

THE GOVERNMENT'S ROLE AND THE FUTURE OF DISCOVERY

by

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I am profoundly touched by the thought behind the medal that has just been conferred upon me. When one receives such an honor, he inevitably thinks of those who have made it possible. My own particular debt is far beyond my power to repay. It is owed primarily to a group of men and women as fine as those with whom any man has been privileged to work. This includes not only the scientists in our laboratories who, by their accomplishments, have earned whatever reputation I may now possess. It also includes our management and particularly our president, John T. Connor, who has played a major part in these scientific accomplishments himself by his understanding and support of our research through the years of bad weather as well as those of sunshine. And I also acknowledge the indebtedness I have to my wife, Elizabeth, who has graciously accepted the unacceptable -- the sharing of her husband with his profession --- and who, through it all, has understood that his devotion to his calling has never diminished his devotion to her.

I am delighted, as we all are, to have our British friends with us tonight. But I am a little surprised that Lord Hailsham let you out of school. From the way he has been talking about Britain's unfavorable balance of trade in scientists, one might suppose he would be afraid too many of you would bring along your degrees from those matchless British universities and bedazzle the less sophisticated Americans into making lucrative job offers. Of course, if any of you would like to talk with me after dinner, you will find me quite receptive. For years we have been allowing the United Kingdom to train some of our most productive scientists.

I am inclined to agree, however, with the member who asked in Parliament what was new about Lord Hailsham's complaint. Hadn't the British, he asked, been exporting some of their best people to America for over 300 years? Right here in Texas we have a fine example of this. Among the greatest heroes in Texas history were the 183 men who died fighting for independence within the walls of the Alamo. Of these, 27 were born in Texas. But 25 were natives of Great Britain. So you see that the United States -- and I include Texas -- is not only grateful for British brains, but we are also indebted to you for Britain's love of freedom and for British courage.

Tonight I would like to discuss an aspect of science and public policy -- a matter of keen interest to all of us, both as members of the chemical industry and as citizens. My thoughts flow out of developments in this country, but I believe that some of the issues are also pertinent to the United Kingdom.

Throughout most of man's history, the inquiring mind has had to labor uphill against the existing power structures and belief systems of the rest of society. This concept is so firmly inbedded in our minds that we have trouble seeing that it no longer fits reality, at least so far as the natural scientists are concerned. For they have already achieved a strategic position in our society and, with an assist from the public's imagination, have made over some of our belief systems in their own image.

This not inconsiderable feat has been accomplished not by conspiracy, but by consent. The scientists have not been seeking power; power has been thrust upon them. And the eagerness with which dollars have been pressed into their not-too-unwilling hands by the greatest patron in the history of science -- the United States government -- has been almost unseemly.

Among the most remarkable features of Federal support for research and development has been the speed and magnitude of its growth following the close of World War II. In 1940 the government spent only \$74 million for research and development. By the first full fiscal year after the last World War, the figure had reached \$900 million, or better than twelve times the pre-war amount. Thereafter it rose steadily.

Since Sputnik's dramatic orbit in 1957, the yearly increases have been even more spectacular. For the past six years, Federal obligations for research and development have been mounting at the average rate of almost \$2 billion a year. The current budget calls for a total of \$14.9 billion, which is 200 times the 1940 rate. This means that 15 cents out of every tax dollar is now devoted to this relatively new activity of government. No item in the budget, except that for defense, is supported so generously by the American taxpayer.

Let us look at the manner in which these Federal funds have grown and transformed the character of research and development in the United States. In 1953, industry -- which performs about three-quarters of the nation's research and development -- still controlled most of its own research. Over 60 cents of every dollar that industry spent in its laboratories came from corporate earnings. Today, when industry is performing about \$13 billion worth of research and development work, the proportion has been reversed. It is the government that is supplying the 60 cents. In those years corporate funds doubled, but they could not keep pace with those of the government, which multiplied four and one-half times. It should be noted -- perhaps with some pride -- that among the large research-oriented industries, chemicals and allied products are unique. We spend more of our

own money for research and development than any other industry group and are dependent on the Federal government for little more than 20 per cent of our total research and development budget.

The Federal research dollar looms even larger in the academic world. In 1940 the government spent only about \$15 million for this purpose in our academic institutions. By fiscal 1963 the government's obligations for research and development in colleges and universities had multiplied more than 100-fold, to \$1.6 billion.

I do not want to dwell on the effects of government funds on the universities, since I have treated this subject elsewhere. But I would like to stress three points.

