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August 31, 1988

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NATIONAL BIOTECHNOLOGY PROGRAM DEVELOPMENT IN KUWAIT

Technical Site Visitation Report and Recommendation

Prepared for the United Nations Industrial Development Organization and the United Nations Development Program
(Revised report was submitted on March 25, 1988)

by

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Reference: Agreement Number, CLT 85/090
Allotment code, UN K-17624-041-4

This report has not been cleared with the UNIDO or Kuwait Government and which does not necessarily share the views presented in this report. (Professor U. Petterson had a site visit, but submitted a separate and independent report to UNIDO, Vienna.)

I. EXECUTIVE SUMMARY

The planning and formulation of biotechnology program in Kuwait with the initiatives taken by the Government is very timely, and this author considers this to be consistent with the long-term national interest of Kuwait.

Biotechnology is one of those emerging high technology areas, and certain well-selected areas of biotechnology, including petroleum biotechnology, agricultural biotechnology, and health-care biotechnology should be the high priority areas for Kuwait since these are the areas which Kuwait should be able to capitalize and take full advantage of for the long-term benefit of Kuwait in terms of Kuwait's economy, industrial development, and public health and welfare of the entire population.

It is, however, very important to recognize the unique situations in Kuwait. These include:

1) The abundant but limited variety of resource base namely the petroleum, oil, solar energy, and water,
2) The affluent capital which can be invested in the long-term lucrative programs of national interest and priority,
3) The limited intellectual property in terms of research and development manpower in the area of biotechnology, and
4) The constraints related to the local climatic and geological conditions as well as regional socioeconomic environment.

In view of these unique situations, this author identified the objectives of primary importance to be addressed as "How can Kuwait make best use of its available resources base for the benefit of Kuwait people by means of developing and utilizing biotechnology effectively".

The biotechnology can be defined as "the multidisciplinary technology that is concerned with economic processing and application of materials of biological origin including the genetic information for the benefit of mankind", and it is highly relevant for Kuwait to include well-selected high priority biotechnology programs in the areas of:

1) Food resources development through agriculture biotechnology,
2) Development of chemical feedstocks and other specialty chemicals through petroleum biotechnology,
3) Medical and health care products development through health-care biotechnology, and
4) Improvement of quality of living environment through all these biotechnology endeavors.

In order to accomplish the national goal for the development of the biotechnology program very effectively, the following recommendations are made. This recommendation should complement, strengthen, and implement the Biotechnology Program plans of the Kuwait's government.

At the national government level a well-organized and well-coordinated "national plan for and policy on biotechnology program" should be formulated. Such plan and policy should include the following important aspects.

1) A "National Biotechnology Program" should be formulated and established on a long-term basis. The national biotechnology program should include:

a) Research and development program,
b) Industrial participation and development program.
c) Research manpower and personnel capabilities development program,
d) mechanisms for program formulation, monitoring,and evaluation, and
e) International scientific cooperation program.

2) The government infrastructure which could support and guide the national biotechnology program should be organized and established at the highest level possible which is equivalent to the Council of Ministers including all ministries related directly or indirectly to the national economy, planning, industry, education, environment, resources including petroleum, health and welfare, agriculture and food, and others.
The "Biotechnology Council of Ministers" might be organized and serve such a function.

3) An "Advisory Board" which has the responsibility of executing, coordinating, and evaluating the National Biotechnology Program should be organized. The advisory board members should have representation from the government, industry, academic and research organizations. The advisory board members should include many experts from broad range of disciplines and should not limit to scientific areas. The Advisory Board should report to the Biotechnology Council of Ministers.

4) Establishment of the 'National Biotechnology Center" should be of top priority. It should play a leadership role in research and development activities and at the same time should have the responsibility of being a liason between the Center and the industry and other academic and reserch organizations as well as other international reserch organizations.
The Biotechnology Center should become the host organization for many experts to be pooled together for the national mission oriented biotechnology research programs.

Alternatively,the Center could be organized as an "Advanced Institute for Biotechnology" with a dual function and responsibility of both academic and research organization. This might be an attractive arrangement for high level expert scientists who have interests in both teaching and research in an university environment. At the same time, such an Advanced Institute serve both functions for research and training of manpower in the area of Biotechnology.

