Science and culture

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SCIENCE AND CULTURE

by

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Mr.Vice-Chancellor, Mr.Vice-President,Graduates of this Convocation, Distinguished Guests, Ladies and Gentlemen:

My first and most agreeable duty is to say how much I appreciate receiving the Honorary Degree of Doctor of Science from this University. I am both pleased and proud, Mr. Vice-Chancellor, that the Senate of this University has seen fit to confer an Honorary Degree on me and thus to make me an alumnus of this forward-looking University.

In choosing a topic suitable for this occasion I considered it unwise to talk about purely scientific matters, although for me this would have been the easiest solution. The trouble is that there is a wide chasm in understanding of scientific matters between scientists and non-scientists.

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A few years ago, C.P. Snow in his Rede lecture at the University of Cambridge on "The Two Cultures and the Scientific Revolution" pointed out the lack of understanding of scientific matters and of the scientific language and scientific method on the part of non-scientists. He was thinking of the gulf between the scientists and the humanists and also between the scientists and the politicians. He said: "Literary intellectuals at one pole - at the other scientists, and as the most representative, the physical scientists. Between the two a gulf of mutual incomprehension - sometimes (particularly among the young) hostility and dislike but most of all lack of understanding. They have a curious distorted image of each other. Their attitudes are so different that, even on the level of emotion, they can't find much common ground."

When Snow made these remarks, eleven years ago, the idea of two opposing cultures was sufficiently novel that the publication of the text of his address led to considerable discussion both in scientific and literary circles, even though the facts had been known for many years.

To-day a somewhat different situation has gradually developed and one is tempted to talk of three cultures: scientists, humanists, and politicians (that is, if you are willing to accept politics as a cultural subject). During the last decade politicians have

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gradually recognized the importance of science for the development of the economy of their countries and, while they still do not understand science, they are aware of the political consequences. Several of them in Canada have recently expressed the thought that "science is too important a subject to be left to the scientists". This reminds me of the situation in the Soviet Union, where the writing of novels and poems is considered to be too important a subject to be left to the inspiration of the novelists and poets and must conform to the dictates of national objectives. We have all heard of the lack of freedom of authors in Communist countries, and it is precisely this lack of freedom that is the principal difference between their system and ours.

The reason why politicians feel that scientists ought to be told what to do is partly that they do not make the distinction between science and technology. They consider that all that science is good for is to help in improving the economy of the country. They do not realize that science, at its best, is a creative (cultural) pursuit which is not (or not necessarily) concerned with economic betterment.

It is perhaps for this reason that, as was pointed out to me by my colleague Dr. J.D. Babbitt, the antagonism between the two cultures about which C.P. Snow was mainly talking (namely scientists and humanists) has softened greatly, and that both to some

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extent have joined forces in the defence against the third culture, the politicians, in order to maintain the freedom of creative work whether it is in science or the humanities. It is significant that in its submission to the Senate Committee on Science Policy the Canada Council came out more strongly for freedom in creative work including science than the National Research Council dared to do under the circumstances.

Another group (perhaps a fourth culture) are the student activists. Most of them also don't understand science. They also think of technology when they speak of science. They are concerned, and rightly so, about the consequences of some of the technological developments of our time, but they want to throw out the baby with the bath water. Clearly pollution, over-population and overcrowding are serious problems, but to believe that we can return to the day of the pre-scientific age is sheer folly. Student activists are largely non-science students, and they have not grasped the fact that scientists are principally interested in under-standing the nature of the universe (i.e. in knowledge) and not in increasing the complexities of modern life. In fighting science in general the student activists would be fighting precisely what I would suppose is their main aim, that is, to emphasize the cultural aspects of our life over the technological aspects, or, put differently, they join the politicians in our triangle because of the

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same misguided idea that science is technology, but they take a view opposite to that of the politicians who want to make use of technology and therefore circumscribe the scientist.

The factor that complicates greatly all these mutual confrontations is the fact that fundamental discoveries in the physical sciences made by scientists interested only in knowledge of the physical or biological universe can be exploited in technology and can help to better the economic position of people and countries. Indeed, the best way to ensure progress in technology is to give creative scientists freedom to follow their own inclinations in the pursuit of knowledge. The amount of technological fall-out obtained in this way is bound to be much greater than when all the work of scientists is determined by administrators who insist on various missions. I don't really consider this an advantage of the situation of science, but it is a fact of life.

To illustrate what I mean, I would like to remind you of the origin of electric power. All our present electric power is produced by dynamos and these dynamos are based on the principle of electromagnetic induction. This principle was discovered only about 140 years ago by Michael Faraday. Faraday had no idea that his discovery would be of such enormous practical use. He was interested in understanding the nature of electricity and magnetism and seeing whether the two

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were somehow connected. Since he knew that an electric current produces a magnetic field, he asked himself: Would a magnetic field be able to produce an electric current? - a question that he so brilliantly answered by the discovery of electromagnetic induction.

