indicates that the DNA-bound O may nucleate a "self-assembly" reaction of O dimers analogous to phage head assembly (as for the DnaA case described below). There is no evidence available as to the relative stability of the four-repeat O-some and the two-repeat structure.
51. J. H. LeBowitz and R. McMacken, *J. Biol. Chem.* **261**, 4738 (1986).
52. J. W. Zyskind, J. M. Cleary, W. S. A. Brusilow, N. E. Harding, D. W. Smith, *Proc. Natl. Acad. Sci. U.S.A.* **80**, 1164 (1983).
53. R. S. Fuller, B. E. Funnell, A. Kornberg, *Cell* **38**, 889 (1984).
54. T. A. Baker, B. E. Funnell, A. Kornberg, personal communication.
55. Additional complexities remain. The *ori*λ initiation reaction in vivo is bidirectional and strongly stimulated by RNA polymerase (*40*); in vitro the unwinding reaction is unidirectional and does not require RNA polymerase. The *ori*C initiation reaction in vivo is bidirectional and probably depends on RNA polymerase (*1*). The unwinding reaction in vitro is bidirectional; RNA polymerase is not required but is important under appropriate conditions (*42, 54*).
56. J. Germino and D. Bastia, *Cell* **34**, 125 (1983).
57. M. Filutowicz, E. Uhlenhopp, D. R. Helinski, *J. Mol. Biol.* **187**, 225 (1986).
58. A. L. Abeles, K. M. Snyder, D. K. Chattoraj, *ibid.* **173**, 307 (1984) and personal communication.
59. T. Tokino, T. Murotsu, K. Matsubara, *Proc. Natl. Acad. Sci. U.S.A.*, in press.
60. R. Tjian, *Cell* **13**, 165 (1978).
61. S. T. Smale and R. Tjian, personal communication.
62. D. R. Rawlins, G. Milman, S. D. Hayward, G. S. Hayward, *Cell* **42**, 859 (1985).
63. A. B. Lassar, P. L. Martin, R. G. Roeder, *Science* **222**, 740 (1983).
64. D. D. Brown, *Cell* **37**, 359 (1984).
65. W. S. Dynan and R. Tjian, *Nature (London)* **316**, 774 (1985).
66. H. R. Scholer and P. Gruss, *Cell* **36**, 403 (1984).
67. R. Brent and M. Ptashne, *ibid.* **43**, 729 (1985).
68. P. Robbins, D. Rio, M. Botchan, *Mol. Cell. Biol.* **6**, 1283 (1986).
69. W. S. Dynan and R. Tjian, *Cell* **35**, 79 (1983).
70. P. Sassone-Corsi, A. Wildeman, P. Chambon, *Nature (London)* **313**, 438 (1985).
71. A. G. Wildeman *et al.*, *Mol. Cell. Biol.* **6**, 2098 (1986).
72. F. Payvar *et al.*, *Cell* **35**, 381 (1983).
73. D. DeFranco, O. Wrange, J. Merryweather, K. R. Yamamoto, in *Genome Rearrangement*, I. Herskowitz and M. Simon, Eds. (Liss, New York, 1985), p. 305.
74. R. Bram and R. Kornberg, *Proc. Natl. Acad. Sci. U.S.A.* **82**, 43 (1985).
75. E. Giniger, S. M. Varnum, M. Ptashne, *Cell* **40**, 767 (1985).
76. Of the examples in Fig. 5, only for SP1 has a transcription activation function been demonstrated in vitro; this limitation is not surprising given the complexity of the available transcription systems, but it serves to emphasize the preliminary nature of the conclusions that can be drawn.
77. L. Guarente, *Cell* **36**, 799 (1984).
78. S. McKnight and R. Tjian, *ibid.*, in press.
79. A. D. Johnson and I. Herskowitz, *ibid.* **42**, 237 (1985).
80. D. J. Stillman, M. Better, E. P. Geiduschek, *J. Mol. Biol.* **185**, 451 (1985).
81. I thank Michael Botchan, Nicholas Cozzarelli, Arthur Kornberg, Roger McMacken, and Robert Tjian for valuable discussion and critical reading of the manuscript. I thank Marc Better and Mark Dodson for their many contributions to the ideas discussed here, Terri DeLuca for editorial help, and Mark Dodson and Chris Vasilikiotis for figures. Research on this topic in my laboratory has been supported by a grant from the National of Institutes of Health (GM17078).

