stitutions can do to assist in achieving protection of ideas should be disseminated as widely as possible. Thirdly, liaison should be established between the institution and Research Incorporated (*32*), or some similar nonprofit organization serving the educational community, in order that the developmental aspect of the idea may be guided at an early stage, so that when it is presented for commercial evaluation it will be in a protectable package and appropriately wrapped.

References and Notes

1. According to this doctrine, a wild animal is possessed by its captor and is not "owned" by the person on whose land it is found. When applied to intellectual property, the doctrine is complicated by the fact that more than one person can have the same idea. Can two people own the same rabbit?
2. Publication has implications in both patent and copyright fields. In the case of patents, publication may support a claim of priority of invention, or priority of discovery. Thus, in the case of patent infringement actions or copyright infringement, the prior publication may establish failure to contribute to the art, or lack of originality.
3. Title 35, *U.S. Code Annotated*, sect. 1–293.
4. Title 17, *U.S. Code Annotated*, sect. 1–216.
5. See, "General Information on Copyrights," *Circular 35* (Aug. 1963).
6. Trademarks, the modern-day counterpart of the Guild Mark of the 14th Century, are outside the scope of this article. It should be noted, however, that they play an important part in protecting the identity of manufactured articles. See A. H. Seidel, *What The General Practitioner Should Know About Trademarks and Copyrights* (American Law Institute, Philadelphia, Pa., 1959).
7. See also, A. H. Seidel, *What The General Practitioner Should Know About Patent Law and Practice* (American Law Institute, Philadelphia, Pa., 1956).
8. Common-law copyright represents a right to the *form* of the author's expression, an exclusive right until such time as the work is published or otherwise enters the public domain.
9. Certain works are not afforded protection. See "General Information on Copyrights" (*5*).
10. *Arthur Murray Dance Studios of Cleveland, Inc. v. Witter*, **105** *Northeastern Reptr. ser. 2* 685 (Court of Common Pleas, Ohio, 1952), contains an exhaustive list.
11. A patent or copyright is, actually, only a license to exploit, with the right to protect (successfully) against someone else "trespassing" on the area. It is, in effect, a license giving the holder, and none other, the right to hunt a particular form of rabbit.
12. Existing federal statutes and regulations forbid the issuance of certain patents concerning atomic energy; the patent must be issued to the government.
13. The basic assumption is that the constitutional authority to issue patents was intended to protect inventors. As a corporation is an artificial entity it obviously can invent nothing; invention is the prerogative of the individual, but the corporation can buy the right—that is, the patent rights—from the individual.
14. Reduced to its elements, the situation is this: protective laws are interpreted by the judges, and, naturally, the judges are influenced by traditional views on what constitutes intellectual property.
15. Actually, the views of the scholar and the corporate sponsor are not far apart: the former wants protection for his reputation and for his rights as a discoverer; the latter wants protection that will enable it to control the use of the "property."
16. **378** *Southwestern Reptr. ser. 2* 147 (Court of Civil Appeals, Tex., 1964).
17. **158** *Federal Suppl.* 919 (District Court, Maryland, 1958).
18. *Furr's Inc.* v. *United Specialty Advertising Co.*, **385** *Southwestern Reptr. ser. 2* 456 (Court of Civil Appeals, Texas, 1964).
19. **200** *Northeastern Reptr. ser. 2* 615 (Illinois Court of Appeals, 1964).
20. **130** *Federal Suppl.* 554 (District Court, Maryland, 1955).
21. J. H. Munster, Jr., and J. C. Smith, **145** *Science* 1276 (1964).
22. It must be remembered that institutional research organizations are not limited to a single sponsor. The institutional research organization may be involved in research for competing sponsors who may not even be aware they are patronizing a single source of ideas. So far as the research organization is concerned the result may be a conflict of interest.
23. Where confidential information is so disclosed, the fact of confidentiality should be disclosed, preferably in writing.
24. **248** *U.S. Repts.* 215 (1918).
25. It has frequently been said that mere extension of the existing state of affairs is not enough to render the idea patentable. This is not quite a true generalization. There are extensions and extensions, and patentability will depend on the "size" of the extension. After all, each advance in knowledge is an extension of prior knowledge.
26. **248** *Federal Reptr. ser. 2* 799 (1st Circuit Court, 1957).
27. H. R. Olsson, "Dreams for sale," **23** *Law & Contemporary Problems* 34 (1958).
28. H. C. Havighurst, "The right to compensation for an idea," **49** *Northwestern Univ. Law Rev.* 295 (1954).
29. **376** *U.S. Repts.* 225 (1964).
30. *Compco Corp.* v. *Day-Bright Lighting, Inc.*, **376** *U.S. Repts.* 234 (1964).
31. "The unsolicited creative idea: A copyright perplexity," **28** *Albany Law Rev.* 108 (1964). See also, **9** *Cleveland-Marshall Law Rev.* 1 (1960).
32. Research Incorporated, 405 Lexington Ave., New York, N.Y., is an organization which services the needs of the academic community in the development and promotion of intellectual properties.

