Naked Science

Anthropological Inquiry into Boundaries, Power, and Knowledge

edited by
Laura Nader

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CHAPTER 8

Political Structuring of the Institutions of Science

Charles Schwartz

Introduction

Two predominant political interests shape the direction of physical science and technology in the United States: the military and large manufacturing industries. The question I have studied over a number of years is this: How does the system work? In particular, what are the institutional arrangements that integrate the expertise of scientists into the reigning political-economic system of this country?

In thinking about such questions, it is important to understand that science is an organized human activity. Scientists work to collect and analyze information about the world around us and then frequently use this knowledge in practical ways. The work of science, when it is not just an exercise in idle curiosity by some individual, is generally integrated into the social and economic structure of society. That is to say, science is not separated from politics. In a world where knowledge is power, one should thus expect that the activities of science are largely under the control and direction of those sectors of society that hold dominant political power.

This external "control" of science is not complete control because scientific research itself has unpredictable outcomes; but it is effective control. It lies in setting the funding priorities—which areas of investigation will be thoroughly and rapidly explored (i.e., well funded) and which areas will be slighted or ignored. This control of science by dominant groups within society reinforces and legitimizes their positions of power and concomitantly places science in a privileged position in American society. Thus, science serves power.

This view of science and society is unremarkable to social scientists. To professionals in the natural sciences, however, these ideas may speak an awful heresy. We scientists are manufactured and delivered into the world with a special protective wrapping—the firm belief that science is neutral. We believe that the search for Nature's truth is pure and that the work of science is free from the contaminations of politics, money making, religion, passion, and prejudice of any kind.[1] Indeed,

many young people are drawn into the study of science because it provides a comfortable refuge from the turmoil of human interactions.

This myth of the neutrality of science has been criticized by scholars of various disciplines, including historians, philosophers, and certainly scientists themselves (Bernal 1939; Feyerabend 1978; Hessen 1971). There have also been critical studies of the ideology of science and its integration into the political economy of society (Arditti, Brennan, and Cavrak 1980; Rose and Rose 1977; Yearley 1988). Such critiques include studies of the political malleability of scientists, illustrating the ease with which prominent scientists, as well as the rank and file of the profession, may be bent to serve the interests of those in command of the power of the state (Busch et al. 1991; Haberer 1969; Mukerji 1990). In this paper, I will contribute to such critiques by illustrating some of the concrete ways in which the external political control of science in the United States works through an examination of selected institutions and their leaders in the national scientific establishment.

The science that I talk about most is my own profession, physics, together with the branches of engineering that stem from the main divisions of physics, namely mechanics, electromagnetism, and atomic and nuclear structure. These fields of inquiry and invention have produced the material stuff upon which the industrial and military might of this nation is built.

Physics came to the forefront of science in this country during and after World War II. Over the past fifty years, a national establishment has been in control—not absolute control, but effective control—to stimulate, channel, and exploit scientific work in certain preferred directions. These directions are, by any definition, political, since the bulk of research and development (R&D) funding comes from the federal government and the directions in which they are invested have important consequences for all of us.

The principal method I have used in my work, termed "power structure research," follows the sociological analyses of elite culture by C. Wright Mills (1956) and G. William Domhoff (1967). Their studies elucidate why and how it is that a tiny minority of people (the elite ruling class) control the major decision-making institutions in our society. The time-honored study of "interlocking directorships" (e.g., the president of oil company X also sits on the board of directors of bank Y) shows how various large corporations are tied to one another. Power structure research follows that method to examine other dominant institutions, such as government (appointments in the executive branch), higher education, and the media, along with the major corporations. My study identifies the science establishment integrated into this network.

This paper, summarizing some of what I have learned, focuses on three contemporary institutional settings where scientists come into contact, either explicitly or implicitly, with national politics. The first concerns scientific advisory committees, wherein select scientists from academia work as expert advisors to the federal agencies most involved with the funding of and the applications of science. The second focus is on the two unique laboratories at Los Alamos and at Livermore, which have held a near monopoly of technical expertise in the fashioning of nuclear weapons.

Third, I examine universities (my own turf), where science professors like to think of themselves as engaged in the autonomous pursuit of "pure" knowledge and generally disregard the sociopolitical implications of their chosen work.

As a physicist and a professor, my personal experiences inform this study. While my criticisms of the very people and institutions that have benefited my career might seem ungrateful, my purpose and hope is to encourage more attention and commitment to social responsibility in science. To that end I conclude this paper with some practical principles that address the root problems of science and power.

