Science and Technology for Development

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Although science is always pushing the frontier of the unknown further back, there are also other frontiers to reckon with. In this world, a political entity with only one frontier stands in isolation. To avoid becoming an isolated island or an ivory tower, science has to act at the interface of many frontiers that include not only knowledge, but technology, society, politics, and development.

Summary. Science and technology are an integral part of international development, and it is important to convince our governments in the developed countries that money invested in science and technology in the Third World is for the mutual benefit of all.

The frontier between science and the unknown is well understood and does not require further explanation, because it is the only one that can be crossed in only one direction. The boundary between science and technology is more complex because it is a constant two-way crossing, with science contributing to the development of technology and vice versa. That science has a common boundary with society is obvious. Scientists tend to believe that their discoveries benefit society immensely and are often convinced that it is a one-way crossing. Much to their surprise, they are now finding that there is a push-and-pull phenomenon all along this frontier. The person in the street is no longer passive with respect to the subject and orientation of research and, furthermore, his or her voice may influence governments and the funding of research. This influence of society is responsible for another frontier, which we seldom want to discuss openly: the frontier between science and politics. The fact is that politics, through the funding mechanisms of research, has invaded that which was until recently our almost complete freedom of action. Although we, as scientists, have tended to remain passive, reacting only to defend budgets, this frontier is also a two-way crossing, and we could have a profound effect if we were well coordinated in our actions on the other frontiers just mentioned.

Finally, the frontier between science and development is relatively new, although it tends to become longer every day and more difficult to control.

After World War II, as we began to envision the enormous possibilities for our countries offered by science and technology, the Third World countries, just emerging from their colonial status, saw therein a route to their own development. Modern science and technology were expected to accelerate their development and even to bridge the gap between the former colonial powers and the new independent states.

In 1963, the United Nations organized a conference on the application of science and technology for the benefit of underdeveloped regions. It gave cause for even greater hope. Alas, 18 years later, the gap between rich and developing countries has scarcely been bridged. Science and technology in developing countries have not lived up to expectations; the tremendous progress during these years has been mainly in our developed countries.

At a meeting in Singapore in 1979, the International Council of Scientific Unions (ICSU) and 18 other international scientific organizations concluded that

> . . . the present moment is one of great danger for all humanity. The growing disparities in wealth, the prospects of large increases in population, carrying grave consequences with regard to food, the provision of shelter and pressures on materials and energy resources which we have finally come to appreciate as limited, threats to the environment; these and other problems of a global character cannot be solved by countries and demand a concerted international effort if humankind is to survive with dignity and with reasonable material conditions.

What Is Expected of Science and Technology?

"Science and technology are not simply to be applied to development . . . they are an essential part of development. They are inextricably bound up with the social, economic and political parameters of development." So said Dr. W. K. Chagula, former chairman of the U.N. Advisory Committee on the Application of Science and Technology (ACAST). Indeed, science and technology are not neutral. Much depends on the way and for what purpose they are utilized. The way in which they are integrated within the overall policies of a given country can lead to developmental failure or success. Local responsibilities must therefore predominate. Few will dispute the need for the governments of the developing countries to elaborate and to select carefully and to implement for themselves the various scientific policies needed at a particular period and at a given phase of their development. Nevertheless, there is much that we can do.

There are several ways by which we can contribute directly and indirectly to the utilization of science and technology for the development of the world. Financial aid is not the only important contribution. Active collaboration in joint projects, intensive participation in the training of young scientists, wider diffusion of research and technological innovations, and intensification of research programs geared to the solution of problems of relevance to the Third World are only a few examples of what can be done. But let us also consider why we should contribute to a better utilization of science and technology for international development.

First, our resources are limited and must be shared. Disparities that are too wide lead to disputes and, sometimes, wars.

Second, as scientists we are clearly responsible for disseminating our knowledge and sharing our experience and competence with the community at large.

It was agreed among the participants at the Singapore meeting in 1979 that an expanded commitment by the world community of scientists and technolo-

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gists to the problems of development could be articulated in an action program. This program would entail a reshaping of the present attitudes and institutions of the international science and technology community to work on the technical problems restricting social and economic development. New patterns of cooperation would be devised through the use of existing institutions that would become characterized by increased flexibility and experimentation. For such a program to succeed, however, the cadre of scientists and technologists dedicated to the creation of new science and technology knowledge for development and to its application to the solution of key development problems would have to be greatly expanded.