Escape to the Endless Frontier

How can science be related to our political purposes and to our economic and constitutional system?

Don K. Price

The United States was founded at a time when philosophers were beginning to believe in the perfectibility of mankind. Ever since Benjamin Franklin and Thomas Jefferson, Americans have been inclined to put their faith in a combination of democracy and science as a sure formula for human progress.

Today that faith burns much less bright. Since the Second World War it has seemed to many, and especially to scientists, that the faith was dimmed by the mushroom cloud of the atomic bomb. The scientists who found themselves, to their great surprise, caught up in the political troubles of the contemporary world are tempted to blame their fate on their success in discovering nuclear fission: they see their tragedy, like that of Prometheus, as the result of seizing the secrets of the gods. But it seems more realistic to remind them that their own faith in inevitable progress had been dampened before Hiroshima—during the Great Depression or even before.

The earlier creed of progress had two main articles of faith, one relating to the progress of science, the other to the progress of society. The first was that men's desire for material benefits would lead society to support the advancement of science and technology, just as the profit motive would encourage the development of the economy. The second was the corollary that the advancement of science would lead society toward desirable purposes, including political freedom.

The depression gave the general public reason to doubt these beliefs, as many scientists and philosophers had already come to do. After economists and politicians lost their confidence that the individual profit motive would automatically guarantee

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economic progress, and that technological innovation would necessarily further social welfare, it became easier for the general public to share the skepticism of scientists. The leaders of the scientific world, of course, had already come to understand that science makes progress less by the effort of inventors to find solutions for the practical problems of industry or government than by the formulation of abstract theory and the search for basic knowledge. And they had much earlier given up their faith that science was certain to further either divine purpose or political progress.

The Bush Report

At the end of the Second World War, the scientists' skepticism became a basis not for despair, but for vigorous action to guarantee the progress of science. Under the leadership of Vannevar Bush, the scientists undertook to teach the nation that basic research would not be produced automatically by the efforts of industry or government to apply science and technology to their own purposes, and that as a matter of policy the government should support basic research without regard to its application. The United States had been weak in basic science, and had had to rely on Europe for the fundamental knowledge that guided the development of the spectacular new weapons during the war. Now, knowing that "basic research is the pacemaker of technological progress," the United States must provide support from government funds for the advancement of fundamental science. This argument, presented to President Roosevelt by Dr. Bush in his famous report, *Science the Endless Frontier,* reversed the traditional policy of the United States in two ways: it persuaded universities and private research institutions that they had to ask the government for financial aid, and it persuaded the government that basic science, as well as applied research, deserved support.

But although the report abandoned the traditional faith in automatic progress with respect to science, and proposed deliberate governmental policies to encourage that progress, it did not undertake to deal with the second and more general aspect of the problem—progress in social and political affairs. The relation of science to political purposes was set aside with the assurance that the progress of science is essential to "our health, prosperity, and security as a nation," and the disclaimer that science alone would provide no panacea for social problems (*1*).

The Bush report thus dealt—as, of course, Dr. Bush was asked by the President to do—with only half of the total problem of science in its relation to politics. On that half of the problem, it taught its lesson well, and the electorate learned it thoroughly. The results can be graded, in a crude way, by looking at what Congress was persuaded science is worth to the taxpayer: we are spending more dollars today on research and development than the entire federal budget before Pearl Harbor. If the lesson was an incomplete one, no one should single out the scientists for blame. Dr. Bush was not asked by the President to revise our political philosophy, but only to present a plan for the support of science. It is curious, in retrospect, that the political questions were not raised, but the fault was not that of the scientists, but of the politicians and political scientists. There were, indeed, some arguments about such questions as how the officials should be appointed who were to make grants to scientists, and what the procedures should be for accounting and overhead payments. But these were applied details, and hardly anyone stopped to ask the fundamental question: how is science, with all its new power, to be related to our political purposes and values, and to our economic and constitutional system?

By ignoring this question, we have been trying to escape to science as an endless frontier, and to turn our backs on the more difficult problems that it has produced.

The Problems

For more than a decade, this escape seemed a sound strategy for science. Plenty of money was being provided, although there were indeed some minor inconveniences, as well as some worries in principle about the way in which basic research was subordinated to certain applied programs. But then it began to be clear, in two ways, that troubles were sure to arise in the relationship between science and politics. The first way has now become clear to everyone in practice; the second is more theoretical, and therefore more important, but less obvious.

The practical trouble has arisen because practical politicians came to doubt that the identity of purpose between government and the scientific community should be taken for granted. "Health, prosperity, and security"—it was an argument, in a more sophisticated form, that what's good for science is good for the nation. This is surely true, in a general sense, but it is no longer completely persuasive as unfriendly members of Congress begin to look for conflicts of interest between the scientific community and the nation as a whole.

