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BIOTECHNOLOGY AND THE THIRD WORLD: THE MISSING LINK BETWEEN RESEARCH AND APPLICATIONS[1]

by

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ABSTRACT

A United Nations University study investigated the activities of four major UN agencies that focussed on helping developing countries gain advanced capabilities in biotechnology. Relevant program and project documents were scrutinized at agency headquarters and managers were interviewed. Then, projects underway in three case countries (Egypt, Thailand, and Venezuela) were examined. The resulting information was used to assess whether UN projects were fulfilling these countries' needs and/or advancing their capabilities in biotechnology.

The minute UN-originated assistance available was directed solely at increasing capabilities in research and thus benefited bioscientists and their institutes. However, as virtually no linkage exists between the research establishment and the industrial/marketing sector, results from indigenous research does not reach industrialists, farmers, or health workers. Consequently, biotechnology is largely irrelevant to the economic and social development in the case countries. This situation is likely to persist as corrective systemic changes will be difficult to implement. Major implications of these findings are discussed, particularly as they bear on the UN system.

Introduction

This article contains the synopsis of a study undertaken to investigate the activities that four major United Nations (UN) agencies are undertaking to help developing countries gain advanced capabilities in biotechnology (Zilinskas, 1987b). First, the author researched the concept development process in industrialized countries. Second, three developing countries selected as case studies (Egypt, Thailand, and Venezuela) were visited in order to scrutinize the biotechnology-related activities related to health and industry they had planned or that were underway.[2] Third, information from the case countries was used to derive the concept development process as it takes place these countries. Fourth, information about relevant projects was collected at the headquarters of the UN agencies of the UN Development Program (UNDP), the UN Educational, Scientific, and Cultural Organization (UNESCO), the UN Industrial Development Organization (UNIDO), and the World Health Organization (WHO). Fifth, the two information sets were analyzed to clarify major gaps in the assistance being provided by agencies, and to assess whether the UN-sponsored projects are indeed augmenting and advancing the case countries' capabilities in biotechnology. Sixth, suggestions are made for evolving a cohesive approach by UN agencies in the field of biotechnology.

1. The "Ideal" Concept Development Process

Fermentation industries utilizing traditional techniques have a long history in both developed and developing countries. However, beginning ten years or so ago, advanced biotechnology R&D has given rise to a rapidly growing bioscience-based industry that is now starting to market its first products. With this development, it is possible to chart the progression of events whereby an idea or concept becomes a marketable product (i.e., the concept development process) in order to identify its important components and the forces that act on it. Further, it is possible to distinguish and evaluate the elements essential for capability building in its research and applications sectors. Hence, the concept development process may be schematically presented (see Figure 1).

Fundamental to the process is the easily accessed knowledge base. In science, the most important contributions to the knowledge base come from basic research. Only a small fraction of this base has the potential for practical application. That fraction, accessed by innovators, inventors, and entrepreneurs, is further researched in an applied research facility. If the concept is demonstrated as having the potential for meeting a need and of being workable, it enters advanced research and development. In a developed country, advanced R&D typically takes place at one of three types of facilities; national laboratory, defense establishment laboratory, or industrial laboratory. If development is successful, a product or process results. To lay the technical basis for its large scale manufacture and to determine its economics, the product is scaled up at a pilot plant facility. Pilot plant operations and down-stream processing may occasionally be done at development laboratories, but more typically takes place at the industrial plant. If the feasibility of the product is proven, industrial plant scales up for the commercial manufacture of the product, and the marketing and sales division makes certain that the product reaches those for whom it is intended. The education system produces the scientists, technicians, and managers that operate the process.

2. Biotechnology-related Activities in the Case Countries

The "ideal" concept development process provides a framework for analyzing biotechnology-related activities in the case countries of Egypt, Thailand, and Venezuela.[3] The major findings are as follows:

Knowledge base. The knowledge base is theoretically as accessible to educators, scientists, and industrialists in developing countries, as it is to anyone else. However, practically speaking, severe impediments prevent the Third World researcher from important information sources. First, due to high expense, scarce funds and, at times, a lack of hard currency only a few libraries in the case countries have book and journal collections adequate to support strong research efforts in biotechnology. These few are located in the capitals; researchers elsewhere in the countries are generally not adequately served by libraries. Second, access to data banks is not available, or is limited, due to lack of funds, poor communications lines, and lack of technical expertise. Third, person-to-person contacts between researchers from developed and developing countries are relatively infrequent because the Third

World researcher have few opportunities to travel, while scientists from industrialized countries do not usually travel to developing countries. One may conclude that outside of the fortunate scientists working in capital cities, the knowledge base is neither readily, nor easily, accessible to bioscientists in the case countries. Limited accessibility to the knowledge base is thus a principal barrier hindering the advancement of biotechnology.

