spacecraft, would have been turned through an angle of about 12 degrees, in a direction away from the top of the spacecraft, which in flight points near the horizon. This probably accounts for what was seen in the photographs. The existence of these reflections has been directly verified in the Mercury procedures trainer at the Mercury Control Center. It was further found, in spacecraft No. 18, that one of the reflections (there were two) was a light tan in color, like the band observed by Glenn.

Since it is a spacecraft phenomenon, the luminous band produced by reflection must also have been present in the night sky, especially after moonrise. It may have been the band observed by Glenn. The color which he remarked on may have resulted from an antireflectant coating which had been applied to the windows.

(*Addendum*. This supposition does not explain the disappearance of stars as they reach the level of the luminous band. However, let us note Glenn's comments on stars disappearing during the time between sunset and moonrise. During that time, the bright planet Venus set. It is possible that what Glenn saw was the disappearance of the reflection of Venus as it reached the level of the reflection of the horizon.)

If the band is not due to reflection, it may be possible to attribute it to some auroral phenomenon. There is a line in the auroral spectrum at 5577 angstroms. This line is known from rocket measurements to stop at 100 kilometers. A height of 100 kilometers would appear, at the spacecraft height of 250 kilometers, as a false horizon at an angular altitude of about 3 degrees. It would be green in color and would be more difficult to see after moonrise. In height and color it does not agree with the luminous band.

There are, in addition, two auroral red lines, at 6300 and 6464 angstroms, respectively, which are known to come from a height greater than any so far reached by rockets sent to observe them. From theory we estimate that they ought to be at a height of about 240 kilometers. These might be reconcilable with the observed luminous band, though they ought not to be easier to see after moonrise. They would explain the tan-to-buff color observed. On the other hand, these lines are much fainter than the line at 5577 angstroms, so it is hard to understand why they would be observed while it was missed.

On the whole, the balance of probability is that the luminous band was due to reflection in the spacecraft window. The outstanding reason for connecting the two is the belief that the inclined windows would have given a ghost image.

Glenn reports that the sunset appeared to be normal until the last moment, when the sun appeared to spread out about 10 degrees on either side, and to merge with the twilight band. Glenn specifically states that he did not see the sun as a narrow, flat object.

On the other hand, three consecutive photographs of the setting sun can be well interpreted in terms of the theoretically predicted sausage shape. In two of these there is some slight spreading of the image, evidently partly photographic and partly due to motion, and in the third the motion is considerable. All, however, appear to indicate a solar image of about ½ degree in its greatest dimension, as required by theory, rather than a much shorter image, as would have been the case if the sun, setting, had looked as it does from the ground.

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The Scientific Establishment

The American system gives scientists in government a freedom and influence unmatched in other countries.

Don K. Price

Now that the federal government is spending more money on research and development than its total budget before Pearl Harbor, American scientists find it hard to figure out their new role in society. They used to assume that democracy would never be a patron of the sciences, and even after the Second World War the Executive had to urge the support of research on a skeptical Congress. But even though the last Administration started to cut back on expenditures for science, it ended by quadrupling them. And this was by no means for defense alone; over those 8 years the Congress multiplied the budget of the National Institutes of Health more than ninefold, giving them each year more than the President recommended. It is almost enough to make one try to apply to politics the theory of Henry Adams that science, as it becomes more abstract, increases in geometrical progression the power that it produces (*1*).

In his farewell message President Eisenhower warned the nation against the danger that "public policy could itself become the captive of a scientific-technological elite." Even though he quickly explained that he was not talking about science in general, but only those parts allied with military and industrial power, this was a shock to the scientists (*2*). To one who believes that science has helped to liberate man from ancient tyrannies—who, in short, still takes his political faith from Franklin and Jefferson and the Age of the Enlightenment—it is disconcerting to be told that he is a member of a new priesthood allied with military power.

Yet the plain fact is that science has become the major Establishment in the American political system: the only set

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of institutions for which tax funds are appropriated almost on faith, and under concordats which protect the autonomy, if not the cloistered calm, of the laboratory. The intellectual problems involved in this new status are likely to trouble scientists almost as much as the fears of the apocalyptic uses to which their discoveries may be put by politicians.

The scientists are not the first, of course, to find it difficult to adjust their political ideals to the new world of technology. For example, the old corporation executive liked the great power technology had given to industry, but wished to limit the role of government on Jeffersonian principles. But the American scientist has a better right to his political nostalgia. For while the Founding Fathers had very little idea that industrial corporations would ever exist, let alone claim freedom of enterprise as a fundamental of the Constitution, some of them had a strong faith that free science would advance the cause of political freedom.

This faith of the Enlightenment tended to persist in the political thinking of American scientists, even in the period between the two world wars, when it came to seem naive to their colleagues abroad. Even to this day they have shown singularly little interest in the conservative political theorists who have been telling them that science cannot deal with basic values or solve the major human problems, and the radical theorists who tell them that science can, if it will only join in a political system that will give it real power over society (*3*). The conservative theorists have usually supported the conventional views of those in the European parliamentary tradition who believed that major political issues should be dealt with by party leaders and career administrators, with scientists speaking on such matters only when spoken to. And the most important radicals have been the Marxists, who proposed to let science, as they defined it, determine all human values through a disciplined system that would leave no room for the disorder of liberal democracy.

