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Linus Pauling Award Speech

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Mr. Chairman, Professor Pauling, Distinguished Guests, Ladies and Gentlemen:

I feel deeply honoured by the award of the Linus Pauling Medal and even more honoured and privileged that Professor Pauling himself is present at this occasion. Looking over the list of previous recipients of this medal I cannot help but feel that I have very few credentials to be counted among this distinguished group. Indeed it appears to me that the very kind words that have been said about me must refer to somebody much better than I am. Nevertheless I am very happy indeed to accept this honour that you have done me.

When I was informed of this award a few months ago I was told that on previous occasions the awardee had one award address to give and that was at this dinner. It was felt however and I believe rightly so that for a captive audience including many who are

not scientists a technical address is somewhat of a hardship and it was suggested that the scientific part of the award address should be presented during the symposium which I have done this afternoon. What I am going to say now is not what you might call a formal award address but rather consists of a few thoughts that I hope you will find of interest.

It is well known that there is a wide chasm in the understanding of scientific matters between scientists and non-scientists. A few years ago, C.P. Snow in his Rede lecture at the University of Cambridge on "The Two Cultures and the Scientific Revolution" discussed this 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 C.P. Snow made these remarks, twelve 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 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".

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, 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 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 in the humanities.

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, overpopulation 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 understanding the nature of the universe and not in increasing the complexities of modern life. In fighting science in general they 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 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 fall-out to be 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 [illegible] these dynamos are based on the principle of electromagnetic induction. This principle was discovered only about 150 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 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. 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 in the 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.

The reason why I mention all these examples is to impress on you, 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 former Science Advisor to the President of the United States, 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 we must 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 to combat pollution we have to apply sound scientific principles and seek

ways and means of reducing its effect. All that is 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. 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.

At this point I would like to quote an interesting exchange that happened two or three years ago in the United States Congress between Senator Pastore and Dr. R. Wilson the Director of the National Accelerator Laboratory in Batavia. The Senator asked

> Is the accelerator connected in any way with the security of our country?

Dr. Wilson. No, sir, I do not believe so.

Sen. Pastore. It has no value in this respect?

Dr. Wilson. It only has to do with the respect with which we regard one another, the dignity of men, our love of culture.

It has to do with those things. It has nothing to do with the military, I am sorry.

Sen. Pastore. Don't be sorry for it.

Dr. Wilson. I am not, but I cannot in honesty say it has such applications but it has to do with whether we are good painters, good sculptors, great poets, I mean all the things that we really venerate and are patriotic about in our country. In that sense, this new knowledge has everything to do with honor and country but it has nothing to do directly with defending our country except to help make it worth defending.

While it is true and I believe desirable that the application of science in modern technology has greatly improved our standard of living, is helping to remove poverty, to avoid hard physical labour and so on and so on, it would be a sad situation if that were the only way that we made use of our intellectual capability and the only reason why we do science. A colony of ants does precisely this. There are no areas of poverty in an ant hill, everyone has his purpose in life and that

is to live, to eat and to propagate. The real difference between man and beast comes when he uses his intellectual capabilities for things that are not related to survival. As we all know, since the earliest days of history, man has spent some of his time on art, on literature, on philosophy and on science. Just as we should and do support education for its own sake or support museums of art or support the performing arts (although that has come rather late on this continent but has been quite common in Europe for more than two centuries), we should also continue to support the pursuit of science for its own sake, for the aim of understanding our place in the world and understanding the nature of our universe without any thought of material benefits that may arise from this work. I believe that science ranks with literature and art as one of the things that make human life worthwhile or as Robert Wilson expressed it, "Makes our countries worth defending".

After saying this I should emphasize that I am not trying to deprecate the activities of those scientists engaged in mission-oriented work in trying to combat pollution and trying to cure diseases like cancer and many other such activities. All I am saying is that there is and there should be an

important place for scientific activities which are not aimed at anything else but the improvement of knowledge for its own sake.

In conclusion may I say again how honoured I am in having my name linked to that of Linus Pauling. I thank you Mr. Chairman and the Oregon and Puget Sound sections of the American Chemical Society for this wonderful evening and the great distinction you have conferred on me, and I thank you all for your warm reception.