Basic research. Wide-ranging basic research in the traditional areas of bioscience is proceeding at universities and government institutes in the case countries; it is rather strong in Venezuela and Thailand. Thus, a substantial scientific base exists from which research in biotechnology could expand. Nevertheless, before such research can be undertaken on a larger scale, certain barriers have to be overcome. One is mentioned above; access to the knowledge base must be improved. Second, there is a pervasive shortage or lack of rare chemicals; enzymes and radioisotopes are particularly difficult to procure. The barrier presented by the unavailability of rare chemicals is very serious since some of them, particularly the endonucleases, are the indispensable tools of the modern biotechnologists. Without an assured and adequate supply of these substances, it is not practicable to expand a biotechnology research program, nor is possible to lay a basis for a bioscience-based industry.

Research laboratories in the case countries in general lack recent equipment, especially major pieces of hardware such as mass spectrometers, gamma counters, ultracentrifuges, automatic DNA sequencers, and flow cytometers. The relatively small sums of money allocated by governments for research does not allow for the purchase of these "big ticket" items. Without major equipment, researchers performing advanced biotechnology research will sooner or later reach limits that cannot be surmounted. Sophisticated research cannot usually be undertaken. Therefore, the lack of major equipment presents a serious barrier to the development of biotechnology in the case countries.

Even if equipment and instruments are available, other problems may prevent their full utilization. Spare parts are often unavailable, so when equipment breaks down, it stays down for lengthy periods of time while the request for needed parts is processed through official channels and funds are procured for the unexpected expense.

The problem of breakdowns is compounded by instrument and repair technicians not having the training, or the motivation, to clean and perform preventive maintenance of equipment. This situation is very difficult to correct because it often stems from systemic reasons: low wages, job security despite poor performance, minimum or non-existing criteria for licensing of technicians, and lack of incentives for superior job performance. The net effect of equipment being down, whether from normal wear or due to careless maintenance, is that the productivity of the affected research laboratory goes down. Researchers are forced to spend precious time away from the bench on frustrating tasks, such as trying to deal with bureaucracies to affect repair, negotiating with irritable officials and repair men, and designing temporary fixes. Projects underway are stopped; some may have to be redone. Planned projects are delayed.

On sometimes a daily basis, Third World scientists face difficulties rarely encountered by their colleagues in developed countries, such as power shortages or outages, interrupted water supplies, supplies of vital reagents running out with little chance for timely replacement, equipment breakdowns that will take long periods of time to fix, lengthy delays in communications caused by poor telephone systems, and so on. The net effect of these factors on research productivity is without doubt negative.

Scientists and technicians are civil servants in the case countries, compensated according to scales set for government employees. As part of austerity measures, governments have for the last five years or so refused or limited pay raises to civil servants. The wages in the public sector have accordingly not kept pace with increases in the cost of living, nor with the wages in the private sector. Scientists and technicians are poorly compensated when compared to somewhat equivalent employees in the private sector. Further, the possibilities for earning supplemental income are severely restricted for scientists. This situation stems from there being no alternative employment opportunities for scientists as no research and little development is done in the private sector.

Applied research. In the case countries, the amount of applied research being done at universities is rather low. There appear to be two reasons. First, the role of scientists in universities is traditionally to teach, implant a love of learning among students, and to perform basic research. A university scientist would find it trying to take up applied research projects since there is minimal appreciation for such work among colleagues (some may actually denigrate it). Further, on a professional level, there are no, or very few, contacts between professors and industrialists or health providers.

Second, with few exceptions, there are no contractors for applied research or consumers for research results in the case countries. As a result, it would make little sense for university researchers to perform applied research since results, even if potentially useful, will not be developed. The exceptions tend to prove the rule. The few applied projects underway in Thailand and Venezuela are being done by groups that have through strong efforts in basic research developed expertise in narrow areas pertaining to various disease agents. The expertise allows the groups to take on projects supported by IOs or funding organizations in developed countries, who may then use the results for their own purposes.

Outside the universities, at public research institutes, a certain amount of applied research does take place in the three case countries; in Egypt it is quite significant - more than 75% of research carried out by its science and technology organizations is applied (El Nockrashy, et al, 1986). Only a small percentage of research results is eventually used because either the work is inappropriate, of low quality, or there is little association between the research units and potential users of results in agriculture and industry. No applied biotechnology research funded by indigenous industry is done in the case countries.

Advanced research and development. No units capable of advanced research and development in biotechnology, whether at universities, national laboratories, or industries, exist in the case countries. The advanced research and development component so strategically located in the ideal concept development process (see Figure 1) is missing in the case countries. As a result, it is difficult, if not impossible, to effect the transfer of knowledge and technology from research units to indigenous industry. This absent component presents a fundamental barrier to the development of biotechnology.

Industry. The industrial unit in the case countries takes one of two forms. Neither form has a research capability. In its first form the enterprise is merely a packaging and marketing unit of bulk products produced elsewhere and imported. This is probably the most common form of transnational corporations' subsidiaries. The second form is the indigenous industry which can have a development capability, but is in the main a manufacturing facility. When either form needs a technology, it is imported. The importing industry's development capability, at the maximum, allows the industry to adapt the imported technology to meet its own requirements.

