IV. University, Industry, and the Government in Postwar Society

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Science after 1940
Recent Historical Research on Postwar American Science and Technology

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The Cold War is over. However, historical studies of the Cold War are now actively under way. The 1992 issue of *Osiris*, entitled "Science after '40," focused on papers about the history of science and technology during and after World War II.[1] The emergence of large-scale sciences during this century has been discussed in articles collected in *Big Science*.[2] With the financial support of the NSF, a workshop including a dozen historians was held to discuss "science, technology, and democracy during the Cold War."[3] Following that, good amounts of historical works are being done about science and technology during the postwar and especially the Cold War period. [4]

The central issue in these works is concerned with the role of the military in the postwar history of American science and technology. This chapter introduces some of these historical works and the important interpretive issues raised in these historical studies. I will first

1. Arnold Thackray, ed., *Science after '40, Osiris*, second ser. vol.7 (1992).
2. Peter Galison and Bruce Hevly, eds., *Big Science: The Growth of Large-Scale Research* (Stanford: Stanford University Press, 1992).
3. "Science, Technology, and Democracy in the Cold War and After: A Strategic Plan for Research in Science and Technology," *A Report Prepared for the National Science Foundation*, n.d. The workshop was held in September 1994.
4. This paper does not aim at a comprehensive survey of recent historical research on this topic. For those who are interested in a more extensive list of recent literature on this theme, consult the bibliography provided at the following web site: <http://www.cmu.edu/coldwar/bibl.html> (as accessed on 26 January 2009). This site was created by the staff of Carnegie Mellon University and provides a variety of useful information about historical research about science and technology during the Cold War.

briefly survey the history of American science and technology during and after the war, and demonstrate how the military increased its role in funding scientific and engineering research in this period. Then, I will discuss some of the interpretive issues raised by these historical studies.

1. American Science and Technology after 1940

During World War II, American scientists and engineers were mobilized to develop a variety of weapon systems and received an enormous budget to facilitate this. The nerve center of this wartime mobilization was the Office of Scientific Research and Development (OSRD), organized by former MIT Professor and Director of the Carnegie Institution of Washington, Vannevar Bush. In creating this new office, Bush argued that only scientific experts familiar with the latest laboratory research could posit the best way to develop new weapons.[5] Whereas scientists had previously been government advisors whose function was to solve requested problems from government leaders, they were now considering the feasibility of new weapons and taking the initiative to develop and produce them. Under the OSRD, scientists and engineers successfully developed a host of high-tech weapons, including radar, the proximity fuse, and the flame-thrower, to name the few.[6]

Although all the creation of these weapons was a harbinger of doom for Japanese military and people, the development of these wonder weapons was an eye-opening event for Americans, especially for military leaders. Before the war, they had tended to be skeptical about most of the ideas presented by scientists. They agreed with physicists on the technological feasibility of making the atomic bomb but considered the idea flatly unrealistic and unpractical. Most scientists, they felt, only made useless gadgets while wasting a large amount of money. But facing the significant achievements of scientif-

5. Daniel Kevles, *The Physicists* (New York, 1971), p. 308.

6. James P. Baxter, *Scientists against Time* (Boston: Little, Brown, 1946).

ic and technological mobilization under the OSRD and the Manhattan Project, they completely changed their perspective and began to recognize the importance of high-tech weapons devised by scientists. As General Dwight Eisenhower put it: "The lessons of the last war are clear. The armed forces could not have won the war alone. Scientists and business men contributed techniques and weapons which enabled us to outwit and overwhelm the enemy."[7]

Scientists and engineers engaged in projects were demobilized after the end of the war. Bush, who wrote a pamphlet, "Science: the Endless Frontier," hoped to create a civilian agency to support basic science modeled after the OSRD, which was to become the National Science Foundation (NSF). Its establishment, however, was delayed due to the debate over its basic policy and management. Democrat Congressman Harry Kilgore criticized the OSRD during the war, despite its accomplishments. Kilgore argued that the management of the OSRD was controlled by a few elite scientists affiliated with elite academic institutions, and that the OSRD failed to mobilize scientific and engineering manpower effectively, especially those affiliated with local or minor institutions. An antitrust ideology lay behind Kilgore's criticism toward what he considered was a monopoly of elite scientists controlling the OSRD. Kilgore and his followers recognized and criticized the elitist nature of the OSRD and attempted to organize a more democratic funding agency. The NSF was established only in 1950, after being modified from Bush's original plan.

