Pure science and government

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PURE SCIENCE AND GOVERNMENT

It is a great pleasure for me to be here on the occasion of the opening of Queen's University's new physics building, and my first duty is to congratulate the university on the completion of this important phase in its development. As a physicist, I am particularly happy to join in this celebration.

Until 100 or even 50 years ago physics was a scientific discipline which represented part of man's endeavour to understand the nature of the physical universe in which we live. Today physics does not only represent this aspect of our striving for knowledge but it is also essential for our survival.

It is commonplace to a scientist, but is not always fully appreciated by the layman, or even by the engineer, that most of the important phases of our present technology are based on discoveries in pure physics or chemistry which were made in the pursuit of science for its own sake. It is only 134 years ago that Faraday made his great discovery of electromagnetic induction which forms the basis of all of our modern electrical power production. There was no thought of power production in Faraday's mind. He was interested in understanding better the nature of electricity and magnetism. So was Heinrich Hertz when 67 years after Faraday's discovery, he dis-

covered radio waves in his attempt to verify the prediction of Maxwell's theory of the electromagnetic field.

Only five years ago we celebrated the 100th anniversary of the start of spectroscopy by Kirchhoff and Bunsen, a field which has developed not only as a means of studying the nature of the universe and the structure of matter, but nowadays also provides indispensable tools in the production of aluminium, steel and other metals in industry, as well as the production of a host of other chemical substances which are vital to our present technology.

The atomic nucleus was discovered only 54 years ago by Rutherford in experiments which in his mind had no connection with the problem of producing power; but today we are on the threshold of the nuclear age.

Any number of further examples of recent scientific history could be quoted to show how purely scientific studies, aimed at nothing but the understanding of natural phenomena, have led, quite unexpectedly, especially to the discoverers, to important technical developments.

There is also an important feedback in that the technical use of scientific discoveries has led to improved instruments which in turn have helped the pure scientist to advance the borders of knowledge, and in that way to make further contributions to technological developments. I might perhaps mention a recent example

with a specifically Canadian background: physicists at the Chalk River laboratory of AECL recently developed a new radiation detector, a so-called lithium-drift germanium detector, which has increased the sensitivity of detection by something like a factor of 100. As a consequence, a group of physicists at NRC, in collaboration with a group at the University of Chicago, have been able to advance the study of μ-mesonic atoms by a very significant step. Now laboratories all over the world are wanting to acquire these detectors and one can only hope that Canadian manufacturers will be able to satisfy these demands.

There are certain fields in pure science where one is inclined to feel that they will never lend themselves to any technological applications. Astronomy is one of them, and high energy physics is another. Everyone seems to be agreed however that astronomy is worth pursuing even though it has no practical use, but the consensus of opinion is not as close with regard to high energy physics. Yet as a scientist, I feel that we should pick our field of research, not with a view toward possible applications, but with a view toward its significance in our attempt to understand the nature of things. Technological fallout, if I may use this horrible expression, will come anyway, and will justify the expenses involved in the pursuit of pure science, and it is quite

impossible to foresee where the future returns will be most rewarding from this point of view.

As a consequence of the feedback which I mentioned a moment ago, scientific research has become more and more sophisticated, and for that reason more and more expensive. Although at the same time the effect on technology has become greater, and thus the material returns have become larger, still people continue to worry about the expense of scientific research since in the last resort the money of course has to come from the taxpayer.

That applied research should be supported by government funds would seem to be obvious to everyone because it brings more income to everybody including the government. That universities should be supported by the government is also generally approved if only to train more scientists and engineers who can exploit the fruits of scientific research. However, to what extent pure science should be supported, directly or indirectly by government funds, seems to be questioned by many.

There are clearly two principal reasons for the support of pure science in Canada, and elsewhere. One is strictly mercenary. Experience has shown that pure science represents the goose that lays the golden eggs; it helps applied science and technology in their development as I have tried to exemplify by the examples given earlier. Many people do not seem to appreciate this point fully.