In industrialized countries, the acquisition of scientific knowledge and new technology may enable the recipient industry to become more competitive in local or international markets. At times, changing markets create conditions whereby a continuous flow of new technologies are required by industry. Industrial managers rely on science and technology providers to respond quickly and appropriately to meet such demands. This the research sectors in the case countries cannot do, so indigenous industry habitually turns to foreign technology suppliers for these needs. For example, in Thailand it was noted that a local industry was interested in acquiring a technology for processing palm oil. Although appropriate R&D was taking place at a Thai university, the firm chose to buy the technology from an enterprise in the United Kingdom.

The two major reasons why industrialists in the case countries forsake turning to the research sector for needed technology are that scientists in the public institutions are perceived as having little appreciation of real life problems and their services are difficult to secure because of bureaucratic restrictions. Consequently, industrialists as a rule have no professional contacts with the research establishment in the country they are located. Therefore, industry is unable to access the knowledge base, cannot assimilate results from basic or applied research, and is incapable of independently performing research to solve problems or to develop new products or processes. The absence of research consumers in the industrial sector is a serious barrier to the development of biotechnology.

"Technology push" and "demand pull". In the ideal scheme of concept development, technology push and demand pull exert forces that act at every point along the concept development process.

Thus, the push of a powerful technology is likely, for better or worse, to result in the delivery to customers of new products and processes. Conversely, the pull generated by customer demands can and does give rise to applied research. However, the concept development process in the case countries is different from the ideal because of the breach between the research sector and the industry/marketing component. As a result, differing push and pull forces act on the two element. In reference to the research sector, technology push in the case countries results from proponents of biotechnology (bioscientists and officials who support them in the government) striving to include biotechnology research in the programs of universities and institutes. Push is accomplished when biotechnology research programs are taken up by universities and institutions, and even more so when the field is designated by a government as having high priority and commensurate funding is made available for its expansion. On the other hand, there is no demand pull for biotechnology research since there are no consumers of research results.

In the industry/marketing component, a technology is pushed by an industry for much the same reasons as in the industrialized countries; i.e., the technology has led to the development of improved or new products or processes, so the industry, whether indigenous or a multinational, attempts to market them.

Consumers in the Third World are apparently considered only marginally important in economic terms by research directors in the industrialized countries, as is demonstrated by the finding of the Science Policy Unit at Sussex University that less than 1% of the research in the developed world has relevance to developing countries (Freemantle, 1983). Hence, products and processes developed and marketed for consumers in the industrialized world are also marketed willy-nilly in developing countries, without much regard for their populations' wants or needs. Demand pull possibly exerts a more telling force on indigenous industry than on the multinationals, but since this industry lacks capabilities in applied research and advanced research and development, it cannot be well accommodated.

From my survey of activities in biotechnology in the case countries, I determined that nearly all are designed to increase capabilities in research; practically none is designated for the purpose of increasing capability in development or industry. The relatively high level of support for the biotechnology research sector in these countries results from bioscientists having successfully organized themselves to form relatively powerful political pressure groups to lobby for the support they want. Close, continuous relationships exists between scientists and the policy-makers who deal with scientific/technical matters in governments. This "normal" political activity in democracies cannot be faulted, except for one matter -- the bioscientists appear myopic in how they neglect establishing relationships with the industrialists and health providers. Although several of the interviewed scientists acknowledged and deplored this lack of communications, neither they as individual scientists nor their interest groups had made meaningful attempts to begin a dialogue between the two groups. The sentiment prevalent among scientists appears to be that they are not interested in helping turn their research into profit-making enterprises for others, and that their governments, rather than themselves, should take the necessary steps whereby their research findings are applied. As long as this attitude prevails among bioscientists, it is unlikely that attempts will be made by them to bridge the gap between the research sector and the industrial/marketing component.

Efforts by bioscientists are leading to an increase in their countries' research capabilities; possibly the research sector's productivity will go up, and more remarkable results could be generated from improved research units. But even if research productivity increases, its results are not likely to be applied by industry or health providers. As a consequence, for the foreseeable future biotechnology is unlikely to stimulate economic growth or to advance national self-reliance. Conversely, it is entirely possible that if scientists in the case countries maintain their present course of action, they may in the end weaken their own position since the public and its representatives could come to the realization that the bioscientists, while ready and able to draw scarce funds from governmental coffers to feather their own nests, do little of practical worth for their home nations. The disparity between the great expectations of biotechnology and the actual lack of achievements could in the future cause governments to look less favorably on proposals to support biotechnology and bioscientists.

3. Concept Development in the Case Countries

The foregoing analysis can be used to construct a scheme of the concept development process in the case countries (see Figure 2). The process is quite different than the ideal depicted in Figure 1.

The first difference is that accessing the knowledge base by researchers in the case countries is often difficult, time consuming, and may be expensive.

Second, in contrast to industrialized countries, where a proportion of basic research is performed in order to solve fundamental problems that may have arisen in applied research or in development, in the case countries practically all is basic research in its purest sense. In other words, results from basic research becomes part of the knowledge base; little, if any, is applied or used for problem solving.

Third, an important difference pertains to applied research. In contradistinction to industrialized countries where applied research is strongly supported whether in universities or industry, in the case countries it is either weak buds of strong basic research units in universities, or it is performed in public institutions. No applied research takes place in industry.