Federal Science Advisory Committees

Academics in the United States are familiar with the peer review system, whereby a number of established scientists are asked to evaluate and rank the many competing proposals submitted to Washington for research funds within each specialized subfield. There is little politics at this level. However, when one asks how much money should be provided for each field and subfield, then fundamental political choices are being made.

The federal government, in addition to its own politically appointed staff—in the Department of Defense (DoD), the Department of Energy (DoE), the National Science Foundation (NSF), and so on—makes use of a number of advisory committees composed of selected individuals from a variety of relevant institutions. Thus, the army, the navy, and the air force each has its own Science Advisory Committee. Over them sits the Defense Science Board, which shapes the overall priorities for the Pentagon's R&D budget. (Federal R&D has three standard subdivisions: basic research, applied research, and development.) Recent budgets for all federally funded science and engineering work amount to some $75 billion per year; about 60 percent of this is dedicated to military programs.[2]

These science advisory bodies are made up of experts from the most relevant industrial concerns, weapons laboratories and think tanks, some officers from the military services, a few former government officials, and a number of professors from our leading universities. It is widely supposed that this arrangement provides input for shaping government science priorities that is diverse, if not democratic, and balanced, if not unbiased. But this is an illusion. Let me give an example.

The President's Science Advisory Committee (PSAC), established in 1957, was the pinnacle of science advisory bodies in Washington until its abolishment in 1973. Its members enjoyed the highest access to political power and they were correspondingly looked up to by their fellows in the scientific community. A majority of the members on PSAC came from academia, with only a minority from private industry or elsewhere. This committee composition gave the impression that this was a body that could be trusted to act in a "purely scientific" way since they were free from the influence of any "special interest." This impression was an illusion.

The following data were published a number of years ago following my study of the membership of the PSAC (Schwartz 1975). Out of a total of seventy-eight individuals who had served on PSAC over its sixteen-year lifetime, fifty-five members (71 percent of the total) were identified as academics. More than 66

percent of these academic members, however, were also shown to have significant ties to large corporations involved with science and technology. Indeed, over 50 percent of the academic PSAC members were found to have been members of the boards of directors of Exxon, General Motors, IBM, McDonnell-Douglas, DuPont, Xerox, Westinghouse, Dow Chemical, Northrop, TRW, Hewlett-Packard, Raytheon, Squibb, Merck, and other major corporations.

Similar situations were found on a number of other leading science policy bodies. The NSF is thought of as the home of funding for pure academic science. A study of the NSF board members over that same sixteen-year period showed that 79 percent came from academia, the rest from industry, government, private foundations, and other nonprofit organizations. However, it was also found that over 50 percent of these academic NSF board members had important ties to large corporations, as with the PSAC members. This interlocking demonstrates a substantial integration at the top levels of scientific leadership, the federal government, and the major corporations (Schwartz 1975).

How were individual scientists selected to serve in these elevated positions? It was not enough to have earned a strong reputation as a scientist and to be at a respected institution. A well-established "old boys' club" still carefully selects and cultivates initiates into the circles of government science advising. How this system works was described in an interview some years ago by one of these most experienced and respected individuals (Berkeley Scientists and Engineers for Social and Political Action 1972).

He said that there was a good deal of incest in science advising. People with the most experience were reused, and younger people were brought into subsidiary committees where they could learn how to handle things and then gradually move up if their performance was found satisfactory. He listed the criteria as talent, objectivity, and a willingness to work. It was also basic practice for the adviser to accept the idea that he worked privately for the agency or the person whom he was advising—complete secrecy was required even though the scientific recommendations given were often not followed. He stated that the human element—the personal relations between the adviser and the advisee—were very important to the success of the advising process; yet he continually stressed that the advising was strictly objective, nonpolitical, and related only to technical evaluations.

These desiderata (private, secret, personal) are clearly based upon the subservience of the scientist to the authorities presently in power. That this subservience contradicts the nominal ethic of science, which requires independence of thought and action with frequent challenges to existing authority, seems not to bother the chosen advisors.

PSAC was abolished in 1973 by President Richard Nixon. Since that time, the chairs of science advisers to the White House have been filled with individuals selected quite explicitly for their political reliability in supporting the administration's programs. That is, newer White House science advisors see themselves as near cabinet-level political appointees, while the earlier PSAC members thought of themselves as above partisanship.