This recommendation in combination with the National Plan for the Biotechnology proposed by Kuwait government should provide the basic framework and foundation for implementation of National Biotechnology Program in Kuwait.

It is of this authors considered opinion that the long range impact of biotechnology program in Kuwait, if well planned and executed, will be highly beneficial to Kuwait. It is anticipated that Kuwait economy and industrial development will be further advanced, public health and welfare significantly improved, domestic food resources and its supply more abundant, supply of fine chemicals and specialty chemicals including pharmaceuticals more secure and stable, and the living environment far more attractive and comfortable.

II. BACKGROUND

In view of the fact that Kuwait is very much interested in launching a major reserach and development program in the area of biotechnology, the government of Kuwait and UNIDO jointly requested that Professors Dewey Ryu and U. Petterson have a site visit to assess the following questions as the terms of reference for the UNIDO consulting mission.

1) Current situation in Kuwait in terms of research and development activity and existing reserch groups.

2) Infrastructures & training: requirement for building up the biotechnology research and development capability.

3) Anticipated impact of biotechnology on industrial development, and

4) Evaluation of the Kuwait's five year program in biotechnology and genetic engineering and recommendation on the national biotechnology program.

For these objectives, Professors Ryu and Petterson had a site visit to Kuwait during May 2 through 10, 1985 and held series of meetings and discussions with appropriate counterparts (list of discussants are given in the Table 1) on the relevant issues related to the terms of references and had site visits to several key institutions to assess the current situations in Kuwait (the list of institutions visited is given in Table 2). In addition, some references relevant to our mission were provided by the Kuwait authorities and these references (the list is given in the Table 3) were judiciously used in our study.

III. Current Situation in Kuwait Context

We made the following observations and assessment of the unique situation in Kuwait. This has to be taken into consideration for biotechnology program development in Kuwait.

1. Kuwait has population of about 1.7 million, land area of about 18,000 square km, and it enjoys high living standard with the highest income per capita in the world.

2. Kuwait has a large amount of oil reserve and will last about 300 years at the current rate of production. Earnings from oil revenue alone in 1984 was about 10 billion US dollars.

3. Kuwait economy is heavily dependent on imported food and other commodities.

4. Kuwait has a very good relationships with other Gulf Cooperation Council (GCC) states and the regional economic unit as a whole should be considered.

5. Kuwait has a vast arid land and fresh water is scarce although it is surrounded by the Gulf sea water. It is currently producing 100 million gallons of fresh water per day.

6. Kuwait is no exception in having some local public health problems. Some parasitic infections, hepatitis, sickle cell anemia, and thalassemia, are a few examples.

IV. Research and Educational Institutions, Training, Existing Research Groups, and Their Activities.

1. The undergraduate training in science relevant to biotechnology is provided at the Kuwait University (KU), the KU Medical College and the College of Science. A limited Master of Science program is available at the Medical College in the areas of Microbiology, Biochemistry, and Zoology. No Ph.D. program is available in Kuwait. Students usually go abroad for Ph.D. level and advanced training.

2. Kuwait Institute of Scientific Research has established an excellent facilities for applied microbiology and fermentation that could be directly applied to their expanded research activities in the area of biotechnology. Their facilities are not as yet adequate enough to handle the basic life science research. No facilities are available for recombinant DNA work as of now, but one laboratory has been allocated for basic work in molecular biology and genetic engineering. Plans are currently being made to refurbish the laboratory to do the recombinant DNA work.

Another important development at KISR is their new building facilities recently completed, and some of these facilities could easily be utilized for the new biotechnology program and genetic engineering work. In fact, this facility could house the newly organized National Biotechnology Center until such time that the Center becomes independent and separate organization.

KISR has excellent scientific personnel and they are on a par with first rate research institutions in the world. The departments visited include:

Food Resources,
Agroproduction,
Marine Culture and fisheries,
Petroleum Technology,
Biotechnology,
National Scientific and Technical Information Center, and
Information Service Department.

The scientists there are mostly very well trained and many of them have research experience in U.S. or Western Europe. They also have good international contacts, and they organize many advanced international seminars on selected topics of frontier's research. Their research management is of the first rate by international standard. Their research productivity and accomplishments are of excellent quality and national pride.