Conflicts of interest appear first in petty problems, such as those of accounting for federal grants to universities. But then they appear in graver problems, like the degree to which scientists as such should have a voice in policy decisions, or government should control the direction of research and the use of its results, especially in view of the new potentialities for both good and evil of the biological and social, as well as the physical, sciences. The simple reassurance that science is bound to be good for you is not likely to be adequate. Our popular worries about intercontinental missiles and radiation fallout, in which our alarm can be directed against an alien enemy, are bad enough. But to these worries we have added the fear that scientists are about to use chemistry to poison our crops and rivers, biology to meddle with our heredity, and psychology to manipulate our ideas and our personality.

So we are about to reach the point when both scientists and politicians begin to worry not merely about specific issues, but about the theoretical status of science in our political and constitutional system, and no longer rely on the assumption—which was acceptable enough to the general public when Dr. Bush presented his memorable report—that science and democracy are natural allies. Especially since some scientists have never believed it: some have been profoundly suspicious of the American version of democratic politics, rather preferring the status of science in the more conservative and traditional societies of Western Europe, and a few have been persuaded that science would prosper better under some form of socialism.

But most scientists, of course, like most politicians, have not thought very much about the problem at all. Indeed, any reasonable foreign observer would be obliged to conclude that we

have socialized our science at best in a fit of absence of mind, and at worst with the purpose of subordinating it to the purposes of military power.

Accordingly, the scientific community and the United States generally are in even deeper trouble for their lack of a theory of the politics of science than for their failure to solve practical problems of organization or policy. The nation that was born of the first effort in history to marry scientific and political ideas—the political heir of Franklin and Jefferson—is apt to speak of the relationship of science and politics with an air of apology, while throughout Asia and Africa the missionaries of Marxism teach the developing intelligentsia that the Communist system is the only approach to politics that is firmly grounded on the scientific method.

Insights from Science Fiction

The clearest example of this contrast, as it has percolated down from the scholarly elite to the general public, may be found in science fiction. This is a form of literature unwisely neglected by students of politics. On something like the theory that if I could write a nation's songs I would be glad to let someone else write its laws, I am inclined to think that it is the space cadets of the comic strips —and their fictional counterparts back to Jules Verne or even Daedalus—who have fired our enthusiasm for the race with the Russians to the moon. That enthusiasm is certainly shared on both sides of the Iron Curtain. But with a difference, and a difference that may be more important to the future of our political system than the amount of money that we spend on space exploration.

The difference is that the Soviet space cadet, in sharp contrast to his opposite number in Western science fiction, seems to be very conscious not only that he is in a race for prestige or power with another country, but that he has discovered the key to the use of the scientific method in human affairs. This is the materialist dialectic, which is supposed not merely to let the Communist system make the best use of science in technical matters, but to give the scientific intellect a generally dominant role in the society of the future.

This notion began to appear in Soviet space fiction long before the first Sputnik. Forty years ago Aleksei Tolstoi, with some technical help from the pioneering rocket engineer Tsiolkovski, used a new propellant to put a heroic Red Army man on Mars, where he proceeded to help organize a proletarian revolution against a decadent Martian society (*2*). More recently, it has become even clearer that the Soviet conquest of space will be a means of extending to the cosmos the spread of Marxist philosophy. Thus, as one space ship rushes through the void to its first meeting with beings from another solar system, the hero reassures his colleagues that sympathetic communication will surely be possible: "Thought, no matter where it is found, will inevitably be based on mathematical and dialectical logic." (Incidentally, the hero does not rely entirely on such spiritual comfort, for he goes on to issue tranquilizers to all hands on board.) And his comrade replies with a sententious expression of confidence that they will be congenial with the beings they are about to meet, since it is inevitable that on other worlds, as on the Earth, "humanity has been able to harness the forces of Nature on a cosmic scale only after reaching the highest stage of the communist society" (*3*).

In the West, of course, the science fiction hero is a good deal less sure that science is about to bring the cosmos to a state of perfection. As Isaac Asimov has noted, most contemporary science fiction in America is not utopian, but anti-utopian (*4*). If the hero is not full of complexes from his infancy or frustrated by romantic difficulties, he is likely to be upset by the feeling that the social system in which he lives is not all it should be. The clear-eyed young hero in his space suit (like the clear-eyed cowboy or the earlier pioneers and pathfinders) is all too likely to be betrayed by selfishness or weakness in high places. Or in the more recent and more apocalyptic stories, the hero, if any, is likely to be struggling in a world that is about to be ruined, or has been ruined, by the inability of politicians to understand and control the powers released to mankind by modern science (*5*).