The other reason for support of pure science by government funds is that scientific research of the purest kind is an intellectual activity which, just like art, music, literature, archaeology, and many other fields, helps us to understand who we are, what is the nature of the world in which we live. Anyone who does not accept this as an important reason for generous support denies that man liveth not by bread alone. Obviously if Canada were an under-developed country in which the first priority should be given to increasing the standard of living, one might question the wisdom of spending considerable sums of public money on pure scientific research. But Canada is the world's second or third most affluent country, and if it cannot set aside a substantial amount of its income to furthering knowledge, pure and simple, we will be in a bad way. Are we really going to be a nation satisfied with good eating, good cars, good advertising on radio and television, or anything else that is good for the economy of the country?

The high cost of modern scientific research, both pure and applied, has led many people to demand that our government should have a clearly stated and pursued national science policy. And I presume that it is with these thoughts in mind that the organizers of this symposium have chosen the subject matter. Unfortunately I am not well qualified to talk about this matter since I have been mainly concerned with work in the laboratory and only

incidentally with policy and administrative questions. Although I have for some years had the responsibility for the direction of the Pure Physics Division of NRC, the highly decentralized organization of NRC, modelled on the university graduate schools, has kept me free from too many administrative and policy responsibilities, and has allowed me to continue to pursue my own scientific interests. Therefore I speak today as a scientist who has benefitted from, rather than been responsible for, NRC policy. However, I have had an excellent opportunity to observe the way in which the Honorary Advisory Council of NRC has in the past carried out its responsibility to develop the scientific resources of Canada. When I have, somewhat reluctantly, accepted to participate in this symposium, it is because recently there have been some developments in Canada which, if they are not closely watched and guided with great wisdom, may destroy the congenial climate and the loose but effective organization of science in this country. Perhaps it is therefore my duty to put on record my personal views, but I should emphasize that they are personal views and that I am not speaking on behalf of NRC in any official capacity.

I have always believed that we have been fortunate in Canada in that we have had a policy for science as enlightened and as foresighted as that of any country I know. This policy of course was established with the

formation of the National Research Council in 1917 and, under the leadership of a succession of able presidents, has been modified with the development of the scientific resources of this country. I do not need to tell you that the basis of this policy was the decision in 1917 to establish a programme of support for research and graduate students at the universities. Then there followed the establishment of the laboratory part of the National Research Council in the 1930's which were greatly extended during the war; and after the war the decisions to establish DRB and AECL as separate independent research organizations modelled on NRC; finally, the more direct development of scientific work in Canadian industry by a grants programme for industrial research. What impressed me was not only the sound way in which scientific activities have been built up, but also the compactness and flexibility of scientific organization in Canada as represented by the Research Council Act.

It came therefore as a great shock to me when, two years ago, the Glassco Commission came along and suddenly discovered that there was a lack of a science policy in Canada. They talked about "an evident breakdown of the system as designed". This is in spite of their reluctant admission that "science in government has, from some points of view, flourished as never before". Of course, no two people are agreed on what they call "national

science policy". The commissioners had one idea, while those responsible for the implementation of the Research Council Act had another. In my opinion the Research Council had a very clear conception of what a science policy can do and cannot do. They saw that the first requirement for building up scientific research in Canada was to build up research at the universities. As, much later, Dr Steacie stated so aptly: "it is quite possible to have first-rate university research with little or no industrial research, and in fact this has been our history. It is absolutely impossible to have first-rate industrial research without first-rate university research". Industrial research at the time of the framing of the Research Council Act did not exist in Canada. It would have been foolish to start building up industrial research without first developing research work of a high calibre at Canadian universities.

According to the Research Council Act, the function of the Honorary Advisory Council was, in addition to administering the programme of university support, also that of advising the government in scientific matters. And it is with regard to this item that the Glassco Commission makes such strong statements as "breakdown of the system as designed". Before discussing this point further however, it is necessary to emphasize another important move of the framers of the Research Council Act: the establishment of the laboratories of the National

Research Council with the President of the Council acting both as chief executive officer of the laboratories, and as Chairman of the Honorary Advisory Council. It seems remarkable that in those early days the framers of the Act, and perhaps we should give Dr Tory, as their advisor, credit for it, were so far-sighted (or if you like, so lucky) that they adopted an organizational structure which has proved singularly effective in minimizing the great danger in government control and administration of research, namely, bureaucracy. The combination of a first-class laboratory system with an Advisory Council of independent research scientists has proved to be one of the most effective deterrents against bureaucratic tendencies which has yet been found. The Honorary Advisory Council by this combined activity was forced to be far more down to earth than it would otherwise have been, and at the same time the members of the research staff have had an opportunity to contribute to the development of research at the universities and in industry.