Table 13

Past and Present Directors

Directors of the Los Alamos Laboratory:

J. Robert Oppenheimer (1942–1945); founder of the laboratory

Norris Bradbury (1945–1970); Ph.D. 1932, first postwar director

Harold Agnew (1970–1979); Ph.D. 1949, with Los Alamos from 1942

Donald Kerr (1979–1985); Ph.D. 1966, with Los Alamos from 1966 (DOE 1977–1979)

Siegfried Hecker (1985-); Ph.D. 1968, with Los Alamos from 1968 (away 1970–1973)

Directors of the Livermore Laboratory:

Herbert York (1952–1958); Ph.D. 1949, first director of Livermore

Edward Teller (1958–1960); founder of the laboratory

Harold Brown (1960–1961); Ph.D. 1949, with Livermore from 1952

John Foster (1961–1965); Ph.D. 1952, with Livermore from 1952

Michael May (1965–1971); Ph.D. 1952, with Livermore from 1952 (away 1957–1960)

Roger Batzel (1971–1988); Ph.D. 1951, with Livermore from 1953

John Nuckolls (1988–1994); M.A. 1955, with Livermore from 1955

C. Bruce Tarter (1994-); Ph.D. 1967, with Livermore from 1967

Table 14

Assistant to the Secretary of Defense for Atomic Energy and Chairman of the Military Liaison Committee (linking DoD and DoE)

Gerald W. Johnson (1961–1963); with Livermore 1953–1961, 1963–1966

William J. Howard (1963–1966); with Los Alamos 1946–1956, Sandia 1956–1963

M. Carl Walske (1966–1973); with Los Alamos 1951–1956, 1965–1966

Donald R. Cotter (1973–1978); with Sandia 1948–1966, 1968–1970, then with DoD, AEC

James P. Wade, Jr. (1978–1981); with Livermore 1961–1965, then with DoD

Richard L. Wagner, Jr.(1981–1985); with Livermore 1963–1981

Robert B. Barker (1985–1994); with Livermore 1971–1983, then with ACDA, now back at Livermore as a high level administrator

Nuclear Weapons Laboratories—Los Alamos and Livermore

In institutions of nuclear weapons research and development, there is an even tighter structure of interlocking, self-selecting leadership that not only works directly for the government, but also has had enormous influence upon it. This particular clique of scientists influenced the whole history of the nuclear arms race, particularly in its political and technical dimensions.

All the nuclear weapons design work for this country is conducted at two laboratories: one located in Los Alamos, New Mexico, and the other in Livermore, California. These may be the largest scientific laboratories in the world. They employ about 8,000 people each and have annual budgets of over $1 billion a year each. Their funds and their mission are dictated by the DoE, acting as a surrogate for the DoD. These are strictly hierarchical organizations, structured like a corporation or the Pentagon, not like a university campus. Promotion results from recognition of leadership and management skills; that is, getting a project done, on time and within specifications. The ability to initiate and sell new programs is highly rewarded. Loyalty to the organization is key to an individual's success.

Table 13 lists all the past and present directors of the Los Alamos Laboratory and of the Livermore Laboratory.

What is significant about this table is that, apart from the founders J. Robert Oppenheimer at Los Alamos and Edward Teller at Livermore, the scientists worked their way to the top from within the laboratory. Indeed, it appears that almost all have been with their laboratory from the beginning of their career. The nuclear weapons lab is not the end of the road by any means, however, as is illustrated by the subsequent career paths of three scientists who were early directors at Livermore.

Herbert York left the lab in 1958 to become the chief scientist in the Pentagon (his official title was Director of Defense Research and Engineering). With the change of administration in 1961, York left Washington and was the founding chancellor of the University of California campus at San Diego. He continued to serve on important advisory committees (e.g., PSAC) and was a key arms control official under President Carter. York's successor as head of the Livermore Laboratory was Harold Brown. He took over the Pentagon post of director of Defense Research and Engineering when York left in 1961. Brown went on to serve as secretary of the air force under President Johnson; during the Republican White House years 1969–1977, he was president of the California Institute of Technology; he returned to Washington as Secretary of Defense in the Carter administration. Brown's successor as director of Livermore was John Foster, who likewise became director of Defense Research and Engineering and eventually left the government for a corporate vice presidency at TRW.