A generation ago, the popular utopias were mainly in the tradition of Edward Bellamy's *Looking Backward*, which in turn was still in the tradition of Francis Bacon's *New Atlantis*: the world remade to the heart's desire by the rationalism and the power of science. But today, the few scientific utopias are not calculated to inspire much hope for humanity. Even a Marxist scientist like J. D. Bernal finds some of them repulsive because "a lack of freedom consequent on perfect organization" leads to a society in which the "Utopian seems, notwithstanding his health, beauty, and affability, to partake too much of the robot and the prig" (*6*). The anti-utopian theme, on the other hand, appears in serious pronouncements by scientists as well as in science fiction; even at meetings of scientific societies, speeches are likely to be made gloomily predicting disaster from our advance in scientific knowledge, and calling for a revival of something like traditional faith (*7*).

And if the utopias have changed, so have the horror stories. A generation or two ago the traditional symbol of political oppression had not changed since before the days of Thomas Jefferson: it was the rack of the Inquisition. If you were brought up on *Westward Ho!* and Browning's dramatic monologues, to say nothing of Jefferson and Macaulay and later political historians in the liberal tradition, you were likely to believe that the main historic threat to human freedom had been averted from the English-speaking world by the defeat of the Armada, and destroyed in America by the disestablishment of the church in Virginia. About all that was necessary to perfect the possibility of human freedom (one could learn from *Huckleberry Finn* or *Elmer Gantry*) was to destroy the last vestiges of enforced conformity in our society.

But within a few decades, the popular symbol of oppression had changed completely. The techniques of torture in *Westward Ho!* had been replaced by the more scientific methods of Orwell's *1984* or Zamyatin's *We*. A society founded on technology, rather than superstition, had become the most plausible system of tyranny.

Communist Orthodoxy

The difference between the democratic and Communist camps in the popular attitude toward the political significance of science might be dismissed as the product of frivolous fiction if it did not also appear in the writings of eminent scientists. It is tempting to hope that the Soviet scientists are really dedicated only to their science, and eager to join in an international community with their West-

ern colleagues. But it is hard to write off completely the official point of view, as expressed by Academician S. I. Vavilov, that Lenin had correctly comprehended the philosophical significance of science in general, and physics in particular, when he had "pointed out that the crisis in physics could be overcome by mastering the science of dialectical materialism. This provided a sure way for physics to surmount every kind of crisis and develop further." As a result, it is supposed to be the obligation of Soviet physicists to take the dialectic as their guide not only in their approach to politics and philosophy, but also to physics itself (*8*).

In practice, all the evidence suggests that this has very little to do with the way physicists actually work in their laboratories; if they make a few rhetorical gestures in the direction of political orthodoxy in an introductory paragraph of a scientific paper, they can write as they please on scientific subjects (*9*). But Marxist dialectic is still the orthodoxy; like other authoritarian orthodoxies, it cannot stamp out skepticism and cynicism, but it can stamp out open dissent (*10*).

Szilard's Dolphins

The scientists of democratic nations, even if they are ardent anti-Communists, take no such confident view of the role of science in their political systems. Some of this pessimism comes out when leading scientists take to science fiction as a medium. Fred Hoyle, the Cambridge University astronomer, has his hero in *The Black Cloud* sum up the British political system thus (*11*): "Politicians at the top, then the military, and the real brains at the bottom. . . . We're living in a society that contains a monstrous contradiction, modern in its technology but archaic in its social organization. . . . We [scientists] do the thinking for an archaic crowd of nitwits and allow ourselves to be pushed around by 'em in the bargain." And the late Leo Szilard, University of Chicago physicist, seems to sum up his view of American politics when he has his delightful dolphins, who are surely the most engaging heroes in recent science fiction, tell why politicians fail to solve modern problems (*12*):

> Political issues were often complex, but they were rarely anywhere as deep as the scientific problems which had been solved . . . with amazing rapidity because they had been constantly exposed to discussion among scientists, and thus it appeared reasonable to expect that the solution of political problems could be greatly speeded up also if they were subjected to the *same kind* of discussion. The discussions of political problems by politicians were much less productive, because they differed in one important respect from the discussions of scientific problems by scientists: When a scientist says something, his colleagues must ask themselves only whether it is true. When a politician says something, his colleagues must first of all ask, "Why does he say it?"

The same themes come out when scientists undertake to write explicitly about the relation of science to politics. The difference that Dr. Szilard's dolphins noted between science and politics is indeed a major difference, and one that could be a starting point for a political theory. Why, indeed, do politicians, unlike scientists, have to worry about the unstated purposes of another politician, or another government? But a great many scientists do not like to follow up on the implications of that question. It is more satisfying to argue that the straightforward scientific approach of the scientist should replace the devious and prejudiced ways of politicians, and to wonder whether the scientific revolution has indeed not made obsolete the institutions of modern democracy, or at least the present way in which they are organized and managed.

