THE ROLE OF SCIENCE IN NATIONAL DEVELOPMENT

by

J. A. K. QUARTEY

Professor of Chemistry
University of Ghana, Legon

An Inaugural Lecture delivered at the University of Ghana, Legon on Thursday, 10th February, 1972

THE ROLE OF SCIENCE IN NATIONAL DEVELOPMENT

by

J. A. K. QUARTEY
Professor of Chemistry
University of Ghana, Legon

An Inaugural Lecture delivered at the University of Ghana, Legon on Thursday, 10th February, 1972

GHANA UNIVERSITIES PRESS
ACCRA
1972

Published for the University of Ghana

by

GHANA UNIVERSITIES PRESS

P.O. BOX 4219, ACCRA

Exclusive Agent in USA: Pantheı House Ltd.,
Box 3552,
New York City 10017

PRINTED IN GHANA
BY GHANA PUBLISHING CORPORATION (PRINTING DIVISION)
ACCRA-TEMA, GHANA

It is usual to start a discussion or a lecture by defining the terms involved so that we all have a clear idea, or at least the same idea, of what we are talking about. In this case, the task is easy. It seems to me that the only term we need expand on at this stage is "national development". There are several ways in which this has been interpreted. Notable among such ways has been the quantitative dimension which it has often been given by a measurement of the gross national income per capita or some similar term. This of course consists in taking the gross national product and dividing by the total number of inhabitants of any given country. A manipulation as simple as this gives us a simple arithmetical average. In the nature of such an average, it tells us nothing about the standing of individual citizens or the state of development of separate regions of a given country. The notion of national development which I propose to use in this talk is that which includes not only the income per capita, but also the actual physical development of individual regions of the country and the very quality of life of the individuals of the nation. It would be observed that in this notion we have shifted from a strictly quantitative idea to one at least having an admixture of some quantitative aspects. The question which then arises is: By what quantitative characteristics shall we recognise when the desired development is occurring? It would be convenient to choose the objectives set out in a development plan as constituting these characteristics. This choice can be defended on the grounds that the objectives of a development plan are those which the people in general, or at least the authorities in any given country, consider as worthy of pursuit and achievement over the period of the plan. They are also often considered as necessary to be achieved in order to lay the foundation for further development even after the period covered by the plan. Occasionally it does happen that a development plan is out of date almost even at the time it is published. This happens not only in the case of developing countries, but also in the case of advanced countries. An example is the five-year development plan which was introduced in Britain in 1965 with great fanfare, and then was practically never heard of again. In such a case the development plan no longer gives us any indication of the desirable direction or extent of development. However, in most developing countries the basis of economic and social development is still a National Development Plan. This is a policy document which is the yard-stick against which the efficacy of all scientific

and indeed any other development and applications are judged. It often represents the basis on which financial allocation is made. Experience has shown that unless a project or programme has clearly demonstrable relevance to the national development plan, it will not command sufficient priority to obtain government support either in finance or in services and facilities. For this reason, and also since the development plan covers all the policy aspects of economic and scientific development in the country, the various programmes within the plan are closely integrated and co-ordinated. To assess the role of a particular activity without reference to the entire development plan is thus not an easy task.

For the activity which we have chosen, however, namely science, it is both practicable and, I suggest, profitable to assess not what its role *is*, but what we might consider its role *should be* in the formulation and the prosecution of a national development plan. It would be observed that in essaying a definition of national development, I have introduced the terms "advanced countries" and "developing countries". I do not think it is necessary to dwell on these terms, because they are so familiar. I would, however, like to draw attention to one aspect which tends to lure certain people into a false sense of satisfaction. The countries now called developing countries used to be described as "undeveloped", and then later as "under-developed", and later still as "developing". Presumably, this last term "developing" is emotionally more acceptable. But it has the psychological tendency of making people slide easily into thinking that since they are "developing", all is well. This is a tendency which needs to be watched consciously all the time, and as long as we keep this proviso in mind, throughout this talk I shall use the terms "undeveloped", "under-developed" and "developing" quite indiscriminately. We belong to the group of "developing countries", and we have here as in such other countries ample evidence of three main characteristics of under-development which are: scarcity of finance, inadequacy of appropriate manpower, and under-developed natural resources. As far as the financial aspect is concerned, there is very little that I consider myself qualified to say, except that I shall discuss later the way in which external aid can influence our scientific development. I intend to devote most of this lecture to the role of science in the development of the two other aspect, natural resources and manpower.