Natural Philosophy in the Constitution

GERARD PIEL

The natural philosophers who wrote the U.S. social contract held the advancement of science to be the supreme exercise of citizen sovereignty. The rising nation, in the late 19th century, established the seat of that sovereignty in its universities. Today those institutions have come to be regarded as contract research centers at the service of the federal government. Research contracts in support of the proposed Strategic Defense Initiative are pressed on them against the consensus of the scientific community that holds this "Star Wars" enterprise to be technically infeasible. The time has come to reconstruct the relation between the federal government and university science in the spirit of our social contract.

AS THE SOCIOLOGY OF SCIENCE HAS SHOWN US, THE seeking of consensus is the habit that gets the work of science done. This social process goes forward simultaneously and consecutively in two phases, private and public. In the image of Galileo standing before the most awesome power in his world and time, the scientist can accept no authority but his own lonely reason and judgment. Yet, in the words of Robert K. Merton, founder of the sociology of science, it is "only after the originality and consequence of [his] work have been attested by significant others [the colleagues most closely engaged in his work] can the scientist feel reasonably comfortable about it" (*1*). Those others arrive at consensus not by taking a vote but by the same lonely exercise of reason and judgment.

Scientists tend to carry this habit over into their consideration of public issues. As Jerome Wiesner has observed, "Reasonable men in possession of the same set of facts tend to arrive at the same conclusion" (*2*). Issuing from perhaps the only community in society capable of forming assured consensus, the consensus of the scientific community on public issues ought to be more widely recognized in the deliberations of our federal government.

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Consensus Unheard

For reasons that betray ignorance of science among persons who have a responsibility to know better, however, that consensus goes largely unheard. The title of scientist is clothed with received authority in its most antiscientific mode. The title is, moreover, indiscriminately bestowed. In accordance with custom—and from failure to exercise professional judgment—the press almost invariably gives equal time to the consensus of the community, on the one hand, and to the eccentric celebrity and others equally unqualified to speak about the topic at issue, on the other hand (*3*).

Among the citizenry at large there is little understanding of the social process of science. Worse yet, there is widespread misunder-

standing, reaching even into the scientific community, of the social contract by which our society attempts to foster science. Ignorance of civics as well as of science blurs the connection between the scientific enterprise and our liberty and sovereignty as self-governing citizens. Now, on the eve of the bicentennial celebration of the U.S. Constitution, we should consider that connection. The ominous state of the present relation between the scientific community and the federal government gives urgent priority to reexamination of the terms of our social contract.

One of the great questions of history asks how and why the scientific-industrial revolution got under way so recently in Western Europe. Why did it not start 2000 years ago in the high civilizations of the Mediterranean basin and Asia? The history most relevant to this question is, of course, the history of science.

Science had a role in all of the high civilizations; in all but Western civilization, however, the progress of science and technology came to a halt. Alfred North Whitehead cited India and China as "instances of civilized societies which for a long period in their later history maintained themselves with arrested technology . . . [providing] the exact conditions required for the [working] of the Malthusian law." In these and other agricultural civilizations, through countless repetitions of history, "the normal structure of society," in Whitehead's words, "was that of a comparatively affluent minority subsisting on the labors of a teeming population checked by starvation and other discomforts [promised by Malthus]" (*4*).

The Practicability of Purpose

In the West, science went forward to become a consciously and formally constituted social enterprise. Because no scientifically established truth has been forgotten, science is accumulative. Because each new truth set in the context of the others asks more than one new question, the accumulation of objective knowledge proceeds exponentially; it accelerates. Within four centuries, again in Whitehead's comprehensive vision, the enterprise of natural philosophy brought "Steam" and "Democracy" and "Persuasion" in the place of "Force" in the organization of society. Of this change in the human condition, Whitehead said (*4*):

> When we think of freedom, we are apt to confine ourselves to freedom of thought, freedom of the press, freedom for religious opinions. Then the limitations of freedom are conceived as wholly arising from the antagonism of our fellow men. That is a thorough mistake. The massive habits of physical nature, its iron laws, determine the scene for the sufferings of men. Birth and death, heat, cold, hunger, separation, disease, the general impracticability of purpose all bring their quota to imprison the souls of women and men. . . . The essence of freedom is the practicability of purpose. . . . The literary exposition of freedom deals mainly with its frills. The Greek myth is more to the point. Prometheus did not bring to mankind the freedom of the press. He procured fire. . . .

