FUNDAMENTAL RESEARCH in UNDERDEVELOPED COUNTRIES

The view that basic research in the less well-developed countries of the world is neither desirable nor appropriate is challenged by the author, a theoretical physicist at the University of California's Lawrence Radiation Laboratory at Livermore, who spent the last academic year as an IAEA visiting professor at Pakistan's Atomic Energy Center in Lahore.

By *Michael J. Moravcsik*

If the reader senses a certain evangelistic undertone running through these pages, he will have perceived accurately the intent of the author. I have recently undergone a very stimulating experience, receiving from it certain enlightenment, and I now hope to find converts willing to share both in the experience and the enlightenment.

The inspiration for this sermon comes from my having served for a year (while on leave from my regular institution) as a technical expert of the International Atomic Energy Agency. My assignment was to be a visiting professor at the Atomic Energy Center in Lahore, Pakistan, to help in its advanced education program and to cooperate in the effort to build up fundamental research in physics at the Center.

Why is this worth writing about? In this day and age, technical assistance is a widespread phenomenon. Persons of special qualifications in the applied sciences go in large numbers to the underdeveloped countries to work on specific applied research and development projects, and educators on Fulbright or other programs also go in large numbers to these countries, usually to teach elementary or intermediate courses. I believe, however, that persons with primary orientation toward fundamental research have rarely gone to one of these countries to assist in the building up of advanced education and pure research work. The experience has moved me to extol the urgent need for and the benefit of this kind of program, and to entice some of my research colleagues to undertake similar adventures.

The first step, of course, is to convince them that advanced education and fundamental research is something the underdeveloped countries really need. This is not at all an obvious point. I know of several rather prominent physicists (including at least one Nobel prize winner) who think that the fostering of advanced scientific education and fundamental research in these underdeveloped countries is premature by several decades or inadvisable altogether. Such a view was also advanced, in a mild form, by David Tabor in the August 1963 issue of *Physics Today*. Indeed, for a country whose agricultural methods have remained essentially unchanged in the last two thousand years, whose total industrial output is perhaps that of a medium-size Western city, whose social institutions have undergone few changes since the Middle Ages, whose political sophistication, by Western standards, is perhaps on the level of a high-school debating team, why should there be serious concern with fundamental research in the sciences?

Let me, therefore, list some of the most important reasons why I believe basic research is of paramount importance even today in these countries.

1. Since the urgent need for applied scientists who can work on research related to the peculiar economic and technical problems of the country is seldom questioned, I first want to point out that the fundamental science of today will become the applied science of tomorrow, and that competent applied scientists can best be educated by those whose interests and competence are deeply rooted in the forefronts of science in the fundamental fields. The training of a future reactor engineer in the late 1930's, or the education of a future transistor specialist in the late 1940's, should have been in the hands of physicists intimately associated with the most modern branches of physics, that is, by those actively working in research in advanced fields. The practice of teaching yesterday's science to tomorrow's scientists can lead to what might be called scientific featherbedding. This is a real problem in the newly developing countries, and I could point to many examples out of my own experience.

2. Successful applied work can be carried out best if the applied scientists have constant access to the knowledge and views of those working in fundamental research. The training and experience of a person working in fundamental research

The Pakistani Atomic Energy Commission's Center in Lahore

tends to be more thorough and broader (at least in the underdeveloped countries where applied research is defined in the narrowest possible sense of the word); he is educated to absorb changes easier and can often serve as an "idea man" to his colleagues in applied research, suggesting new approaches or analogies from other fields. This interplay between people in fundamental and applied fields is common in the advanced countries, where the basic research workers often spend part of their time serving as consultants to industrial firms or government agencies on applied projects. The results can be spectacular, if one is to take seriously the high consulting fees and widespread demand for such consultants. The underdeveloped countries, since they are faced with many more applied problems which often must be carried out under the most difficult circumstances, could benefit greatly from such practices.