When we come to consider the way in which science could contribute to the attainment of the objectives set out in a national development plan, I should like to distinguish between two aspects. Since a national development plan is so important in determining financial allocation and the distribution of effort on specific areas, it is vitally important that science should play a significant role in the original formulation of the plan. I do not by this mean that the plan should be formulated by practising scientists. I do mean, however, that science affects so much of our lives nowadays that those who are responsible for drawing up such a plan should not be unmindful of the way in which science could be brought to bear in the achievement of their objectives. They should be in a position to understand and assess any programme put forward in science areas. For this reason it is best if they themselves have had some scientific training in their general education. If they are scientists turned administrators, well and good. But they need not be experts in any particular scientific field. It is important, however, that they should be willing to seek, and that they must be in a position to understand, advice from the scientists. As someone has aptly put it, "it is not necessary that the scientists must be on top, but they must be on tap". I do not imply by this that training in the arts is better than one in the sciences from this point of view. On the contrary, the days are long past when an arts training was considered as the only suitable one for administrators. These days the ability for clear thinking, and critical logical examination, analysis and synthesis which are necessarily part of the scientific method *may* be quite lacking in the education of a person trained in the arts. It is generally recognised these days that one can receive quite a good and broad education which is entirely science-based. Indeed the general experience is that it is the arts rather than the science people, who tend to have wide gaps from the point of view of general education. Thus it is commonplace to find that a person whose education has been largely scientific nevertheless knows something of Greek political thought; has heard of the Red Revolution; has an intelligent view on Beethoven's Ninth. It is not uncommon, however, to find a person educated largely in the arts who knows nothing of Greek mathematical ingenuity; has not heard of the Green Revolution; has no concept of Einstein's Relativity—and what is more, does not feel the slightest need for any remedial action. If I advocate that scientists should be on tap but not on top, it is not because I hold that as

administrators they are inferior or that there is any deficiency in their education by comparison with those trained in the arts, but simply because in the present state of our development, it is better to employ our comparatively small number of scientists in scientific activity.

Since it will take some time to redress the present balance, we should start now infusing such science into our general education that the products of that process, even if they be arts people, have a sufficient scientific background to be able to listen to and understand the scientists. The operative phrase is "listen to and understand". Equally important, those who are in charge of formulating the objectives in a national development plan must go out of their way to invite opinion and discussion from the scientists. They must furthermore make a determined effort to understand any schemes which the scientists put forward, and be prepared to press the scientists to explain until they do understand. The scientists, on their part, must also realise two things. First, they must take a broad view of the development of the nation as a whole, not merely their particular scientific activity; and they must explain any schemes which they put forward and the benefits expected to accrue from such schemes in non-technical language as far as possible. I do not share the view that unless an idea is expressed in technical scientific jargon it has no merit. On the contrary, I personally believe that if a scientist is quite clear in his own mind on what he is talking about, he should be able to find such language to express it as to make it intelligible to a layman, even at the risk of sacrificing a little technical accuracy. Taking "a broad national development view" of scientific schemes involves consideration not only of the purely scientific aspects, but also of the cost-benefit and other economic aspects. If a scientist feels that he is unable to do this by himself, he should seek assistance from competent persons, just in the same way as an arts administrator would seek assistance on the scientific aspects from him. Secondly, since scientists would be potentially of such great use even at the formulation stage of a national development plan, and since in developing countries the scarcity of scientists tends somewhat to inflate their value, they must realise that there is a great onus on them to give intellectually honest and professionally unbiased advice. It is even more important for them to realise that in the formulation of a national development plan and the general direction of affairs, the ultimate decision is political and the ultimate responsibility rests with the politician. Even if we consider the case of a scientist who

takes up politics as a career, as for example an Engineer who becomes a Minister of Fuel and Power, on being presented with a technical scientific report on a plan for power development, his first reaction would be to bring his scientific knowledge to bear on interpreting the report. Nevertheless, if it comes ultimately to deciding whether he should opt for a fossil-fuel power station, a hydroelectric power station, or a nuclear power station, the decision can never be on scientific grounds *alone:* it must be related to a number of other factors in other Ministries and in the general life of the society. That is to say, he will ultimately decide not as a scientist but as a politician. It is therefore important for the professional scientists to be able to assume the attitude where they give as much technical advice as dispassionately as they can. Let them, even if they wish, give their advice passionately and also exercise their general right as citizens to comment on aspects other than the purely scientific ones of any particular problem put to them. But *qua* scientists, their advice should be purely technical and neutral. It is essential for harmonious national development that when the final objectives have been defined by the appropriate authorities, the scientists should then be prepared to apply their energies to the attainment of the desired objectives, being neither aggrieved nor elated, and without seeking to arrogate to themselves the power of final decision, because the corresponding ultimate political responsibility does not lie with them. Conversely, it should be made quite clear to all where the ultimate responsibility does in fact rest, and the authorities should ensure that science and politics are sufficiently "decoupled" to make this state of affairs possible in practice.