The American Revolution came about midway in this momentous deflection of history. By that time, the accelerating advance of science and technology was bringing improvement in the well-being of society at a rate that could be sensed by the living generation. The fire that Prometheus brought had begun to make steam. Increase in production, exceeding the growth of population, had repealed the iron law of Malthus. A substantial and increasing percentage of the population was discovering practicability of purpose. The citizen could be installed as sovereign.

That sovereignty is asserted in the first words of the Constitution: "We the people. . . ." It was reaffirmed in the unambiguous language of the First Amendment. That Amendment says: "Congress shall make no law . . . abridging the freedom of speech, or of the press. . . ."

The plain injunction of the First Amendment has been made ambiguous by rulings of our courts since our country took its place as a power in the anarchy of nations. At the close of World War I, in the *Schenck* opinion that jailed a pamphleteer who maintained the draft law was illegal, Oliver Wendell Holmes, Jr., propounded the test of "clear and present danger" (*5*). That test "balances" the citizen's freedom of speech against the federal government's concern for national security. Although Holmes, in the dissents for which he is famous, tried later to redress the balance in favor of free speech, his original ruling leads the line of decision that places the sovereignty of the citizen in jeopardy.

Citizen Sovereignty: A Paradox

We should not be discouraged that the outcome of our attempt at self-government remains still in doubt. The very idea presents a paradox—the paradox of citizenship that says each of us is at once the ruler of, and a subject ruled by, the government we rulers have established.

We are indebted to the clear insight of Alexander Meiklejohn for the resolution of that paradox. When, as citizens ruled, we pursue our self-interest, our liberty is properly subject to constraint by governmental authority. Against that authority, says Meiklejohn, our liberty is hedged by the "due process" clause of the Fifth Amendment. In his notion of "the marketplace of ideas" resounding to the "roar of bargain and battle," Holmes confounded the pursuit of self-interest, as so many others before and after him have done, with the citizen's sovereignty. It is only when, as citizen rulers, we engage mind and will in public policy and share in the effort to advance the common welfare that our liberty is unqualified. The First Amendment, forbidding any constraint by law, makes that liberty sovereign (*6*).

Science in the Social Contract

The authors of our social contract well understood that the supreme exercise of citizen sovereignty is the enterprise of natural philosophy. Thus, Thomas Jefferson, author of the First Amendment, wrote to a young man who sought his counsel (*7*):

> It is impossible for a man who takes a survey of what is already known, not to see what an immensity in every branch of science remains to be discovered . . . great fields are yet to be explored to which our faculties are equal, and that to an extent of which we cannot fix the limits . . . while the art of printing is left to us, science can never be retrograde; what is once acquired of real knowledge can never be lost. To preserve the freedom of the human mind then and freedom of the press, every spirit should be ready to devote itself to martyrdom; for as long as we may think as we will, and speak as we think, the condition of man will proceed in improvement.

Plainly, in Jefferson's vision, freedom of the press is not a "frill." Surely, it is not when it is exercised in the central role that publication plays in the work of natural philosophy. Whitehead would concur, I am sure. He must have had in mind the much more common occasion when the press is preoccupied with private interests and not the public business.

From its beginnings in the West, science was the work of heretics like Galileo and then of revolutionaries like Thomas Jefferson. By contrast, the Mandarin kowtowed to the despot; the Brahmin was at the service of the Moghul and the European conqueror in turn. Here must be the answer to the arrest of technology in earlier civilizations. Conducted by heretics and revolutionaries, the advance of science and technology in the West has changed not only the relation of man to nature but of man to man. In its brief history, our

country has been transformed from a rustic republic to an industrial world power. That transformation has been attended by radical redistribution, more than once, of economic and political power in the social order. The work of the scholar and scientist is bound to challenge and make obsolete first this and then that special interest in established ways of making and doing things. The freedom to conduct the supreme public business of the advancement of human understanding must be protected, therefore, by defenses as absolute as social institutions can provide.