Another key government position is the Assistant to the Secretary of Defense for Atomic Energy. This person also heads the Military Liaison Committee, which links the DoD to the DoE's nuclear weapons complex. I have tabulated all the scientists who have held this position over the past three decades (see table 14). Every one of these officials has come out of Livermore, Los Alamos, or the Sandia Laboratory, which works intimately with these two labs on nuclear weaponry.

Many other scientists at the upper management levels of the two laboratories have moved into a variety of government positions, and frequently these people return to the labs with increased importance owing to their contacts and experience with the government officials who determine the laboratories' budgets. They carry with them not only their technical expertise but also their narrowly constructed sense of values, shaped from a career devoted to the weapons laboratories, and loyalties to the well-being of those institutions. They have played a vital role in shaping the government's options and priorities not only for the budgets of these laboratories but also for the direction of national policy on all aspects of nuclear weapons development and arms control. We have documented their aggressive promotion of the neutron bomb, their relentless lobbying against a comprehensive test ban, and their scandalous campaigning for President Reagan's Strategic Defense Initiative (SDI). The pervasive cloak of military secrecy prevents a thorough study of the extent and character of the interaction and interlocking of the weapons laboratories with the government's policy-making apparatus, but what we do know is very troubling.

A few years ago I had the opportunity to present this data about the self-perpetuating clique of nuclear weapons scientists and their pervasive presence in the government at a Seminar on Controlling Processes at Berkeley. A visitor at that seminar was someone who had spent many years working inside the Pentagon and he confirmed the picture that I had drawn from outside sources of data. He also said that the members of this select group are very conscious of their special sociology. They jokingly refer to themselves, he said, as "the nuclear mafia." I sometimes think that the analogy to "mafia" in describing the sociopolitical organization of science is an insightful one but I will not pursue that topic here.

A final issue concerning the Livermore and Los Alamos nuclear weapons laboratories is the role played by my employer, the University of California. The University of California Board of Regents manages these weapons laboratories under contract with the DoE. This has been a matter of controversy in the university for over twenty years. The university does not really manage the weapons labs in any responsible way; laboratory officials, and their associates in Washington, use the University of California name and reputation in their own self-interest to extend the aura of respectability. Harold Agnew, formerly director of the Los Alamos Laboratory, has acknowledged that this academic affiliation gives them added credibility in Washington.

In 1990, the faculty academic senates on all campuses of the University of California voted—by a 64 percent majority—to phase out this relationship with the weapons labs. The regents, ignoring the faculty vote, decided to renew the contract for another five years. I believe that money is not a major factor in shaping the university's role as patron of the laboratories. It is rather the political and ideological orientation of the Board of Regents. It is not unique to the University of California but is found throughout the country—a historical legacy that the governing boards of our great public universities (not to mention the private ones) are dominated by wealthy and well-connected individuals (members

of Mills' and Domhoff's elite ruling class) who rule without restraint and without accountability to anyone but themselves.[3]

Universities

Finally, I focus on university campuses to see where and how the political needs of the military establishment are served by research in and teaching of science. This is more subtle than straight power structure research. The research managers in the Pentagon know about the sensibilities of professors and are careful to keep unpleasant details about warfare concealed behind the purity of scientific challenge and research opportunities.

Let me give one recent example. The Superconducting Super Collider (SSC)—was a planned multibillion dollar particle accelerator that high-energy physicists worked on—until the project was killed by Congress in 1994—as their last best hope for blasting loose the secrets of elementary particles. This was a project in the purest of pure science, to which President Reagan gave his blessing (that is, he approved funding) in 1987. Acting out of curiosity, I wrote to the DoD asking them, under the Freedom of Information Act, to provide me with copies of all Pentagon documents relating to the SSC. This is not a DoD project; it is funded by the civilian science branch of the DoE. Nevertheless, I wondered if the government's internal decision making might have included some broader considerations. After two years of waiting I did receive a document, written from the Office of the Secretary of Defense to the White House just days before President Reagan gave his approval to the SSC. Here is the relevant quotation.

