Government, Science, and Public Policy

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A friend of mine came up to me at luncheon not long ago and started to tease me. Most of you will know his name. It is William Penney, and he is one of the most gifted of our scientific administrators. He has done great services to my country, and we are all in his debt. He and I have known each other since we were very young men. He enjoys teasing me, and what he said was something like this: "Well, now you've had a turn in Government yourself, it will be a fatal disadvantage for you. You will never be able to write so clearly about these problems again."

By "these problems" he meant the whole complex of matters which we are discussing this morning. Penney knows, as well as any man alive, how intractable they are. But for once, I told him, he was wrong—that is, if he expected me to take refuge in incomprehensibility from this time forward. The problems are intractable; to some of them there are no good solutions—perhaps, in intellectual terms, no solutions at all. If we were thinking of ourselves as research workers, wanting to add something to knowledge, we should judge the problems to be intolerably muddled, put them on one side, and look for something more esthetically satisfying. But we are living in a world which is only too real: the problems are desperately, and probably vitally, important; we can't duck them; we have got to find partial answers if that is the best we can do. We are not very wise, so we had better be as clear and straightforward as we can manage.

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In fact, I haven't altered my attitudes much as a result of having a little direct experience of Government. I couldn't resist the experience. It seemed to me that, if one expresses opinions on these subjects for years and then is invited to go out in public and take the rap, it would be cowardly to stay in the back rooms. It has been a fascinating experience. It has certainly been a moral exercise—though it is unreasonable to think that Her Majesty's Government is specially concerned with improving my character or building my soul. But it has not altered the opinions that I formed while I was still lurking in the back rooms. Some of those opinions have been strengthened. Certain chances for useful action have come to seem more important. I shall mention later one or two practical steps which may be worth experimenting with. Above all, I believe, even more strongly than I ever did, that we have got to be humble. In your country, in mine, in the Soviet Union, anywhere, decisions about science and technology have to be taken. In my country we have local difficulties, which is why we have separated, for Government purposes, technology from science (I will have a word about that later). But in many ways the decisions are of the same kind. No sensible man in any country can afford to be certain that we know the way to take them. There is growing up a study called the Science of Science—that is, the application of scientific thinking to the way science itself works and develops. This study ought to be encouraged, so long as we don't get into an infinite regress—the Science of Science of Science. . . . Yet in some areas, including some of the most dramatic, I believe we are deceiving ourselves if we believe that within foreseeable time we shall either understand all of the scientific present or be able to predict enough of the scientific future.

Allocation of Funds

Let me give the sharpest of examples—that is, how any country allocates its funds for research in pure science. By pure science I mean, of course, the search for the unknown. Although the border line between pure science and technology is blurred, and ought to be blurred, yet there is a difference in kind, and decision making about pure science is qualitatively more difficult than it is about technology. What is one to go for? Your country and the Soviet Union are the only two which can possibly command the resources to attempt everything; and even you, at the present rate of the development of science, will in 20 years find your money stretched, and, even more, your men. We need not, I think, take the growth curves too seriously; it is fairly evident that every man, woman, and child in the United States will not in fact be employed in scientific research by the year 2100, as the curves at present indicate.

But there are limitations, even for you. Much more so, of course, for countries of the middle size, like mine. It is fairly easy for a country to see that a good proportion of its gross national product should be spent in pure research. You spend a great deal, but we do better than you might think. But allocating this sum between research topics is quite another matter. In fact, though not necessarily in form, all countries rely on the judgments of eminent scientists. And these eminent scientists, in any country, are the first to say that the job contains only a modest element of reason. You watch what other countries are doing and fill the gaps; you rely on a man (or a group) who knows what he wants; you are influenced, as we all are, by the scientific fashions of the time; you even back a hunch. I am not using the stately language of official reports.

Take three great contemporary fields. To what degree are these going to be financed?

1) High-energy physics—very unpopular with other scientists because it has run away with such enormous quantities of money; prospects of prac-

tical application, remote; and yet, yielding results on the nature of matter of extraordinary depth and beauty. Only you and the Russians can, on a national scale, support much of such research; we have to make an international arrangement.

2) Molecular biology—less expensive; prospects of practical application, not too far away, even if we don't accept all the sombre predictions of Macfarlane Burnet (this is something man ought not to try to know); intellectually one of the great triumphs of our generation.