Thus a federal research administrator may complain of the scientists' lack of influence by comparison with lawyers and politicians, and argue that the federal government should have a Secretary of Science to mobilize the nation's scientific resources and coordinate all its policies from a scientific point of view (*13*). Or a great German physicist and Nobel prize winner may summon his colleagues to international discussions of their difference in ideology, and to international cooperation to end the race in atomic armaments, arguing that they need to apply to politics the methods of thinking used successfully in physics—"to think out these problems, which have arisen out of our research, in our own simple realistic manner" (*14*). And one of his colleagues in those international discussions, Dr. Eugene Rabinowitch, poses the central problem directly (*15*): "The capacity of the democratic, representative systems of government to cope with the problems raised by the scientific revolution is in question."

Dr. Szilard and Dr. Rabinowitch probably represent a distinct minority of American scientists, rather than the majority who are (or wish they were) consultants to corporations and members of Rotary Clubs, and who do not trouble their heads about political theory. But the question that this minority poses about the relation of representative government to the scientific revolution cannot be brushed off lightly. For the scientific revolution has changed not only the basic sciences themselves, but their consequent ability to produce new technology; it is this ability that has led to their new financial support by government, and changed the nature of military strategy and even of the economic and political system. It is accordingly very difficult, when speaking of the social effects of science, to distinguish it from technology; even those who keep accounts on government expenditures for research and development admit that the distinction they make between basic research and applied technology is not a precise boundary.

The relationship of the scientific and technological revolution to our system of representative government is a cogent question, both in its own right and because it has been raised with such urgency not only by those who seek to strengthen the political influence of scientists, but by others who are worried about the way in which such influence may be used.

Cautionary Words

During the early 1960's, it was a rare scientific meeting that failed to discuss two pronouncements on the relation of science to politics. The first was Sir Charles Snow's vivid story about the wartime rivalry of Tizard and Lindemann as scientific advisers to the British government. That "cautionary tale" warned us that democracy was in danger from the great gulf in understanding between the Two Cultures of science and the humanities, and from any possible monopoly on scientific advice to high political authority (*16*). The second was the farewell address of President Eisenhower, warning the nation that its public policy might "become the captive of a scientific-technological elite" (*17*).

It is easy to appreciate why President Eisenhower felt as strongly as he did. His administration had started out to cut back on expenditures for research and development, but had ended

by quadrupling them. This increase was by no means for defense alone; during his eight years in office the Congress multiplied the appropriations for the National Institutes of Health more than ninefold, giving them each year more than he had recommended. Science seemed clearly to be getting out of hand. It was almost enough to make one try to apply to the budgeting process the theory of Henry Adams that science, as it becomes more abstract, increases in geometrical progression the physical power that it produces (*18*).

The President's statement was a great shock to the scientists, especially to those who had been working with the administration rather than criticizing it in the columns of the *Bulletin of the Atomic Scientists*. President Eisenhower, indeed, quickly explained that he was not talking about science in general, but only those parts allied with military and industrial power (*19*). Nevertheless, to the typical American scientist who still believed that science had helped to liberate man from ancient tyrannies, it was disconcerting to be told by a conservative president that he had become a member of a new priesthood allied with military power.

Symptoms of Friction

Yet it had begun to seem evident to a great many administrators and politicians that science had become something very close to an *establishment*, in the old and proper sense of that word: a set of institutions supported by tax funds, but largely on faith, and without direct responsibility to political control. The terms under which this support is now given to science do not seem to many politicians to fit into the traditional ideas of Jeffersonian democracy.

From the point of view of scientists and university administrators, on the other hand, the growing dependence of science on government brings a great many problems, especially the danger of increasing government control over universities. It is hard to turn money down, but more and more scientific spokesmen are beginning to worry about the conditions that come with it (*20*). From the point of view of government, the sentiment in Congress now seems to be considerably more critical of the terms on which money is provided for scientific research. Edward Gibbon summed up the cynical 18th-century attitude toward a religious establishment by remarking that all religions were "considered by the people, as equally true; by the philosopher, as equally false; and by the magistrate, as equally useful" (*21*). And now, it seems that all sciences are considered by their professors, as equally significant; by the politicians, as equally incomprehensible; and by the military, as equally expensive.

So we are beginning to observe in the Congressional attitude toward science some of the symptoms of friction between an establishment and a secular government. The symptoms showed up, for example, in Congressman L. H. Fountain's investigations of the National Institutes of Health, wherein he sought reform by uncovering abuses in the administration of the cloistered but tax-supported laboratories. And they showed up in Congressman Wright Patman's attacks on the tax-exempt foundations—institutions which by a modern kind of *mortmain* give science a range of political initiative outside the control of politics.