3. Eventually, every country should have its own scientific life in the fundamental branches of science. However, the development of a strong tradition in fundamental research takes a very long time—several scientific generations. Thus, the familiar five-year duration of economic plans might be increased to fifty years for corresponding plans for scientific development. Some of these years must be devoted to fostering pure research, at least on a small scale. The young scientists of today will head the schools of fifteen years from now, directing the initial efforts of those who, in turn, another fifteen years later, will inspire the groups which eventually will be able to carry out work on a level competitive with the more advanced countries.

4. The need in the newer nations for administrators with scientific backgrounds is very great. The innumerable applied projects dealing with health, industrial processes, agricultural methods, etc., all need to be administered by people capable of understanding the technical aspects of these projects in order to make intelligent decisions. It is my contention that the best training for the scientific aspects of such a job is a thorough training and working experience in the fundamental sciences. In the underdeveloped countries, the influence of one brilliant and well-trained person can be enough to determine the pace of development in the whole country in a given field.

5. Achievement in fundamental science serves to encourage and boost morale in these newly developing countries. This point should not be underestimated, for the state of popular morale is one of the most important ingredients in the progress of a country. As an example, the name of Abdus Salam is widely known in Pakistan, even among those having little concern with science, and his international prominence is a shining example to many young Pakistanis.

Physicist Abdus Salam of Pakistan, shown in a 1955 photograph at the International Conference on the Peaceful Uses of Atomic Energy in Geneva, Switzerland, where he served as one of the scientific secretaries

United Nations photo

Assuming that I have managed to make a case for fundamental research in the developing countries, it might be asked whether such undertakings are financially feasible. My contention is that they can be if the research is carried out on an appropriately modest scale. The advanced countries spend, roughly, about one thousandth of their gross national products on fundamental research. I believe that the same fraction could be spent

by the young countries for the same purpose, without undue strain. In actuality, they spend much less than that.

In my arguments for fundamental research I have tacitly assumed that advanced education in these countries should be carried out on home soil. One might ask, however, why this should be so, and why the scientists of a country could not all be sent abroad for advanced training.

There are several very practical reasons why this cannot be done on a large scale and without serious handicaps.

1. Training abroad is expensive. Most of the underdeveloped countries have serious shortages of foreign exchange, and cannot afford to train their people abroad if this can also be done at home. Only limited reliance can be placed on foreign fellowships, since such financial help is generally provided on a rather small scale. Thus, beyond the very first stages of the country's development, when hundreds of scientists must receive their education, scholarships do not suffice.

2. Western institutions of higher education are already overtaxed by demands for admission from their own nationals. Thus, a candidate from an underdeveloped country, even if treated on equal footing with his colleague from an advanced nation, might well be turned down. This problem will only become more severe in the coming years.

3. The best way to establish a scientific tradition is to create schools in situ, where staff and graduate students can work together, where the instrumentation problems and the technicians can be coordinated once and for all, and where a certain continuity can be established. With people receiving their training at widely varied institutions, and then being thrown into a quite different environment, the establishment of such a research group is much more difficult. This point has again been borne out very vividly by my own personal experience when visiting various research institutions in underdeveloped countries.

4. Living abroad and then returning to one's home country raises a large number of problems of adjustment. Some trainees would never be able to do their best in the advanced countries because of an inability to adjust to a different way of life. Others do well, but then get weaned away from their home country and are lost from a national point of view. Still others come home, but feel frustrated and out of place. These are all problems extraneous to science and therefore should be avoided by offering higher educational and training opportunities on home soil.

Let me also briefly allude now to two problems connected with the development of fundamental research in underdeveloped countries which Dr. Tabor also discussed in his already-quoted article.

The first of these pertains to the material remuneration of scientists in underdeveloped countries compared to the advanced countries. It is often stated that the underdeveloped countries cannot possibly build up manpower in the natural sciences, because these sciences are international enough so that any trained person can easily be lured away by the advanced countries with the promise of a good salary. The trouble with this argument is that it assumes that, other things being equal, anyone would rather live in the United States than anywhere else in the world. This, of course, is by no means the case, even in countries such as Israel, where the way of life is roughly similar to that in the United States, and it is certainly not so in those countries in which the traditions, social conditions, and general way of life are markedly different from the West. I am convinced that most Pakistani physicists would much prefer to live in Pakistan than anywhere else, provided that they can receive a good salary, by Pakistani standards, and provided that the research opportunities offered in their homeland are at least adequate. As an example, take the Pakistani scientist who recently returned from an advanced Western Country (although efforts were made to keep him there). He returned to a salary which was about one quarter of what he received in the West, and to research facilities which, although very adequate, were modest compared to those available to him in the West.

