The dangers of science policy

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Convocation Address, York University

7 November, 1969

"The Dangers of Science Policy"

by

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Division of Physics

National Research Council of Canada

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Eminent Chancellor, President Ross, Graduates of this Convocation, Distinguished Guests, Ladies and Gentlemen:

On behalf of Professors Swings, Underhill, Dr. Petrie and myself I should like to express to you, Mr. Chancellor, our sincere gratitude for the honours you have just conferred on us. York University, since its foundation in 1959, has very quickly developed into a large and forward-looking institution of learning, with a character all its own. We are proud, Mr. Chancellor, that the Senate of this University has seen fit to confer Honorary Degrees on us and thus to enable us to take part as alumni in the further development of this University.

The occasion which has led to this event is the formal opening of a new building devoted to physics, chemistry, astrophysics and astrochemistry, and named after a great Canadian astronomer, the late Robert Methven Petrie. We honorary graduands would like to join with all other friends of York University in extending our congratulations to the University on the completion of this important phase in its development.

It was my privilege to know Bert Petrie for many years and to be able to appreciate his great contributions to astronomy as well as to the development of this science in Canada.

Astronomy is sometimes referred to as the Queen of the Sciences. It uses the results of many other sciences in order to explore and understand the universe in which we live, an aim that lifts man above other creatures of the world.

Since ancient times man has spent a great deal of effort on astronomy, partly because of its use in navigation, but mainly to search for knowledge about the nature of the universe. Yet it was through astronomy that the fundamental laws of motion were first recognized by Newton. Without a clear recognition of these laws, modern technology could never have been developed.

There are, of course, many other examples of human effort in pure science resulting in great scientific discoveries which later turned out to be of enormous economic benefit to mankind. Let me give you a few further examples. When Faraday discovered electromagnetic induction, a phenomenon on which the whole of modern electric power production is based, the then Prince of Wales asked him after a lecture "Of what practical use is this new discovery?", and Faraday's answer is reported to have been "Sir, of what use is a new-born baby?". In other

words, the great Faraday, even after the discovery of electromagnetic induction, did not foresee what great practical benefits might arise from it.

Lord Rutherford, who spent a number of years in Canada at McGill University and who is rightly considered to be the founder of nuclear physics (he was the first to produce an artificial nuclear disintegration), until his death in 1937 scoffed at the idea that nuclear energy might one day become useful. That was only five years before Fermi constructed the first self-propagating nuclear chain reaction in Chicago in 1942, the beginning of the nuclear age.

Another interesting and more recent case is provided by the history of the maser and laser. Professor Townes, who first proposed these devices, gave last year in the journal Science (vol. 159, p. 699) a very interesting presentation of the history of their development. The Bell Telephone Company and three other companies, each of which had strong research groups in microwave spectroscopy shortly after the last war, gave up this activity because they felt it was not of any foreseeable practical use. This was just two years before the maser was developed on the basis of this work in microwave spectroscopy. Again, a few years later when Townes and Schawlow wanted to patent their basic ideas for an optical maser (laser), the Bell Company's patent department refused to consider it because they thought

"the invention had little bearing on Bell System interests". To-day there are more than a hundred research workers at the Bell Telephone laboratories working on laser problems, and thousands in other industrial laboratories throughout the world. There is no longer any question of the great practical importance of lasers.

There are innumerable other examples of discoveries and inventions with similar histories.

What I am trying to suggest is that

(1) it is impossible (even for the people directly involved) to foresee what practical uses may arise from discoveries in physics and chemistry, and therefore it is impossible to plan for such discoveries;

(2) many scientific discoveries of technological importance have been made by scientists dedicated to the pursuit of knowledge for its own sake without any thought of possible economic benefits;

(3) even if one were not convinced of the importance of pure science as a cultural pursuit and adopted a completely mercenary attitude, one would have to support the work of top-rate pure scientists in order to reap economic benefits of their discoveries, and these benefits are not obtainable in any other way.

There is nothing new in these three points; they are easily documented. The reason I emphasize them

is that they are often overlooked. Of course, lip service is often paid to pure science as a cultural pursuit, but it is only rarely emphasized that really new technological developments depend on discoveries in pure science made without regard for their possible usefulness.

Our modern life has been so strongly influenced by the technological developments based on the scientific discoveries of the last hundred years that we are prone to over-emphasize the utilitarian aspects of science. Indeed, many people seem to equate science and technology and seem to believe that you only need to tell a team of scientists what problem they ought to solve and they will come up in short order with the solution, in much the same way as a team of steel workers when told to build the framework for a new skyscraper will build it up promptly. Some people seem to think that this sort of procedure is the essence of science policy. At a hearing of the Senate Committee early this year it was seriously suggested that there should be a scientific audit system according to which every scientific project, at least in government laboratories, would be reviewed every year by outsiders in order to establish whether it still served its particular aim or should be discontinued. It seems to me that such a procedure would be apt to stop dead in its tracks all scientific progress in government laboratories and, at the same time, so many university scientists would be required for this audit that their scientific

productivity also would be seriously impaired.