Present Framework for International Cooperation in Science and Technology

As a whole our scientific communities are well organized and meet their objectives rather efficiently. All year around we have meetings, symposia, and seminars of all kinds and on all subjects. We publish journals and books. We make films and we develop teaching aids. We produce sophisticated instruments and, more important, we can service them. But while all this scientific effort is oriented toward the solving of problems of fundamental importance to mankind, the major part of it is also directed to the solving of problems of practical importance to the developed world. Only a negligible proportion of it is directed toward problems of importance to countries of the Third World.

Most of us know about the World Bank and the other U.N. agencies that have programs in science and technology: UNESCO, WHO, FAO, UNDP, and UNEP. We are not so familiar with the specialized U.N. conferences on such subjects as water, oceans, habitat, science and technology for development, environment and energy.

We are even less informed about the work of smaller organizations such as the International Foundation for Science (Stockholm), SAREC (Sweden), NUFFIC (Netherlands), GATE (West Germany) and their 10-year-old ancestor, the International Development Research Centre (IDRC) (*1*) of Canada. Although they vary considerably in their day-to-day operations and their internal structures, these organizations share in common a few remarkable characteristics:

1) They finance research projects and training programs of local scientists working in the developing countries according to their own priorities.

2) They spend most of their funds in the developing countries.

3) They contribute directly to the building and strengthening of the scientific capabilities of the developing countries.

4) Their achievements, which are well recognized by the governments of the developing countries, are made possible with budgets that are equal to only a very small percentage, less than 3 percent in most cases, of the official international development programs of these industrialized countries.

The U.S. National Academy of Sciences' Board on Science and Technology for International Development (BOSTID) has also done remarkable work in many developing countries and will expand in the near future. The International Council of Scientific Unions has recently reorganized its Committee on Science and Technology for Development which may soon extend its activities outside the Indian subcontinent. The other scientific unions of ICSU have also established programs for the benefit of the Third World. And, of course, there are the private foundations such as Ford, Rockefeller, and Volkswagen. All this is encouraging, but it is not enough.

What Should Be Done by Our Governments?

In 1970, 0.70 percent of the gross national product was set and agreed on by most nations as an appropriate target sum to be spent on international development. This sum is relatively low, because most of it would be spent locally in the developed countries for the manufacture of goods which subsequently would be given to the Third World as aid for development. Nevertheless, few countries except those of Scandinavia have reached this target.

Because of the difficult economic situation in most Western countries, it has been suggested in some quarters the international aid should be reexamined and eventually reduced. In my view, such a step would be a mistake; rather, the level of aid should be increased by all developed countries to the target regarded in 1970 as a minimum.

We should indicate to our governments that every dollar spent for research and training in science and technology in the Third World is a sound investment. It might be argued that aid for international development in the field of training and research in science and technology should come mainly, if not exclusively, from the U.N. specialized agencies which were created for that purpose. Indeed, such agencies as UNESCO, UNDP, and WHO have done good work and have made remarkable contributions, despite the normal inertia of international bureaucracy. But the task is of such magnitude and means are so limited that contributions from other, smaller and more flexible organizations are essential.

Third World scientists had placed high hopes in the creation of a special fund for science and technology. An initial sum of \$200 million was to finance science and technology projects in the developing countries. To guarantee the quality of the projects and to ensure good management, the fund was to be administered by UNDP, which has an excellent record of past achievements. However, the recent pledging conference did not succeed in raising the fund even to a small percentage of the initial target.

There are undoubtedly compelling reasons for this. For example, some countries are reluctant to contribute to the development of science and technology in the Third World via the U.N. machinery. Nevertheless, there are no sound reasons for our governments not to act bilaterally or through other multilateral or regional organizations such as the Organization for Economic Cooperation and Development, the European Economic Community, or the Latin American Organization.

Role of Nongovernmental Organizations

Let us now turn to the nongovernmental organizations, which are best exemplified by the various international scientific societies and organizations devoted to particular fields of science such as biochemistry or physics, and the various national scientific organizations, of which the American Association for the Advancement of Science is an example.