If American scientists generally ignored both the conservative and the radical critics of the Enlightenment, it was probably, in the main, because they were simply not interested in political theory, or even in politics. But it may have been also because neither theoretical position seemed very relevant to their practical experience. In disregard of the conservative and conventional theory, American scientists have come to have a much more direct role in high administration and in the making of policy than their counterparts in the parliamentary systems of Western Europe. (This is not to say that they had a more satisfactory role in the performance of scientific functions in the government.) And the more influence the scientists acquire, the more they now seem to work toward the dispersal of government organization and the decentralization of decisions, a trend impossible to explain to technocrats or the theorists of Marxism.

The Scientist in Public Affairs

If we wish to understand the nature of our present scientific establishment, and its role in the making of public policy, perhaps we should look at the unusual way in which the role of scientists in public affairs has developed in the United States, and what its influence has been on the governmental system. That influence, I think, has been profound, not because of anything the scientists were seeking to do deliberately, at least until quite recently, but because of the special opportunities that were offered them by the nature of American political institutions. From the Jacksonian period, indeed, American scientists rarely had any distinctive opinion about politics or its relation to science; they were most often inclined to combine the antipolitical prejudices of the business community with an envy of the social status of the European scientist. But while the American scientist lacked the honorific status of a member of a European Academy, he probably found it easier to play a direct role in government policy-making.

Sir Charles Snow has written with great insight of the Two Cultures, of the persisting failure of the humanists to understand the scientists or the changes they are working in the world, and of the scientists' personal and institutional difficulties in their relationship to government administrators and politicians. He has warned Americans most cogently against the naive belief that their constitutional system protects them against the dangers that face all countries as the result of the terrible weapons that scientists have put at the disposal of politicians who still think in prescientific terms (*4*).

But in the United States we need to understand the idiosyncrasies of our institutions not in order to admire them but to know how to remedy their shortcomings, which were only a minor nuisance a generation ago, but may be a mortal threat today. Our television experts and editorial writers may be addicted to oratorical overconfidence in our peculiar institutions, but our scientists and intellectuals generally—and government reformers in particular—are rather more addicted to applying constitutional cures that do not fit the disease.

I suspect that Sir Charles has a special degree of popularity in the United States for a reason that he would probably disapprove. We enjoy what he writes not only because we see many important ways that it applies to us, but also because of ways in which it does not. We like it much as we like Anthony Trollope; we like to read about a scholarly world in which the classicists can still snub the scientists and social scientists hardly exist at all, just as we like to read about the squire and the vicar and the butler. And American scientists like to imagine, as they read about the problems that scientists have when serving under the career administrators of the United Kingdom, that they can blame their own problems on lack of status in the bureaucracy.

The British System

Yet a look at the main outlines of the two systems gives a different picture. In Great Britain, in spite of decades of debate about the basis of recruitment of the Administrative Class, it is still dominated by men trained in the classical and historical studies; not one man in twenty among these guardians of public policy has had a scientific or technical education. In spite of recurrent criticism of its role, it still maintains a professional monopoly (though in a studiously amateur and nonscientific way) over the organization of the government departments, and a major share of influence in the formation of national policy. It thus has no great interest in maintaining easy institutional channels by which scientists could move into its membership, or the universities could work closely with it on its major policy problems (*5*).

Now that we are both constitutional democracies, it makes much less difference that Great Britain has a king and the United States a president, but a

great deal of difference how we set up the professional group of men who actually run the government. Our Jacksonian revolution indeed destroyed the hopes of John Quincy Adams for a continuation of the Jeffersonian alliance between science and republicanism. At the same time, by wiping out the beginnings of a career system, it prevented the development of an elite administrative corps and thus cleared the channels of promotion for the scientists who, decades later, were to begin to move up in the civil service. The frontier radicalism of the day distrusted all forms of Establishment; this was the era in which state constitutions forbade ministers to hold public office and prohibited educational qualifications for admission to the bar. But as the business of government got more complicated, the frontier had to admit that certain skills were necessary. Its essentially pragmatic temper insisted, as it became necessary to hire civil servants for merit rather than patronage, that the requirements be defined in terms of the needs of the specific jobs, rather than by general educational status. It was easiest to prove the need for special skills, of course, in technical fields, partly on account of the objective nature of the problem, partly because scientific societies were determined to raise and maintain their professional standards in the civil service as well as in private practice (*6*).

As a result, it was in the scientific and professional fields that the career civil service system was first pushed up to the higher ranks. As we developed our top civil service, we made it something quite different from a career Administrative Class; most of its members are not only nonpolitical but nonadministrative as well, and they are not career officials in the same sense as a U.S. Navy officer or a British civil servant.