3. The Kuwait University Medical College has excellent facility. Although we visited only the Department of Microbiology, their facility could be used as one of the satelite biotechnology laboratories with a focus on health-care biotechnology. It was found that most equipments needed to start basic program in genetic engineering were available or on order. Especially, Dr. M. Olive's laboratory and his program in basic biochemistry and molecular biology is on a par with any western forefront research laboratory. He might organize a satelite health-care biotechnology program which is well coordinated with the National Biotechnology Center.

The scientists especially in the Microbiology Department came from U.S. and Western Europe and they are developing their laboratory to a level of international standard. Their clinical microbiology group is at the very advanced level. It was noted, however, that their basic biology group is too small to have any impact and its size and research manpower is far below the level of critical mass. This group should be expanded rather quickly in order to develop their health-care biotechnology program.

4. The Maternity Hospital of tne Ministry of Health has a relatively small laboratory for advanced medical genetics. They have fairly good facilities for cytogenetics. For the recombinant DNA work the facilities are not adequate, but they have a plan to expand their facilities. The work of Drs. S. Durban, S. A. Al Awadi, A. A. K. Al Ansari, and others at the Hospital have excellent program in the area of hereditary disease which is unique in Kuwait, and they should vigorously pursue their health-care biotechnology research which may lead to the cure or treatment of the hereditary disease. This is considered another important area of biotechnology research program. The Maternity Hospital Cytogentics Laboratory should be set up as another satelite biotechnology laboratory and should be coordinated with the National Biotechnology Center.

Several medical scientists at the Hospital who are highly competent are available for biotechnology research in the health-care and cytogenetics area, but again the research manpower is far below the critical mass and it is difficult to have any impact in a relatively short time frame. This satelite group should also be expanded and their research manpower strengthened.

5. Kuwait University - College of Science appear to have inadequate facilities for training students, and their facilities should be upgraded or improved for the education and training of students some of whom may go into the biotechnology area and become the next generation research scientists in the field of biotechnology.

They have only several high calibre scientist in the bitechnology related areas, and their faculty and staff in the area of life science should be expanded and strengthened quickly.

6. Although we had no opportunity to have a visit to the engineering college, it appeared that they do not have any biochemical engineering or chemical engineering program which is one of the very important components of biotechnology. Practical application and industrial development of any biotechnology product or process require biochemical engineers well trained in both areas of chemical engineering and life science. Special and urgent effort should be made to develop the biochemical engineering program at the Kuwait University and train adequate number of biochemical engineers for the well balanced development of the National Biotechnology Program in both areas of basic life science and the biochemical engineering.

7. During the early phase of the the National Biotechnology Program development, building up of the research manpower should be considered as the top priority. They should plan to have a broad base of science and engineering that are essential components of highly multidisciplinary biotechnology.

V. Infrastructure and Training: Development of Biotechnology Research and Development Capability

The important requirements for building up the biotechnology research capability as well as meaningful program are:

The supporting infrastructures and the inducive research environment,
The research manpower development,
The research facilities, and
The resources to provide sustained support for the long-term research.

The following points are strongly recommended.

1. At the ministerial level the Biotechnology Council of Ministers should be established to formulate the policy and plan for the National Biotechnology Program. The Council members should include all those ministers who are involved with national planning, economy, petroleum, education, health and welfare, environment, agriculture and food, and others.

2. The Biotechnology Council of Ministers should appoint a group of experts and advisors from many different professional fields as "Advisory Board" members for the National Biotechnology Program. The Advisory Board should be empowered with the authority and responsibility to execute and operate the National Biotechnology Program. The Board will be responsible primarily for:

The program development,
Program monitoring,
Program evaluation,
Research manpower development and personnel,
Research budget, funding, and disbursement,
Coordination of satelite biotechnology centers,
Reporting to and advising the Biotechnology Council of Ministers, and
Management and operation of the National Biotechnology Center.

3. As a center of excellence, the National Biotechnology Center should be established. It will be responsible for most research and development activity of the National Biotechnology Program especially in the first phase of the program development.