The University in the United States

The best institution we have devised to secure that freedom is the university. The university in the United States has an origin distinct from that of the great and more ancient universities of the Old World. Those trace their beginning to self-governing scholars' guilds, secured later by princely endowment. The American university is a corporation created by the community to employ scholars to teach and to advance their learning. It is, moreover, a recent invention. Harvard College is celebrating the 350th anniversary of its founding this year; Harvard University is only a little more than a century old. Some people call Johns Hopkins, founded in 1876, the country's first university.

Henry Augustus Rowland, founding professor of physics at Johns Hopkins, was there at the creation. He described the scene in "A Plea for Pure Science," his vice presidential address at the 32nd National Meeting of AAAS held in 1883 in Minneapolis (*8*). There were then, he observed, "about 400 institutions calling themselves colleges or universities in our country." Rowland declared: "The whole earth could hardly support such a number of first-class institutions. The curse of mediocrity must be upon them to swarm in such numbers. They must be a cloud of mosquitoes, instead of eagles as they profess."

As evidence, Rowland cited one institution that aspired to the name of university "with two professors and 18 students and another having three teachers and 12 students." He could count only 17 institutions with more than 20 faculty members, and only eight institutions with endowments exceeding $1 million.

With the passion that drove his own great work (with his ruling engine and its diffraction gratings, he carried spectroscopy in the optical wavelengths to its limits), Rowland advanced his vision of the university. This institution was to foster the "scientific study of nature in all its branches, of mathematics, of mankind in its past and present, of the pursuit of art . . . the highest occupations of mankind." In Rowland's own case, it was to set him free to do "what must be done to create a science of physics in this country, rather than to call telegraphs, electric lights, and such conveniences by the name of science."

"To have the applications of a science," he said, "the science itself must exist. Should we stop its progress and attend only to its applications, we should soon degenerate into a people like the Chinese, who have made no progress for generations because they have . . . never sought for reasons in what they have done."

As an experimental physicist, Rowland had a practical grasp of the funding required to provide the scientific man with a library, a laboratory, instruments, the expenses of each experiment, and "a respectable salary to live upon, before he is able to exert himself to full capacity." Rowland called upon private wealth to finance the university. "Government appropriations are out of the question," he said, "because no political trickery must be allowed around the ideal institution."

Over the next half century, as applications of the physics of Newton and Maxwell multiplied, the American industrial revolution ran to the culmination of its smokestack phase. The disposable wealth of the nation responded generously to the claims laid upon it by Rowland and his colleagues and their successors. By the time of the Great Depression, it had financed the creation of a dozen universities worthy of the name. Contrary to Rowland's injunction, these included distinguished state universities financed by government appropriations.

Life Tenure

Legally speaking, the professors were (and today remain) employees of these great corporations. The founding professoriate asserted, however, a different identity. By invoking the feudal status attached to their title and by organizing according to the example of the contemporary American labor movement, they won life tenure in their appointment. This is a guarantee of freedom to think and to speak in the public interest that is otherwise accorded (by Article III, Section 1, of the Constitution) only to the sitting judges who constitute the third branch of the federal government.

The writing of this paragraph in the social contract is a cautionary tale demonstrating that liberty is not bestowed by ancestors or charters; it must be asserted by each generation. As Richard Hofstadter and Walter P. Metzger showed, in their history of this critical episode in American civilization, it was the pragmatic faith of their fellow citizens in the utility of the work of the scientists that ultimately ratified the extension of this immunity to the entire professoriate (*9*). The scientists, according to Hofstadter and Metzger, were known also to their fellow citizens as professors who would speak their minds. This propensity among the physicists, at least, may have its explanation in a finding made by Rowland's biographer, A. D. Moore: "Of the 90 American physicists 'starred' by vote of their colleagues" in a mid-1920's edition of *American Men of Science*, 29 claimed Johns Hopkins as their alma mater (*10*).

The Seat of Citizen Sovereignty

Thus, by remarkable and sudden exertion, the citizens of the United States established the American university as the seat of their sovereignty. In the words of Thorstein Veblen at the turn of the century, the university is "ideally and in popular apprehension . . . a corporation for the cultivation of the community's highest ideals and aspirations" (*11*). Because that unpredictable enterprise can lead to dangerous thoughts, the First Amendment freedom to think such thoughts requires fortification by the university's walls and sanction by life tenure.