The other problem I would like to investigate briefly has to do with the proper choice of research fields suited to the needs of an underdeveloped country. Dr. Tabor wondered whether it would not be advisable for an underdeveloped country to stick to branches of sciences which are in some sense related to the economic and technical problems of the country. He suggests that perhaps some kind of an oriented, or directed, research effort would suit such countries the best.

It is clear that in an underdeveloped country (and to a lesser extent also in an advanced country) the kind of research a person can engage in is limited by considerations of economics and manpower. It is clearly not within the capability of, say, Pakistan, to build a 30-BeV accelerator in the next twenty-five years. Beside this rather obvious

automatic selection, however, there is also a second choice to be made, as to which of the economically feasible fields of research to pursue. I believe that some central decision can and should be made in this respect, but the execution of this decision must be carried out with utmost sensitivity to the realities of the situation. It is, for instance, out of the question to order scientific personnel, trained in a certain field, to retrain themselves in another field just because this field is more closely related to some useful applications. The result of such an order would be that the scientists in question would leave for the West where they can pursue whatever fields of interest they wish. It is also impractical to order students to get their training in certain fields because of their promise in applications. It is, however, entirely possible to send students to those graduate schools in the West where a certain field, of interest to the underdeveloped country, is prominent and is actively pursued. Most graduate students eventually end up in a branch of their science which was the center of interest in the school they happened to attend. Similarly, when institutions of higher learning are established on home soil, it is entirely reasonable to emphasize certain fields, so that students at those institutions end up doing work in those fields, if only by sheer inertia.

Finally, I also believe that if there is a truly outstanding scientist native to the country, he should be given every encouragement to carry out his research and form his school no matter what his field might be. Especially in the beginning stages of development, research activities must be built up more around outstanding individuals than according to preconceived plans. To my mind, it is far preferable to have an excellent research group working in a field somewhat less related to applications than to force the existence of a mediocre team whose efforts are in the direction of problems more immediately connected with applications.

Particularly in their initial stages, programs of fundamental research and advanced education in underdeveloped countries are in great need of "experts" from the advanced countries who can spend a year or so of their time to join basic research institutes. What can a visiting scientist bring to such an institution?

1. He will bring up-to-date information on the state of science, up-to-date research methods, up-to-date ideas. One of the major problems faced by an institution in one of the underdeveloped countries is its isolation, which can best be broken with the help of a visiting specialist capable of transmitting the ideas generated in other parts of the world. A set of advanced lectures, some seminar talks, and cooperation with local workers on specific research topics can do a tremendous amount to perk up and modernize the work at such institutions. This phenomenon is well known even in relatively out-of-the-way institutions in the advanced countries.

2. One striking characteristic of science in the underdeveloped countries is the fact that the scientific population consists mostly of very young people. This is natural enough, but it carries the consequence that there is a crying need for research leaders and originators of ideas who can coordinate and guide the work of young scientists until they themselves, after five or ten years of experience, become scientific leaders. Thus a Western scientist with some experience in independent research can do wonders in making effective use of local talent that otherwise might relapse into aimless stagnancy.

3. A Western researcher, even if he has no special interest in scientific organization, is likely to have an implicit knowledge of how an advanced research institution operates, and this knowledge is badly needed in an underdeveloped country. In matters of training, curriculum, library practices, organization of seminars, attraction of short-term foreign visitors (a particularly important aspect of the life of these institutions), the organization of preprint exchange, and in many other areas, a Western "expert" can serve usefully as an adviser.

4. In addition to all these rather tangible activities, a Western visitor represents, much beyond his actual stature as a scientist, a note of encouragement, a source of high morale which, as I said before, is of extreme significance. For instance, in the difficult job of luring young PhD's back from abroad, the knowledge of the presence of a Western visitor might be a decisive factor. Recognition in this form is a very important element in the success of these young institutions.