3) Radio astronomy and observational astronomy combined—not expensive by the standard of particle physics; practical prospects, nil; but the two astronomies have told us, out of proportion, more about the nature of the universe than all the space explorations.

How do you compare these incomparables? I am sure of only one thing —that I, for one, will never know. One can comfort oneself with this reflection, perhaps: that, proceeding by guess and by luck, we can invoke a principle of natural compensation—all countries will make mistakes, but are unlikely to make the same mistakes. And so pure science itself will lunge inexorably on.

Decision-Makers

In all these decisions about science, and in most others about pure and applied science that we can now imagine, there is a special set of features that has worried me since the last war, and does so just as strongly now. It is this —that, partly because of their inherent nature, partly because of our general education, they are made by tiny numbers of people. As the world gets more highly articulated and political problems get more technical, so wide, informed discussion comes to have less meaning. This is preeminently true of scientific policies. The dangers are manifest; they are the dangers of all decisions in closed societies—too much secrecy, too much concentration of power.

I deliberately made a remark a moment ago which a meeting like this, scientifically informed, could discuss with advantage to us all. I said that the *scientific* results—not the technological results—of observational and radio astronomy have been greater by an order of magnitude than the scientific results of space exploration. This meeting will not misunderstand me. The American and Russian space journeys have been among the greatest technological triumphs of mankind. When one of you gets to the moon, I shall stand myself a celebratory drink. But, after remembering the technology, I shall be celebrating very much as I did when Hillary and Tensing got to the top of Everest and quite unlike the way all of us celebrated when Crick and Watson—with one of the major scientific flashes—produced the concept of the double helix. So far, the scientific results of space exploration have not given any commensurate excitement.

I don't think many of the scientists here present will quarrel with that statement; and, if they do, we can discuss it with a modicum of common understanding and common information, on the plane of reason. But I should be surprised if we could have a similar discussion in the Congress or in Parliament—where, remember, the political responsibility for all these decisions, for all these great investments, ought ultimately to rest.

It would be much healthier—this is something I have said before, and increasingly believe—if a far larger proportion of our elected representatives were scientifically informed, and also a far larger proportion of our administrators. I don't want to overstate the case. Being scientifically informed is no substitute for wisdom. I would far rather have choices made by wise men who are not scientifically educated than by unwise men who are. But that is not the real alternative. We ought to be producing wise men who are scientifically educated.

We need them in public, in the open field of the democratic process. It would help save us from some misjudgments; just as important, it would reduce the amount of alienation, the feeling, possessed by good and responsible people all over the world, that their lives and their children's lives are being settled for them in ways they scarcely learn about, much less understand.

Curiously enough, the one political chamber that I know where one can and does have the kind of discussion I have just been envisaging is, of all places, the British House of Lords. No one will imagine that the House of Lords is a flourishing specimen of a democratic institution; it is a curious historical survival, more or less powerless, but of recent years the custom has grown up of appointing to it presidents of the Royal Society, Nobel prizewinners, heads of universities, and so on. Thus, on almost any serious subject, one can be sure of a number of speakers who know a great deal more than the rest of us.

I wish we could get similar people, earlier in their lives, into the House of Representatives and the House of Commons. I am, in fact, fairly optimistic that we shall get more people drawn into politics and administration from various kinds of scientific and technological backgrounds. For at last we are beginning to come to terms with our time. The purely scientific education is incomplete, but a purely nonscientific education is also incomplete. I have seen universities the length and breadth of this country which are experimenting with courses that are designed to fit people for late-20th-century public life. In my country we are usually less adventurous in education, but several of our universities are also trying to find new forms. This seems to me altogether encouraging. Some of the experiments won't work, but we can choose the best. With a bit of good fortune we ought, within a generation, to have men and women more talented than we are, and better trained for the decisions of their time then we ever were for ours.

I believe it has been a strength of the Soviet Union that a very high proportion of their decision makers have been technologically trained. Mr. Kosygin, for instance, and many of his senior colleagues were educated as applied scientists or engineers. I fancy that fact will seem less surprising and unfamiliar in the English-speaking countries within 15 or 20 years.

Technology

As I turn to technology—as opposed to science—I would like to say a little about our specifically British problems. This is mainly because anything I say about yours would be impertinent; some of them I can understand, but I should have to say to you, count your blessings. It is hard for a non-American, even one who owes as much as I do to this country, not to regard your technology with an ungenerous envy.