For their part, the universities undertook to meet the commitment, implicit in life tenure, to support the lifework of their professors. From their own resources they even succeeded for a time in financing the work of their scientists. The expense of doing science increased rapidly, however, as advances in instrumentation opened ever larger frontiers to investigation. External funding from the great private foundations soon became the mainstay of university science. The model for this relation was established by Warren Weaver in his work for the Rockefeller Foundation. Beginning in 1932, Weaver went talent-scouting across the United States and Western Europe in search of physicists and chemists who were working on ideas and the development of instruments that promised to have relevance to questions in biology (*12*). Encouragement of these enterprises by the Rockefeller grants must have accelerated the arrival of molecular cell biology by two decades. The experience gave Weaver a profound insight into the social process of science (*13*):

To the question "What is science?" the realistic answer is that science is what scientists do. . . . What science *ought to be* is what the ablest scientists *really want to do*. . . . The most imaginative and powerful movements in the history of science have arisen not from plan, not from compulsion, but from the spontaneous enthusiasm and curiosity of capable individuals who had the freedom to think about the things they considered interesting.

The Arsenal of Democracy

The capital resource of understanding and of human capacity generated by U.S. universities during the first half century of their creation became apparent to the American public during the prosecution and then the apocalyptic termination of World War II. The arsenal of democracy was its universities. Experiments at the frontiers of understanding were scaled up to technologies overnight. At the Massachusetts Institute of Technology and Harvard, physicists rallied by the Radiation Laboratory fashioned the oscillators and the tactical implementation of radar and counterradar. The same microwaves radiated by the proximity fuse developed at Johns Hopkins brought the high-explosive shell to the peak of its lethality. Freeze-dried plasma from the fractionation of human blood at Harvard Medical School helped to reduce mortality at the battalion-aid station to less than 1%; killed-virus vaccine from the University of Michigan at Ann Arbor averted the prospectively much higher mortality from influenza. Columbia University and the universities of Chicago and of California at Berkeley collaborated to achieve the largest scaling-up of all: the effectively infinite amplification of Enrico Fermi's 1934 experiment to the fireballs that destroyed Hiroshima and Nagasaki. Of the role of university science in the war effort, the political scientist Don K. Price has observed with understatement: "It became apparent that what scientists discovered by unrestricted research might be of greater importance than the things the military officers thought they wanted" (*14*).

The prevailing faith in the utility of science had been compellingly sustained. The country was eager for more science and ready to pay for it. Correspondingly, university scientists looked to the continuation of their wartime partnership with the federal government. No source of funding other than the national treasury could finance the radical innovations in the technology of instrumentation now available to facilitate new advances in the scientific enterprise from which they came.

Even before the war ended, President Roosevelt had commissioned Vannevar Bush, the principal wartime mobilizer of university science, to tell the federal government how to manage the support of science in peacetime. In *Science, the Endless Frontier* (*15*), Bush and his colleagues undertook a restatement of the social contract. It was a bargain: Pure science merited generous public support without strings and for its own sake because it would repay such support many times over in the utility of its discoveries. As wary of "political trickery" as H. A. Rowland, they proposed that the public funds be administered through a National Science Foundation established outside the government under the control of a part-time board of trustees. Their proposal found its way through Congress but was vetoed by President Truman. He declared that their design of the foundation was "divorced from control by the people to an extent that implies a distinct lack of faith in democratic processes."

The aborted National Science Foundation was not much missed. The military departments, concerned to maintain fruitful collaboration with university scientists, improvised procedures to keep funds flowing. A model for years to come was established by the Office of Naval Research (ONR). Under the direction of Alan Waterman, ONR took a generous view of the Navy's interests; it made project grants, on proposals vetted by peer review, to basic research enterprises remote from the quarterdeck.

Mission-Oriented Funding

On this precedent, the military and paramilitary agencies, including the then Atomic Energy Commission and what was later to become the space agency, took over the financing of the physical sciences in the nation's universities. The life sciences soon found a corresponding federal patron in the U.S. Public Health Service and later in the National Institutes of Health, on which Congress pressed increased appropriations every year. By the time the National Science Foundation cleared the President's desk in 1950 the territory for which it was to be responsible was already occupied. Until the most recent times, the foundation never commanded as much as 10% of the federal funding of university science. Its relegation to junior status brought no effective protest. Lloyd Berkner expressed the general satisfaction of the scientific community in its arrangements with the government when he said: "Instead of one National Science Foundation, we have six or seven."