I can assure you that for those of us who are required to help with this programme, it is a real chore, but nevertheless we feel that we are making a contribution, and we feel that the universities benefit by the fact that, unlike most grant-giving organizations in the U.S., we, together with the university members of the grant committees, are able to judge grant applications more fairly, and with

far less red tape, than would be possible in a paper organization. I think it would be most unwise if the close relation between the grant-giving function of the Council and the laboratory scientists should ever be abandoned. I am told by my colleagues at American universities that they are spending about one month every year in order to write up reports and proposals in support of their applications for funds for the subsequent year. I believe it was largely Dr Steacie who insisted that in Canada the paper work involved in the grants programme should be cut, and has been cut, to an absolute minimum, and nobody will have to spend more than a few hours each year to present his case to the grants committees. Here is a case of efficiency in government organization which I believe Mr Glassco and his commission did not recognize, but which is nevertheless very considerable.

Judging by the comments that I have heard from responsible scientisits all over the world, the laboratories of the Research Council have developed into one of the best research organizations in the world. And what is the reason for the success of this development? What is it that attracts first-class scientists to the National Research Council laboratories? And what has made the other operations of the Research Council in support of science in Canada so successful? It is primarily the flexibility of the organization, the capacity to depart from rigid

lines of departmental organization, and particularly the overriding philosophy that it is the working scientists themselves who should largely determine what is to be done. All this is naturally anathema to efficiency experts who look upon the organization of science from the same point of view as they look upon the organization of the Post Office or Income Tax departments. What the Glassco Commission was interested in, and what it was expected to provide to the government, were recommendations for more efficiency in government organization. How can you apply the concept of efficiency to creative thought? If only commissions like the Glassco Commission, and before it the Heeney Commission, would leave research organizations alone, these research organizations would continue to flourish, and would not have to spend valuable time in fighting the aftermath of these commissions. What these commissions want is uniformity, and conformity, and that, without doubt, would be the death of science and creative work. In my opinion if we want to improve the scientific scene in Canada we should not listen to the efficiency experts, we should not listen to the planners who think that they can foresee scientific developments even in the immediate future. To reassure you (and myself) that I am not too far out on a limb with these remarks, I should like to quote to you three excerpts from better known and more responsible people. Lord Hailsham, the former Minister

for Science of the British government, said a few years ago:

"No country in the world has ever successfully set up a Department of Science, in the sense of a Ministry directly controlling the pace, the scope and the methods of scientific research. This is due to two considerations. The first is that the strategic planning of science cannot be undertaken without full participation of the scientists themselves—and by these I mean, not just a staff of administrators with scientific degrees, but also men and women who actually carry on scientific work, whether in universities, government research stations, or industry."

Another well-known administrator and scientist, Warren Weaver, Vice-President of the Rockefeller Foundation, has this to say:

"The crucial word <u>diversify</u> is at the heart of the dependence of science upon the government. There are those who think that the National Science Foundation ought to sit like an infinitely wise spider, at the centre of a web which reaches into every governmental activity in science and presumably into every other science activity in our whole nation, planning just how science should advance, tightening up here, slackening off there. I do not think that many scientists hold this view. There is no person, and certainly no committee, which is wise enough to do this.

"We should, I think, be glad that this is so. For what keeps the total scientific effort from being chaotic and meaningless is <u>not</u> central planning or any attempt to

achieve it, but a kind of grand intellectual homeostasis, under which a multitude of influences interact in a natural way. What science needs is not a lot of planning, but a lot of convenient communication, so that controls may arise naturally from feedback."

And finally, Professor John Jewkes, a well-known economist at Oxford University, wrote:

"There is no kind of organized, or even voluntary, coordination which approaches in effectiveness the synthesizing which goes on in one human mind .... A large team is essentially a committee and thereby suffers from the habit common to all committees, but especially harmful where research is concerned, of brushing aside hunches and intuition in favour of ideas that can be more systematically articulated.