Let us assume that the objectives of a national development plan have been formulated in accordance with the foregoing principles. How then should our scientists, in practice, set about giving their utmost assistance in achieving those objectives? The pursuit of science derives its driving force from two main sources, in turn giving rise to two different kinds of research that have been called pure or basic research, and applied or oriented research. The nature and scope of these two kinds of research are more or less generally understood and agreed, though it is rather futile to attempt such a precise definition of each that there is a sharp division between them. The two main sources from which the desire for the pursuit of science springs illustrate clearly the kinds of research roughly designated as pure and applied. First, there is the inherent curiosity of man to find

out just for the sake of finding out. Secondly, there is the acquiring of new information because it is needed in the solution of a particular problem, or finding out in what way certain already known information can be applied towards the solution of a particular problem. These two sources correspond more or less to basic research, and applied research. But the establishment of this correspondence does not necessarily make the distinction between the two kinds of research any sharper, for the two may, and often in practice do, overlap. Science and technology are often contrasted in the same manner as pure research and applied research are. In this sort of contrast, science is taken as the educative aspect: that of broadening one's horizons in much the same way as the study of the arts might do; technology is more identified with the applicability of scientific concepts. If we adopt this model, we must remember that even in technology there are some areas which might legitimately be described as basic research. It is also very important to remember that science, in the way that we have just described it, is not the predominant factor which has contributed to the industrialisation and material well-being of various countries. It is technology, namely the application of scientific principles and ideas to practical situations, which is the more important in this respect. It would be clear then, that in our circumstances what we need to devote our greater attention to is technology: those aspects of scientific effort which are applicable to practical problems of our country. I place the emphasis on applied research rather than pure research for at least two reasons. One reason is that, if we are honest with ourselves, we will readily admit that it is unlikely that in a reasonably short time we shall overtake the advanced countries in basic research in the field of the physical sciences, for example, when one considers the high cost of such research, the personnel and equipment needed, and the experience which the advanced countries have already accumulated. It is obvious that they have a big lead which is increasing rather than decreasing with time. In brief, they are in front and they are not looking back. Another reason is that to make an impact on the attainment of the objectives of national development, we really do not need to undertake a vast amount of basic research. The simple fact is that there exists already a large body of knowledge of scientific literature which can be applied to the solution of our problems, in some cases directly and in other cases with only minor modifications.

The research which ought to engage by far our greater attention is the application of the already existing knowledge. I use the phrase "by far our greater attention", because I do not wish to imply that basic research should not be pursued at all in our circumstances. As I have already pointed out, basic research and applied research often do overlap. It is necessary to have a certain amount of basic research if only for the empirical reason that no society has made great technological strides if some amount of basic research is not also taken seriously. Even those of our scientists who are engaged in applied research must from time to time have an interaction with basic research so that they keep themselves up to date and are the better able to apply new ideas. It is quite clear that while a limited amount of basic research must be carried on, even in that case it would be an advantage if the basic research arises out of practical situations and the pursuit of predetermined goals. A view which is sometimes put forward is that concentrating our efforts on applied research is likely to result in a massive "brain drain". But the problem of "brain drain" is a universal one, although its effect is felt probably to a greater extent in developing countries than in advanced countries. What we can do, and indeed must do, is to create the best conditions of which we are capable by way of facilities and remuneration, having regard to the overall facilities and remuneration structure of the country as a whole. As far as facilities are concerned, it is important to alleviate the feeling of isolation often experienced by scientists in developing countries by arranging for them to work from time to time in advanced countries with better facilities. In this respect, advanced countries could do a great deal to help us. The question of remuneration is a much more difficult problem to which there is no ready answer. There is no doubt that it would be advantageous to have scientists from advanced countries working alongside our indigenous scientists. The problem is this: it can be argued that the foreign scientists have a higher remuneration in their countries; it may be argued that the existence of differentials between them and the indigenous scientists tends to be divisive; but could we seriously sustain a contention that the remuneration of our scientists should not be related to the remuneration structure of the country as a whole? Scientists are as much a part of society as anyone else; is it justifiable that the circumstances of that class alone—or for that matter any other particular class—should be determined by reference to a society other than the one in which they live? In considering

this problem one needs to bear in mind that the overall circumstances of the society, not simply the salary levels, have to be taken into account. For example, salaries of scientists are generally much higher in the USA than in the UK, but we do not find that for that reason alone all the able scientists in the UK want to emigrate to the USA. Perhaps in this respect also, as in the case of facilities, the advanced countries could help us. To return to the type of research that we do, one other reason why we should concentrate on applied research, and even where we do basic research try as much as possible to relate that basic research to local problems is that there are quite a number of problems which can be tackled far better in this country than in other, advanced countries. Research into tropical diseases, for example, even if of the basic research type, is likely to yield more important results if it is conducted in a tropical country than in a temperate country. It is also to be noted that the true spirit of science—the search for pure knowledge, if you like—is not in any way inhibited by applied research. One can get as much scientific satisfaction, and one can stand as much chance of perhaps making a fundamental discovery by working on a problem of practical importance as on a problem in basic knowledge. It is instructive to recall that last year's recipient of the recently instituted Nobel Prize in Economics was given the award not for some abstruse theory or concept which he had contributed to economics, but for his study of the practical application of the processes of economics and the formulation of empirical laws therefrom. Indeed, I would imagine that a similar high honour in the natural sciences, for example, in this part of the world may well be not for any theoretical aspect of physics or chemistry, but probably for work in some practical application, such as medicine or the chemistry or biochemistry thereof, ecology, geology, geophysics, or some such studies where we have the advantage that the conditions needed for the particular kind of work occur here but not in other places.