Motivation by the utility of science, declared by every grant from the "mission-oriented" funding agencies, excited larger appropriations from the Congress each year. Through the first two decades it secured, no doubt, larger appropriations than could have been induced for the support of pure science as one of "the highest occupations of mankind." The play of something like the market process between the plurality of granting agencies and their grantees obviated the need for an overarching "science policy" and seemingly minimized "politics" as well. The generous support of science had been secured by the closed politics of power in the executive department and spared the open politics of the legislature.

The improvised contract between the government and the universities betrayed nonetheless certain inherent contradictions between the interests of the parties. These have come increasingly into the foreground over the years, especially when federal funding leveled off and even, for a period after 1967, declined. The mission-oriented grant is for the project; the university's commitment is to the scientist. The grant is for the short term; the university is charged with the long-term interests, the next generation's at least, of society. Ever present is the question whether the work being done for the granting agency would be done by the grantee under the university's sponsorship, anyway.

Voids in the 360° Horizon

However liberally a particular granting agency construes its mission and administers its grants, the missions of the agencies taken together leave large voids in what would be the 360° horizon of autonomously motivated scientists. Funding by the health agency has notably neglected plant life, and molecular biologists are late in addressing the plant cell in a world that must feed a population of 6 billion at the end of this century. John R. Pierce and Patrick Haggerty years ago attributed the well-known decline in the competitiveness of U.S. industry in international trade to the preoccupation of physical scientists with questions relevant to the exotic technologies of interest to the military (*16*). The present increase in funds for "engineering" seems to confirm their judgment.

The past 40 years and $40 billion of federal funding have brought U.S. science to world eminence—on the popular score of the Nobel Prizes, to "Number One." The universities have grown in wealth and size, albeit "out of all faculty control" as Clark Kerr observed (*17*). The granting agencies now count 100 "research universities"; they receive 85% of the federal funds (*18*).

There is not yet a line in the federal budget, however, for science and higher education. The funding has come from appropriations for other purposes and has waxed and waned as the priorities of the

federal government have changed. The recent upturn in federal funding and declarations of concern from the present Administration have now lost their promise. The increased funding stems from the renewal of the arms race and anxiety about the country's standing in the world economy; so it goes largely to applied science.

By a kind of Gresham's law, the allocation for pure science has declined since 1972 from three-quarters to two-thirds of the total flow (*18*). Project funds now are goal- and result-oriented, not merely mission-oriented. Each agency has its priorities for university science. Mega-objectives framed in Washington bring the installation of heavily financed centers and institutes on university campuses, setting up new fields of centrifugal force around the weakened center (*19*).

Contract Research Centers

Despite the increased flow of funds, there is increasingly less money for what university scientists might want to do. The universities are regarded as contract research centers at the command of the federal government.

The Strategic Defense, or Star Wars, Initiative (SDI) starkly illuminates this change in the status of our universities and the scientific community. The clear consensus of the community rejects as physically infeasible this proposal to create an "impenetrable shield" against intercontinental ballistic missiles. Against the consensus of the scientists who are called upon to create it, the Administration nonetheless presses SDI. Lieutenant General John Toomay, U.S. Air Force retired, expressed the spirit of the new relation at the AAAS meeting in Los Angeles last year. In a far cry from the military officers of World War II who learned from unrestricted research, he insisted that his hearers accept their research assignments and declared "we in the military find ourselves disillusioned about the treatment that we sometimes get from science and engineering" (*20*).

The first appropriation by Congress for SDI authorizes $100 million to buy the services of university science; if the program goes forward there will be enough funds to hire half of all the country's physicists. Unfortunately, in the dearth of funding otherwise, some physicists are willing to warp their research proposals to fit the program. The Pentagon has thus warped already outstanding research contracts with university physicists in order to count them in the program and thereby to imply their endorsement of its feasibility. For the same public relations ends it has bought the cooperation of government scientific agencies in England, West Germany, and Israel.