In addition, the Center should be instrumental in:

a) In-house training of future scientists with both academic curricula and research programs,
b) International cooperative activities,
c) Providing centralized research facilities for the entire biotechnology research community,
d) Developing industrial liason for technology transfer,
e) Undertaking the high priority National Biotechnology Programs that is of critical importance to the national interest, and
f) Coordinate research activities with the satelite biotechnology center.

4. In view of the fact that the KISR is a very well established research with international reputation, has very strong research and development programs in many areas closely related to the biotechnology programs, and has excellent facilities and research personnel, the National Biotechnology Center should be established either as a affiliated Center or within the KISR organizational structure in the intial phase of the program development. By doing so, the National Biotechnology Center will benefit from the excellent research management support from the KISR and it could be fully functional very quickly, since the research management and administration at KISR is by far one of the very best in Kuwait.

5. Once it is well established, other satelite programs with different specializations can be established in other academic and research organizations where the critical mass of research manpower can be organized and adequate research facilities can be established. At least, four to five biotechnology satelite programs can be organized and their collective research endeavor can be coordinated by the National Biotechnology Center during the first five to ten year period of program development. In this author's considered opinion, the establishment of the National Biotechnology Center, which can be instrumental in achieving the overall objectives of the National Biotechnology Program mandate very effectively, should be the top priority. The Center will provide the very efficient working infrastructure for the speedy development of the National Biotechnology Program, coordination of all of the biotechnology programs, and for the achievement of the program goals.

6. The networking of international cooperation with other biotechnology research centers in advanced countries like U.S. will be very important for bringing up the research capabilities to the international level rather rapidly. It should also establish a very active international cooperative research programs and should have excellent communication net work with overseas research centers.

It is highly recommended that an arrangement for a sister academic and research institution be made (possibly with the University of California, Davis) to enhance the international activities and use it as an efficient mechanism for international collaboration and communication.

7. The Advisory Board may want to decide that a consultant group composed of internationally recognized experts in biotechnology should be organized and the Advisory Board could work closely with the consultant group in order to maintain the quality, objectivity, and credibility of their biotechnology program.

8. The National Biotechnology Center should have sustaining research support for the long range research programs. It should, by all means, avoid interruptions of the progress of research by turning on and off the research funding.

9. One of the most important program to be initiated immediately is the manpower development plan for the research capabilities development. It should have a broad scope and base including the following areas;

Basic life science;

cell biology, microbiology, biochemistry, molecular biology, genetics, protein chemistry and protein engineering, immunochemistry, enzymology, analytical chemistry, plant physiology, plant genetics, animal cell physiology, animal cell genetics, animal breeding, petroleum biology, environmental biology.

Biochemical engineering and applied science;

biochemical engineering, fermentation technology, enzyme technology, separation and purification, large scale bioreactor engineering.

10. In order to build up the critical mass of research manpower for the highly complex and diverse multidisciplinary biotechnology program, approximately five to ten trained scientists in each specialty area will be required. For the entire National Biotechnology Program, total of about 180 research scientists should be trained or recruited within the first phase of the Program development in the time frame of five to eight years. This appears to be a realistic plan for Kuwait. A well balanced and mixed group of all three levels of research scientists will also be important, namely, a good mix of B.S., M.S., and Ph.D. level experts or specialists in each and all fields indicated in the previous paragraph.

The building up of the critical mass of the research manpower in the earliest possible time frame will be of critical importance to the success of the National Biotechnology Program and the National Biotechnology Center, since the productivity of the Program and the Center as well as the achievement of the Program objectives will all depend on the development of the research manpower capabilities and their intellectual productivities.

11. This research manpower development program may include the following mechanisms and methods:

a) Study abroad for M.S. and Ph.D. level training to the leading academic institutions in the U.S. and other countries,
b) Research visits to the leading research institutions abroad,
c) Seminar, lecture series, and short courses to be offered by expert consultants in relevant areas of specialization,
d) Placement and/or repatriation of well trained scientific personnel from abroad,
e) Very attractive inducement and incentive plans must be formulated and provided for the sustained and effective utilization of those well trained and well qualified research personnel to be recruited for the National Biotechnology Program, especially in view of very competitive manpower market worldwide, and
f) Continue with upgrading and improvement of in-house(or in country) manpower training program at the Kuwait University, the National Biotechnology Center or the Advanced Institute of Biotechnology to be established. Eventually, this will reduce the manpower training cost and reduce the training abroad.