"In so far as society can usefully interfere, its task might well be to try to maintain the balance between the different sources of invention, to strive to prevent any one dominating to the exclusion of others. That country will, therefore, be happily placed which has a multiplicity of types of research agencies .... As contrasted with the ideal ways of organizing effort in other fields, what is needed for maximizing the flow of ideas is plenty of overlapping, healthy duplication of efforts, lots of the so-called wastes of competition and all the vigorous untidiness so foreign to the planners who like to be sure of the future."

I think these quotations emphasize the point that, for the scientific development of this country, it is far more dangerous to over-organize than to under-organize science.

The planners and efficiency experts will of course point to the Soviet Union where planning is done in a big way in science, and apparently successfully so. The Academy of Sciences of the U.S.S.R. seems to hold all the threads of scientific research in the Soviet Union, and one has the impression that our Russian colleagues cannot even answer some of our letters without the permission of the Academy. When you talk to individual Russian scientists however, you learn very quickly that by various dodges they free themselves of the shackles imposed by the Academy, and succeed in doing creative work. Considering the great successes of the U.S.S.R. in the space race, it must be emphasized that this has not much to do with creative scientific developments. The space race is a race in technology, and certainly I would not deny that planning and efficiency play an important part in successful technology.

It is very obvious to anyone who has looked at the figures that university support by the government as well as support of pure research in government laboratories has to increase considerably if Canada is to do its share in the development of new knowledge, and if Canadian economy is to derive the maximum benefits from scientific research.

If the new National Science Council is looking sympathetically at this problem and, above all, is able to obtain more funds for science, then perhaps it is worthwhile to set it up. However, there have been disturbing indications from some of the statements coming from the secretariat that when the new Science Council is established it will be immediately subject to great pressure to re-orient the science policy of the country and to take a very one-sided view of scientific requirements. There seems to be a feeling that the policy of the past has not been sound, that in the future pure research should be given low priority and all the emphasis should be on research giving immediate economic returns. The importance of applied research is recognized by everyone but if the increase in applied research is to be at the cost of pure research it can lead eventually only to a sterile technology. This will mean that 50 years from now Canada will end up having colonial status as far as science is concerned. All the creative scientists who might have sparked new unforeseen developments would have left the country, and all that will be happening in science in this country will be imitations of what other countries have done; and there will be no possibility of reciprocating to the other countries with something really new.

If that should become the attitude of the National Science Council, we would have done much better if we had

continued to rely on the Honorary Advisory Council and the National Research Council Presidents for guidance of our national science policy.

The National Research Council has always taken the view that the various departments and agencies of government should be responsible for the policy for the research needed for their own operations and has never felt that it should, in the words of the Glassco Commission, "scrutinize" the research of other organizations, or in any formal sense attempt to "coordinate" it. It was this attitude of the Council that caused the Glassco Commission to disqualify it from becoming more directly engaged in the formulation of the science policy. In this connection I should like to quote again Lord Hailsham who says, in the same speech which I quoted before:

"There is a sense in which there is no such thing as science, but only sciences. Another way of stating this is to say that science is in fact an all-embracing term, and that scientific researches into particular fields are functions of those fields and not of a comprehensive entity called science. From one point of view, medical research bears a much closer relation to the climate, population, health, diseases and economic activities of a nation than to their nuclear physics. In terms of science, as distinct from economic policy, it would be meaningless for a Finance Ministry official to try to

block a grant for medical research on the ground that the money was needed for a synchrotron. It is true that both projects must take their stand in the queue for the general investment programme. But they are related to other items in the programme more closely than to one another.

"What is wanted, therefore, is not a single scientific general staff forming part of a single department of science, but a series of scientific general staffs or Research Councils directing scientific research in the general fields to be occupied, independent of day-to-day bread-and-butter work in those fields, but in close contact with them."

