell, thought highly of analyses of weapons as they might be integrated into strategy. At the urging of Jerrold Zacharias, the group decided to seek a meeting with the President and the National Security Council to urge the creation of a special group to study the overall problem of science

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[29] Truman to Oliver Buckley, April 19, 1951, C/K MSS, Box 256, folder 8; Press Release, April 20, 1951, Golden MSS.

[30] Conversation with Lee DuBridge, July 15, 1988; I. I. Rabi, "The President and His Scientific Advisers," in William T. Golden, ed., Science Advice to the President (1980), pp. 21-22; DuBridge to Members of the Science Advisory Committee, Feb. 15, 1954, C/K MSS, Box 257, folder 2.

and national defense.[31] On March 27, 1954, the committee met with the Eisenhower, who focused attention on the problem of surprise attack and asked that his science advisors conduct a study of the matter. The request led to the formation of the Technological Capabilities Panel under James R. Killian, which interpreted its charge broadly and set about investigating not only the gathering of intelligence to guard against surprise attack but also several other topics, including what technology might do for the retaliatory power of American deterrence.[32] In February 1955, the panel delivered its report, stressing, in a tone of foreboding, that the United States was vulnerable to surprise attack and urging, among other things, that the country establish overflight surveillance of the Soviet Union and give highest priority to the development of both long-range and intermediate range ballistic missiles. The panel presented its recommendations in an extended discussion of the National Security Council -- a session that Robert Cutler recalled as the high point of deliberations during his tenure as the president's special assistant for national

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31 "Meeting of the Cambridge-New York Group of the Science Advisory Committee," March 10, 1954, attached to Killian to Beckler, March 17, 1954; Beckler to Killian, March 19, 1954 and attached "Scope of Proposed Examination of New Weapons and National Strategy," draft, March 19, 1954, C/K MSS, Box 257, folders 2, 18; enthusiasm for Hartwell-type projects was manifest at the meeting and also earlier in Oliver E. Buckley, "Notes on Report of the Committee on Plans for Mobilizing Science," draft, June 8, 1951, attached to Buckley to Killian, June 15, 1951, C/K MSS, Box 256, folder 9.

32 James R. Killian, Sputnik, Scientists, and Eisenhower (1977), pp. 70-71; DuBridge to Flemming, July 21, 1954, C/K MSS, Box 257, folder 18..

security.[33] The recommendations helped obtain the highest national priority for the ICBM program and also precipitated what became the Thor, Jupiter, and Polaris programs.[34]

The extensive military patronage of basic civilian science had worried a number of the nation's scientific leaders a good deal before the Korean War. DuBridge had declared, "When science is allowed to exist merely from the crumbs that fall from the table of a weapons development program then science is headed into the stifling atmosphere of 'mobilized secrecy' and it is surely doomed -- even though the crumbs themselves should provide more than adequate nourishment." Unversity scientists were constantly -- and rightly -- apprehensive that the military might impose security restrictions on their research. Some worried that the military's overwhelming presence in university science would distort its intellectual direction.[35] A number hoped that the situation would improve when, in March 1950, after five years of dispute, President Harry S Truman finally signed into law the bill establishing the civilian National Science Foundation, which was intended to be the flagship of fundamental science in the United States and was expected in many quarters to take over much of the pure-

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[33] Armacost, The Politics of Weapons Innovation (1969), pp. 50-53; Killian, Sputnik, Scientists, and Eisenhower, (1977), pp. 71-86; Killian, "The Origin and Uses of Scientific Presence in the White House," in Golden, ed., Science Advice to the President (1980), p. 29.

[34] York and Greb, "Military Research and Development: A Postwar History" (1977), pp. 21-22.

[35] Kevles, The Physicists (1987), pp. 378-79.

research activity of the military.[36]

Such concerns continued after Korea, but with much-diminished intensity. The war had put a hold on any serious move to transfer support for basic science out of the military and into the National Science Foundation. When the Eisenhower administration took office, it ventured such a transfer, perhaps out of the Republican propensity for efficiency. However, the Office of Naval Research had turned against any such idea, and the attitudes of many university scientists were no doubt represented by Lee DuBridge, now the head of the California Institute of Technology, who took arms against the move, stressing to a high official in the administration that the poor-relation NSF would have to be granted appropriations "ten times their present level" to do the job properly, an amount of money that Congress would surely decline to provide. The NSF, DuBridge added, was "wholly unsuitable for the support of large research projects at large research centers. The California Institute of Technology, for example, would go broke very promptly if all of its basic research support were suddenly transferred to the National Science Foundation."[37]

While at times during the 1950s, Republican economizing

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[36] Department of Defense Directive, "Policy on Basic Research," June 19, 1952, C/K MSS, Box 256, folder 13; Kevles, The Physicsts (1987), p. 356; William T. Golden, Memo to Files, "Conversation with Dr. Vannevar Bush," Dec. 5, 1950, Golden MSS.