An Endless Frontier

The proposition that the SDI enterprise may secure a defense against a missile attack is not a mere fantasy; it is a hoax. Its centerpiece is the x-ray laser powered by an atomic explosion. This and other "third-generation" nuclear weapons, we are told, require the indefinite prolongation of underground nuclear weapons testing; "hundreds, perhaps a thousand, more tests," it has been said. Star Wars supplies a disarming argument to make the arms race permanent—a new endless frontier for science. It tells us once again that, however else the Reagan Administration justifies its extravagant military budgets, the Administration persists in seeking the unattainable goal of military superiority.

Whether the President is a perpetrator or a victim of the Star Wars hoax we may not live to know. Military superiority in the age of thermonuclear weapons is unattainable: In principle one infinity of destructive power cannot exceed another such infinity. It is unattainable in fact because, short of its attainment, the destabilizing of the economy and the social fabric of one or the other party to the arms race will ignite World War III.

Restore the Social Contract

The time has come to reconstruct the relation between our universities and the federal government; that is, to restore the social contract. In that contract the citizen is sovereign. The scientific inquiry that changes the world we live in is the supreme exercise of citizen sovereignty, and the university is its seat. It is for the government to respond to the will of the people and to the dictates of reason and sanity.

There are alternatives to the present improvised relation between university science and the government. One of them, reluctant as scientists and university administrators have been to consider it, is the institutional grant. Institutional grants to conserve and foster the public domain of objective knowledge can restore the autonomy of our universities. Serving at worst as apples of discord, they can reunite the community of scholars in the governance of the university. It is not difficult to conceive of ways to secure administration of such grants by peer review and to make them respond adaptively to institutional need. Institutional grants need not bar project grants; they can improve the bargaining power of universities and scientists in the acceptance and negotiation of project grants from the mission-oriented agencies.

A second step in this alternative is to make the legislative branch of the federal government, rather than the executive, the source of the institutional funding. Under the separation of powers this can be seen as a legitimate function of the Congress in fulfillment of its obligation to consult the will and counsel of the citizenry. To this end, under the leadership of Emilio Q. Daddario, the Congress created the Office of Technology Assessment. The endowment of the universities would extend naturally the function of that agency. The consensus of the scientific community cannot serve to rationalize the execution of policy by the executive; the counsel of the community enters public deliberation much more usefully and honorably in the framing of public policy by the Congress.

REFERENCES AND NOTES

1. R. K. Merton, *The Sociology of Science* (Univ. of Chicago Press, Chicago, 1973).
2. J. Wiesner, personal communication.
3. For example, B. Rensenberger, "Star Wars splits experts into two camps," *Washington Post*, 3 March 1985.
4. A. N. Whitehead, *Adventures of Ideas* (Macmillan, New York, 1933).
5. *Schenck* v. *United States*, 249 U.S. 47 (1919).
6. A. Meiklejohn, *Free Speech and Its Relation to Self-Government* (Harper & Row, New York, 1948).
7. In facsimile, in *Scr. Math.* **1** (no. 1) (Yeshiva University, New York, 1932).
8. H. A. Rowland, *Proceedings of the AAAS 32nd Meeting* (Permanent Secretary, AAAS, Salem, 1884).
9. R. Hofstadter and W. P. Metzger, *The Development of Academic Freedom in the United States* (Columbia Univ. Press, New York, 1955).
10. A. D. Moore, *Sci. Am.* **246**, 150 (February 1982).
11. T. Veblen, *Essays in Our Changing Order* (Viking, New York, 1934).
12. W. Weaver, *Scene of Change* (Scribner, New York, 1970).
13. ———, *Sci. Am.* **189**, 47 (September 1953).
14. D. K. Price, *The Scientific Estate* (Harvard Univ. Press, Cambridge, 1965).
15. V. Bush *et al.*, *Science, the Endless Frontier* (Government Printing Office, Washington, DC, 1945).
16. J. R. Pierce, *Science* **149**, 397 (1965); P. E. Haggerty, in *Science and the Evolution of Public Policy*, J. A. Shannon, Ed. (Rockefeller Univ. Press, New York, 1973), pp. 189–215.
17. C. Kerr, *The Uses of the University* (Harvard Univ. Press, Cambridge, 1982).
18. *Science Indicators 1982* (National Science Foundation, Washington, DC, 1983).
19. W. D. Carey, *Science* **228**, 7 (1985).
20. *Star Wars and the Strategic Defense Initiative*, symposium transcript, 151st National Meeting of AAAS, Los Angeles, CA, 1985.