The five-year blank was filled with several defense agencies financially supporting civilian researchers who returned to their home universities after the demobilization. Among others, the Office of Naval Research (ONR) of the U.S. Navy played a substantial role for this purpose. It allowed many university scientists to continue with their wartime research, which was more or less related to weapons development. The Radiation Laboratory responsible for radar development during the war, for instance, was reorganized into a new

7. Dwight Eisenhower, "Memorandum for Directors and Chiefs of the War Department," quoted in William S. Leslie, *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford* (New York: Columbia University Press, 1993), p. 24.

Research Laboratory of Electronics (RLE), as an adjacent facility to MIT. The RLE staff, many of whom were Ph.D. physicists, continued to investigate the behavior and characteristics of microwave devices, after receiving a handsome annual budget ($600,000) from the ONR as well as from the Army.

After the birth of Communist China, the Soviet success of their atomic bomb, and the eruption of the Korean War, the U.S. military increased their spending for military R&D for various technological developments, including the development of hydrogen bombs and guided missiles. Despite the establishment of the NSF, the ONR continued to offer a significant amount of financial support to basic research conducted by civilian scientists. Some scientists, such as the former Radiation Laboratory Director Lee DuBridge, requested the continuation of the ONR's support because he considered the NSF "wholly unsuitable for the support of large research projects at large research centers" [8]. Military support was key for helping science expand into large-scale science. After the Korean War, President Eisenhower proposed the "New Look" policy, which attempted to reduce the defense budget while maintaining or increasing military power by increasing the R&D budget, thereby improving the performance of weapons systems. Eisenhower's policy helped to sustain steady growth in military spending for R&D at universities and government institutions. Research directors and department chairmen at academic institutions actively approached the military and received significant financial aid to develop and conduct substantial research projects.

RLE of MIT also expanded its facilities and consequently further fostered the electronics industry in the region. The Pentagon decided to build an early-warning strategic radar system to counter-measure the development of guided missiles, and recognized the necessity of establishing a new separate facility—Lincoln Laboratory—to accomplish this mission. To make such a radar warning system, Lincoln Laboratory relied on a digital computer in its infancy, Whirlwind,

8. Quoted in Daniel Kevles, "Cold War and Hot Physics: Science, the Security and American State," *Historical Studies in the Physical and Biological Sciences*, 20 (1990): 239–264, on p. 259.

which was being developed by another division at MIT. Computer Whirlwind, together with basic hardware technologies, was eventually sold to IBM, which in turn redesigned it into a very profitable airline reservation system. RLE also helped to create and expand electronics corporations such as Raytheon. Raytheon expanded with the help of its military contract as well as through its close ties with MIT faculty and graduates. It manufactured a variety of electronic equipment for military and scientific use, and also invented and sold the microwave oven. The Sputnik shock in 1957 again increased the financial support for scientific research and education at American universities. In response to the need for promoting space-related technology, the Department of Defense (DOD) created an Advanced Research Projects Agency (ARPA).[9] However, soon afterward, NASA (National Aeronautic and Space Administration) was organized, based on the previous National Advisory Committee for Aeronautics, and it started to support basic and applied research related to space science and technology. The ARPA's mission consequently shifted toward more general, basic research at universities, but its funding policy was markedly different from the NSF. It offered large grants, each about ten times more than an NSF grant, to a few young faculty members who were recognized as pursuing promising research, primarily affiliated with elite academic institutions. The ARPA grants-in-aid are now widely recognized to have promoted the development of new materials and computers among others.[10]

The ARPA, or as was later renamed DARPA (Defense Advanced Research Projects Agency), however, was not welcomed by all military officials.[11] Its support for basic research received criticism from some quarters of the DOD. Among many projects conducted under the DOD, there was a project called "Project Hindsight," which aimed at evaluating the usefulness of militarily supported R&D for weapons.