The Scientist as Civil Servant

In recent years, scientists and engineers, while certainly rare among those in high political office, have done reasonably well in the civil service. The positions of administrative continuity and bureaucratic power in Washington are, in the civil service departments, the bureau chiefs. A study in 1958 of the 63 bureau chiefs showed that 9 of them had advanced degrees in the natural sciences and 17 others had been trained in lesser ways as engineers or technicians. By comparison with these 26 from various branches of technology, there were 9 economists and only 8 lawyers, and 20 from miscellaneous administrative or business careers (*7*). Aside from the positions of bureau chief, the top career positions are the so-called "super-grades," which were added above the regular civil service grades to let the government compete for scarce talent (*8*). The favorite justification for these positions is the need to employ capable scientists and engineers, notably in the technical branches of the Defense Department and the National Aeronautics and Space Administration. Administrators have ridden along to higher salaries on the political coattails of scientists.

Scientists who become bureau chiefs are, of course, no longer practicing scientists; they are doing work that in the United Kingdom would be done by a member of the Administrative Class educated in history or the classics. But when they are good at their jobs, as some of them are, it is for a reason that would have appealed to Macaulay, who used to argue that he wanted to recruit university graduates in the classics not because they had been studying the classics but because the classics attracted the best minds, which could adapt themselves to anything (*9*). And the American scientist who turns administrator is the equal of his English humanist counterpart in at least one respect: his lack of interest in management as a science, or sometimes at all.

But while the scientists in top civil service posts have not been deeply interested in administration, they have been interested in policy. What chance do they have to make their policy views prevail?

In their influence on policy, as in their advancement in the hierarchy, the scientists in American government had a special opportunity because they did not have to work under a tightly organized governing elite. After the Civil War, there was no strong conservative tradition based on a landed interest, and no national party with a coherent ideology, to take control.

As a result, policy tended to develop separately in every field. There was no one to tell the scientific experts that they were on tap but not on top; indeed, they were listened to all the more readily because they were usually not thought of as bureaucrats. There was no one from whom Congress wanted advice less than from the regular career service. But each group of scientists had one foot in government, so to speak, and one outside, and the policy views that the insiders developed would come back to the Congress from the National Academy or the scientific societies (*10*). In a government of limited constitutional powers, a research program could be justified in a given field when an action program could not. But the research ultimately seemed to lead to action, in spite of the lawyers' scruples and the lack of interest of the party machines. This was only in part because the politicians were persuaded by objective data; it may have been even more because scientists (and in some fields, the economists) were the major organized communities of professional opinion with a continuous interest in specific public programs. This is a summary of the development of many new federal programs; you can trace it in agriculture, in natural resources, in the regulation of business, in labor and welfare, and we now see its beginnings in the support of education.

The most influential pattern was set in agriculture. Washington and Jefferson had been interested in fostering scientific improvements in agriculture, and in federal support of a national university. They were blocked by the lawyers' scruples about states' rights, until the agricultural scientists found a way to get there by a different route—one that evaded constitutional barriers by merging federal and state interests through the device of federal grants to states in either land or money, and by building a program up on scientific and educational bases. The foundation was, of course, the land-grant college; from it grew the experiment station, the extension program, and the whole system of policy which has let the federal government play a more effective role in the agricultural economy than the government of any supposedly socialized state. In all this development, the land-grant colleges and the associations of various kinds of agricultural scientists maintained an important influence on the Department of Agriculture, supplied most of its career personnel, and generally provided the intellectual leadership for national agricultural policy. They thus, in effect, greatly weakened the old constitutional distinction between state and federal functions, but without subjecting the field of agricul-

ture to the control of a centralized bureaucracy.

The pattern of grants in aid, with its new set of administrative relationships, met two cardinal needs: to provide money, as well as national policy direction, from Washington, and to maintain the autonomy of the states. It accordingly became the basis on which new programs were developed—highways, public health, social security, welfare, housing, and others. This was what political scientists came to call the "New Federalism," which has given the scientists and specialists in each field of policy a chance to work out programs without too much constraint by any party doctrine.

An elite administrative corps may look on scientists as properly subordinate, and on science as a way of thinking that should deal with the means to support a policy, a tradition, or an ideology, rather than as an end in itself. We can understand this relationship in other countries if we recall how until recent years our military services thought that civilian scientists in military laboratories should conduct their research only pursuant to "requirements" defined by military staff work. This notion was exploded as it became apparent that what scientists discovered by unrestricted research might be of greater military importance than the things the military officers thought they wanted —in short, that the means might determine the ends.

This example provides the extreme (and almost the only conspicuous) example in American politics in which scientists have been faced with difficulties in getting a direct political hearing for their policy ideas. The typical editorial writer may still think in terms borrowed from the experience of parliamentary constitutions with tightly knit administrative elites, but all the habits of American public life run on a different pattern.