First, the problems created by this relationship do not arise from the classic kind of overt direction and control by a source outside the university. Aside from contracts with clearly defined, mission-oriented objectives, government agencies have thus far been scrupulous in this regard. Outstanding have been the two I know most about -- the National Institutes of Health and the National Science Foundation. The N.I.H., whose exploding budget has risen from a mere \$2 million in 1945 to \$980 million for the coming year -- a multiplication of 490 times -- has been able to administer this extraordinary expansion in research with great skill, understanding, and most of all, forbearance toward the motivations, needs, and freedoms of the men, women, and institutions in the health sciences. Much of the credit for this goes to the vision, wisdom, and leadership of James A. Shannon, the N.I.H. Director. The same may be said of the National Science Foundation and its recently retired Director, Alan T. Waterman.

My second point is that the \$1.6 billion in Federal funds now floating in through the windows of university laboratories has created problems that are far more subtle than the ancient one of outside dictation. They include the resulting imbalance between teaching and research, between basic and applied research, and between science and the humanities; the disproportionate growth of the physical sciences; and the rising quality of the best institutions, which are those most favored with funds, at the expense of the spreading mediocrity of the rest.

To this should be added the hard-to-measure effects of mission-oriented research. Although Federal agencies have in general tried to leave the initiative for projects in the hands of campus investigators, the fact is that tax money can be spent only to support projects that promise to further the purposes set forth by Congress. And it is marvelous to behold how much more adept the mind of man is at thinking up ideas in areas where support is plentiful than in those where support is scarce.

The third point is that notwithstanding the determination of universities to maintain independence and to resist demands inconsistent with this determination, they are in fact becoming financially dependent on the Federal government. Twenty per cent of the total expenditures for all activities carried out in institutions of higher learning now comes from Federal sources, and about 75 per cent of all academic research in the physical and life sciences is now being paid for with tax money.

Let us now turn from the universities and examine briefly the effect of the Federal research dollar on industry and its research. As in the universities, the character of research in industry is changing -- again

because the golden hand of government has been laid upon it. Although a pattern and direction have not yet evolved, the relation between government research and industry is becoming a matter of great concern. To understand the reasons for this concern, it is necessary first to glance at the evolution of industrial research in this country.

Although the scientific revolution is more than three centuries old, it was not until a little more than fifty years ago that a few pioneer corporations set out to organize their own search for new knowledge in the belief that this kind of risk-taking might turn out to be profitable. By the time of Pearl Harbor, industrial laboratories had been seeded all across the country. World War II, as we all know, gave new impetus to this development. The victories that were won in the laboratories of Britain and the United States dramatically changed both the character and significance of research and development in the postwar world. In 1939, U. S. industry, government, universities, and foundations spent altogether only \$500 million on research and development. For the coming fiscal year it is expected that this figure will be above \$20 billion. The industry that produces chemicals and allied products alone will be spending out of its own funds almost twice as much on research and development as the whole nation spent on this activity only 25 years ago.

The concept that research can be harnessed for the benefit of industry and the economy is relatively new. Scientific research, long the exclusive province of the universities, has extended from the campus into the laboratories of industry. Scientists have learned that this new home can also be congenial and stimulating to the inquiring mind. In industry they find commensurate fulfillment and recognition, plus the new

experience of translating the fruits of research into the satisfaction of human needs. On the side of industry, corporations have learned how to nurture the organized quest for knowledge for their own welfare and economy.

This growth of research in industry is neither accidental nor a whim of management. If research had not been productive, its increasing support by corporations would never have happened. In a free-enterprise, highly competitive society, industry cannot afford to maintain research without tangible returns to pay for it. Industry has learned the lesson that Sumner Slichter, the late economist, pointed out when he said:

"The discovery that an enormous amount of research can be carried out for profit is surely one of the most revolutionary discoveries of the last century."

There is no need for me to dwell on the impact of research on post-war economic growth. We have seen so many new things and so many technological advances during our lives that rapid change has become normalcy. Although society recognizes the role of research generally in this new way of life, it is less likely to recognize the part that industrial research has played in the accelerated pace of discovery. A good illustration is my own industry, which during the past 25 years has drastically altered the armamentarium of the physician. According to a recent report of the New York Academy of Medicine, "it is estimated that 90% of present prescriptions are for drugs that were unknown as therapeutic agents fifteen years ago."