> We have reviewed the SSC proposal and . . . support [it]. . . . The SSC project will have many spinoffs for the DoD, especially in technologies required by the Strategic Defense Initiative, including particle beams, information processing, computer control, pulse power sources, and high energy accelerators.
>
> The nuclear weapons community will benefit from the fundamental research on the building blocks of atomic matter. The SSC will provide a valuable resource of scientific personnel. Many of the scientists now in the DoE nuclear weapons laboratory complex received their training while working on particle accelerators. (Office of the Secretary of Defense 1987)

While the Pentagon directly controls the majority of all federal R&D funds and about 80 percent of federal R&D funds in the physical sciences, its presence in basic research support on university campuses is much diluted, amounting to about 25 percent of academics' outside research funding. In certain fields, however, such as computer science, and on certain campuses, it may be the largest player. Just because a research project is funded by an agency other than the DoD does not mean it is free of military implications. The main funding agencies—DoD, DoE, NSF, and NASA—regularly consult and coordinate their research support programs. A 1982 report by the Defense Science Board states, "Research and devel-

opment in universities is supported by many sponsors, each relying on complementary funding from the other sponsors to leverage its own expenditures."[4]

Existing university policies require that no secret research be allowed on campus; most recipients of this money will assert that they are not designing weapons but merely engaged in basic research. Sometimes the purpose of a particular research program is clearly militaristic, as in the case of SDI or the DoD's computer science funding for automated battlefield systems. Healthy discussion, debate, and even dissent may develop around such projects. Frequently, however, it is not a simple matter to draw connections between research projects conducted at a university and the development of particular end products. Nevertheless such connections can be drawn, especially by people actively working at the frontiers of a given field of research. It appears that most academic researchers find it more comfortable to avoid, rather than face up to, these troublesome questions. This silence is one more mark of the political success enjoyed by the military establishments in directing universities to do what they want.

There are some exceptions. Several years ago a large number of academic researchers protested publicly against the SDI program, pledging to refuse money for work on that dubious military project. This famous protest was, to my mind, the exception that proves the rule of what some observers see as compliant academic science. Again, I reiterate that the nature of the interaction is subtle and indirect. What the military wants from university scientists is not only the results of their research. The training of students in selected areas of science and engineering is also a top priority for the DoD. Most of the money provided in research grants to the campus goes to supporting graduate students and other research staff working under the direction of the professors given the funding. Even though most of this campus research and training is unclassified (i.e., nonsecret), basic research with no obvious weapons application, the payoff for the Pentagon comes when these highly skilled and specialized students seek employment outside academia.

As an example of delayed military benefits, consider this statement:

> The point at which career decisions, career directions, begin to be set for graduate students is the point at which they decide what direction they are going to go on their dissertation. If they are engaged early in work that is intellectually stimulating to them and that has some promise for the future and is supported by the DoD, it seems to me you are well on the way to having them hooked into that enterprise for a long time. (Rosenzweig 1985)

These are not the words of a military officer or even a civilian on the staff of the Pentagon, but Dr. Robert Rosenzweig, the president of the Association of American Universities, speaking at the 1985 congressional testimony in support of Pentagon funding for universities.[5]

Far too often I have found that scientists in the university don't want to talk about the problem of the militarization of science. They are unwilling to admit

that it is a problem that touches them. It seems that many of my colleagues, when confronted with this issue, will automatically draw upon some familiar rationalizations in order to avoid getting more deeply involved. One good way to develop a deeper understanding of the problem of science and the military—and an exercise I have recommended to students in science—is to think about and discuss the following list of rationales that are commonly used. Each has a core of truth, but also a serious shortcoming.

- We need the best in science and technology to maintain our national security.
- Research is essential so that we know what threatening weapons are possible.
- I only work on defensive weapons, not offensive ones.
- If I don't do this work on weapons, someone else will.
- It is better to have weapons work done by an enlightened person like me.
- By being involved in the weapons program I can be an effective influence on the government.
- With nuclear weapons, war is unthinkable and we provide the political leaders with time to resolve the international problems that cause war.
- I am just a scientist doing my job; I stay out of politics.
- I only do pure research; whether it leads to weapons or not is out of my control.
- I take DoD money, but I am just doing basic research, not work on weapons.
- The DoD is the only agency that has money for the work I want to do.
- My research, although paid for by the DoD, is completely unclassified and it is the work I want to do, not what they tell me to do.
- I am fooling the DoD by taking their money for my research, which they would otherwise spend on weapons.
- I don't use DoD money; DoE and NSF fund my research.
- I don't have any government research funds; I am just a physics teacher.