Fourth, a major difference is the lack of continuity between the research components and the industrial/marketing components. In the ideal process, continuum is provided by the advanced research and development units that are either part of the research component, or of industry (the usual situation). These units do not exist in the case countries.

A fifth difference is that it is common in the case countries to inject a technology, usually imported, directly into the industrial component without in any way involving the research sector.

Sixth, the types of industrial units prevalent in the case countries may be grouped under two headings. The first is a subsidiary of a multinational corporation; its major function is to package and market bulk products manufactured abroad by the multinational. The second type is indigenous industry that may import a technology as need arises. In contradistinction to industry in developed countries, neither of these two types possess advanced research or development capabilities.

4. UN-sponsored Activities in Biotechnology

A survey was made of past, on-going, and planned biotechnology-related activities sponsored by the UNDP, UNESCO, UNIDO, and WHO (Zilinskas, 1987b). The number of biotechnology-related projects being sponsored or supported by the IOs is very small, as can be witnessed by UNDP supporting less than 10 biotechnology projects out of more than 4,600 in 1986, while UNIDO has fewer than 15 out of a total of more than 1,500 projects. The nature of these projects was analyzed in order to answer three questions: Is there a coherent approach by IOs in the field of biotechnology? What kinds of assistance is being provided by IOs to the Third World and what is its impacts? What assistance is ·ot being rendered?

Coherence of IO approaches. Usually UN agencies do not formulate general policies that serve as guidelines for advancing technologies in the Third World because low or medium technologies do not require special conditions to flourish. For example, even the complex technologies necessary to build an automobile do not require their users to access the knowledge base, or to develop close associations with universities or research institutes. Thus, the technologies function easily in line with the concept development process as it takes place in the case countries (Figure 2); i.e., they may be effectively introduced directly into the industrial/marketing sector with no referral to the research component. However, in order for a science-based technology to achieve practical results, a far-reaching, complex environment is required, as demonstrated by the ideal concept development process (Figure 1). Wise policies should be formulated and applied to create that environment and the infrastructure to support it. Yet, due to their small number biotechnology is for the time being of lesser importance to UN policy-makers than are many low and medium technologies. Thus, it is understandable that agencies have neglected to formulate a general policy for this field among, or within, the UN system. The low number of IO biotechnology-related activities probably stems from two factors; few IO managers are familiar with the field, and its practical applications are perceived by knowledgeable IO and national officials to be far off in time.

Kinds of assistance provided by IOs. An examination of the IO activities indicates that there are three categories of assistance; help to policy-makers, support for country research and training activities, and providing backing for the establishment of international networks.

(i) Help to Policy-makers.

UNESCO and UNIDO in particular have taken a "from the ground floor up" approach to introducing biotechnology to developing countries; i.e., they first seek to familiarizing decision-makers and their scientific advisers with biotechnology through briefings by scientific missions, the holding of national symposia, and the providing of informative material. This proactive approach appears to have borne fruit; observers have found a widespread awareness among Third World officials about biotechnology. Information elicited from interviews conducted in the course of this project with scientists and politicians in developing countries supports this contention.

Once familiarization has been achieved, decision-makers need to consider how to deploy biotechnology and for what purposes. UNIDO especially has assisted nations in this regard by setting up fora where the possibilities of biotechnology for the nation in question have been discussed and evaluated. National conferences have been held in Morocco, South Korea, Kuwait, Saudi Arabia, and other countries. Since such national symposia or workshops have been held rather recently, their effects cannot be evaluated as yet. A first indication from Korea is positive; the symposium held there in 1983 is credited with helping to stimulated the government to support the field. On a preliminary basis, one can conclude that national symposia and workshops are worthwhile for IOs to sponsor since they focus national efforts in biotechnology. Such assistance, though not critical, is valuable.

(ii) Support for Capability Building in Research.

Most of the surveyed IO activities in biotechnology falls within this category; there appears to be two reasons why. First, UN project managers have supported them. There is the pervasive belief among these managers that a high technology industry cannot be built in a country without it first having a sound base in the underlying science to that technology. Since few developing countries have an adequate scientific base for biotechnology, it logically follows that assistance should first be given to lay or strengthen such a base.

Second, bioscientists from both developed and developing countries have been successful in persuading IOs to support biotechnology research projects. Biotechnologists and bioscientists from developed and developing countries serve as consultants to the UN; in addition, those from developing countries are often advisers to their governments in negotiations having high scientific/technical content. These activities afford scientists many opportunities to contact UN officials. Program managers cannot help but be influenced by these people -- they are articulate, sensitive, caring, and persuasive. The end result is that bioscientists, who without doubt firmly believe that biotechnology can and will help the Third World develop, are identified by project managers as presenting the prevalent view among policy makers in developing countries; a perception that is at the least one-sided since bioindustry is not represented. By not taking into account differing interests, even if not articulated, projects were, and continue to be, designed to boost capability building in research, but that are otherwise too circumscribed to have practical effects.

Support for capability building in research takes four forms; the providing of technical information, training opportunities, funds to purchase major equipment, and funds to purchase chemicals.

a. Technical information.