The "industry of discovery," as Professor Slichter named it, is probably America's most valuable asset in the highly competitive struggle

for world markets. Again let me illustrate with my own industry. Prior to World War II, American pharmaceutical companies sold only negligible proportions of their output abroad and had little influence on the treatment of disease in foreign countries. But in the intervening years we have erected highly efficient research establishments that are turning out new and useful medicinal agents at an unprecedented rate -- agents which, in terms of human lives and needs, recognize no national barriers. As a result of these developments, foreign sales by the research-oriented pharmaceutical companies, either through exports or subsidiary manufacturing in other countries, now amount to upwards of a quarter of their total sales. Merck thinks of itself, for example, as a Free World enterprise based in the United States.

Let us look now at the effect of government research and development expenditures on this private dynamo for economic growth. I pointed out earlier that the Federal government has long since become the dominant source of funds for industrial research and development. In the past fiscal year, according to National Science Foundation estimates, Washington obligated \$8 billion to be spent in industrial laboratories. Nearly 99 per cent of this money has been appropriated to support the missions of three agencies -- Defense, Space, and Atomic Energy. Industrial research -- once devoted exclusively to the promotion of economic growth -- has become predominantly a government-dominated institution for protecting the nation's security and exploring the solar system.

The question is being asked with increasing persistence whether we are devoting a disproportionate amount of our scientific and technical resources to the government's objectives. It has been pointed out that

between 1954 and 1961 three quarters of the increase in scientists and engineers engaged in research and development was absorbed by the defense and space programs, and that the programs on the drawing boards of these same agencies will require as many scientists during the next decade as all our institutions of higher learning will graduate during the same period. Yet it is reported that Switzerland, Sweden, Japan, and West Germany, unmotivated by Sputnik and unburdened by the needs of defense, spend a higher percentage of their gross national product than we do on research and development not directed toward military needs. How far and how long can this situation progress without damaging our country's capacity to maintain its broad leadership in research?

The Defense Department and the Space Agency have countered these concerns with predictions of spin-offs for the civilian economy from developments financed by them. So far, the evidence for this contention is unpersuasive. Whether or not the prophecy will come true does not alter the unrelenting fact that too little attention is being paid to the long-range effect on the civilian economy and to the manner in which we have been using tax money to divert our scarce scientific and technical resources into such crash projects as the race to the moon. Our government has been prone to act as if these resources are either unlimited or can be expanded indefinitely by appropriating dollars. Neither proposition is correct.

Federal expenditures for research are endangering the future of industrial research and development in another and unexpected way. They are doing this by weakening the incentives for private investment in corporate laboratories. Now that three out of four dollars spent on research and development come from taxes, it is increasingly difficult

to find a discovery untouched by public funds at some point during its development. If the government takes the position that we cannot permit a private company to have property rights in any such discovery, no matter how much of its own money it risks in the research and development effort needed to turn it into a marketable product, we will surely find companies less and less interested in taking that risk. Clearly if all discoveries were in the public domain, there would be little incentive for private enterprise to make large investments for the development and commercialization of new products and for the support of the huge industrial laboratories that are among our most valued national assets.

Public funds have permeated so many areas of research that we can already see quite clearly the outlines of the national problem that this invasion is creating. In my own field of health research, the U. S. Department of Health, Education, and Welfare has recently taken the position that scientific observations financed in whole or in part by the government through a university grant should fall into the public domain and generally remain there. They hold this despite the long, risky, and expensive process and the inordinately high proportion of scientific and technical skills needed to turn an observation into a genuine discovery and subsequently into a new and useful drug.

The results of this policy as applied to NIH research grants can be devastating unless the situation is modified. The fruitful relationship between university scientists and those in our industry, which has produced so many of the landmarks of modern medicine, can be cut by this

policy as cleanly as if it had been done with a sharp knife. And the incentives to industry to transform promising scientific observations made in university laboratories into new medicines for the control or cure of disease can be reduced to a danger point.

By taking this position, government may feel it is serving the public interest. But, in my opinion, this is a very narrow view of where the public interest really lies. It does not lie in the destruction of the free interchange between university and industry laboratories, nor in the slowing down of the rate of developed discovery. It does lie, it seems to me, in speeding up the process whereby we have learned to turn new scientific knowledge into better health for all mankind.

Another aspect of the same problem exists in research carried out in industry with the financial support of the government. Those of us in the pharmaceutical industry who have accepted government contracts -- they generally amount to less than 5 per cent of our research and development budgets -- must surround these projects with curtains of steel, lest one of the discoveries emanating from the "private sector" of research should inadvertently fall into the area of the public domain. This is foolish and unnecessary. Obviously, the entire resources of an experienced and productive research laboratory, irrespective of its source of funds, should be freely applied to projects financed by government agencies and deemed by Congress to be of national import.