The next aspect that we may look at is the kind of institutions which should exist for the prosecution of this applied research. In a number of developing countries, including this one, scientific research is carried out both in University institutions and in Research Institutes. Usually the Research Institutes work on applied problems whilst the research carried out in the University institutions is of a more fundamental type. As I have pointed out earlier, it is difficult to draw a rigid distinction between the two types of research. It is

nevertheless true that the Research Institutes are normally oriented towards predetermined goals. In this country, by and large, the Research Institutes are the responsibility of the Council for Scientific and Industrial Research. This is a good arrangement since it ensures a fair degree of co-ordination in the formulation of a national scientific policy and the prosecution of that policy. It is part of my thesis, however, that unless the work of Research Institutes and the research activities of the University institutions are closely integrated, our efforts will not be yielding anything like the full contribution which could be made to national development. Let us remind ourselves at this juncture that in the developing countries there is a scarcity of qualified manpower. There just are not enough scientists to have some in the Universities whose entire preoccupation and emphasis is on fundamental research, as a group distinct from other scientists whose concern is in predetermined goals only. The kind of co-ordination and collaboration which would seem desirable is that the Universities should encourage students working for higher degrees in science to do at least part of their work in one of the Research Institutes, under the joint supervision of someone in the Research Institute and someone in the particular University. The Universities could make far more use of the Research Institutes in this respect than has been the case hitherto. It should also be possible for the staff of the Research Institutes to work at the University institutions from time to time, particularly on some problems which have originated from their own Institutes. More frequent contact among the staffs of the Universities and the Research Institutes could be ensured if, wherever possible, scientists in the Universities are encouraged to "adopt" one or two Research Institutes related to their fields of interest, to take a practical interest in the particular Institutes and to visit them from time to time. This kind of informal consultancy would make it easier to bring to the notice of the Institutes' staff recent developments in their fields, and would also keep the University staff constantly thinking of applications to which various recent developments could be put.

The scheme of collaboration suggested between the Universities and the Research Institutes is attractive because the two kinds of research organisations already exist, and it would be fairly easy to bring the scheme into practice. However, it should be one of our chief aims to extend this kind of consultancy to Industry as well. It is in the field of industry—and here I include agriculture—that

the most rapid and significant change and advancement can be made in our national development. Arrangements could be made which would ensure that industrial firms, or Ministries which deal with industry have, if not research laboratories, at least research groups with whom personnel from the Universities and the CSIR Institutes can have close contacts. It should be possible, if the firms have laboratories, for work to be done in those laboratories for higher degrees of the Universities, just as in the case of the CSIR Institutes. It should also be possible for the research groups of such firms and Ministries to be given time off occasionally to work in the University laboratories in much the same way as outlined for the CSIR Institutes. Applications in the field of industry need not wait upon the making of fundamental discoveries in science by our own nationals. An example that readily comes to mind in this respect is that of Japan, which has taken an impressively short time to become a highly industrialised country by the single-mindedness of its pursuit not so much of basic science as of the applicability of science. But even among advanced industrialised countries which have been in the forefront of basic research for some time, there is still an important lesson for us in the sense that more and more of their scientific resources are being channelled into applied problems. For example, in the Federal Republic of Germany, nuclear research was not permitted after the Second World War until about 1955. Since that time there has been a great deal of such research; practically all of it has been applied, predetermined, goal-oriented research, and the Federal Republic of Germany is now one of the foremost producers of nuclear reactors for the generation of power. In other areas of science as well, their industrial firms have their own laboratories where they conduct research. The general pattern of distribution of the scientific manpower of such firms is something like one-fifth on administration, as much as three-fifths on applied research, and one-fifth on basic research which, even though basic, is still peripheral and related to the applied topics. The time between the discovery of a new idea or a new technique in science and the beginning of its application on an industrial scale is becoming shorter and shorter. About 50 years ago, it took about 25 years for new scientific ideas to find their way into industrial application. Some 30 years ago, it took only 15 years. In the last 15 to 20 years it has been taking under 10 years. Obviously, not only should our industries be constantly fed with a stream of new scientific ideas and techniques which could

be of use to them but also they should be urged to investigate the applications of these new ideas and techniques as quickly as possible. If the degree of collaboration envisaged is to be achieved, there would have to be a great deal of informal contact, and it is necessary therefore to avoid too much institutional rigidity.