Let us now investigate the matter from the point of view of the visitor himself. What I advocate is that active research workers from advanced countries take off a year from their regular work and spend it, scientifically speaking, "out in the woods". If the institution is carefully chosen and has an existing nucleus of advanced research, if an appropriate time is picked, and if thoughtful preparations are made for the stay, such an ad-

venture can be beneficial not only for the host institution but also for the person involved.

An existing program of advanced work would ensure the presence of a few interested and cooperative colleagues, ready with criticism and capable of serving as sounding boards for ideas. The organization should also have adequate standards with regard to physical accommodations such as experimental equipment, desk space, library facilities, and adequate supporting staff. In connection with libraries, the visitor might be well advised to try to make sure that preprints continue to reach him at the new place, and he might also intensify his exchange with colleagues of "private communications" for the year. Actually, the experimental equipment is usually not the most serious problem; money for equipment is usually more readily available than for any other purpose, and can be obtained easier than trained personnel.

The visitor will have considerable time for his own personal research. This time can then be used to work on some specific research problem, on which the initial spade work has already been done back at his home institution. Another useful purpose for which such a stay is well suited is, for either a theorist or an experimentalist, to work himself into a new field or to broaden his background in his own field. If one lives at one of the busiest centers of physics, one sometimes feels that between going to seminars every day, and picking up tidbits here and there, there is real need for a more quiet and peaceful time when one can do some systematic and extensive work to catch up with developments in the field. I used part of my time in that way, and perhaps achieved more in Lahore than I would have in California.

It might also be worth saying a few words about the way such a visit to an underdeveloped country can be arranged. It turns out that, for somebody who is primarily research oriented, the avenues of financial help for a visit emphasizing research are not nearly as well worked out as in the cases of visits by applied technical experts or college educators. Several organizations, however, are interested in sponsoring such undertakings. One of these is the International Atomic Energy Agency, one of the specialized agencies of the United Nations, which supports visits by experts at the request of a host government. Under such circumstances, individual applications must be coordinated with requests from the country to be visited. The United States Department of State, under Public Law 480, can also, in some instances, release funds in local currency for the support of such projects. The National Science Foundation has expressed interest in projects of this type, although it has no regular fellowship program organized to this end. In cases where university scientists spend their sabbatical leave on research-oriented visits, many of the underdeveloped countries are willing to supplement sabbatical pay with stipends in their own currency. I would be very pleased to supply further details concerning some of these available sources of funds to anybody who may be interested in such an undertaking.

Planning for such a trip is, of course, somewhat more complicated than for a comparable trip to Europe, and correspondence and arrangements also take a longer time. Thus it is not at all too early to start thinking about the trip a year and a half before the planned departure date.

Finally, the picture would remain incomplete if I did not mention the other-than-scientific benefits that can accrue to the person participating in such an adventure. Since Western scientists are supposedly known for their wide variety of interests outside science, this is a point worth mentioning. For many of us steeped in the academic atmosphere and fed on political science fiction of the "Ugly American" type, the political education received by being actually confronted with the practical problems of foreign aid, world opinion, our image abroad, democracy vs. other political faiths, etc., is literally overwhelming. In this respect, even one week of practical experience seems to be equivalent to years of armchair discussions at symposia, and can be both refreshing and stimulating. To this one can add the personal experience of being exposed to totally different cultures and the acquaintance with those who are trying to reconcile new and old ways of life in their own personal conduct. The right of freedom of travel and association with others is an important part of our Western heritage, and this right can hardly be better exercised than by going to a completely different part of the world for a somewhat extended stay.

In summary, my purpose here is to persuade some of my readers that if an active worker in fundamental research spends a year or so in an underdeveloped country, cooperating in the development of basic science, he performs a service that is uniquely valuable to the country involved. At the same time, he will benefit from his stay on scientific and on other levels. Thus far, few scientists have tried this adventure. So if you are thinking of spending a year abroad, why not consider the possibility of doing it in this way? You will hardly regret it.