It was only about 80 years ago that Heinrich Hertz, following up the discovery of Faraday and the theoretical predictions of Clerk Maxwell a few years earlier, discovered electromagnetic waves, that is, radio waves. Whether or not you believe that radio and T.V. are good things, it is I believe beyond question that the discovery of radio waves has contributed greatly not only to our understanding of the nature of light and other natural phenomena but also to the material benefit of mankind, for example in the safety of travel both on the sea and in the air, and, for that matter, in space.

When Albert Einstein developed his relativity theory he was really interested in a philosophical question. He wanted to determine whether or not there is an absolute system of reference in the universe and he showed that it does not exist, but as a result of his studies he also showed that mass and energy are equivalent. This knowledge for the first time explained the production of energy by the sun, without which there would be no life on earth. It also opened up the possibility of producing energy from atomic nuclei, with all the attendant problems of atomic weapons, etc.

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Again, Einstein did not foresee when he developed his theory that it would have in the hands of technologists and politicians such enormous practical impact, for better or for worse, on mankind.

Finally, let me give you a more recent example, the discovery of the laser. The history of its discovery has been ably described by one of its discoverers, Professor C. H. Townes [SCIENCE 159, 699 (1968)]. He and his collaborators were interested in microwave spectroscopy in order to study with its help the structures of simple molecules. There were also interesting questions concerning the radiation field, in particular whether the stimulated emission predicted by Einstein could be detected. These studies led to the invention of the MASER (an acronym for microwave amplification by stimulated emission of radiation). When the same ideas were applied to light the LASER was born. It is interesting to read in Professor Townes' article that, in the early stages, industrial laboratories like the Bell Telephone Laboratories had very little interest in this development. Indeed, the patent department of the Bell Company, as Townes relates, "at first refused to patent our amplifier or oscillator for optical frequencies because, it was explained, optical waves had never been of any importance to communications and hence the invention had little bearing on Bell System interests". Now, there are hundreds of research workers

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... Bell laboratories working on lasers because lasers have turned out to be important for communications. What this example shows (and many similar ones could be given) is (1) that the drive for a really new development comes from creative scientists who are motivated entirely by the desire to understand certain natural phenomena, and (2) that it is extremely difficult to foresee the possible technological applications of new advances in basic research even for the originators of these advances.

The reason why I mention all these examples is to impress on you, particularly on the new graduates, that the prime motivation for scientific research is the desire to understand nature. It is an urge that, just as art and literature, lifts man above animal. It is, as Dr. Lee DuBridge, the Science Adviser to the President of the United States, recently expressed it "an enterprise of prime importance to the human spirit and to the human condition". It is true that often the applications of scientific discoveries lead to technological advances, but I would urge you to distinguish clearly at all times between technology and science, a distinction that our politicians so often fail to make and to appreciate.

It is, of course, also true that a great deal of work in science is mission-oriented, is directly concerned with some practical problems. Indeed, almost all medical research is entirely motivated by the aim to reduce suffering from disease and to improve health. If we want

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to combat pollution we have to apply sound scientific principles and seek ways and means of reducing its effect. All that is a perfectly legitimate and desirable scientific activity. All I am trying to say is that there is in science also a most important component that has nothing to do with the gross national product or economic betterment but is solely directed to an intellectual aim. A country like Canada, which is inherently wealthy, cannot afford to overlook the need for abundant support of this kind of science. Actually, of course, as I have already emphasized, it has always turned out that the results of pure research have an effect on practical problems, so that even the people who are solely interested in the growth of the GNP will have to support pure science, but to my mind that is a poor motivation.

Another point that we must remember is that it is very difficult to recognize at an early stage whether a given person will develop into a creative scientist. Some people develop early, some people late. Very few people would have suspected, when Einstein was simply a clerk at the patent office in Zürich, Switzerland, that he would be the greatest scientist of this century. Therefore we cannot restrict our support of pure science to the support of a few scientists of proven excellence. We must support a very much greater basis, and indeed, even for the moderately gifted people there is a wide

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field of worthwhile activity in science, pure or applied.

Democracy does not mean that all people are equal, it means that everybody should have the same opportunities. Some people are brighter than others and therefore can make better use of the opportunities given to them and thus make greater contributions to the physical and spiritual goals of their country and of humanity. It is not necessarily the student who gets the highest marks in examinations who will become the most creative person. But everyone should strive for excellence to the best of his ability. If he cannot himself make creative contributions he can still help those more gifted than himself to do so. Above all, however, even if he himself is doing fairly routine work he should, as an academically trained person, appreciate the fact that man does not live by bread alone, that some of our resources must be spent on things that have no connection with economic well-being, on 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.