Scientists in the case countries are usually unable to access technical information easily or quickly. Relatively frequently information that is sent them is lost in the mail. More disturbing, however, within governments there seems to exist an invisible, yet real, barrier that prevents the dissemination of information to researchers. These barriers are found in the ministries under whose auspices or authority researchers work. Simply put, large quantities of general and technical information is routinely sent by IOs to the ministries they liaison with; very little of it is forwarded to anyone outside these ministries. Apparently, information dissemination is poorly practiced by governments of the case countries.

Other information is provided by IOs directly to scientists on request; yet, few of them take advantage. For example, free subscriptions to UNIDO's Genetic Engineering and Biotechnology Monitor, a quarterly publication that sums up recent developments in biotechnology throughout the world, are extended to anyone requesting it. One would believe that scientists and libraries in developing countries would be clamoring for such a valuable source of information. Instead, there are only about 1,200 subscribers, mostly in developed countries. The likely reason for the low number of subscribers to the Monitor is that Third World scientists do not know of it.

Even in those few cases where the issuing organization has a program for the active, direct forwarding of information to scientists, the potential recipients rarely benefit. Thus, for example, the International Network of Biotechnology (INB), through its member governments' diplomatic missions in developing countries, exerts much effort in sending information circulars directly to scientific societies, university departments, institute research units, and individual scientists. Yet, it was only the rare researcher in the case countries who had heard of the INB.[4]

Clearly, the passive method of information dissemination that is usually employed by IOs is ineffective; better, active mechanisms should be developed to ensure that technical information gets to the intended recipients.

b. Training opportunities.

The providing of training opportunities by IOs is a major, widely practiced activity, and the one most requested by scientists in the case countries. By providing training opportunities, IOs augments existing capabilities of scientists to perform research and makes it possible to introduce new techniques to research units. Sometimes the beneficial effects of training can be readily observed, as a joint, cooperative UNIDO project between the Universities of Lahore and Dublin demonstrates. As part of that project, the Pakistani principal investigator received hands-on training in cloning and sequencing. Upon completing training and returning to Pakistan, this scientist was the first to do cloning in that country. Further, he quickly acted to set up a local two-week workshop during which twenty other Pakistanis received training in this technique.

Unfortunately, it is more usual that resources spent on training is wasted. Many scientists from developing countries who receive advanced training cannot use it in their home institutions due to lack of facilities, equipment, and expendable supplies. Some respond by allowing their skills to languish. Others leave their home countries and use their new knowledge in developed country laboratories.

c. Funds to purchase major equipment.

With the possible exception of WHO (through its Research Capability Strengthening program), IOs are wary of financing projects when the equipment component adds up to more than 30% of the project's budget. There may be several reasons:

First, since a piece of major equipment is usually shared, because it remains with the supported research unit after a project ends, and because very few projects would by themselves necessitate its sole use, it could be considered part of the infrastructure. Thus, in the IO's view, the apparatus should be purchased by the institute running the project or by the home government.

Second, it can be difficult for a funding agency to evaluate requests for major equipment. The need for some can be measured; for example, that of a fermentor can be calculated by considering the value of its output over time. Requests for other instruments can present problems; for example, on what grounds could a UN agency justify giving support for the purchase of an automatic DNA synthesizer? It may be justified when a project has as its aim institution building. Thus, when a national or regional centre is being established, equipping it with sophisticated, expensive equipment is reasonable because it will serve as a reference and training centre for an entire nation or region. But its purchase for a particular research project may be questionable since only the rare project would have need of that sophisticated equipment, few researchers would know how to use it, backup support by its manufacturer is often unavailable, and few, if any, technician are able to maintain it.

Third, every IO project manager is aware of expensive equipment that has been unnecessarily purchased with IO funds. For instance, UNIDO's Selected Committee, while evaluating the status of biotechnology in six countries, observed in an institute "... a set of about 20 gamma counters laid out on benches behind locked doors" (UNIDO, 1983). Similarly, while visiting the case countries, I was informed of an electron microscope located at a vaccine research institute, purchased six years previously with UNDP funds, which had never been used.

Nevertheless, leaving aside the questions of wastage and inefficiency, the amount of major equipment being provided by IOs to research institutions in developing countries is minute when compared to the need.

d. Funds to purchase chemicals.

Rare chemicals, and other expandable supplies, are vital to research and to bioscience-based industry. Thus, all biotechnology-related research projects supported by IOs include provisions for their purchase. While such funding helps carry individual projects forward, it does nothing to help solve the overriding problem, namely, no dependable manufacturers of rare chemicals exist in the case countries or, with the rare exception, in the Third World. In order to secure these chemicals, researchers have to use up much time and spend scarce hard currency, and even so they are usually in short supply. Clearly, the shortage of rare chemicals limits growth of biotechnology R&D and places what may be a fundamental barrier in the way to the establishing of bioscience-based industry in the Third World.

(iii) IOs and International Networks.