I have deliberately in this lecture refrained from commenting on problems we face in agriculture and medicine. This is most emphatically *not* because those fields are unimportant, but simply because this inaugural lecture is sandwiched between one by the Dean of the Faculty of Agriculture and another by the Dean of the Medical School. I am devoting my attention to considerations which may have relevance in science generally, rather than in specific fields. One such factor which greatly influences the potential contribution of our scientists to national development is the availability of an adequate scientific infrastructure. This, incidentally, is as true of advanced countries as of under-developed countries. It is significant that in the advanced countries, scientific laboratories which are the best equipped in one particular line or other are also generally those which are best equipped in general scientific infrastructure. This fact tends to be overlooked sometimes when a research institute or organisation is being planned in a developing country for the purpose of tackling a specific problem. For example, it may be argued that the possession of some sophisticated scientific equipment or facility might provide an impetus for scientific advancement in a developing country by encouraging the retention of the indigenous scientists in their own country. But the planning of such a facility should be properly integrated into the overall educational and scientific programme of the country; this, in turn, requires that the envisaged equipment should be considered not in isolation, but in relation to the general scientific infrastructure. Unless this is done, the equipment could easily become one which is not used to the optimum advantage. Indeed, in the experience of some countries which do not have the requisite infrastructure in scientific services and scientific manpower at a particular stage of development, the establishment of such a facility has been a very effective way of retarding their general scientific advancement and national development. This necessity to fit a particular scientific facility or activity into a national development programme, in addition to ensuring that it does not in practice hamper the country's overall development, also meets the very desirable goal that the planners are obliged to think

of its effect for several years ahead in order to ensure that the impetus given to other parts of national development is sustained. One way of increasing the effective use of whatever facilities exist, however inadequate, is for our scientists to engage in groups on collaborative schemes rather than go their own individual ways. It is well known that quite often in any field, before a significant advance can be made, one needs a certain minimum number or "critical mass" of people, so that by their co-operation and the interaction of their ideas their collective output is far greater and far more impressive than their individual achievements could ever be. What is needed is that groups of scientists should select problems which are theoretically interesting, but also of practical relevance to the country. Two subjects for such collaborative effort which can easily be identified are the investigations on medicinal properties of our local herbs and plants, and the investigations on abnormal haemoglobin. Round these nuclei, a number of our present chemists, medical doctors, biochemists, geneticists and probably others could quite easily crystallise into really effective groups.

Provision of adequate scientific infrastructure applies to the availability both of scientific equipment and of trained manpower. As far as production of scientific equipment is concerned, it is hardly likely that the developing countries would be self-sufficient in the foreseeable future; for a considerable time to come we shall have to rely on the advanced countries. Because of the scarcity of financial resources in developing countries referred to earlier, most of the equipment which they need is at present supplied under what is generally known as *technical assistance*—both by international organisations and bilaterally. It seems to me that in the past few years a very desirable change has been taking place in the thinking of certain advanced countries and international organisations on the provision of technical assistance. The concept of technical assistance has been "the transfer of skills" from advanced countries to underdeveloped countries. There is nothing much wrong with such a concept; but there seems to have been the assumption as well—perhaps subconsciously—that the transfer of skills could be brought about only by sending out experts from the advanced countries. This meant, of course, that when a certain amount was entered in the books as being devoted to technical assistance to a particular underdeveloped country, what was really happening was that something like 15 per cent of that amount was spent on the travelling expenses

of the expert from the donor country, about 10 per cent on administrative expenses in the donor country, about 35 per cent on the salary of the expert, paid in the donor country, about 25 per cent on the equipment needed for the expert's programme, and the remaining 15 per cent on expenses connected with the actual programme of the expert in the under-developed country. It is thus clear that quite a sizeable proportion of what the advanced countries gave by way of technical assistance was spent on their own nationals and found its way back to the donor countries. This is not to say that the achievement brought about by technical assistance of this kind has been without significance. But it is certainly true that since there was a change in thinking, shifting the emphasis from experts to equipment where necessary, technical assistance to developing countries has achieved much more than previously. However, what one should aim at avoiding is a rigid commitment to one extreme view or the other, namely the "experts view" or the "equipment view". The ideal situation is one of extreme flexibility, taking each case on its own merits. There has also been the practice of a number of advanced countries stipulating that any equipment approved under technical assistance must be purchased in their respective countries. Whereas of course such assistance can be valued in financial terms, it has recently been estimated that the effectiveness of such "tied aid" might be as low as only one-third what it could be if it were "untied" and could be used to purchase the lowest priced equipment on the open world market.

As I pointed out elsewhere sometime ago, the introduction of scientific equipment and techniques into a social and economic environment differing vastly from that in which they were originally developed requires a high degree of adaptation. A major task of a recipient government is therefore to assess how, and at what level, a particular equipment or technique can be applied in a way really appropriate to its own particular circumstances. This means that an important element in estimating the role of science in national development is to ensure that apart from identifying the areas in which science can contribute, the planning authorities realise fairly precisely what any given facility or technique can achieve as well as what it can *not* achieve. Even when the facility or technique forms part of a "new project", indiscriminate acceptance of external aid should, as far as possible, still be avoided. Without proper assessment and planning of projects to ensure that they are appropriate, are