The American Pattern

Its constitutional peculiarities are typified in one trivial incident: in a recent Congressional hearing, a friendly Representative addressed the newly appointed political head of the National Aeronautics and Space Administration, to his mild embarrassment, as "Doctor." In a legislature that is supposed to distrust eggheads, a Congressman often wants his advice on a specific program undiluted by either party doctrine or the policy views of general administrators; he is so conditioned to go directly to the scientific expert whenever he can that he sometimes treats his witnesses as experts even when they are not. This constitutional model is worth looking at with more critical sympathy. Its essential parts—none of which exists in the classic parliamentary system—are the standing Congressional committee that considers policies without being bound by party doctrine; a chief executive who is elected independently of the legislature, on a nonideological platform so that he can tolerate loose coordination and experimentation in policy matters; and a civil service which lets scientists move freely up into top administrative positions, and in and out of government, thus maintaining a continuous interchange of men and ideas between the government and universities. This system makes it impossible to maintain an institutional distinction between ends and means, between policy decisions on the one hand and, on the other hand, scientific research or administration. Hence, it makes party responsibility in the parliamentary sense impossible, and it greatly complicates the task of coordinating either policy or administration.

On the other hand, to deny the distinction between ends and means is a part of the scientific approach: no scientist likes to feel that his basic values and objectives have been set by others so rigidly that he cannot follow where his research leads him. It was, after all, the purpose of the Enlightenment to free both politics and science from the monarchical and ecclesiastical institutions that defined traditional values (*11*). It may be even more necessary to deny the distinction between ends and means, in an institutional sense, in the 20th century, when it is the requirements of new ideology, rather than old orthodoxy, that threaten freedom For science itself, by introducing so many complexities into public policy, destroyed the comfortable 19th-century notion that public issues could really be determined by the parliamentary competition of two opposing doctrines. At the same time, it made possible, by the development of new techniques of mass communication, the means for producing disciplined support of authoritarian government. If the structure of political institutions does not specifically encourage some social experimentation based on scientific initiative, with some degree of deliberate freedom from the constraints of policy as determined by either partisan theorists or an administrative elite, it will narrow the range of free scientific and political development. Perhaps our 18th-century Constitution, with its implied distrust of party discipline, will yet prove to be more adaptable to our scientific era than the classic 19th-century parliamentary model of Walter Bagehot or Woodrow Wilson (*12*).

After World War I

At any rate, it is easy to guess why large groups among American scientists —especially in the agricultural sciences —were less pessimistic in the period after the First World War than their European colleagues with respect to the role of science in democratic politics. In two very practical ways their situation was entirely different; in civil service, their advancement was not blocked by a career bureaucracy, and the constitutional system gave them a chance to advocate policies in comparative freedom from administrative or political discipline. It was no wonder that they had not lost faith in the political approach of the Enlightenment, for they had made it work.

Nevertheless, by the time of the Great Depression this naive faith was least prevalent in the most important universities and the most advanced fields of science. In them, science was supported more by private corporations and foundations than by government, and its leaders in newer fields like nuclear physics and biochemistry had closer intellectual ties with their European counterparts than with the agronomists or engineers of the land-grant colleges. For the loose American consitutional system had worked best in those aspects of public affairs in which the power of government and the power of the great industrial corporations were not in rivalry. The scientists in institutions that derived their support from industrial wealth and were interested in problems of the industrial urban economy saw the constitutional model in a different political perspective. Among them, accordingly, were to be found both those conservative scientists who were most distrustful of government, and those radicals who tended to take a Marxist view of the role of science in society.

The Depression had thus made it impossible for the American scientist to avoid the second challenge, explicit in Marxism, with respect to the significance of his role in society: does science as it grows in importance lead us away from constitutional liberalism, and require party dictatorship? In a society of growing complexity, is not an increase in the role of government inevitable, and does not that inevitably lead to a centralization of power that will destroy democratic freedom?

These are still troublesome questions, but they are being discussed on a somewhat higher level of sophistication than three decades ago. The change has come about partly because scientists, under the pressure of the Second World War, worked out a new type of contractual relationship that has brought private scientific institutions into a connection with the federal government as intimate and active as that of any land-grant college. And the extension of this system to industrial corporations may now be bringing about a new relationship between government and business, following the quarrels of the Depression era, much as the grant-in-aid system transformed federal-state relations after the Civil War.

Before going into the nature of this new system, let us note two peculiarities of American politics that made it possible.

The first was the assumption that it was just as appropriate for the voters and legislators to control the administrative organization and procedures of government as its policies—that is to say, the means as well as the ends. This was a radical departure from British or European assumptions. The political progression from conservatives to liberals to socialists never changed the fundamental European assumption that, while governments might be responsible to legislatures for the substance of their policies, it was better for politics and legislation not to meddle with internal administrative organization, or the management of the bureaucracy. The socialist political leaders took the unity of the state and its bureaucracy for granted. If anything, they tended to make it all the more monolithic, and to push to its logical conclusion the tendency of Benthamite liberalism to abolish the privileges of guilds and public corporations. But in the United States the current of radicalism ran in the opposite direction; after the age of Jackson, lobbyists and legislators were likely to concern themselves at least as much with the details of administrative organization as with major policies, generally with the purpose of creating centers of independence within government. This tendency was pushed so far that it destroyed the unity of administration, and had disastrous effects on the competence and the political responsibility of government. But it also made it a mistake to assume—as was often assumed both by those who admired and those who feared socialism—that an extension in the scope of governmental business in the United States would automatically involve a corresponding centralization of power.