We are not so fortunate. I think I can say without chauvinism that our pure science is pretty good. It has been pretty good for a long time. Judged by the ordinary standards of international competition, we don't mind comparison with any country of our resources. This is not so true of our technology. Some of it, again, is pretty good. In some of the most modern technologies we have done nice things—in aircraft, in nuclear power stations, in desalination plants, to take three examples at random. At this moment, in nuclear engineering and desalination engineering we don't fear comparison with anybody. But the total picture is patchy. It has been patchy for 100 years, for reasons we are still arguing about.

One reason seems to be that in England there exists what the senior permanent official in my Ministry calls a principle of maximum purity—that is, most people of talent want to do pure science if they have the choice, and pure science drives out applied. Often we have got on before anyone else to a good technological prospect and then let it slip. We did that with computers, and it was a bitter lesson which still rankles.

By and large, our technological position is uncomfortable, and we have got to change it before we get our economy sturdy again. That was why in October 1964, immediately the new Government came to power, we set up a separate Ministry of Technology. I know this step has puzzled well-wishers here and elsewhere: it has been criticized in England; it has seemed artificial and wrong to separate science and technology. The choice, however, was quite deliberate. It had been deeply considered for months before the election. In the British situation—not necessarily in any other situation—it seemed necessary to give technology a special significance of its own. A Department of Science, Technology, and parts of Education—this was the most serious alternative—would see technology as usual, according to the principle of maximum purity, emerging as very much the junior and unfavorite partner. So a Ministry of Technology was established, with a minister of Cabinet rank, which, as you know, in our country carries its own weight of meaning.

I am sure that this was right. The Ministry has a very tough job, and by the standards of political time—in which, one has to remember, political memory lasts about a fortnight—a very slow one. It will take 10 years to do all that has to be done. But it will be done. By the end of this decade our economic and democratic health will be a surprise to our enemies, and perhaps to some of our friends.

I am not going to inflict local details and arrangements upon you. But, before I return to matters of common interest, perhaps I might say this. It is obvious that, in the fields of advanced technology, a country of limited resources cannot do everything. Once again, only you and the Soviet Union can do that—and, I suspect, in the long term, China. We just can't. It is not pleasant to face and act upon, that fact. But we have to. We have to make some hard choices, deciding where to invest and where not to.

We can't do everything; but that doesn't mean that we can do nothing. Anyone who expects us to abdicate from all the fields of advanced technology is making a mild misjudgment. We all know that research, development, and design in any of these fields is inordinately expensive. There is a feeling, which some of you may have heard expressed, that, accordingly, this research, development, and design will become polarized, and that, in the Western World, it will all flow to the United States. Well, that state of things might be acceptable to some of our American colleagues; you will forgive me for saying that it would not be acceptable to us. I remember the Morgenthau plan for Germany, which was discussed during the war, according to which Germany was to give up her industrial aspirations. We are not overenthusiastic about the Morgenthau plan for Britain. It is essential that in some fields of advanced technology—and some of the critical and exciting fields—we should either remain or become as proficient as you are. Otherwise we shall lose our talented young men, slide into somnolence, and be no good to ourselves, to you, or to the world. That will not happen.

Let me leave our insular concerns. In the course of the last 15 months I have been in the Ministry, some points have emerged which are not, I think, so insular. Organizing a new Ministry gives one some extra degrees of freedom. The most interesting use perhaps of that freedom has been an experiment in minimizing the difference between scientists and everyone else.

Educationally we are all trying to do this; it is one of the themes of our time. But in London we are trying to do it administratively or hierarchically. That is, in the new Ministry we have a setup where, in form and official standing, it is impossible to say whether the administrator is a scientist or a civil servant. British high-level civil servants are traditionally efficient, intelligent, proud, with a very strong corporate loyalty, but they are cheerfully reporting to scientists, and scientists are reporting to even grander civil servants, and it is often impossible to tell t'other from which.

This seems to me a small-scale model of what may become a common pattern of administration machinery. The signs are hopeful. Not long ago I had a youngish official working with me on a fairly delicate and quite nonscientific task—the sort of task the British Civil Service is excellent at—and I assumed he was an orthodox entrant. I happened to ask him what his background was. I was both taken aback and delighted to hear that he was an electrical engineer.