phased over convenient periods, and conveniently fit into a development plan, the projects are likely to be sustained only for as long as assistance from the external source continues: and even during that time, such projects may have the effect of shunting off some of the badly needed internal financial and manpower resources. The effect of the resulting imbalance may be just the reverse of that intended in the overall national development. From the point of view of the advanced donor countries, it is equally important to ensure that they do not grant all aid requests indiscriminately and uncritically. It is natural, of course, for individual scientists to request equipment—and usually expensive equipment—which may be of use in their own very narrow field of specialisation. This fact by itself is no reason why such requests should not be favourably considered. But as already pointed out, technical assistance is likely to have its maximum effect if requests which are granted can be clearly demonstrated to be part of the overall development programme of the under-developed country. Furthermore, there must exist conditions in which equipment granted under echnical assistance can be adequately maintained and serviced. tIf these conditions do not already exist, it should be one of the purposes of the technical assistance to create such conditions. We shall take up this aspect again later. It would be clear from the foregoing that in giving technical assistance to an under-developed country, advanced countries should attach as few strings as possible, apportion the expert component and equipment component as the particular practical situation demands, give that assistance in the areas which would make the maximum contribution to the overall national development of the under-developed country, and give it in such an amount as can usefully be absorbed having regard to the general infrastructure of supporting services. When that amount has been absorbed, when its usefulness has been proved, another quantum can then be provided; that way one would avoid the classical error of "too much too soon".

I propose that we should now examine further the question of what kind of scientific education there should be so as to produce people competent to make the kind of contribution to national development that we have been outlining. I have argued for the inclusion of more science even at the lower rungs of the educational ladder. I have stated that scientists can be, and often are, at least as good administrators as those who have received their training mainly in the arts.

Furthermore, since it is important that in all aspects of national development our planners should understand and harness the benefits of science, it is obvious that an education in as broad a spectrum as possible in general science, even if not technically advanced, would contribute a great deal to national development. The suggestion which I would like to put forward for consideration is that as many as possible of our undergraduates should be encouraged to read science. We do need some specialists, but for most of the undergraduates, the science that they do must be very broadly based. We should not be hide-bound by traditional patterns of advanced countries. It should be possible, for example, for our undergraduates to incorporate into their science practical subjects such as computer programming and electronics. I would go as far as to say that it should be possible for a majority of the students to combine the traditional science subjects with economics, for example. It should also be possible, and indeed a great number of the arts students should be encouraged, to take a course in general modern science which could give them sufficient acquaintance with the main branches of natural science needed for industrial development. It must be faced squarely that although patterns are now changing, it would seem that traditionally, the chief aim of lecturing in the advanced countries has been to prepare students for research. Those who did not go into either academic or industrial research but went into industrial applications had to learn most of what was required of them on the actual job. It is quite clear that we simply cannot have this kind of pattern in a developing country. We must aim at giving our students the kind of training which would enable them, *as soon as they leave the University institutions*, to make a significant scientific impact on the development of the country. This means that their training at undergraduate level must include industrial and applied aspects of the technical topics which they treat. It must also—and here I may be considered somewhat of a heretic—include, even at undergraduate level, a fair amount of training in searching the sceintific literature for potentially useful ideas. Traditionally, in the advanced countries, training in literature search has been reserved till the postgraduate level. I suggest the inclusion of some amount of literature *recherche* in our undergraduate training because, as would be recalled, it has been pointed out that the time lag between the discovery of a new scientific idea and its application on an industrial scale is becoming shorter and shorter.

It is worth re-emphasizing that, for a number of developing countries, solutions to many urgent and important problems can be found by the application of established techniques or discoveries made in advanced countries. Attention should be drawn to the fact that recorded information is a cheap and effective resource for development. Compared to the great benefit to be derived from this source, the expenditure needed for the acquisition of scientific and technical literature is not excessive, and is well worth its value as an investment. Indeed, many developing countries already have collections of scientific literature, and any gaps in these collections can be filled easily, for example, by the offer of free publications from advanced countries. The problem as I see it, however, is to train a large number of "librarian-scientific information specialists" who regard themselves not as guardians of the scientific literature, but as promoters of its utilization, quickly disseminating information to the appropriate users in order to give an effective impetus to current scientific and technological programmes. In this respect particular mention may be made of the CSIR abstracting service. This unit is doing a very useful and necessary job, and I do not wish any of my comments to be taken as lessening the importance of its contribution. Indeed, it may be concluded from what I have said that the more we have of such services, the better for us. However, one is tempted to wonder whether the present form of the abstracts is not just a little too heavily weighted on the side of basic research. The real need I wish to emphasise here is the identifying, summarising and retrieving of scientific literature likely to be of use in practical fields of national development, and the dissemination of that information as quickly as possible. One other direction in which the CSIR abstracting service could expand its usefulness is by serving as an information exchange centre, if necessary in collaboration with another centre, to which scientists, research organizations, industries, and Ministries would send information they consider might be useful to other similar groups, and to which they could refer specific problems on literature and techniques for guidance on existing information.