9. ARPA soon changed its name to the Defense Advanced Research Projects Agency (DARPA). Its name recently returned to the original ARPA.

10. For mission oriented research at Stanford and MIT in the disciplines of material science, electronics, nuclear science, and aeronautics, see Leslie, *The Cold War and American Science*, op.cit.

11. It now has returned to its original name ARPA.

The project conducted a historical survey of the past development of a variety of weapons, and reached the conclusion that military research was not useful for the development of weapons. It was immediately followed by another project, called "Project TRACES," which conducted a similar historical investigation and found a more positive correlation between military funding for basic research and the development of weapons systems. What this difference reveals is that such an investigation tends to be influenced by the intention of clients. In this case, the clients for Project Hindsight in the DOD were not pleased with spending a significant portion of the defense budget for basic research. With the notable increase of federal support for basic research, universities enjoyed a "golden age" of expansion and American science grew, as the sociologist of science Derek J. de Solla Price has called, from "little science" to "big science." But a significant part of their financial support from the government came from the DOD and defense related grants. Most university research was thus mission-oriented research. Research on materials was connected to the development of new parts and materials for missiles, for instance. The department organization was accordingly modified and shaped under the influence of such military support. This raised many concerns among university faculty and students. In the late 1960s, students and some faculty protested the fact that university research was financially dominated by the military.

2. "Distortion" of Postwar American Science

Did military sponsorship really distort postwar American science? The question seems to be one of the fundamental issues discussed by recent historians of science and technology in the United States. The new social constructivist historiography, according to which many facets of scientific and technological activities are socially constructed rather than derived from internal logic and motivations, seems to have generated a renewed scholarly interest regarding this question. A historian of engineering, Stuart Leslie, closely traced the postwar growth of engineering departments at MIT and Stanford, and examined "profit and loss" with regard to military sponsorship.[12] He points out many weapons-related topics permeated scientific textbooks, for example John Slater's Microwave Electronics. Paul Forman and others argue that physics research was greatly influenced by military funding and changed its course from what it would have been otherwise. He cites a comparative study of American and European research on atomic physics and attributes the American pragmatist and instrument-oriented tendency to American scientists' involvement with weapons development projects. Leslie states in the conclusion of his book, *The Cold War and American Science*, that "the full costs of mortgaging the nation's high technology policy to the Pentagon can only be measured by the lost opportunities to have done things differently," although no one can know exactly about such an alternative path. He concludes the nation should consider relocating substantial funds to rebuilding the infrastructure of civilian science and technology that more than two generations of war, and preparing for war, has so badly depleted.[13]

However, other historians have a different view on the postwar military sponsorship of university research. A historian of physics, Daniel Kevles, questions the existence of the "true" physics implied in Forman's paper and in the "distortion" thesis in general.[14] He admits that certain subjects in physics, such as particle physics, are driven by an internal logic of science toward a deeper understanding of nature and the universe, but points out that many other subjects draw significantly from their relevance to technology as fluid mechanics draws from its engineering relevance to ships, airplanes, and missiles.

A historian of education, Roger Geiger, presents a more apt criticism on the "distortion" thesis. Based on his comprehensive research on the history of American universities before and after the war, in his article that was published in a history-of-science journal, he calls attention to the positive as well as negative aspects of military finan-

12. Stuart W. Leslie, "Profit and Loss: The Military and MIT in the Postwar Era," *Historical Studies in the Physical Sciences*, 21(1990): 59–85.