The Cybernetic Revolution

It is a vulgar error to think that scientists should be employed only as scientists. The more mixed-up we are, the more we can take the edge off our social fractionations. At the same time—and this is a lesson that I wasn't altogether willing to learn—we have got to chase after and cherish certain special abilities more than we have ever done. In this kind of job one can't help brooding over the cybernetic revolution which is now breaking over us—the revolution which is being caused by the new sources of information and control, the computers whose effect (and whose putative nature) we are only partially beginning to understand.

One thing stands out as a warning and as a hope. This is going to be the biggest technological revolution men have known, far more intimately affecting men's daily lives, and, of course, far quicker, than either the agricultural transformation in Neolithic times or the early industrial revolution which made the present shape of the United States. To understand the actual technique of this cybernetic jump, we shall need deep and original conceptual minds. No country has many Norbert Wieners, but we need the nearest approach to Norbert Wien-

ers that we can find, and a lot of them. This means that mathematicians—or, more exactly, any men and women of mathematical insight—are going to take on a new relevance in all advanced societies. Much of our future —not the far future, but 15 years ahead—depends upon the talent of children not yet in their teens.

To an extent, this fact has been realized. Mathematical education, largely on initiatives from this country, though we have done some valuable work too, is radically different from what most of us went through. There are also growing up systematic attempts—this time pioneered by Russia—to select the minds which can benefit from intense mathematical education. There are probably not very many per million in any population.

The Russians call them "wunderkinder." There they are selected by a nationwide competition, which goes by the name of the Olympiad. The questions are deep, and the competition is tough, but it is obviously enormous fun for anyone with real mathematical ability. I know that some states here are making a start in the same direction. So are we, through the devoted efforts of some professional mathematicians and a private foundation. This year we have 10,000 entrants for the first stage of our Olympiad. I must say I should like to see more international competition among these boys and girls. It would be salutary for all of us.

Anyway, these will be the people who push through the next wave of the cybernetic revolution. We shall also need many people of different abilities, who are at every step of the way studying, controlling, and humanizing its effects. There was some excuse for our ancestors' not foreseeing the effects of the first industrial revolution. There is no excuse this time. And any change on this scale is bound, at best, to cause disquiet and, at worst, suffering. This is one of the many good reasons why we should be investing more—and more, perhaps, even than this country does, though in this you lead the world by streets—in the social sciences.

We need to know more exactly how we are living here and now. We are ignorant of the social life around us; we are more ignorant than is wise, or safe, or human. And this is where I come back to a plea for the mixed-up-ness of scientists, politicians, administrators, all the others—doctors, priests, citizens of goodwill—who are not cut off from our common humanity. We must get the ideas of what is happening to us because of the computers, and of what is going to happen, right into the open world of the Congress and of Parliament; for it is their duty not to be supine, not to be just carried along dumbly by the technological tide.

Conclusion

I am going to finish with a mixture of confidence and anxiety. I said, to start with, that there are no perfect solutions to the problems we are discussing and often no good ones, but I am sure we shall find work-a-day ones which will keep us afloat. Nothing can stop this country's scientific and technical advance. My country will soon be doing well. I don't believe that anything will stop the material progress of all advanced societies—that is, North America, nearly all of Europe, the Soviet Union, and a few more. And I believe these societies will find livable human answers to the cybernetics revolution, whatever the difficult patches on the way, for human beings are more resilient than some intellectuals give them credit for being; otherwise the whole species would have hanged itself long ago.

In short, the rich countries will get richer. Here my anxiety comes in. I wish I could believe that the poor countries, containing more than half our fellow men, would not get relatively poorer. The more we look at our own scientific and technological problems, the more, perhaps, we comprehend the enormous effort that is required by societies which have not had our history and our luck.

You don't have to go outside this continent to see this fantastic disparity in terms of flesh and bone. Or, go to an Asian town and see human beings lying absolutely still on the city streets; you may ask why they don't move, and the answer is, the less they move, the less hungry they will be. Of course, this fantastic disparity is reflected in the events of the tumultuous century in which we live. To echo with reverence the greatest of democratic leaders: the world cannot survive in peace half-rich and half-poor. It remains to be proved whether it can for long survive at all.

That is the greatest challenge to the next two or three generations. That is the greatest challenge to our science and technology and all our thinking about them and all the actions we take. That is the greatest challenge to our humanity—and maybe its final test.