All these bodies have a common characteristic: a perpetual lack of money. But, because they represent the active scientific community of their milieu, they constitute a pool of knowledge and expertise that is the envy of our colleagues from the Third World. This pool of knowledge and expertise is not tapped sufficiently to provide the solutions to the problems of the developing countries. Again there are good reasons for this. It was economically important for us to do research on polymers to replace natural rubber and natural fibers. But nothing prevented us from doing intensive research on renewable sources of energy before rather than after the petroleum crises. We did not care, mostly because we did not see a need to do so;

we had plenty of cheap oil. And we did not know of, or did not pay enough attention to, the needs of certain areas of the globe that were and still are in need of cheap sources of renewable energy.

I now present some suggestions that are appropriate for our universities and scientific organizations and for the scientific community at large. These suggestions concern the training of students and collaboration with our colleagues from the developing world.

Universities. The philosophy of training has evolved considerably over the last few years. Bringing a bright student from Africa to one of our campuses and sending him or her back with a Ph.D. on an esoteric subject a few years later is not regarded as the best solution to the problem of development. Without denying the importance of good research in the best academic surroundings, there are new mechanisms that give better results. For instance, a student can work on a subject of practical relevance to his or her own country and can carry out at least part of the required practical work in the home country while still getting the best theoretical background available at one of our universities. Such an approach has two important advantages. First, a student trained in this manner finds that his or her return home and employment possibilities are facilitated. Second, the directors of the research in our universities also gain knowledge and a further interest in the Third World. For this kind of training to become available, however, universities will have to be flexible in their requirements and graduate schools will have to be ready to embark on new and unorthodox experiments in education.

Scientific organizations. Symposiums and training seminars could be organized in developing countries with the active participation of our scientific societies. For example, the AAAS in the United States and the Association of the Scientific, Engineering, and Technological Community (SCITEC) in Canada have been involved recently with Interciencia Association in Latin America. Similar collaboration in setting up the infrastructure of science in Africa and in Asia should be started with the financial help of the nongovernmental funding agencies mentioned previously, the agencies for international development of the West, or the specialized agencies of the United Nations. The numerous scientific international unions and the well-organized national societies such as the American Chemical Society and the various engineering associations should organize special meetings to deal with the problems of relevance to the Third World, with the active participation of invited scientists from these countries. The successful CHEMRAW I organized in Toronto 2 years ago on the chemistry of raw materials, which will be repeated in Manila next year (CHEMRAW II), is a good example of what can be accomplished.

Cooks preparing the midday meal at a school canteen near Abidjan, Ivory Coast. Applications of science and technology to development-related problems, such as scarcity of firewood in many developing countries, are examined by such organizations as BOSTID, the National Academy of Sciences' Board on Science and Technology for International Development. [A. Defever, Food and Agriculture Organization photo]

The wider and easier diffusion of scientific documentation, journals, books, and films should be encouraged with special funds for this purpose. "State-of-the-art" books on recent developments in the various scientific disciplines, as exemplified by the texts produced and distributed by the U.S. National Academy of Sciences, the IDRC of Canada, and the International Foundation for Science (IFS) in Sweden, should be widely distributed in the Third World as part of our aid to international development. Translation of these books into other languages should also be encouraged.

Individual scientists. As individual scientists, we can also contribute to international development. First, we can learn more about the prevailing attitudes and the needs of our colleagues from the Third World. Second, when deciding about the relevance of a given research program, we can start to add another criterion: "Will it help the developing countries?" Third, we can make a real contribution to the training of scientists and technicians in our countries or abroad. Fourth, when retiring or even in the midst of a successful career, we can spend some time on sabbatical leaves or short leaves of absence to work with our colleagues in their own environment on some of their problems where our expertise could be used to advantage.

In our countries, perhaps not more than 2 to 3 percent of the active scientific community are working on problems of importance to the Third World. Approximately 5 to 10 percent are interested in and have some limited knowledge about these problems. If we could just double these figures, it would make a huge difference in the Third World without altering or diminishing the benefits we derive from our total national research and development effort.

Conclusions

1) Science and technology are an integral part of international development.

2) For the good of humanity as well as for our own good and safety we must contribute our share to the task of bridging the gap between the rich and the poor.