The second peculiarity of American politics was the extent to which universities and private foundations had a hand in the initiation of new public policies. Private universities as well as the land-grant colleges were drawn into public-service functions, partly because they were, in the absence of a career bureaucracy, the main reservoir of expertise on which politicians could draw for advice, and partly in response to the influence of the philanthropic foundations.

By the 1920's, some of the major foundations had lost interest in the charitable alleviation of social problems, and began to hope that science might solve them. This idea led to a strategy of supporting both scientific research and demonstration projects to test the application of such research, which could then be extended by the greater resources of government. Their aid to scientific education and research is a familiar story, in almost every branch of science. But equally important, they went on to help strengthen the professional organizations of scientists (*13*) and to pay for the efforts of governments to improve their organization and administration, and to make use of research and research institutions as they did so. By the time of the Second World War, the leading scientists knew that a grant-making agency like a foundation could initiate nationwide programs by working with independent universities and governmental agencies, as the stories of hookworm and malaria control, the foundation of public libraries, and the reform of medical education all suggested. And political leaders were inclined to turn to private funds to help them explore future policy opportunities, or experiment with them, as when President Hoover sought foundation financing for his Committee on Social Trends and for a National Science Fund, and the Public Administration Clearing House provided the initial administrative costs for President Roosevelt's Science Advisory Board (*14*).

As scientists learned that the organization of government was something that could be influenced from the outside, and that universities and foundations could have a substantial influence on public policy, they were in effect freeing themselves from the assumption that government and private institutions were sharply different in nature. They were accordingly ready, at the outset of the Second World War, to work out a thoroughly pragmatic set of arrangements for the conduct of weapons research. The approach that they adopted was simply to enlist institutions rather than individuals in the two great scientific programs of the war: Office of Scientific Research and Development (OSRD) and the Manhattan Project of the Army Engineers.

To those who expect wartime crises and military authority to produce a centralization of authority, this approach must have been as surprising as if the Army had used the war as an excuse to increase, rather than decrease, its reliance on the state militias. But in the hands of Vannevar Bush, James B. Conant, and Karl T. Compton the government contract became a new type of federalism. Under the OSRD, the Massachusetts Institute of Technology took on the responsibility for developing radar, and California Institute of Technology rockets, and under the Manhattan District, the University of Chicago set up the first sustained nuclear reaction and the University of California fabricated the first atomic bomb, while du Pont, General Electric, Union Carbide, and other industrial giants built the facilities to produce the fissionable materials (*15*).

Postwar Sequel

The postwar sequel is a well-known story. Through a continuation of this system of administering research and development programs by grant or contract, the Atomic Energy Commission, which was hailed by the draftsmen of the Atomic Energy Act as a triumph of socialism (*16*), supports a program in which some nine-tenths of the employees work for private

corporations. The adamant arguments of many scientific leaders of the 1930's against federal support of science now seem as ancient and irrelevant as debates over infra- or supra-lapsarianism; no major university today could carry on its research program without federal money. The Massachusetts Institute of Technology, California Institute of Technology, Chicago, and Johns Hopkins, of course, all administer special military or atomic energy programs and consequently draw from three-fifths to five-sixths of their budgets from government, while Harvard, Yale, and Princeton now get a larger proportion of their operating revenues from federal funds than do land-grant colleges like Illinois, Kentucky, and Maryland (*17*).

In dollar volume, the biggest contracts are between the military services and industrial corporations; while most of this money goes for procurement, much of it goes for research and development, and for the kind of systems analysis and the direction and supervision of subcontractors that, in a simpler age, would have been done by the technical services of the Army and Navy. And even in the business of procurement, the contractual relation is not the traditional market affair: the contract is not let on competitive bids, the product cannot be specified, the price is not fixed, the government supplies much of the plant and capital, and the government may determine or approve the letting of subcontracts, the salaries of key executives, and a host of other managerial matters. A sizable proportion of the government's (and nation's) business is done this way; any one of six industrial corporations spends more federal tax dollars than any of the four smallest executive departments (*18*).

Significance and Effects

But the significance of this development does not turn on the sheer quantity of money, but on the possibilities of institutional development: if a contract can be made with an established academic or industrial corporation, why cannot a new one be set up for the purpose, and if the system will work for scientists and engineers, why not for others? Accordingly, we have been seeing not only the splitting off of certain functions that government might have operated directly, and their administrative fusion with private institutions, but the creation of entirely new private corporate entities (for example, the RAND Corporation, the Institute for Defense Analyses, the Aerospace Corporation) for the performance of government business.