The thinking behind many of the discussions on science policy (particularly when it refers to science rather than technology) completely overlooks the way in which a creative scientist works. It has been pointed out many times that no team has ever come up with a new idea, just as no team has ever written a good novel or poem. A scientific idea originates on rare occasions, in the mind of an individual scientist after he has struggled with the subject of his studies for many years. It cannot be foreseen by a committee or a scientific administrator. In order to do his best original work a creative scientist needs freedom from specific directives, and this applies irrespective of whether he works on fundamental principles or on applied problems.

Let me give a recent example that occurred at NRC. Two scientists in our Radio and Electrical Engineering Division conceived of a new principle of electrical measurement and adapted it to the development of a new potentiometer an order of magnitude more sensitive than previous instruments. This has now been put into production by a Canadian company. Orders which they have received indicate clearly that this instrument will soon be an indispensable tool in every standards laboratory in the world. It is interesting to note that this potentiometer was not developed by scientists in our electrical standards laboratory (to whose mission it would

have belonged) but in another laboratory of NRC, and it was not developed because the Council was asked to find a more sensitive potentiometer but because the two scientists were interested in an idea they had and were given the freedom to pursue and follow it just to see what would come of it. In this way are the great - and the profitable - scientific discoveries made. Think what might have happened if the scientists had been so circumscribed that they could only do research on immediately practical problems. Since no request for a more sensitive potentiometer had been formulated they would never have been allowed to waste their time following up their scientific interests and would have been assigned to more practical problems. Or, worse still, think if some committee or some bureaucratic administrator had placed a request for a more accurate scientific instrument and scientists were assigned to the job but there was no original idea. There would have been a long and industrious effort to improve instruments along traditional lines with perhaps an improvement of a few percentage points in the accuracy, but there would have been no new export industry for Canada.

In the United States Professor Townes, in the article that I have referred to already, has made an overwhelming case against the planned development of basic research, showing that the actual developments in science in innumerable instances have gone far beyond

anything that people expected or were planning for. For the same reasons, Dr. DuBridge, the Science Adviser to President Nixon, at a dinner of the National Academy of Sciences last April made a very strong plea for an increase in the support of basic science, without restrictions introduced by administrators. In Canada, unfortunately, the views of people who agree with Professors Townes and DuBridge are drowned by those who believe that national objectives and economic returns can be achieved only through bureaucratic control and work on predetermined projects. The Science Council and almost all the administrators who testified before the Senate Committee start with the thesis that there has been too much basic research in Canada and that, in future, everything should be mission-controlled. It is this general attitude toward basic science, even more than the cut-backs, which is having such a bad effect on the morale (and therefore on the creativity) of scientists, both pure and applied, in government research laboratories.

What are the ways in which we should support science? The National Research Council, entrusted with the support of research at universities by the government, has always maintained that the most important thing is to support excellence in research and not to worry too much about the particular research projects for which grant applications are made. No top-rate research scientist will waste his time on trivial research. On the basis of

this general policy, both for the awards program and for the in-house research, the National Research Council succeeded in building up an organization that has been the envy of most other countries. Even the Glassco Commission, entrusted with the task of recommending improvements in government organization, had reluctantly to admit that the National Research Council had been very successful. However, the Glassco Commission was really not interested in good science. It was interested in good accounting. Mr. Glassco, after all, was an accountant. There is, of course, nothing wrong with good accounting, except that it does not necessarily lead to good science. The Glassco Commission considered the National Research Council in the same way as the Post Office or the Justice Department. Of course, these are important government departments, but their way of working is of necessity quite different from that of a research organization. This difference was clearly not recognized by the Glassco Commission. What it should have done was to enquire what particular organizational features were the reason for the high international standing of the National Research Council and how this standing could be further improved. Instead, the Glassco Commission recommended reorganization aimed at making the set-up tidier and more amenable to accounting. Among many other things it recommended that all purchasing in government departments and agencies be centralized in one single

purchasing department. Applied to a research laboratory it means that we are to save a few dollars at the expense of thousands of dollars wasted in the time of creative scientists which they would have to devote to overcoming the delays and other roadblocks introduced by the centralizers. Efficiency in creative research of course cannot be measured in dollars and cents and so it does not appear on the balance sheet, but the small savings that might be accomplished by centralizing do appear. Thus the centralizers are likely to win.

The Prime Minister recently quoted in Parliament (27 February 1969, p. 6017 of Hansard), a Roman official, Petronius Arbiter, who lived at the time of the Emperor Nero almost two thousand years ago, and who said "We tend to meet any new situation by reorganizing. And a wonderful method it can be for creating the illusion of progress while producing confusion, inefficiency and demoralization". I believe that the opinion expressed by Petronius Arbiter, taken with a grain of salt, is still as valid to-day as it was 1900 years ago, particularly when attempts are made from outside to reorganize and centralize flourishing research laboratories.