3) As members of democratic societies we must convince our politicians and governments that money invested in science and technology in the Third World will not harm our economies. Collaboration is for the mutual benefit of all.

4) As members of various scientific organizations, we must insist that programs of annual meetings, specialized symposiums, and various publications should include discussions on problems of importance to the Third World. Furthermore, we should make sure that colleagues from the Third World are invited to bring to us their views and to share with us their experiences.

5) Finally, as individuals, we must devote more time and effort to solving

the problems of development in the Third World.

If, say, 5 percent of our scientific community were working directly on solutions to problems of the Third World, and if this 5 percent had the backing of the remaining 95 percent and the financial help of our governments and institutions, I am sure that the results would be extraordinary. Furthermore, our colleagues in the developing countries would be so stimulated and encouraged that their governments would be more willing to create and sustain their scientific and technological infrastructures.

The existing barriers between us would then become frontiers, which could be crossed at all points, in both ways.

Reference

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Science and Industry

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The views I present in this article on science and industry are those of a North American industrialist. My industrial experience has included the building of companies based on physics-related knowledge. Some of the companies have been concerned with the supply of investigative tools to the scientific community. I am a user of science and a supplier to scientists, as well as an observer of the scientific community.

Summary. Industry is concerned with basic science as the source of its technology, as the force of its philosophy of deductive thought, as its eye to the future, and as the impetus it provides for industrial innovation. Industry's strengthened advocacy of the support of basic science is essential for its future growth.

Let me begin by defining science and industry. Science to me is the acquisition of knowledge of nature through the methods of proof or disproof. That acquisition of knowledge involves the reduction of complex phenomena to simple, elegant rules of action. Industry in a broad sense is the systematic use of knowledge and energy in the transformation of materials of low intrinsic usefulness (or value) into materials of a higher degree of usefulness (or value). Thus increased knowledge holds the key to increased industrial efficiency, and science is a basic contributor to this efficiency.

If one reflects on what was written of the industrial experience at the turn of the century, one finds that the thinking of such people as Henry Ford, although revolutionary at the time, is quaint by our standards. However, modern day industrial thinking directly parallels that of scientific thinking. The knowledge-based industry of today uses the same tools of deductive thinking and inference as are used by the scientist. Applied research, product development and manufacture, and quality control all require the same kind of problem-solving that is required of practicing scientists. Thus it is no accident that increasing numbers of knowledge-based industries are directed by managers recruited from the ranks of scientists.

It is tempting to argue that, given the similarities between science and industry, it is feasible and efficient to "mission-orient" and force the industrial application of science. This is a favorite government position, and notable successes with this approach were achieved in the space program and defense program. However, companies using this approach have fallen prey to two key factors of the industrial equation—market and timing. Several excellent initiatives, such as the Concorde, Hovercraft, and video phone, have failed in their stated goals simply because the market or the timing was wrong.

In my view, modern industry has a particular responsibility to be an advocate and sponsor of basic research. In the knowledge-based industrial sector, we have a situation that is largely technology driven, where many products, such as semiconductors and computers, are technically obsolete in 4 to 5 years. This contrasts with a product life cycle of 20 or more years in industry in the early part of this century. If we assume that the cost of research to replace a product remains constant, the yearly increase in research and development funding to effect a replacement is now four times as high. At least as important as the financial stakes are the constraints on judgment. If the wrong decision is made there is only one fourth of the time to catch up with the next product generation.

This has several important consequences. First, if industry is to stay competitive from product generation to generation it must be aware of, have access to, and use the results of both applied and basic science. Second, there will be more chance of success if the industrial planner utilizes the deductive principles that have served as the base of basic science. Third, the industrial world has many examples of industries that have made the wrong development choice and have disappeared. North American industry needs not only its own current research endeavors to chart future direction but also the vision and independence of view provided by basic research.

It can be argued that since basic science generally is not proprietary to a nation or a company, why not simply let other societies do basic research and then put our money in applied science or technology? I have mentioned that industry needs the vision that basic science provides as well as the intellectual rigor of its discipline. In a very real sense, the thinking of the purist sets the foundation and opens the view to the future in a particular branch of knowledge. Without access to that view, today's knowledge-based industry would operate in isolation. A knowledge-based industry that depended on secondhand access to information would be courting failure.

It is increasingly evident that the strength of our industrial base and also

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