As for the kinds of business that can be done under this system, Sir Henry Maine, who believed that progress was measured by the change from status to contract, would be intrigued to note that private corporations have contracts to maintain the Air Force's bombers and its missile ranges, private institutions make strategic studies for the Joint Chiefs of Staff and foreign policy studies for the Senate Foreign Relations Committee, universities administer technical-assistance programs for the State Department all over the world, and telephone and radio companies are about to help the National Aeronautics and Space Administration carry our messages through outer space.

This new system is doubtless breaking down the political opposition to federal programs even more effectively than did the system of grants to the states. State and local governments and private corporations used to join in their jealousy of purely federal activities, any extension of which was considered socialistic. The federal grants to states in the field of agriculture, however, were no longer socialistic in the eyes of the governors and the farm bloc; they were a defense of the American way of life, even though they involved more government controls than some avowedly socialistic states have ever managed. And now that the atomic energy and space and military programs support such a large share of the nation's business, and so much of its enterprise and innovation come from research and development financed by federal funds, and so much of that innovation and enterprise spills over quite naturally and properly into related commercial fields, it is no wonder that private business corporations are less jealous of government. More accurately, their jealousy no longer takes the form of fighting socialism, but of haggling over the administrative provisions of contracts. A great deal of private enterprise is now secreted in the interstices of government contracts. In short, what the grant-in-aid programs did to the arguments for states' rights, the new contractual systems are doing to those for pure private enterprise.

But the argument for a measure of independence from central authority still remains valid in either case, and so does the need to recognize that the fundamental responsibility of government cannot be delegated. In a proper sense of the term, "sovereignty" is, of course, not affected by this type of delegation. Policy decisions remain the responsibility of government. But "policy" here means simply those aspects of the business that government authorities consider it important enough to warrant controlling, either because they think them of major importance or because they realize that voters or Congressmen think so.

This means that they will consider as policy certain aspects of management (for example, fair employment practices or prevailing wage rates). But, as long as they retain ultimate control, they may act on the advice of contractors with respect to the most momentous new issues, or delegate major segments of the business whenever they can specify the purposes to be accomplished; the complex and costly nature of certain types of military studies, and the sophistication of the new techniques of operations research, make the possibility of such delegation very broad indeed. There is nothing in the nature of the contract itself (or the grant, which differs from it only symbolically and in technical detail) to determine whether in this relationship a central bureaucracy will control every detail of the contractor's management or will leave him free to decide matters in secret that ought to be determined by the President and Congress.

But the general effect of this new system is clear: it has destroyed the notion that the future growth in the functions and expenditures of government, which seems to be made inevitable by the increase in the technological complexity of our civilization, would necessarily take the form of a vast bureaucracy, organized on Max Weber's hierarchical principles, and using the processes of science as Julian Huxley predicted to answer policy questions (*19*). To the considerable extent that scientists have shaped this development, its political and administrative patterns have reflected the way scientists actually behave rather than the way science fiction or Marxist theory would have them behave: they have introduced into the stodgy and responsible channels of

bureaucracy the amiable disorder of a university faculty meeting.

Compare, for example, our oldest and least scientific federal agency with a large operational mission with the newest and most scientific—the Post Office with the Air Force or the Space Administration. The Post Office is a relatively self-contained hierarchy. The Air Force develops its policies and runs its program with the advice and cooperation of several dozen of the most influential universities and industrial corporations of the country, whose executives and faculty members consequently have independent bases from which to criticize any policies, strategic plans, or administrative arrangements they dislike—and they can always find a Congressional committee to listen to them.

Science's Role in the New Structure

I do not think the role of science in this difference is entirely accidental. This is in part because the pursuit of science itself is a nonhierarchical affair; the best scientists either personally prefer, or are taught by their guilds that they should prefer, the university's combination of research, teaching, and irresponsible administration, and to get the best scientists the government took them on their own terms. But more important, I believe, is the long-range and indirect connection: when the Revolution of the Enlightenment proposed that the organization and procedures of government, as well as its policies, should be open to scientific inquiry and independent criticism, they started a process which has had deep effects on the constitutional system. These effects showed first in the relation of scientific administrators to their executive superiors and to Congressional committees, and later in the new structure of federalism, and in the new contractual relationships between the federal government and private institutions.

As the story of the President's Science Advisory Committee illustrates, to say nothing of the similar advisory groups to the military services and the Atomic Energy Commission, this type of relationship very greatly reduces the possibility that great issues will be decided by closed scientific politics, or that the increase in importance of scientific staff work will reduce the free play of policy debate. For the institutional bases from which advisers operate give them a measure of independence as public critics, and thus provide something of a counterbalance to the centralizing pressures of wars and rumors of wars.