As pointed out earlier, provision of an adequate scientific infrastructure involves ensuring the existence both of the required equipment and of the required manpower. Let us now turn our attention to an important aspect of the manpower problem, namely the training of technicians. This, of course, is also part of the question

of scientific education. Indeed, it is clear that the individual headings under which we have considered the role of science in national development are inter-related, and it is difficult to identify certain aspects as being of importance to the exclusion of others. However, it seems to me that priority could well be given to the training of technicians. This problem, of course, is part of the general one of providing middle-level personnel in all aspects of the country's development, namely the training of secretaries and managerial auxiliaries, the training of nurses and medical auxiliaries, and the training of technicians and scientific auxiliaries. Apart from the possibility in comic opera, it is difficult to imagine an army functioning efficiently in which the generals outnumber all the others. As everyone knows, for successful scientific work, one needs technicians in the ratio of something like three or four to every scientist. This is true in a number of advanced countries; in under-developed countries competent technicians are even more necessary. Not to put too fine a point on it, we do need people who can ensure that telephones work, so that a simple instruction can be communicated from one end of a factory to another; people who can ensure that an automatic research or production process, programmed on a certain voltage or hydraulic pressure does not break down because of power failure or water shortage. To put it at its lowest level, we do need people who can turn screwdrivers, maintain and repair scientific equipment however elementary and, above all, improvise where a particular piece of equipment is for some reason or another unobtainable. If we do not take steps to train such people then a great deal of our investment in scientific education may easily turn out to have been misplaced. Unfortunately, our present scientific education in the institutions of higher learning does not seem to cater for this class of scientific auxiliary. It is assumed that almost anyone with the necessary 'A' Levels who presents himself and wishes to become a scientist *can* become one. We thus lose a great number of people who could become first-rate technicians. It seems to me that one of the ways in which science can make a great impact on national development is by providing for the training of technicians from among some of those who at present go on to take science degrees. This is easy to say, but in practice I expect it would need a good deal of structural change in the pattern of our higher education. In a number of under-developed countries, the present educational pattern, especially in higher education, is the result of historical association with former

colonial powers; in our case Britain. Osborne, writing on this aspect of Science in Developing Countries in a recent issue of *Minerva*, had this to say: "I do not wish to defend this transfer of irrelevant patterns, . . . but I would like to defend some of the people who were responsible for the transfer. Their aim was to transfer the best they knew. Indeed at one time any suggestion that education in Africa should be different from that in Britain was taken by educated and independent-minded Africans as an insult . . . The trouble is that too many African academics still think in much the same way." In a later issue of the same Journal, I commented that in my view it was true that one of the earlier psychological driving forces for academics in the developing countries had been a desire—almost an obsession—to demonstrate that they could be as good as their brother-academics anywhere else in the world. But it seemed to me equally important to reaslise that in the past 10 years or so those academics themselves, as well as their counterparts in planning and development, had come to consider that the point had been established beyond all doubt. This was evidenced by a change of emphasis from trying to *excel at those old patterns* to the self-confidence with which they now approached the problem of *modifying those patterns* to suit the particular needs and circumstances of the developing countries. In brief, while there still was, of course, a concern with *how good* the products of the institutions of higher education ought to be, there was as much or even a greater preoccupation now with *what* they ought to be good at.

The training of technicians, and middle-level manpower generally, should be part of this concern. It has not been an infrequent occurrence in some developing countries that necessary equipment has had to be packed up and shipped off to the country of origin for repairs: a process which holds up vital work for periods out of all proportion to either the cost or the complexity of the repairs. Until comparatively recently, the post of technician was merely a period of transition during which the incumbents waited while they picked up the necessary entry requirements to embark on a more remunerative and status-worthy job. We can train all the M.Sc.'s and the Ph.D.'s that we wish to turn out, but without competent technicians the country will realise only a tiny fraction of the real potential of those scientists. Quite simply, the horse must be put before the cart. The training of technicians in scientific manipulation and the maintenance of equipment should not be considered

too unimportant a matter, however simple the training required. About two years ago the Ghana Atomic Energy Commission ran a training course in radioisotope applications for technicians, with some assistance from the International Atomic Energy Agency. This was a modest effort, but it went off so well and was seen to be meeting such a great need that under the auspices of the United Nations Development Programme the IAEA, for the first time ever, ran a course last year on a broader basis for the training of technicians not only in radioisotope applications, but also in general scientific techniques. That course was run here and was of a regional character attended by a number of participants from English-speaking countries in Africa. The course succeeded in establishing a workable programme for training a specialist cadre of technicians able to undertake the basic laboratory work involved in medical, agricultural and industrial scientific work, by way of maintenance of equipment, provision of routine services, as well as active participation in the type of research that would provide developing countries answers to their practical problems. As a result of the success of that course and the realization of its importance to several countries in Africa, consideration is being given to the running of a similar training course again in the near future. It cannot be over-emphasised that this is one of the most important ways in which the scientific infrastructure in developing countries can be strengthened. It is obvious that although the advanced countries could give much assistance in this matter, the problem rests in a large measure with the developing countries *themselves*, and those that take early steps to ensure the effective training of technicians would reap a rich and timely harvest.