13. Leslie, *The Cold War and American Science*, op.cit., p. 256.

14. Kevles, "Cold War and Hot Physics," op.cit.

cial support on American universities.[15] The influence of military sponsorship, he argues, varied depending on the purpose of funding. He characterizes the complex relationship between the military and universities by three different functions: a contract research center, support for the development of critical technologies, and more "benign" support for general university programs. In addition, he feels that focusing on a few exemplar cases such as MIT and Stanford, as in Leslie's work, only offers a partial view of the whole relationship between the military and universities. He also calls attention to the change in the funding policy of the military over time. Whereas programmatic research projects were greatly emphasized in the Cold War era, support for basic research significantly increased after the Sputnik shock. The Sputnik shock led to the reconsideration of the importance of scientific and engineering education, and NASA, aside from more direct space programs, started the "Sustaining University Program." The DOD, initially reluctant to offer such a program, started Project THEMIS, which distributed $94 million to 82 institutions from 1967 to 1971. He thus states: "Support from the defense establishment may have distorted university research, but the absence of such support without question would have produced a greater 'distortion'—in that it would have remained a far smaller enterprise."[16]

Benign support, however, ended because of the enactment of the Mansfield Amendment in 1971, which forbade the DOD to support basic research unless it had a "direct or apparent relationship to a specific military function or operation." The reduction of support from the government actually caused a financial crisis for universities in the 1970s. The effects of this amendment upon the nature of scientific research at universities during this decade still need to be analyzed.

15. Roger L. Geiger, "Science, Universities, and National Defense, 1945-1970," *Osiris*, second ser. vol.7 (1992): 26–48. His following two works respectively cover the prewar and postwar history of American universities: *To Advance Knowledge: The Growth of American Research Universities, 1900–1940* (New York: Oxford University Press, 1986), and *Research and Relevant Knowledge* (New York: Oxford University Press, 1993).

16. Geiger, "Science, Universities, and National Defense," p. 39.

3. Commercial vs. Military Technologies

The word "distortion" would be more appropriately applied to technology than science in the United States. Massive funding for the development of military technology has, in all likelihood, displaced technological resources away from civilian technology and industry, and weakened its competitiveness. In 1984, scholars from Harvard Business School raised this issue and published the work *The Militarization of High Technology*.[17] The book mainly discusses the negative effect on American industries of spending for military R&D. They point out the following defects:

1. Excellent researchers and equipment were utilized for military R&D, which tends to devalue research for social and economically beneficent purposes.
2. Military research was classified and investigators involved in those projects were kept ignorant of research being conducted by other groups, thereby causing specialization among scientists. The investigators were not very useful in industrial R&D.
3. The military tends to select and support large corporations and neglect small and innovative corporations.

It is true that some of the parts and machines developed for military purposes would be utilized for industrial purposes. Many cases of this type of spinoff of military R&D can be found in postwar history. But it is often noted that, in many cases, the military requirement for specification was too strict to be utilized for civilian purposes. In a word, the product is "overdeveloped." The performance and durability of electronic equipment or synthetic materials attained high standards but consequently they became too expensive to be competitive in the civilian market. Transistors for TV sets did not need to withstand severe circumstance like strong radiation and temperatures over 100°C. The Bell Laboratory, where the transistor was created,

17. John Tirman, ed., *The Militarization of High Technology* (Cambridge, Mass.: Ballinger, 1984).

pursued the development of a silicon transistor instead of the germanium transistor to meet an order from the military. In contrast, the Japanese electronics industry focused on the development of the germanium type under an initiative of the MITI (the Ministry of Trade and Industry).[18] Whether the development of industrial technologies in postwar Japan was caused by MITI or by initiatives from corporate engineers is a matter of debate and it would be fallacious to overestimate the value of MITI in the technological development of postwar Japan. But we can say that the difference in emphasis regarding technological R&D between Japan and the United States created two totally different characterizations of technology development and production in the two countries.