American scientists, who have tended to be a little disillusioned about their relationship with politicians ever since the Jacksonian period, are now entitled to look with somewhat greater satisfaction on the domestic Establishment that they have helped set up. For to some small extent science has helped the political system of the United States develop along lines quite different from the classic patterns of either parliamentary government and laissez-faire economics, on the one hand, or socialism and one-party rule on the other. Among its essential institutional features are universities that are concerned with applied as well as basic sciences, and continuously exchange personnel with the government at all age levels; a personnel system which puts up no barrier against the administrative promotion of men with scientific training; and grants in aid and contracts through which federal agencies may influence or guide the policies, but not direct the detailed management, of certain aspects of local governments, business corporations, and universities. Among these institutions, the connecting links are strongest in scientific and technical fields. And the peculiar looseness of the constitutional system enables the scientists in each field to take the initiative in developing policies—just as their innovations are providing the greatest impetus to industrial enterprise. Most important, science is not restrained in its impact on policy by any rigid distinction between ends and means, imposed by institutionalized systems of traditional or ideological values. The key to this is the freedom to influence or determine the organization and procedures of government from the outside, not conceding control over them to professional administrators or party leaders.

Dangers

But there are some good reasons why scientists should not be too self-satisfied about their new status. A good many of them already think that science has been corrupted by this new system and the wealth that it has brought (*20*). They tend to look back on prewar science as the Reformers looked back to the Primitive Church: a period of austere purity, an era in which no vows were needed to guarantee the poverty of the professor, no scientist was seduced by the government contract, and teaching fellows were obedient. One may well be a little skeptical about this point of view and suspect that poverty probably brought its distractions, no less troublesome than those of riches. But even if we discount such dangers so far, the worst may be yet to come. The public and members of Appropriations Committees are being led to think of science in terms of spectacular results, like a space satellite or a cancer cure, and the political pressure to work miracles may lead to some major distortions in our national policy and put some uncomfortable pressures on the independence of scientific institutions. We probably have less reason to fear that major governmental decisions involving science will be secret than that they will be popular.

For while our new system of administration by contract temporarily avoids the political problems that come with the growth of bureaucracy, it encounters them again in more subtle and difficult forms. We do well to recognize that a government bureau is tempted to be more concerned with its own status and power than with the purposes of national policy. But if we entrust those purposes to industrialists or even scientists, we do not sterilize that political temptation. We only let it begin to work directly on the industrialists and scientists. If public ownership is no guarantee of unselfishness, neither is private ownership. And it is ironic, in view of the general public image of his political ideas, that it was President Eisenhower who presented most forcefully to the country the danger that, having hired private corporations to further specific public ends, we will see them use the public means for private profit, or even in political efforts to control the policy decisions of the government.

Government policy, like science itself, needs to be conceived and pursued with some regard for its totality as well as its parts. By giving priority to the parts—by turning over the administration of public functions to private institutions—we have strengthened our ability to do a great many separate things, but not our ability to give in-

tegrity and discipline and direction to our total effort. Indeed, by relying too much on the contracting method we have probably weakened the quality of the scientists within the civil service, whose help is needed by the executive who seeks to manage our scientific programs as a coherent system (*21*).

Summary

In the dimensions of its financial support and in the breadth of its influence, science has indeed become a national Establishment. Politicians are more likely to abuse it by calling on it to advance their special causes than they are to ignore it. In this predicament, scientists cannot protect their essential interests in government by setting themselves apart in a separate status or separate department. They used to be content with the control of particular bureaus or programs. Today, in the White House Office or the lobbies of the Capitol, they are obliged, by the nature of the system they helped create, to play a responsible role in all aspects of national policy, and in the development of a new pattern of relationships between public and private institutions in our society.