These attacks do not get at the main issues. They have so far been only a minor nuisance to scientific institutions, with an effect measured mainly in the time taken to fill out accounting forms. But they are a threat because they may reflect a more fundamental uneasiness in the intellectual as well as the political world. This is an uneasiness not merely about the terms of the financial relationship between government and science, but about the question whether the growing influence of science can be kept compatible with representative government. It is, in short, the same question asked by Dr. Rabinowitch—can democratic government cope with problems raised by the scientific revolution?—but from the opposite point of view.

These attitudes, as yet, may have very little to do with the way most American scientists think, either on or off duty, and practically nothing to do with the amount of money their laboratories get in government grants. They are only a small cloud on the intellectual and political horizon of the United States. But they correspond to a much greater intellectual disturbance, over the past century and a half, in Europe, where the political faith in the alliance of science and reason with free government that was characteristic of the Enlightenment gave way in the late 19th century to various forms of scholarly despair. In America, a faith in the political rationalism of the Enlightenment tended to persist in the political thinking of scientists, even after the depression shook their confidence in the inevitability of progress. Right up to the present, American scientists have shown singularly little interest in either the conservative political theorists who tell them that scientists cannot deal with basic values or solve the major human problems, or the radical theorists who tell them that science can do so if it will only join in a political system, like Marxism, that will give it real power over society (*22*).

Even the strongest critics of the government and its scientific policies—for example, many of the contributors to the *Bulletin of the Atomic Scientists*—are surprisingly traditional in their approach to the political system. They may question the capacity of our representative institutions to cope with the scientific revolution, but they tend to propose as remedies more international good will and cooperation, adequate scientific education of political leaders and the electorate, and unbiased scientific advice for members of Congress.

It is hard to quarrel with any of these ideas. But they are a little like the remedy that was most often proposed for corruption in government during the late 19th century: more good men should go into politics. That exhortation surely did some good, but probably less than the effort to adjust our political and economic institutions to the realities of the industrial revolution. That adjustment required a great many changes, by Congress and the judiciary and administrators, but it did not follow the prescriptions of any of the single-minded political prophets. It came instead from a new way of looking at the problem: we gave up thinking about politics merely in terms of the formal Constitutional system, which had been based on an analogy with Newtonian thought—a mechanistic system of checks and balances. In the latter part of the 19th century, students of politics (if they had not given up their interest in science) might have noted with interest a new analogy: as science penetrated the structure of the molecule, and identified its elements, politicians were becoming preoccupied with the elements of politics—with parties and economic classes and pressure groups —as well as its mechanistic Constitutional balances.

A New Complexity

The scientific revolution in nuclear physics and in such fields as genetics is carrying us into a third stage of complexity. That revolution seems certain to have a more radical effect on our political institutions than did the industrial revolution, for a good many reasons. Let us note three of them.

1) *The scientific revolution is moving the public and private sectors closer together.*

During the industrial revolution, the most dynamic economic interests were more or less independent of the political system. They might depend on it, as many American corporations did by relying on tariff protection, and they might try with some success to control it, but they were not incorporated into its administrative system, they did not receive support from taxation, and the main directions of their new enterprise were controlled by their owners and managers. Today, our national policy assumes that a great deal of our new enterprise is likely to follow from technological developments financed by the government and directed in response to government policy; and many of our most dynamic industries are largely or entirely dependent on doing business with the government through a subordinate relationship that has little resemblance to the traditional market economy.

2) *The scientific revolution is bringing a new order of complexity into the administration of public affairs.*

The industrial revolution brought its complexities, and relied heavily on new forms of expertise, but it did not challenge the assumption that the owner or manager, even without scientific knowledge, was able to control the policies of a business. And the same general belief was fundamental to our governmental system: the key ideas, if not the lesser details, could be understood by the legislature and debated before the public, and thus controlled by a chain of public responsibility. In one sense this was never true; in another and more fundamental sense, I think it is still true. But it is much less apparently true today than it was, and a great many more people doubt it. The great issues of life and death, many people fear, are now so technically abstruse that they must be decided in secret by the few who have the ability to understand their scientific complexities. We were already worrying about the alleged predominance of the executive over the legislature; now we worry lest even our elected executives cannot really understand what they are doing, lest they are only a façade that conceals the power of the scientists—many of whom are not even full-time officials, but have a primary loyalty to some university or corporation—who really control the decisions. If (as I believe) this is not really true, it is nevertheless true that the scientific revolution has upset our popular ideas about the way in which policies are initiated and adopted, and in which politicians can control them and be held responsible for them. We have to reconsider our basic ideas about the processes of political responsibility.