The sister institution arrangement will be especially useful for this research manpower training and development.

VI. Evaluation of the Kuwait's National Biotechnology Program and Recommendations

Their assessments of the enormous and unlimited future potential of biotechnology, the international activity in biotechnology field, and the domestic situation is fairly acurate. The ideas and concepts embodied in their national policy plan for the manpower development, facilities development, and the mechanism for implementation of the plan are excellent. The organizational framework and the action plan are very resonable. However, these plans can be further complemented and strengthened by the suggestions and recommendation presented in this report. More specific and focussed recommendations on the research manpower capabilities development program and the infrastructure supporting system are presented in the previous sections (Sections IV and V). Some comments were implicit in previous sections.

By combining their plan and the recommendations presented in this report, Kuwait should be able to develop a very realistic, practical, and still one of the very best biotechnology development program in the world by improving and strengthening their original plan. Additional suggestions and recommendations for the research and development program for their National Biotechnology Program are presented in the following sections.

In order to develop Kuwait's National Biotechnology Program which is consistent with their long-term national interest, the following research programs are recommended as the high priority programs.

1. Petroleum Biotechnology

One of the most valuable resources Kuwait has in abundant quantity is oil and petroleum products and ths resource must be most effectively utilized to generate the maximum benefit. Although the state of the art in petroleum biotechnology is still in the early stage of its development, Kuwait could take a leadership in the area of petroleum biotechnology if they start their research program immediately. The oil and petroleum can be converted to far more valuable products and commodities by means of novel biological and biotechnological processes. There are many species and strains of microorganisms which can utilize and metabolize oil and petroleum, and convert them into more valuable metabolites or other biochemical products.

The SCP program and other related biotechnology programs at KISR should be further strengthened and expanded into the areas of petroleum biotechnology for the purpose of producing more valuable metabolic products from oil.

It is anticipated that, with the progress of petroleum biotechnology, many more valuable biochemicals, fine chemicals, specialty chemicals, pharmaceuticals, and others could be produced using oil as the raw material or substrate for microorganisms and by fermentation processes. Figure 1 illustrates the important concepts and ideas related to this petroleum biotechnology with specific reference to Kuwait's biotechnology program which could be unique one in the world.

The long term impact will be that Kuwait will be able to develop petroleum based biotechnology industry and produce high value added commodity products which they can export instead of oil as a low value raw material. This in turn will significantly improve Kuwait's income and economy.

2. Agriculture Biotechnology and Food Resources Development

All resource bases including animal resource (livestock), plant resource (agricultural crops and biomass), marine resource (fish and other marine products), and other unconventional resource (including SCP) are all important resources for food and chemicals. Although the agriculture biotechnology appears to be a long-term goal, Kuwait should make the agriculture biotechnology as one of national mandate and the top priority. In fact, tremendous progress in plant genetics and animal genetics areas have been made in recent years, and the practical application of agriculture biotechnology could be realized sooner than most of us expect. Some of the exciting developments in biotechnology is in the area of animal and plant biotechnology. KISR has already accomplished so much in these areas and their program should be strengthened and expanded.

The agriculture biotechnology program should include the folling research areas:

1) Diagnosis, prevention, and control of animal diseases

2) Development of animal vaccines for local animal diseases

3) Marine and aquaculture fisheries for increased production of fish and shrimps

4) Animal nutrition and developemnt of growth promoting agents

5) Genetic improvements of animal breeds for livestocks, poultry, lamb, dairy cattle, etc.

6) Improvement of specific plant characteristics including plant resistance factors (against salt, heat, pesticide, diseases, etc)

7) Improvement of agricultural crop productivity by improving nitrogen fixation and photosynthetic efficiency

8) Development of plant growth promoting agents

9) Primary and secondary metabolites of economic importance from desert plants

All of these agriculture biotechnology programs will be very important to the future economy of Kuwait. The long-term potential of agriculture biotechnology is enormous, and the future impact on Kuwait economy and living environment will be truly great beyond one's imagination.