IOs have the important function of acting as a catalyzing force in the setting up, and in the operation, of networks having international reach. Two networks have the longest history; the Consultative Group on International Agricultural Research (CGIAR) and the Microbiological Resource Centers (MIRCENs). The two are quite different: CGIAR, although an informal organization without constitution or charter, fully funds its 13 member institutions, and its research activities are in a general sense coordinated by the network secretariat (located at the World Bank's headquarters in Washington D.C.). Its focus is on tropical agriculture and animal diseases prevalent in the tropics (UNDP, 1986). The 16 MIRCEN institutions are independent units, only loosely connected through networking, and minimally funded by UNESCO. Initially, MIRCEN's interest was focussed on research pertaining to gene pools; now its scope is wider, including both agriculture and industry (DaSilva and Taguchi, 1986). Despite differences, both networks facilitate communications between widely dispersed units so they may work in unison for achieving certain general objectives by sharing expertise, undertaking cooperative research, integrating training of scientific personnel, and sharing certain resources. Occasionally, research results from a network have had dramatic effects on the Third World; for instance, the highly productive dwarf rice developed by CGIAR's International Rice Research Institute has been adopted by farmers throughout the world, resulting in a marked increase in rice production.

To my knowledge, no objective assessments have been done of CGIAR or MIRCEN. Nevertheless, that over 30 nations (as well as IOs and foundations) contribute in excess of $ 180 million per year to support CGIAR would indicate they find it worthwhile. Similarly scientists who work at institutes that are part of MIRCEN uniformly espouse its value (Colwell, 1983; 1986).

New networks are in the process of being set up by IOs that concentrate on biotechnology. Thus, three IOs (UNESCO, UNDP, and UNIDO) are helping in the establishment of the Regional Biotechnology Programme for Latin America and the Caribbean (UNDP, 1986); UNIDO is setting up the International Centre for Genetic Engineering and Biotechnology (ICGEB) and its network of affiliated centers (Zilinskas, 1987a); and UNU is formulating a network for international cooperation in biotechnology (UNU, 1985). The functions of the new networks will be similar to those of the older ones; i.e., they will seek to integrate the work and training programs of participating institutes, share expertise, pool resources, and perform cooperative research. By doing so, individual institutes in the network can take on projects that it otherwise would have to forsake, perhaps because they would be too expensive, large, or difficult. As a group, network institutes should be more productive than they would have been if working independently.

5. Major Gaps in Assistance by UN Agencies.

The major gap in assistance being provided by UN agencies is related to applying results from research. Three problem areas are particularly noteworthy: disseminating findings to industry; funding projects pertaining to advanced research, development, and industry; and the promoting of research for consumers.

(i) Dissemination of Research Results.

IO-sponsored projects usually include measures for the dissemination of the results they generate to industry, usually through a workshop or symposium, and publications. In actuality, these approaches do not work for five reasons. First, information about the holding of workshops or symposia, or of the availability of publications, most often does not reach those who would be interested. Second, the described results may be in a narrow scientific area of interest to few people in industry or to health providers. Third, since industries as a rule do not have a research or development capability, they cannot take advantage of the presented results. Fourth, even if results could be usable, the adaptive capabilities of the affected industry would most likely be so low that it would be unable to utilize findings without making major new investments in manpower and equipment. Five, capital needed for making investments in development, scale-up, and manufacture is difficult to raise in the developing countries.

(ii) Advanced Research, Development, and Industry.

The scrutiny of UN activities indicates that no resources have been expended on biotechnology advanced research, development or industry, except perhaps indirectly, and no resources have been allocated for this purpose in projects being planned. As a result, there is no natural outlet for the results and findings generated by UN-supported basic and applied research.

(iii) IOs and Research Consumers.

The lack of consumers for research is largely due to systemic reasons, which are best solved by governments. Yet, IOs can help improve the situation by funding projects that involve industrialists and health providers from beginning to end. Some projects do in fact contain such clauses. In addition, UN agencies can provide counsel on how changes can best be accomplished, and what steps governments can take to encourage indigenous industry to contract with local research establishments for needed research or to develop customized biotechnology. No such IO projects are, however, active or planned.

To sum up the findings of the preceding analysis:

* The number of biotechnology-related projects, whether completed, underway, or planned, is small when compared to

the totality of projects being undertaken by the UN agencies, and the resources being committed to them are also minute.

* No general policy in regards to biotechnology has been formulated among the IOs, or indeed within any individual agency. However, even without a policy, or policies, and whichever the executing agency, the activities pertaining to biotechnology are remarkable similar in that they can be grouped under one of three types of activities; either rendering assistance to policy-makers (informing them about biotechnology and its promises, and organizing fora to delineate national programs in biotechnology), promoting capability building in biotechnology research (supporting research and training projects at the national and international levels), or helping in establishing international biotechnology networks.
* No active or planned IO project appears to have as its aim to improve either the biotechnology capabilities of advanced research and development units or the industrial sector.
* No instance of wasteful overlap between activities of different IOs is noted. Possibly, the small number of projects being done in a large technological field occasions few chances for overlaps.
* IO biotechnology projects have created opportunities for productive cooperation between agencies. Specifically, UNDP, UNESCO, and UNIDO cooperate in the Latin American regional program; and the ICGEB is expected to work closely with FAO, UNESCO, UNIDO, and WHO. Future regional projects involving Africa and Asia are likely to provide additional possibilities for IO cooperation. Collaboration on policy-related issues has barely begun, for example, UNEP, UNIDO, and WHO have recently formed a joint working group on biotechnology safety issues.