3) *The scientific revolution is upsetting our system of checks and balances.*

From a moral or ethical point of view, the industrial revolution raised problems that were relatively simple. Everyone admitted that it was possible for economic interests to control politics, but the remedy seemed to be clear: regulate business to prevent abuses, and keep selfish business interests out of the political process. This seemed clearly the basic formula for dealing with the obvious conflict of the public interest with the special interests of business. And the formula of separation of business and government was analogous in a comforting way to the formula for the separation of church and state. A church that was not dependent on government support was able to provide an independent source of moral judgment which could help to control the ethical standards of our politics and our business. As the problems began to seem a bit complex for unaided theological opinion, the universities began to provide an additional source of more scientific, but equally independent, advice to the public on the basic value judgments that should govern our policies. This was the fundamental system of checks and balances within our society: the check on practical political affairs imposed by sources of utterly independent criticism, based on a system of values that was not corrupted by the political competition for wealth or power.

But the scientific revolution seems to threaten to destroy this safeguard in two ways. First, it has gradually weakened the moral authority of religious institutions by the critical skepticism that it has made predominant in Western intellectual life, most notably in the universities. Second, it has made the universities themselves financially dependent on government, and involved them deeply in the political process. Thus, after helping to disestablish churches and free most universities from ecclesiastical control, science has now made those universities dependent on a new form of establishment, in the guise of government grants, and allied them more closely with a military power that is capable of unlimited destruction.

These three developments make some of our traditional reactions—our automatic political reflexes—unreliable in dealing with our present problems. We are automatically against socialism, but we do not know how to deal with an extension of governmental power over the economy that technically leaves ownership in private hands. It is almost an instinct with us to distrust the political bosses who, by controlling the votes of the ignorant masses, seek personal profit or power without accepting official responsibility. But we do not know how to deal with irresponsible influence that comes from status in the highest sanhedrin of science, untainted by any desire for personal profit. And we are fanatically against the public support of any institutions that might impose religious values on public policy, but when the institutions of organized skepticism tell us what science believes or how much money science needs, we have no reliable procedure for questioning their infallibility, or even for criticizing their budgets.

Reverse Twist

Science has thus given our political evolution a reverse twist. It has brought us back to a set of political problems that we thought we had disposed of forever by simple Constitutional principles. These are the problems of dealing not only with territorial subdivisions of government, and not only with economic interests and classes, but also with various groups of citizens which are separated from each other by very different types of education and ways of thinking and sets of ideals. This was the problem of the medieval estates.

The three estates of the realm, whose customary privileges grew into constitutional functions, were the clergy, the nobility, and the burgesses—those who taught, those who fought, and those who bought and sold. In our impatience with privilege at the time of the American Revolution, we abol-

ished the estates in our political system so thoroughly that we have almost forgotten what the word meant. To abolish the first estate, we disestablished the church and provided secular education through local governments. To abolish the second, we forbade titles of nobility, made the military subordinate to civil authority, and relied on a popular militia rather than a standing army. To abolish the third, we did away with property qualifications on voting and exalted freedom of contract and competition above legislative interference.

But now the results of scientific advance have been to require federal support of education and the appropriation of a tithe of the federal budget for research and development, to set up the most powerful and professional military force in history, and to make free competition a minor factor in the relationship to government of some of the major segments of the economy.

Thus we are left to face the second half of the problem which we were afraid to face during the depression, and tried to escape at the end of the Second World War: the necessity for discovering a new basis for relating our science to our political purposes. We learned half of our lesson from the scientists: the lesson that we could not have a first-rate scientific establishment if we did not understand that first-rate science depended on fundamental theoretical work and required the support of basic research for its own sake, and not merely as a by-product of applied science. Now the outlines of the second, or political half of our problem are becoming more clear. Basic science as such became steadily more powerful as it freed itself from the constraints of values and purposes. As an institution in society, it had to free itself in an analogous way from subordination to the applied purposes of the industrial corporation or the government bureau or the military service. And in the unpredictability of its progress it challenges the old notion that in matters of public policy the scientist must be controlled completely by purposes defined by politicians. So we must face the possibility that science will no longer serve as a docile instrument toward purposes that are implicit in a system of automatic economic progress, or even toward purposes that are defined for scientists by business and political leaders. In short, we can no longer take it for granted that scientists will be "on tap but not on top."

Accordingly, we need to consider not only the practical relation of scientific institutions to the economy and the government, but also the theoretical relation of science to political values, and to the principles that are the foundation of the constitutional system. Only with the help of scientists can we deal with the great issues of war and peace, of the population explosion and its effects in the underdeveloped countries, or of the dangers to our environment from our technological advances not only in weaponry but also in civilian industry and agriculture. But before we are likely, as a nation, to let science help us solve such problems, we are sure to want to know the full terms of the bargain. For although some of the political reflexes that we have acquired by several centuries of constitutional experience may be out of date, one of the most automatic is still useful: we want to know not only whether some political pronouncement is true, but why the speaker said it, having a healthy suspicion that we need to know whose interests it would further, and what its effect would be on our capacity to govern ourselves, or at least to hold our governors responsible.