3. Health Care Biotechnology for Public Health

All of those biotechnology groups at the KU-Medical College, Maternity Hospital-Ministry of Health, and KISR should be strengthened and expanded as the satelite biotechnology laboratory groups in conjunction with the National Biotechnology Center. Alternative plan might be that all these groups can be pooled together at the National Biotechnology Center, if consensus can be reached. This would be one effective management approach to build up the critical mass of research manpower rather quickly and organize a very productive biotechnology group.

Some of important research programs that should be undertaken in this area are:

1) Development and production of regulatory proteins including human growth hormone, insulin, etc

2) Development and production of vaccines for bacterial and viral infection, hepatitis, and other parasitic diseases

3) Development and production of monoclonal antibodies for diagnostic, preventive, and therapeutic application

4) Studies on genetic disorder diseases including the sickle cell anemia and thalassemia

Many genetic engineering and pharmaceutical industries have made tremendous progress in many areas of health care biotechnology, especially in those countries with advanced high technology. several gene products are beginning to be available in the market.

The medical application of genetic engineering technique to the Kuwait's unique public health problem areas should be given the high priority. This may include the DNA based genetic diagnostics for thalassemia patients, and development of diagnostic and vaccine production for hepatitis.

In recent years, the medical and health care biotechnology related to the pharmaceutical and medical products are available for technology transfer or licensing, and such possibility should also be considered seriously for rapid development of biotechnology industry in Kuwait as part of overall National Biotechnology Program and decide the policy on the technologty transfer by evaluating the benefit cost ratio.

The government may exercise its option to establish manufacturing facilities for biotechnology derived health-care products for the entire Gulf Council Countries (GCC) or other biotechnology business development plan for the entire region, such as joint ventures and manufacturing of licensed gene products.

VII. Anticipated Impact

In addition to the impact statements made in other sections of this report, the following anticipated impacts are assessed.

The impact of biotechnology program on Kuwait's industrial development, economy, and public health will be very significant, and the long term potential of petroleum, agriculture, health care biotechnologies will be indeed so enormous beyond the wildest dream. They will be able to achieve the primary objectives, namely, "Kuwait will be able to make best use of its available resource base for the benefit of Kuwait people by means of developing and utilizing biotechnology very effectively."

If the biotechnology is well planned and executed as recommended in this report, it is anticipated that:

1) The domestic food resources development and supply will be greatly improved through the Agriculture Biotechnology program,

2) The supply of chemical feedstock and specialty chemicals will be secured and sufficient through research and development of the Petroleum Biotechnology program,

3) The pharmaceuticals and medicins applicable to local diseases will be readily available for general population in Kuwait through the Health Care Biotechnology program

While Kuwait could enjoy its long term benefits derived from the National Biotechnology Program, it will be able to firmly establish the solid foundation for the industrial technology base and at the same time secure highly valued technical manpower and their intellectual properties. It is also reasonable to anticipate that Kuwait should be able to improve its economy so much more by exporting high value added product as well as exporting high technology instead of exporting low priced raw material like oil.

Within the timeframe of about fifteen to twenty years, Kuwait should be able to establish biotechnology industry in the area of agriculture, petroleum, and health care areas that will be competitive world wide.

It is therefore very important that the National Biotechnology Program be supported on a long term basis and execute the excellent plan vigorously and persistently for the next two decades.

It is hoped that the comments suggestions, and recommendation provided in this report will be of some value to the policy makers and planners in Kuwait.