Tirman's *Militarization of High Technology* presents in its conclusion an exception, the DARPA. The present global computer network, Internet, has its origin in the R&D sponsored by the DARPA. It was originally designed as a communication network, even after the eruption of a nuclear war. The authors of *Militarization of High Technology*, in the year 1984, evaluated the significance of the DARPA to be very high in the age of what they called "the second Sputnik," an age of economic and technological challenge from Japan.[19]

More recently, another Harvard group proposed a new vision of integration between military and civilian industries through what they call 'dual-use' technology. Harvey Brooks and Lewis Branscomb, both Harvard professors of Public Policy, initiated the dual-use tech-

18. Thomas J. Misa, "Military Needs, Commercial Realities, and the Development of the Transistor, 1948–1958," in Merritt Roe Smith, ed., *Military Enterprise and Technological Change: Perspective on American Experience* (Cambridge, Mass.: MIT Press, 1985): 253–87. The same argument would apply to the Japanese weakness in developing space technology. Electronic parts do not meet the same high standards of space technology. That was one of the important bottlenecks for the development of space technology in Japan. The frequent failure of Japanese rockets was due to their electronic parts failing under severe physical circumstances. See Shigebumi Saito, *Nihon Uchū Kaihatsu Monogatari* (*A Story of Space Development in Japan*) (Tokyo: Mita Shuppannkai, 1992), pp. 114–17 and 190–207.

19. For the development of computer technology including ARPAnet under the sponsorship of DARPA, see Arthur L. Norberg and Judy E. O'Neill, *Transforming Computer Technology: Information Processing for the Pentagon, 1962–1986* (Baltimore: Johns Hopkins University Press, 1996).

nology project to examine the complex relationship between military and commercial technologies.[20] Their results are summarized in their work, *Beyond Spinoff: Military and Commercial Technologies in a Changing World*.[21] Like Tirman and others, they criticized the often overestimated concept of spinoff. Raytheon's microwave oven, they point out, was not as commercially and economically successful at first as is usually believed. The product, designed for restaurant use, was too expensive to be commercially viable and the company had to cover the difference. They also highly evaluate the performance of the DARPA and favorably mention the unrealized plan for its conversion into the demilitarized agency, the NARPA (National Advanced Research Projects Agency).

But unlike *Militarization of High Technology, Beyond Spinoff* does not oppose the development of military technology itself. The authors propose the integration of military and commercial technologies so that they be freely converted each other. By developing "dual-use technologies," they argue, both the military and industry can share the spoils of the R&D efforts. The book explains this technology policy by using the three model fields of dual-use technology: microelectronics, computer software, and manufacturing. As to microelectronics, the authors refer to Sematech, a consortium of several semiconductor-manufacturing firms that pool together large-scale R&D funds. Their funds together with the matching support from the government are allocated through the DARPA to various commercial R&D programs related to microelectronics technologies, such as dynamic random access memory chips (DRAM) and fine-line lithography. And yet, the authors of *Beyond Spinoff* are aware that the development of each of these cutting-edge technologies does not necessarily mean efficiency in commercial, high-volume production. It is a fallacy and an ill-conceived idea of American engineers, they argue, to believe that optimizing the building blocks of a production system will suffice to optimize the system as a whole.

20. "Rethinking the Military's Role in the Economy: An Interview with Harvey Brooks and Lewis Branscomb," *Technology Review*, (1989): 55–64.

21. John A. Alic et al., *Beyond Spinoff: Military and Commercial Technologies in a Changing World* (Boston: Harvard Business School Press, 1992).

Their dual-use technology policy was, however, questioned by some scholars. In their book, *Dismantling the War Economy*, Ann Markusen and Joel Yudken from Rutgers University pointed out the limits of the dual-use policy.[22] They first point out that only limited industries took advantage of this during the Cold War years. What they call the ACE complex (aerospace-communication-electronics complex) benefited from many advantages during those years after receiving R&D resources and being guaranteed their product markets. In contrast, they point out, "industries that have not benefited from this closet industrial policy, such as steel, machine tools, tractors, autos, and consumer electronics, have stagnated and seen their markets invaded successfully by competitors from rich and poor nations alike."[23] They could have perhaps added some contrastive episodes in Japanese history that show the transfer of wartime aeronautical technology to postwar civilian industry. For instance, a former engineer of the Nakajima Aircraft Company designed a Japanese version of a Volkswagen, the Subaru 360. No doubt he used his experience as an aircraft equipment engineer in designing a car as light and small as possible.[24]