The job market for certain areas of science and technology—most notably physics, electrical engineering, computer science, and mechanical engineering—offers some rude shocks for graduates who do not wish to work on weapons projects. The military aspect of such a career is a life-shaping reality that we educators do not generally bother to tell our students about. Perhaps we prefer to remain unaware of this unpleasantness so as not to spoil the idealization of our academic science. A few years ago I produced a series of booklets containing information on the job market and other military aspects of careers in science and engineering.[6] I had very little success in getting these booklets distributed to students, mostly undergraduates but also graduate students, who were planning to enter these professions. Only a few of my professional colleagues around the country were willing to distribute them to their students, and, not surprisingly, the

leaders of the American Physical Society wanted nothing to do with it. Again, silence and compliance are the marks of successful political control.

Conclusion

Here we have seen some details of the mechanisms by which the enterprise of science is enslaved to the dominant political and economic interests of this society. Money and power (status) are the most apparent variables in this process, and select individuals provide further important linkages between the practitioners and institutions of science and their most powerful patrons, the military and large corporations. The prevailing myth of neutrality in science obscures the influence of these external political forces not only from the general public but also from scientists and students of science.

Leading academic scientists serving on high government advisory committees give an illusion of objective and disinterested expertise in the service of national public interest but the revelation of their many interlocking connections with large corporations raises the spectre of significant bias. A study of the country's two nuclear weapons laboratories reveals a tight clique of technical experts, laboratory administrators, and government officials. In the universities, science professors and their students habitually close their eyes to the ways in which their pursuit of "pure" science is channeled to meet the needs of the Pentagon and industry.

Some people respond to this analysis by wishing that scientists might enjoy greater freedom and independence from such political forces. Such a hope is folly. The enterprise of science is a part of society and cannot exist outside the world of people. Science cannot escape the play of politics, economics, morality, and culture. Yet there is still room for scientists to choose which set of human means and ends they would serve with their skills. Furthermore, citizens who usually leave issues of science/politics to the experts or to the officials in power might also take a more active role.

A haunting story surrounds the famous play *Galileo*, written by Bertolt Brecht half a century ago. In the first (1938) version, Brecht focused Galileo's conflict with the church on the principle of freedom for scientists to search for truth. Writing in the growing shadow of Nazism, Brecht fled Germany where truth and freedom were being trampled under the boot of a totalitarian state. He revised the play in 1947, writing now in the shadow of the atomic bombs dropped on Hiroshima and Nagasaki. Deleting the climactic lines calling for more freedom for science, he substituted a plea for more social responsibility in science. "If I had resisted," he has Galileo say, "if scientists had been able to develop something like the Hippocratic Oath of the physicians, a vow to apply their knowledge only for the benefit of mankind! As matters now stand the most one can expect is a race of inventive dwarfs who can be hired to do anything."[7] In the atomic heat of fear, Brecht turned scientists from heroes to villains. How shall we, today's scientists, confront with this double image?

Scientists need to recognize that they are implements of political power and ask the questions of who, why, and how. We should not expect science to be free or autonomous; this would be an ideological delusion. By denying the existence of the powerful beneficiaries of our work, we only sanctify and increase their hidden power. The basic tenet of social responsibility in science is that we must not shirk the difficult tasks of assessing the likely consequences—in human terms—of the work we do, recognizing that we have choices, and taking responsibility for our actions. I offer two proposals for academic science that, while modest in scope, may assist us in these tasks.

First, any external agency seeking to fund a research project on campus must provide a complete disclosure of its interests and purposes in connection with that project. In addition, each professor receiving an external research grant should be required to prepare and make available for general discussion a detailed assessment of the likely applications and consequences of the research work.

Second, science educators have a responsibility to see that their students, especially in areas that have potentially harmful (e.g., military) applications, are well informed about those aspects of the job market. Study of the concepts and practice of social responsibility in science should become a regular part of the science curriculum.

Notes

My thanks to C. Jay Ou for his assistance in revising this paper.

1. Physical scientists in the United States are overwhelmingly white and male, but I will not address that here.
2. See Irwin Goodwin, "Cheers for Bush's 1993 R&D Budget . . ." in *Physics Today,* June 1992, page 55.
3. The DoD has major weapons laboratories managed by six other universities: the Massachusetts Institute of Technology, Johns Hopkins, University of Washington, University of Texas, Pennsylvania State University, and University of California at San Diego.
4. For reference to this and other relevant quotations, see Selvin and Schwartz (1988:6).
5. For reference to this and other quotes and data see the Schwartz booklet series, "Social Responsibility—Information for Students on the military aspects of careers in Physics" (1989), available from the author.
6. See note 5.
7. These lines, absent from some English versions of the play, were noted and translated from the German edition by Rather (1969:132).