The broad problem is how to protect the public interest and, at the same time, maintain healthy incentives for the growth of private research and our free enterprise economy. In my opinion, a workable solution will

not come from taking a doctrinaire position on either side of the developing argument, but from a creative compromise that recognizes both the public interest in the results of tax-supported research and the need for healthy, expanding, privately-financed industrial research laboratories.

In this connection, it is pertinent to note Canada's recent policy of providing government grants to industry for carrying out approved projects, with no strings attached, in industrial laboratories. Once the National Research Council has given the green light to a project, the government will pay a major share of the research expenditures. The important point here is that industry can get patents from this work. The Canadian action recognizes the power of industry research to create new industry and to foster economic growth. In a similar pattern, the synthetic rubber development begun in World War II went ahead by leaps and bounds when government abdicated its control to industry and industry applied its own scientific resources to this field. And there are many who believe that the development of atomic energy as a source of power would have gone ahead much faster had the policies of the A.E.C. been more liberal.

It would be one of the ultimate ironies of our times if we were to spend scores of billions of taxpayers' dollars to broaden the scientific base of our society only to find that in the process we had weakened our economic structure, damaged our competitive position in world trade, and thus impaired our national security.

The matters I have been discussing are only some of the problems that have arisen since U.S. Government funds have begun to dominate the U.S. scientific scene. There are many others. After a long honeymoon period, during which Federal appropriations for research and development had been

rising at an astronomical rate with almost no audible dissent, it was inevitable that the point would come when the questions would begin to catch up with the applause. There is some evidence that we have reached this point. This summer, for example, Congress made a significant cut in the budget requested by the Space Agency. Both public and private bodies are now launching new studies of specific aspects of the government's support of science. And only two weeks ago the House of Representatives voted unanimously to appoint a nine-man select committee to conduct a 15-month investigation that would probe all phases of the government's role in the conduct and support of research.

Do not misunderstand me. In common with most members of the scientific community, I rejoice in the public's increasing support of the search for new knowledge, made manifest through the actions of Congress. I am also pleased that we are finally getting around to asking some searching questions about the direction in which this support is taking us. Nonetheless, there are some dangers in this new inquisitiveness, and I should like to point out three.

The first is the always present possibility that uninformed investigators with motives of their own can turn inquisitiveness into inquisition. There is no way to spend scores of billions of dollars without a certain amount of waste and duplication and a certain number of ill-conceived projects, all of them tempting targets for the headline-seeker. Science is properly subject to the same scrutiny as the rest of our society, and scientists are just as accountable for the expenditure of public funds as are businessmen and government officials. But let us hope that we can avoid demagoguery rampaging through the domain of research.

The second danger derives from the fact that the questioning by Congress and the public seems to have arisen as a result of their concern over the size of Federal research appropriations. Since 15 cents out of every budget dollar is now being spent for this purpose, this is no surprise. We could not expect the taxpayer to go on spending at that rate for activities he does not really understand without eventually wanting to know what he has bought for his money.

Given the present state of public understanding of the scientific process, it is understandable that the layman expects tangible results. If he has supported the expenditure of several hundred million dollars looking for a cure for cancer, for example, and is told that we are still only following promising clues, having abandoned the trail of other equally promising clues that turned out to be disappointing, he might want to call off the search altogether. In such cases, basic research would certainly suffer.

The third danger has to do with the autonomy of science. Now that government pays most of the bills, scientists may be in danger of losing their most sacred charter: the intellectual freedom to pursue their own paths into the unknown, wherever they may lead.

Science will inevitably be called upon to pay a price for its tax-supported affluence and power. The hand that giveth also taketh away. And the hand in this case belongs to the Congress, a body created by the Constitution in part for the purpose of cutting down to size any segment of our society whose power it thinks has become disproportionately large. In the process of cutting science down to size -- a process whose beginnings one can already sense in this session of Congress -- individuals, programs,

and institutions may be hurt. But there is a deeper risk. Ever since Hiroshima, society has been uneasy about the power of science. This uneasiness has now spread to the life sciences. There are those who fear, for example, the consequences that may follow, in a world unprepared, when those scientists engaged in molecular biology and the chemistry of the genes finally learn how to manipulate human genetics. Yet society has the right to question the basic precept on which science is founded: the pursuit of knowledge wherever it may take us, no matter how prepared or unprepared the world may be to cope with the truth scientists set before it.