FIGURE 1. PERSPECTIVE AND SCENARIO OF KUWAIT BIOTECHNOLOGY DEVELOPMENT

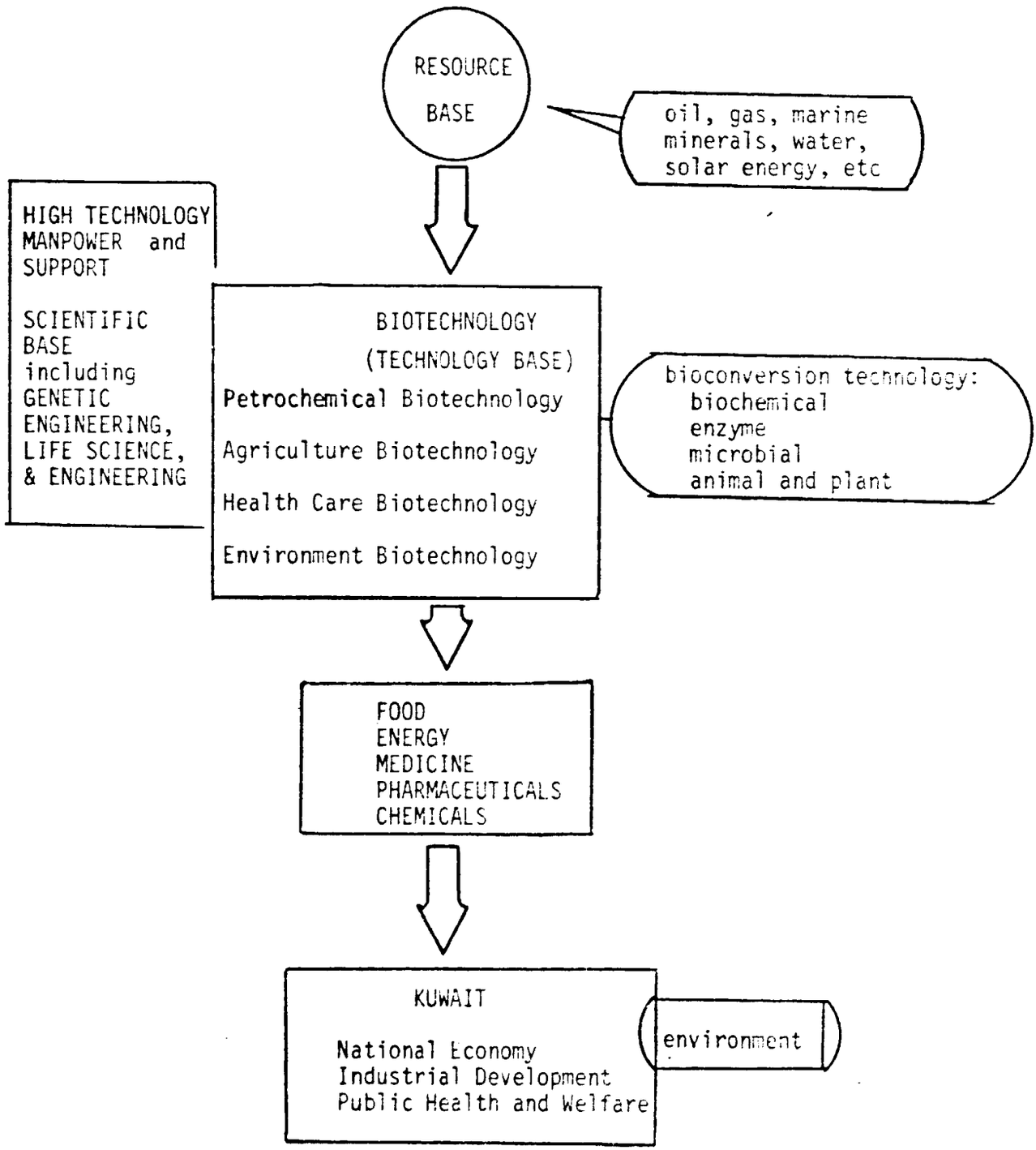

TABLE 1

List of Discussants

Drs. Nazar Hussain
I.Y. Hamdan
O.A. El-Kholy
J. Al-Khadir
S. Durban
A. Al-Awadhi
M. Olive
A.J. Salman
S. Al-Mommin
S. Haditirto
Asthana
N. A-Awadhi
Nader
S. Lahalih
M. Al-Attar
S.T. Nesaratnam
S.A. Ad-Awadi
Ziad
Sait

TABLE 2

List of Institutions for Site Visits

Kuwait Institute for Scientific Research

Departments of Food Resources, Agroproduction, Marinculture and Fisheries, Biotechnology, Petroleum Technology (Petrochemical & Materials Division), and National Scientific & Technical Information Center

Kuwait Medical Genetics Center - Maternity Hospital

Kuwait University Medical School - Microbiology and Virology

TABLE 3

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