The scientific community in the United States is not an organized institution, or a group with definite boundaries. It is not a hierarchical establishment. But its existence as a loosely defined estate with a special function in our constitutional system is becoming apparent, and we would do well to assess its political significance (*23*). If we do, we may find that a deeper understanding of the basic relation of science to government will help us to give it the kind of support it needs for its own purposes, as well as use it more effectively for the practical ends of public policy. And if we are willing to renounce the utopian hope that science will solve our problems for us, we may find that science by its very nature is more congenial to the development of free political institutions than our anti-utopian prophets would have us believe.

References and Notes

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3. I. Yefremov, "The heart of the serpent," in *More Soviet Science Fiction*, I. Asimov, Ed. (Collier, New York, 1962), pp. 50, 57.
4. I. Asimov, *ibid.*, p. 11.
5. See, for example, W. M. Miller, Jr., *A Canticle for Leibowitz* (Lippincott, Philadelphia, 1959); C. S. Lewis, *That Hideous Strength* (John Lane, London, 1945); A. E. Van Vogt, *Slan* (Dell, New York, 1961); or F. Pohl and C. M. Kornbluth, *The Space Merchants* (Ballantine, New York, 1953).
6. J. D. Bernal, *The Social Function of Science* (Routledge, London, 1939), p. 381.
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9. M. Polanyi, *Personal Knowledge* (Univ. of Chicago Press, Chicago, 1958), p. 239.
10. For a brief summary of the comparative degree of success of physicists in the Soviet Union in escaping from the control of the "diamat," but the greater difficulty of scientists in other fields, see the annotations by Herbert Ritvo in "The new Soviet society: Final text of the program of the Communist Party of the Soviet Union," *New Leader* **1962**, 221 (1962).
11. F. Hoyle, *The Black Cloud* (New American Library, New York, 1959), p. 87.
12. L. Szilard, *The Voice of the Dolphins* (Simon & Schuster, New York, 1961), pp. 25–26.
13. See, for example, G. C. Sponsler (Bureau of Ships, Navy Department), "Needed: Scientists on top," *Bull. Atomic Scientists* **1962**, 17 (June 1962).
14. M. Born, *Physics and Politics* (Basic Books, New York, 1962), pp. 66, 83.
15. E. Rabinowitch, "The scientific revolution," *Bull. Atomic Scientists* (Oct.-Dec. 1963).
16. C. P. Snow, *Science and Government* (Harvard Univ. Press, Cambridge, 1961).
17. New York *Times* **1961**, 4E (22 Jan. 1961).
18. Adams predicted [*The Degradation of the Democratic Dogma* (Putnam, New York, new ed., 1958), pp. 277, 303 (first published in 1919)] that "the future of Thought, and therefore of History, lies in the hands of physicists," and went on to speculate that a rapid acceleration of thought in the direction of the abstract sciences might "reduce the forces of the molecule, the atom, and the electron to that costless servitude to which it has reduced the old elements of earth and air, fire and water." His prediction was uncanny, except for the term "costless." For a critique of Adams' loose use of scientific metaphors in dealing with history and politics, see Joseph Mindel, "The uses of metaphor: Henry Adams and the symbols of science," *J. History Ideas*, pp. 89–102 (Jan.–Mar. 1965).
19. See the authorized interpretation by the President's Special Assistant for Science and Technology, George B. Kistiakowsky, in *Science* **133**, 355 (1961).
20. See, for example, the editorial in *Science* **140**, 1365 (1963); see also the study of government-university relationships conducted by the Carnegie Foundation for the Advancement of Teaching, "Twenty-six Campuses and the Federal Government," *Educational Record* (Apr. 1963), and Committee on Science and Public Policy, *Federal Support of Basic Research in Institutions of Higher Learning* (National Academy of Sciences, Washington, D.C., 1964).
21. Gibbon was ostensibly speaking of ancient Rome [*The Decline and Fall of the Roman Empire* (1788), vol. 1, chap. 2].
22. Jacques Maritain, Miguel de Unamuno, and José Ortega y Gasset represent the conservative critics of the Enlightenment: J. D. Bernal may be cited on the socialist side. Judith N. Shklar, whose *After Utopia: The Decline of Political Faith* (Princeton Univ. Press, Princeton, N.J., 1957) begins with the observation that "nothing is quite so dead today as the spirit of optimism that the very word Enlightenment evokes," goes on (p. 3) to admit that "the less reflective public, certainly until 1914, remained cheerfully indifferent to the intellectual currents of despair." In this optimistic category I would include many American scientists, and bring the date up to the present.
23. Paul M. Gross notes that the "estate" metaphor is by no means new; it was used by Arthur D. Little 40 years ago. See Gross's "The fifth estate in the seventh decade," *Science* **143**, 13 (1964). Alvin M. Weinberg made a similar use of the metaphor in a commencement address at the University of Chattanooga, later reprinted in *Yale Scientific Magazine* (Oct. 1963).