We must remember that independence to explore the unknown has had a very short life in the history of man. It has burned brightly several times before, only to be smothered by those frightened by the consequences of truth. In modern times it has had some long and bitter struggles with both temporal and religious power. Its freedom today is not as secure as its present status might lead us to believe. It is once again running its historic risk -- the risk that society may rebel against the enormous power of the discoveries it can unleash on mankind. But, for the first time in this country, it faces this risk having shed the traditional armor of its independence by making itself, at least in part, a hostage of government and a servant of political power.

One of the ways to combat this danger is to meet the fear of the consequences of new knowledge with the defense of more knowledge. The present position of science is weakened by all the unawareness and even the mystery that now surround what it is doing at the behest of government. As this mystery is lifted, science itself will not go unscathed and certain people and institutions -- and not necessarily the worst ones -- are sure

to suffer. But this may be a small price to pay for the outcome -- a widespread understanding of the needs, purposes, and methods of independent scientific inquiry and of the proper roles of government, private industry, and the universities in this endeavor.

As is so often true, government domination of U.S. science has been the result of happenstance, not of plan. We have been busy for 18 years concentrating solely on what is right in front of our noses. Therefore, as a society, we are faced with the usual problem of building order out of the reality bequeathed us by chance. But there is nothing usual about the particular problem with which we are now confronted. It will be one of the most challenging assignments in our political history to devise a wise national policy for the future course of Federal support for research and development.

What I have in mind when I speak of national policy is not a formal document written by a committee. I am talking about a set of guiding principles that must emerge as we scrutinize and really begin to penetrate the complex questions raised by the irreversible trend toward deep Federal involvement in research. A number of highly competent Government and civil groups are actively appraising these issues. Inevitably, their findings and their attitudes will condition our future thinking. It is in this way that policy evolves. No one can predict what our national policy will be ten years from now, much less fifty years from now. But we can predict, I feel certain, that substantial changes will occur in the relationship between science and society, and that scientists themselves must adjust to this change. For the moment, it seems to me, we would do well to pause and evaluate.

Here are some of the questions I believe we might fruitfully try to answer:

1. What have been the major effects on the universities of Federal spending for science?
2. Are we diverting the scientific resources of the nation to what are termed public purposes at the expense of private research and development, the most dynamic force for growth in our economy?
3. At what rate can we continue to increase expenditures for research and still maintain quality at a level high enough to justify the use of the funds?
4. What are the extent and effects of the imbalances we have been creating between various branches of science, between science and the humanities, teaching and research, and between public and private research in industrial laboratories?
5. Are scientists becoming so affluent, in terms of support and status, that they are beginning to lose their sense of direction?
6. Is the nature of scientific inquiry such that any massive effort to control its direction will inevitably slow down its progress and thus invite serious long-run consequences for the society that attempts it?

Such questions as these focus upon science. As they are answered, the nation will gain a better understanding of the issues associated with the Government's heavy participation in research. If questions of this kind are examined in depth -- and there is no alternative -- we will eventually come to grips with an issue of even greater magnitude, one that encompasses

much that we have been talking about and a great deal more. Let me explain. We accept the premise that research and education are inseparable. We acknowledge that the Federal government is not out of place when it acts to help provide the resources and funds required by today's citadels of scientific learning. But is this not merely part of the even greater problem of identifying, developing, and making the best use of our greatest asset, the intellectual capacity of our citizens? The ability to think and to know, in the long run, will determine the fate of our nation. Seen in this light, the distinction between the sciences and the humanities disappears.

For the moment, however, our attention is on science. There is one overriding consideration that I would commend to the policymakers and to the public at large. It is this: The national interest will be best served if we keep continuously in mind that the direction of science never has been and never will be as important as its freedom. Let us remember that many of the great discoveries associated with such names as Newton, Einstein, Kekule', Hertz, Thompson, Compton, and Fleming have not come from programs directed toward solving specific problems. But this overriding consideration does not and cannot absolve either science or society of the responsibility to use the fruits of this freedom of inquiry for the betterment rather than for the destruction of mankind.

The challenge we face has been summed up succinctly by George Wells Beadle, president of the University of Chicago and Nobel Laureate for his revolutionary work in genetics:

"Man's evolutionary future...is unlimited. But far more important, it lies within his own power to determine its direction...an opportunity never before presented to any species on earth....To carry the human species on to a future of biological and cultural freedom, knowledge must be accompanied by collective wisdom and courage of an order not yet demonstrated by any society of man."