Another closely connected point has been raised by many non-scientists, and in particular, quite recently, by Senator Grosart, a member of the Senate Committee. He complains that "each of 22 federal departments and agencies,

as well as other arms of the federal government, make science spending decisions independently without any overall government plan". It is perhaps conceivable to have an overall government plan for technology, just as it may be possible to have an overall government economic plan or even an overall political plan (meaning a central government), but at the frontiers of science this is clearly impossible because scientific discoveries are not made that way, as I have already emphasized. Actually, we are now in danger of having one department tell all the 22 of which Senator Grosart spoke what they may or may not do, and this is a far more dangerous situation than that described by Senator Grosart. It would be a calamity for Canada if Treasury Board alone (as is unfortunately already happening more and more) were to make all these spending decisions on the advice of its own science adviser who cannot possibly be sufficiently familiar with all areas of science and is unlikely to be an active scientist familiar with the needs of his fellow scientists. But if he were, and were to recommend to the Board that it give scientists the freedom to organize their laboratories and their services according to their needs, would his advice be heeded? I fear that the demand for central control, for uniformity and for particular accounting practices would win over the needs of science. Such bureaucratic control may be necessary for some government departments, but when it is applied to scientific laboratories it can only lead to the

exodus of the top-rate scientists and thus to mediocrity.

If science policy implies centralized planning of all phases of science and therefore one gigantic scientific bureaucracy, I am sure we would be much better off without such science policy. In this connection I should like to quote again, as I did four years ago at the opening symposium of the Queen's University physics department, Professor Warren Weaver, a well-known American administrator and scientist, Vice President of the Rockefeller Foundation, who wrote:

"The crucial word diversify 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 not 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."

If you compare this statement of Professor Weaver with some of the pronouncements of people interested in science policy in Canada, you will notice quite a difference in outlook. It has been stated many times in the last few years by politicians, administrators and newspaper writers that science is too important a subject to be left to the scientists and that scientists ought to be told what to do. One may ask "by whom?". It is clear that our lawmakers and other non-scientists find it difficult to understand that the work of top-rate scientists is creative work similar to that of writers and artists. Only governments on the other side of the iron curtain are in the habit of telling writers what to write, artists what style to use, etc. Should we in this country begin this trend by telling our creative scientists to which problems they should turn their attention? As pointed out by Professor Polanyi of Toronto University, in one of the most important statements recently written about science policy (Science Forum, June 1969), even a man like Albert Einstein could not foresee the outcome of his work after he had completed at an early age his epoch-making discoveries on relativity and quantum theory. He spent the major part of his remaining years on what seems to have been a fruitless search for a unified field theory. Could a

science administrator or politician have told him that he was on the wrong track and should do something more useful?

There is no question in my mind that if we want the best possible science we must give top-rate scientists the freedom to undertake what they (the scientists) consider to be the most promising ventures, pure or applied.

Before concluding, let me summarize my main points:

(1) The history of technology shows that many of the major developments of the last hundred years are based on scientific discoveries made by scientists motivated entirely by the quest for knowledge. If we want to ensure further beneficial development of technology in Canada we shall have a much better chance of success if we support basic research with all possible freedom for the individual scientist than if we support only those missions in which we can foresee immediate advantages. We cannot foresee which field of the research of to-day will be an important contributor to the technology of tomorrow. The exclusive or predominant support of mission-oriented work can only lead to mediocrity.

(2) The greatest enemy of progress in science and technology in Canada is bureaucratic control. The interference of politicians, accountants and committees in the free development of creative

processes in the scientific laboratories of the country is becoming more severe every year. If allowed to continue unchecked, this tendency is liable to stop all real progress.

Man does not live by bread alone. Even the cave-dwellers thousands of years ago, in spite of all their hardships, their poverty, their lack of tools, devoted time to paintings, to the study of natural phenomena. What would distinguish us from animals if all we were interested in was the improvement of our standard of living by producing better food, better clothing, better television, better cars, better houses, etc. etc.? What distinguishes man from beast is that he can think about the question of who he is, where he comes from, what the world is like in which he lives, or, in other words, that he can pursue art, literature and science.

If we do support creative men of science we are bound to receive a bonus in the form of economic benefits that arise out of scientific discoveries, as I have exemplified earlier in my talk. In my opinion, however, we should not be greatly concerned whether the material benefits match or surpass the funds that we have put into the support of pure science, just as we should not, as has recently been suggested, reduce university education because the resulting economic benefits are less than the cost of university education.

May I suggest to the new graduates who have just obtained their degrees here that they ponder the problem of our national goals in Canada, and realize that a high standard of living by itself is not, as such, a goal worth striving for unless a high standard of living includes a high standard of art, literature and science. If Canada is to be economically prosperous without at the same time supporting the arts and the sciences for their own sakes, it will not reach the level of a great nation. The countries in past history that we admire most are not necessarily the economically prosperous ones but those that have made major contributions to our cultural heritage. Your aim should be to make Canada a country that is recognized throughout the world, and throughout history, as a country that has advanced in a significant way the progress of science, art and literature.