If the training of an adequate number of technicians requires some structural change in the pattern of our higher education, it requires at least an equally extensive change in the thinking of some of our educationists and planners. We need a new type of technician (and, generally, middle-level manpower): personnel who would look upon their job as a career in itself. Clearly, we cannot hope to train and retain such personnel while—whatever else we *say*—we tend to look down on them, perhaps subconsciously, as some inferior breed. They must surely be given the remuneration and status which reflects the crucial importance that we wish to attach to them. I wish to emphasise that it is absolutely vital to shed the mentality which considers a technician as inferior because he is not

good enough for the "more academic" pursuit of science. To be a good technician requires as much mental and physical effort as to be a scientist;—in some cases, more. The essential thing to note is that the two aptitudes are different—they are different without the one being inferior to the other, and without the one being unnecessary as far as the other is concerned. We must create the conditions in which people become technicians because they feel they have a special aptitude for instrumentation, not because they have a feeling of frustration that "academic" science is beyond their reach. If my thesis is accepted that the essential difference between technicians and scientists is one of aptitude rather than one of superiority of one kind of job over the other, it is important that this acceptance be reflected in comparable salary scales and treatment. Twice recently when there have been salary revisions in the Universities and similar institutions, members of the lecturing grades have had their salary adjustments far in advance of those of this middle-level manpower to whom I refer. It has been no trouble to work out the salary adjustments of the lecturing grades, but in the case of the middle-level manpower, committees were to be set up to look into their case. In the revision before the most recent one it was more than a year before their adjustment was made; in the latest revision, the committees have not even been set up yet. We surely cannot hope to attract and retain good people in these positions while society accords them a status which in material and emotional terms is far inferior to the glamour of scientists or administrators. As I pointed out a little earlier, our educational structure in this respect seems to have put the cart before the horse. The way that a number of advanced countries have translated the same realisation into action is by up-grading their institutions for the training of technicians to the status of Universities and conferring degrees. Our solution here may be somewhat different because our circumstances are different. Given the change in thinking which I have suggested in remuneration and social status, it should not be difficult to bring about the corresponding change required in the pattern of higher education. But, certainly, we must keep seriously addressing ourselves to this problem if we are to maintain the conditions that would maximise the contribution of science to national development.

In conclusion, I make no apology for advocating the harnessing of so much of our scientific talent and effort to the solution of practical problems. During periods of war in advanced countries,

scientific manpower is heavily mobilised on practical applications aimed at getting the nation out of the crisis. The rationale here is the same; the fact that our problems are less sophisticated does not detract from the thesis. Compared with, say, the tracking of enemy positions by radar, our problems may seem rather pedestrian. But I do not know of anyone who has ever been considered to be building badly in forgoing prestige of façade for soundness of foundation. It has been said that the future belongs to science. For us, perhaps even more urgently, the present belongs to technology; and the more our scientists devote their attention to practical problems, the greater and faster will be their contribution to our national development. In this endeavour, if the methods tried in the past have not been too successful, at least partly because they were a direct transplantation from advanced countries, that is no reason for throwing up the sponge. We should borrow, devise, substitute, modify;—until we find those that apply to our circumstances: to adapt a common saying, if at first you don't succeed, try, try, try another method.

OTHER INAUGURAL LECTURES PUBLISHED FOR THE UNIVERSITIES OF LEGON & CAPE COAST

Bryn Davies—*The Novels of Benjamin Disraeli*
Merrick Posnansky—*Myth & Methodology: The Archaeological Contribution to African History*
Virginia Cutler—*Woman Power' Social Imperative and Home Science*
Sadowski Z. L.—*Population Growth and the Strategy of Development*
Westley F. Buchele—*No Starving Billions: The Role of Agricultural Engineering in Economic Development*
Ewer D. W.—*Zoology: Should It Exist?*
Nketia J. H.—*Ethnomusicology in Ghana*
Evans E. V.—*The World of Food and Nutrition*
Smith A. F. J.—*Aspects of Geological Practice and Education in Ghana*
Abraham J. H.—*Technology, Politics and Vzlue*
Ellis J. O.—*Linguistics in a Multilingual Society*
Lawson G. W.—*Ecology and Conservation in Ghana*
McCready Margaret S.—*Why Educate for Living?*
Green T. L.—*Selection, Teaching and Examining in Universities*
Bailon de Sa—*This Strange Universe*
Crawford M.—*Second Thoughts on Learning Science by Rote*
Woodruff A. B.—*Psychology: That Nasty Little Subject or the Science of Rescue*
Hardie Alec M.—*Robert Burns and His Myth*
Lewis Roger A.—*Pollution of the Internal Environment*
Ottenberg Simon—*Anthropology and African Aesthetics*
Crowley D. J.—*Folktale Research in Africa*
Addae Kojo—*Temperature, Hormones, and the Kidney in Sickle Cell Disease*
Amorin J. K. E.—*Concepts of Disease Causation throughout the Ages*
Posnansky Merrick—*The Origins of West African Trade*
Moore G. H.—*Is God in History*
Baeta C. G.—*The Relationships of Christians with Men of other Living Faiths*
Watkins M. O.—*The University's Role in a Developing Country*
Akiwumi A.—*Higher Education for Nurses*
Ampofo D. A.—*The Family Planning Movement of Ghana*
Dickson K. B.—*The Ghanaian Town, Its Nature and Function*
Merton, Love R.—*Agriculture and Civilization*
La-Anyane, S.—*Agricultural Fundamentalism, Man and National Development*