References and Notes

1. Adams predicted that "the future of Thought, and therefore of History, lies in the hands of the 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* [*The Degradation of the Democratic Dogma* (Putnam, New York, new ed., 1958), pp. 277, 303 (first published in 1919)].
2. D. Eisenhower, quoted in the New York *Times* [22 Jan. 1961]. See also the authorized interpretation of this statement by the President's Special Assistant for Science and Technology, George B. Kistiakowsky [*Science* **133**, 355 (1961)]. As Chief of Staff, General Eisenhower had told the Army in 1946 that "the future security of the nation demands that all those civilian resources which by conversion or redirection constitute our main support in time of emergency be associated closely with the activities of the Army in time of peace," and advised the Army to contract extensively for scientific and industrial services ["Scientific and Technological Resources as Military Assets" (Memorandum for General and Special Staff Divisions, etc.) (30 Apr. 1946)].
3. Unamuno, Maritain, and 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* (Princeton Univ. Press, Princeton, N.J., 1958) 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 most American scientists, and bring the date up to the present.
4. See especially C. Snow, *Science and Government* (Harvard Univ. Press, Cambridge, Mass., 1961), p. 55.
5. Edward McCrensky [*Scientific Manpower in Europe* (Pergamon, New York, 1958), pp. 27–29] gives the general picture with respect to salaries and personnel policy. As for the classic attitude of the Administrative Class regarding its relation to the scientific civil service, see the testimony of Sir Warren Fisher, Permanent Secretary of the Treasury, before the Royal Commission on the Civil Service, in *Minutes of Evidence* (1929–30), pp. 1276, 1282. For its contemporary attitude, see C. H. Sisson, *The Spirit of British Administration* (Faber, London, 1959).
6. As A. Lawrence Lowell put it, "The great professions, which have secured general recognition in the community, have been strong enough to insist that strictly professional work must not be intrusted to men who have had no professional training or experience" [*Public Opinion and Popular Government* (1926)]. Detailed illustrations for specifically scientific fields may be found in the series of "Service Monographs of the United States Government" published by the Institute for Government Research—notably in monographs on the Steamboat Inspection Service, the Office of Experiment Stations, the General Land Office, and the Public Health Service. See also L. Mayers, *The Federal Service* (Insitute for Government Research, 1922), p. 21, and L. Meriam, *Public Personnel Problems*.
7. M. E. Smith, in *Public Policy* (Yearbook of the Graduate School of Public Administration, Harvard University) (1960), vol. 10, p. 62.
8. *The Federal Top Salary Network* (U.S. Civil Service Commission, Washington, D.C., 1960).
9. Macaulay put it more pointedly in 1833: "If astrology were taught at our universities, the young man who cast nativities best would generally turn out a superior man" [*Royal Commission on The Civil Service, Fourth report* (1914), cd. 7338].
10. Frederick W. True, in *A History of the First Half-Century of the National Academy of Sciences* (1913), p. 202, says: "from the beginning the membership of the Academy included many officers of the Government. . . . On one occasion at least this led to some embarrassment, for the reason that through this double relationship it was thought that the view of subordinate officers might control the action of those higher in authority." The same fear, or hope, exists in the present relationship between the Academy and the Federal Council for Sciences and Technology. True's history of the Academy, and his "History of Agricultural Experimentation and Research in the United States," *U.S. Dept. Agr. Misc. Publ. No. 251*, tell a great deal about the role of scientific societies in the development of new federal programs.
11. C. Frankel, *The Case for Modern Man* (Harper, New York, 1956), p. 58. Ernst Cassirer [*The Philosophy of the Enlightenment* (Beacon, Boston, 1955), pp. 45, 46] noted "the almost unlimited power which scientific knowledge gains over all the thought of the Enlightenment," and wrote: "deeper insight into the spirit of laws, of society, of politics, and even of poetry, seems impossible unless it is pursued in the light of the great model of the natural sciences."
12. W. Bagehot, *The English Constitution* (1867); T. W. Wilson, "Cabinet government in the United States," *Intern. Rev.* (Aug. 1879) (reprinted in 1947 by the Overbrook Press, Stamford, Conn.). By the turn of the century, Wilson had apparently changed his mind, in view of the new role of the Presidency, especially in international affairs [*Congressional Government, a Study in American Politics* (ed. 15, 1900), preface].
13. The National Research Council, created by President Wilson to do in the First World War (in a rudimentary way) what the Office of Scientific Research and Development did in the Second, was supported not by appropriations but by the Rockefeller and Carnegie foundations [R. G. Axt, *The Federal Government and Financing Higher Education* (Columbia Univ. Press, New York, 1952), p. 78].
14. *Report of the Science Advisory Board* (Washington, D.C., 1934), p. 15.
15. R. G. Hewlett and O. E. Anderson, Jr., "The New World" (vol. 1 of the official history of the Atomic Energy Commission), in preparation.
16. "The field of atomic energy is made an island of socialism in the midst of a free enterprise economy" [J. R. Newman and B. S. Miller, *The Control of Atomic Energy* (McGraw-Hill, New York, 1948), vol. 4]. Newman, in a preface to this book written a year after the text was completed, noted (p. xi) that "only one major policy formulation, the decision by the Atomic Energy Commission not to conduct research in its own laboratories, departs sharply from the interpretations of the Act set forth in these pages."
17. See the forthcoming study, to be published by the Carnegie Foundation for the Advancement of Teaching, on the relationship of American universities to the federal government.
18. For a general discussion of this problem from the legal point of view, see A. S. Miller, *N.Y. Univ. Law Rev.* **36**, 957 (1961). The economic aspects are discussed in a study by Carl Kaysen, "Improving the Efficiency of Military Research and Development," to be published by the Committee for Economic Development, and the general problems of weapons development and procurement programs are discussed in a study by J. M. Peck and F. M. Scherer, "The Weapons Acquisition Process: An Economic Analysis" (Harvard Business School, in press).
19. J. Huxley, *Man in the Modern World* (Oxford Univ. Press, New York, 1948), pp. 120–121. See also J. Huxley, *Religion without Revelation* (Harper, New York, rev. ed., 1957), p. 4.
20. M. A. Tuve, "Basic research in private research institutes," *Symposium on Basic Research, Publ. Am. Assoc. Advance Sci. No. 42* (1959), p. 178.
21. H. Brown, "Research and Engineering in the Defense Laboratories" (an address by the Director of Defense Research and Engineering, delivered 19 Oct. 1961 in Washington, D.C.).