[37] William T. Golden, Memos to File, "Conversation with Mr. Charles Stauffacher re National Science Foundation . . .," Dec. 6, 1950; "Conversation with Rear Admiral T. Solberg, Director, Office of Naval Resarch," Jan. 15, 1951, Golden MSS; DuBridge to Flemming, August 12, 1953, C/K MSS, Box 256, folder 15; authors's conversation with Lee DuBridge, July 15, 1988;.

threatened to curtail defense R&D, the demands of hi-tech armament -- nuclear warheads, rockets and missiles, antisubmarine warfare and continental defense systems, and the like -- prevented federal, including military, research expenditures from falling; indeed, in areas related to these major military systems, they kept rising at a moderate rate.[38] Defense, and defense-related, agencies provided between 80% and 90% of federal R&D monies. They made hi-tech industrial research increasingly a ward of the military, with defense projects supplying an ever-larger fraction -- the portion crossed the 50% mark in 1956 --of total expenditures for industrial research. DOD and the AEC together were pervasive presences on the nation's campuses, the source of funding for the vast majority of research in physics, electronics, aeronautics, computers, and myriad other branches of the physical sciences and engineering.[39]

Recently, the historian Paul Forman has contended that the incentives of national security, somehow, perverted American physicists from the course of "true basic physics," encouraging them to the self-

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[38] A bête noir of the basic research community was Secretary of Defense Charles E. Wilson, who, having spent his career at General Motors, where there was no significant tradition of scientific research, tried to cut the defense R&D budget more than once during the Eisenhower administration and opined while at the Pentagon that "basic research is when you don't know what you are doing." See Killian to DuBridge, June 25, 1953, C/K MSS, Box 256, folder 14; Kevles, The Physicists (1987) p. 383; Armacost, The Politics of Weapons Innovation, (1969), pp. 32-33, 267.

[39] See Melvin Kranzberg, "Science, Technology, and Warfare: Action, Reaction, and Interaction in the Post-World War II Era," in Wright and J. Paszek, eds., Science, Technology, and Warfare (1969), p. 162; Forman, "Behind Quantum Electronics" (1987), pp. 161-64, 191-94, 220-21; Kevles, The Physicists (1987), pp. 374-75.

delusion that they were engaged in basic research of intrinsic interest while in reality they were merely doing the military's bidding.[40]] I must here take issue with him. Certain subjects in physics seem to be driven by an internal logic that impels them toward ever-deeper understanding of the physical universe; particle physics might qualify as an example. Other subjects may draw significance initially from their relevance to a technology, yet they can easily take on lives of their own as intellectually compelling areas of inquiry. Among the numerous instances that come readily to mind, one might mention fluid mechanics -- a respected field of physics that owes no small part of its development to problems arising from the movement of ship's prows, wing surfaces, and missile nose cones through fluids of variable density. Whatever the source of interest, it would seem arbitrary to say that one type of investigation is truly basic physics, while the other is not.

To embrace such a point of view is to risk conceding the claim that physics is characterized by a hierarchy of fields. The claim is frequently heard from particle physicists, especially those of the Los Alamos generation, who equate the physics they regard as the most fundamental with the physics that is the most important. Yet inherent in that attitude are value judgments that are not only intellectual but social -- judgments whose nature is suggested by the tendency of some particle physicists to refer to solid state physics as "squalid state" physics. These judgments are not merely that solid state physicis is

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[40] Forman, "Behind Quantum Electronics" (1987), p. 185.

less worthy because it confronts natural phenomena that are disorderly and, hence, intellectually dirty but also because it is involved with the practical world -- with microelectronics, with industry, with defense.

The self-image of the Los Alamos generation of physicists had its members preponderantly devoted to the pure physics of atomic, nuclear, and particle structures and involved in the technologies and policies of national security merely as a necessary distraction. Yet for many of those physicists, the technological was not a mere distraction. The fact of the matter is that even particle physics, while intellectually perhaps more elegant, is itself a creature of the practical world of national security. One is hard put to imagine the great acclerator laboratories in the United States having come into being and flourished in the absence of the deep concern for national security that came to pervade the United States after World War II.

The fact of the matter, too, is that between 1945 and 1957 many physicists happily involved themselves in -- or piggybacked their projects onto --valuable research of technological pertinence.

The AEC laboratories encountered no serious difficulties in recruiting capable physicists for research related to weapons; though there were tight security restrictions, the urge for scientific exchange and status was served by the evolution of "black" systems of scientific communication and reward, including classified meetings, journals, and reports. On the campuses, a number of physicists perceived the military's interest in technologically oriented research as a distinct opportunity. The point is easily demonstrated by the electronics research laboratories at MIT and at Stanford, where Felix Bloch argued, rightly, that the microwave venture promised to be of high value for accelerator physics. Key MIT physicists welcomed ONR's establishment there of the Laboratory of Nuclear Studies and Engineering, which was heavily concerned with the practical side of nuclear studies and which even accepted security restrictions in some facets of its research and teaching. Space physicists ostensibly served military purposes by collaborating with the armed services to probe the upper atmosphere and the lower reaches of space, but by loading detection equipment onto B-29s and V-2 rockets, they also accomplished a good deal of important research in cosmic ray, solar, and ionspheric physics.[41]]

The history of postwar physics is to be found not only in the great accelerator laboratories but also -- perhaps even more -- in the R&D installations of industry such as the Bell Telephone Laboratories and in the laboratories of the federal government, both military and civilian or those -- such as Los Alamos and Livermore -- that are hybrids of the two types. It is also to be found wherever in academia that physics has been pursued -- which is not only in departments of physics but in departments or programs of space science, astrophysics, materials science, electrical engineering, and so on -- all of which

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[41] Seidel, "A Home for Big Science" (1986), p. 146; S.S. Schweber, "Big Science in Context" (1988), p. 27; Leslie, "Playing the Education Game to Win" (1987), pp. 62-63; Needell, "Preparing for the Space Age" (1987), p. 97; David Devorkin, "Organizing for Space Research: The V-2 Rocket Panel," <u>HSPS: Historical Studies in the Physical and Biological Sciences</u>, 18:1(1987), 1-24.

were doubtless heavily populated by people trained in physics.

Physics is what physicists do -- or have done. In the first decade or so of the Cold War, physicists fanned out into diverse hot new areas, each representing the diversification of the field, which was a key feature of its postwar restructuring -- and each, too, expressing its integration into national security policy, from which it derived both opportunity and enrichment.

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