Markusen and Yudken admit that Branscomb and others' dual-use policy would be counter to the military's aerospace-centered industrial policy of the past forty years, but they argue "the high-tech dual-use strategy is seriously deficient in a number of ways." They argue: First, it does not address a number of critical national needs—such as protecting and cleaning up the environment, improving public infrastructure, mass transportation, occupational health and safety, and education, and

22. Ann Markusen and Joel Yudken, *Dismantling the War Economy* (New York: Basic Books, 1992).

23. Ibid., p. 34.

24. Takanori Maema, *Man-Mashin no Showa Densetsu* (*A Legend of Men and Machines in Showa Era*) (Tokyo: Kodansha, 1993), chapters 11 and 12. Many more cases of postwar conversion from military to civilian technologies are explained in the following report: Nihon Gakujutsu Shinkokai, Sentan Gijutsu to Kokusai Kankyo, the 149th Committee (日本学術振興会先端技術と国際環境第149委員会), ed., *Gunji Gijutsu kara Minsei Gijutsu eno Tenkan: Dainiji Sekai Taisen kara Sengo eno Wagakuni no Keiken* (*The Conversion of Military Technologies to Civilian Technologies: The Japanese Experience from Wartime to Postwar Period*), 2 vols (Tokyo: Japan Society of the Promotion of Science, 1996).

developing renewable energy sources. These efforts will require carefully tailored investments in science and technology. A national industrial policy dominated by the agenda of a relatively small number of military and civilian high-tech industries is unlikely to cover all economically or socially important areas of S&T development.[25]

The emphasis on high technology, they went on, would divert R&D resources away from more incremental improvements in process technologies and product design, which are equally important for vitalizing civilian industries. They also point out that the difficulty inherent in the implementation of technology into production lines is greater than the ideologues of the dual-use policy have considered. They refer to "middle-ground" engineering linking generic R&D to manufacturing and production. "It is at this 'middle-ground' level," they argue, "that the divergence between military and civilian interests presents the greatest difficulties…. The way DARPA would test a new state-of-the-art parallel-processing computer chip for a 'smart' guided munitions system is not remotely similar to its potential for desktop or workstation computers."[26]

4. Toward a More Comprehensive Understanding of Cold War History

Based on the recent research and discussion about the history of postwar science and technology, social studies workshops about science, technology, and democracy during the Cold War have been held with the financial support of the National Science Foundation.[27] The report it prepared for the NSF had six points on the basic research agenda:

1. The interaction of science, technology, and democracy in the Cold War
2. The production of knowledge during the Cold War
3. Institutions of Cold War science and technology

25. *Dismantling the War Economy*, op.cit., p. 128.

26. Ibid., p. 129.

27. See note 3.

4. Economic impact of the Cold War and the economics of the Cold War
5. Comparative and international dimensions of the Cold War
6. The Cold War and American Culture

For each of these problems, a basic discussion on the topic is provided and a list of supplemental questions is added. In it, the "distortionist thesis" has also been referred to as a starting point of discussion for the second agenda, posing the question, "How might scholars evaluate this essentially counterfactual issue?" The report tells us that they placed the development of the university and its relationship to industry and government in a long-term perspective, and that they discussed the continuities and discontinuities marked in the Cold War period. As to the discontinuities, they refer to the increasing entrepreneurship in the academe during the Cold War, and also to the question left by the participants, who wondered "whether the scientific and technical meritocracy fostered by the Cold War is consistent with democratic principles, and whether it will optimize the social benefit of knowledge production in the long run."[28]

The historical examination and evaluation of scientific and technological R&D during the Hot and Cold War eras are important not only for scholarly purposes but also for present political and economic goals. They are expected to provide indispensable information and insights on the basis of which they will reconstruct the relationship between the university, the industry, and the government in post Cold War society. They are especially so in the attempt to shift the emphasis of the allocation of scientific and technological resources from military to civilian industrial sectors. It is sincerely hoped that this active historical research generates fruitful dialogues with social scientists, policy makers, and the like, and that their research results are integrated into the effort to "optimize the social benefit of knowledge production in the long run."

28. "Science, Technology, and Democracy in the Cold War and After," op. cit.