6. A Cohesive Approach by UN Agencies

For reasons discussed, IO biotechnology projects are almost entirely aimed at increasing capabilities in research, while little effort is given to making certain research results are applied. Unless a more balanced approach is taken, i.e., that the applications side receives at least equal attention to that given to the research side, biotechnology for the foreseeable future is not likely to be a factor in helping solve pressing problems facing the Third World or to contribute to its economic development. This should not be allowed to happen, and IOs could take the lead to in fact prevent it.

The first step in designing a coherent action plan for making certain that biotechnology is deployed for the benefit the developing countries would be to hold a workshop for IO managers. One of the more policy oriented IOs, perhaps the UNU or the UN Centre for Science and Technology for Development, should organize a workshop comprised of managers responsible for funding and executing biotechnology-related projects by major UN agencies. The workshop would have four objectives:

* To develop a broad consensus among the UN agencies on concepts, ideas, and issues pertaining to capability building in biotechnology research and applications by developing countries.
* To identify key policy and institutional constraints that prevent capability building in biotechnology by developing countries, especially in their health delivery, industrial, and agricultural sectors.
* To identify promising approaches that may be taken by the UN agencies to assist developing countries help overcome these constraints and to otherwise facilitate capability building in biotechnology.
* To delineate in general terms areas of responsibilities for the various UN agencies in future efforts to overcome constraints and to facilitate capability building.

Once UN program managers have a good perspective of the problems hindering the advancement of biotechnology in the Third World and how to deal with them, corrective measures can be taken. An initial measure could be for them to make certain that industrialists or health providers participate in a certain proportion of UN-sponsored research, from inception to completion. In particular, principal investigators should be obliged to clarify in concrete and practical terms how the findings they generate will be applied.

NOTES

1. An oral version of this paper was presented at the XVIth International Congress of Genetics, Toronto, Canada on 26 August 1988.

2. Due to project limitations, agriculture and other fields were not included.

3. The many biotechnology-related activities and initiatives in the case countries were described in the original UNU study. Due to their large number, only the findings from the analysis of them can be presented here.

4. The INB is jointly coordinated by England and France. In addition, Canada, the Federal Republic of Germany, and Japan belong to it. The INB provides financial aid and training opportunities in biotechnology for Third World students at universities in member countries.