In other words Hailsham believes, and I agree, that there is no particular merit of planning agricultural or medical science policy in the same office as science policy with regard to physics research. This means that there is nothing wrong with the system that we have had until now in which agricultural scientific policy, that is the amount of money spent on agricultural research, is decided by the government department of agriculture (without interference from or scrutiny by NRC); or in which geological and mining research is supported by the Department of Mines and Technical Surveys, defence research by the Department of National Defence, while policy with regard to the support of pure physics, chemistry and biology, as well as with regard to much of the applied work close to

these fields, is decided by NRC.

What is needed, according to Warren Weaver, is "a lot of convenient communication", and we have had just that by way of the numerous associate committees set up by NRC. In these associate committees all government departments that are affected by a certain problem are represented, as well as the universities and industry. Historically, one of the earliest examples of the effectiveness of such an associate committee was the Associate Committee on Cereal Rusts which, at the suggestion of Dr Tory, was a joint committee of the Research Council and the Department of Agriculture; and this committee can take a good deal of the credit for stimulating the research on the prevention of rust which, as is well known, has been so successful. Many other examples could be cited.

Another question with regard to which I cannot agree with the new scientific secretariat is their preoccupation with weak areas. The Research Council and its grants committees have always kept away from any interference with the research subjects that scientists are working on. A first-rate scientist knows far better what the important problems in his field are than any high-level committee. In the National Research Council laboratories there is very little direction from above, and I believe that that is as it should be. We at NRC, as at the universities, are relying on the ability, wisdom, and

creativity of the individual scientist, and the main problem is to find top-rate men. If you have found them then give them the wherewithal to do the work, let them find their own problems and don't bother them with planning from above, or recommendations for efficiency, with problems of collective bargaining and centralized purchasing, and so on.

Imagine the time when Rutherford was teaching at McGill University, and suppose that the experiments he was planning and which eventually led to the discovery of the nucleus, had been far more expensive than they actually were, so that he had to make an application for a special grant from the Canadian government. Suppose further that a prominent agricultural scientist had asked the government for an expensive institute for the study of wheat. What are the chances that the right decision would have been made by any high-level committee in weighing these two proposals against each other? The only safe procedure would have been to find money for both. Does anyone really suggest that the National Science Council, had it been in existence at that time, should have recommended to Professor Rutherford that it would perhaps be better if he spent his energy on a somewhat different topic, more in line with the needs of the economy of the country? Well Professor Rutherford left the country, and I do not know whether it was because he did not get sufficient support. All I am suggesting is that it is unwise to direct pure science into weak areas. It is far wiser to rely on the imagination of the top-rate scientist

even if he does not produce results that will lead to great benefits to the country. He will at least produce something equally valuable, and that is an advance in our knowledge of the subject in which he is interested. And here it must be remembered that in the more recent past almost all significant advances in knowledge have also led to technologically important applications.

If the time comes, and some people I am sure believe that it is already with us, when the funds available for pure research will be insufficient to support all the top-rate people who deserve to be supported, then it would be far better in my opinion to have a committee of the top-rate people involved decide which big installations should be given high priority, rather than to leave this matter to a committee preoccupied with the economic problems of the country in the immediate future. It is in the distant future that the results of pure research will bear fruit with regard to the economics of the country.

In closing I would like to come back for one moment to the point which I originally made and quote to you from a convocation address given at the University of Saskatchewan by Professor D.N.W. Wilkinson of Oxford University at the time of the official opening of the linear accelerator. Anyone who has heard Professor Wilkinson speak will, I believe, agree with me that he is one of the finest lecturers physics has today, and in addition he is

known throughout the world for his contributions to nuclear physics and high energy physics. On the 6th of November last year, at the close of his convocation address, Professor Wilkinson said:

"And so we delight in physics for the same reason that we delight in the arts, because it makes us feel good inside and because it takes us further along the endless road that is ours alone, the realization of Man as Man.

"The pursuit of physics is not just a contribution that must be made by society to its own intellectual standard of living, it is also a deep contribution to Man's self-realization; it will bring an ever-widening understanding of Man's place in Nature and Nature's place in Man.

"It is for us to recognize that, in a deep sense, the world, life and joy are what we make them and finally to ask in concrete terms: "Is this not worth two per cent of our Gross National Product?"".