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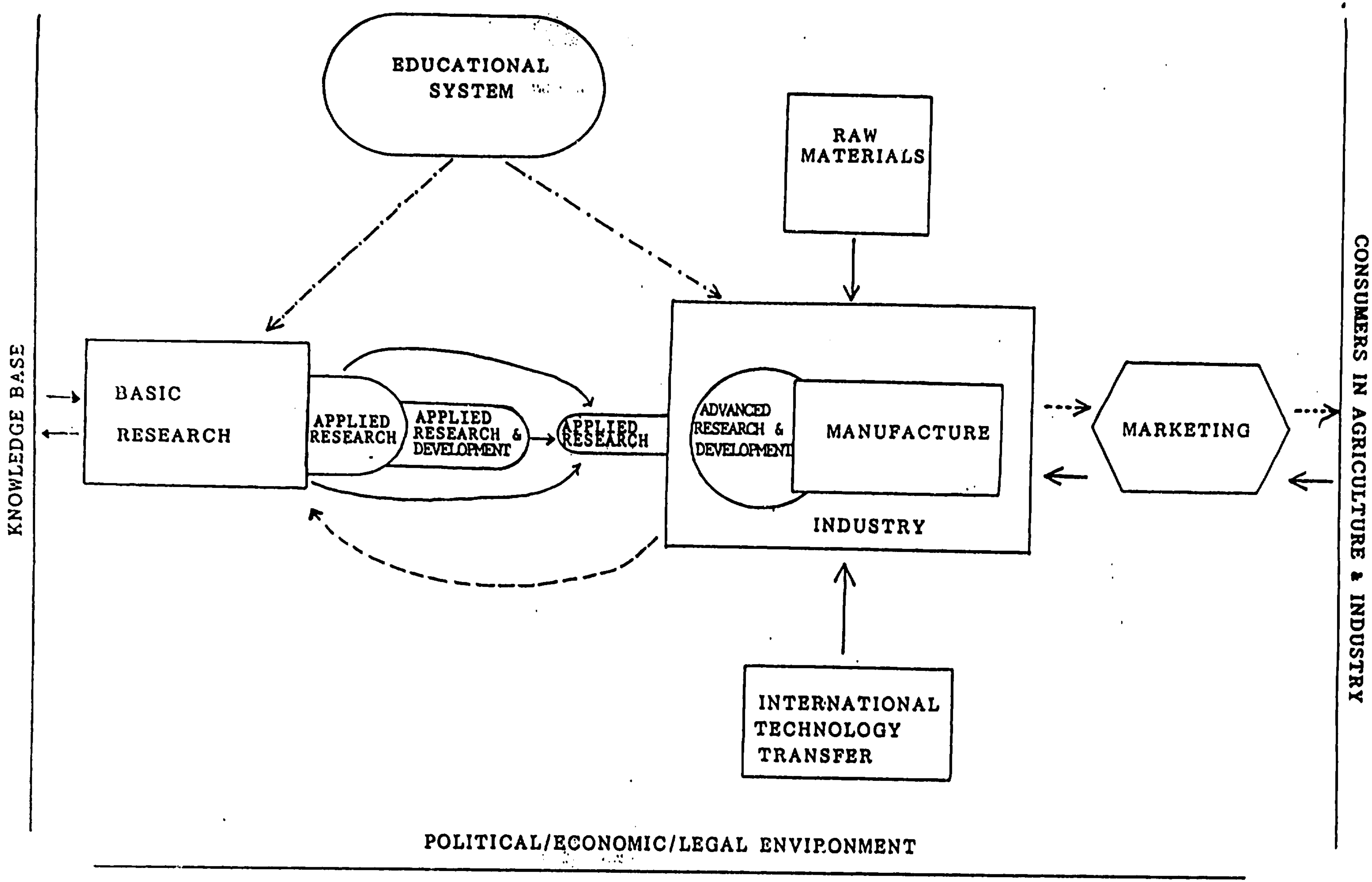
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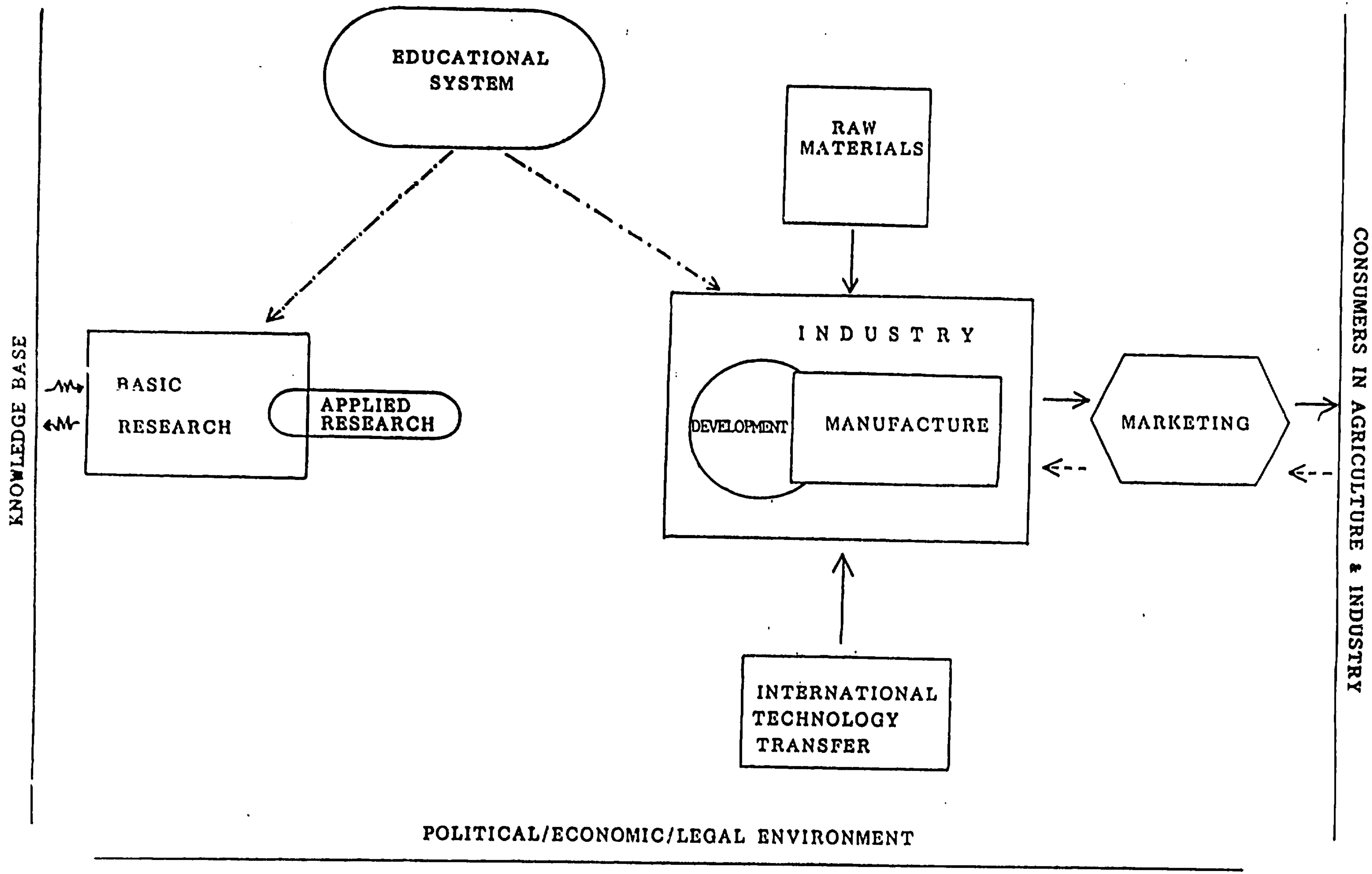
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