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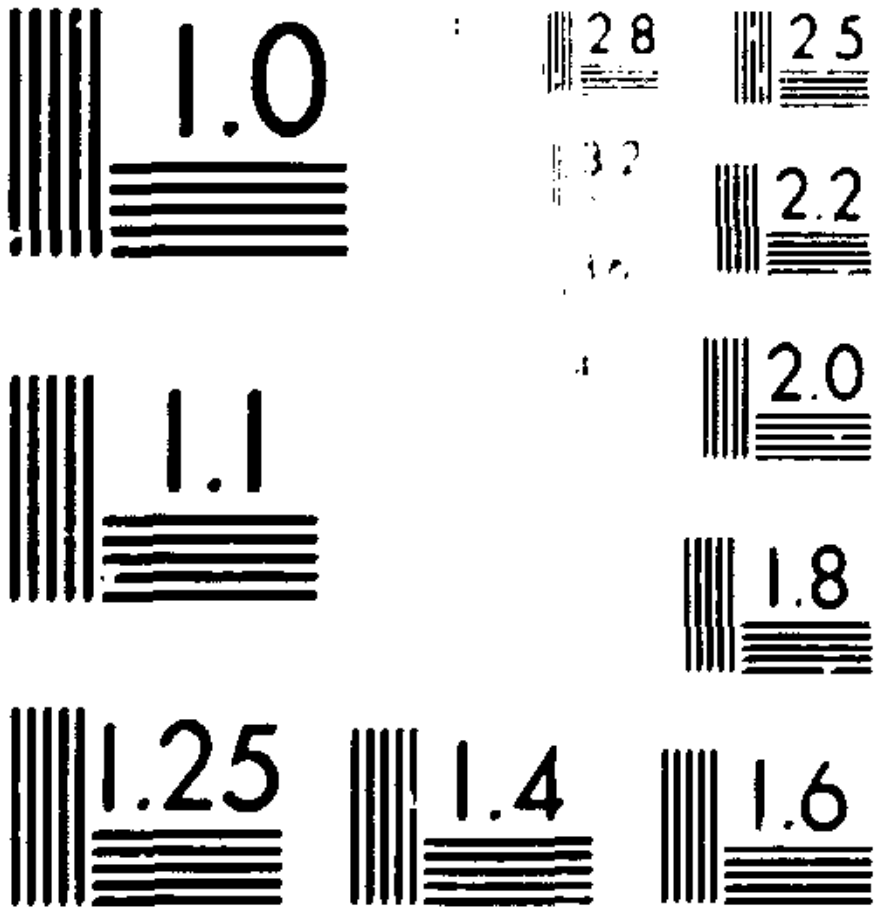

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THE ESTABLISHMENT OF AN INTERNATIONAL CENTRE FOR GENETIC ENGINEERING AND BIO-TECHNOLOGY (ICGEB)

REPORT OF A GROUP OF EXPERTS*

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*The views expressed in this paper are those of the experts and do not necessarily reflect the views of the Secretariat of UNIDO.
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UNIDO
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16 October 1981

Dear Mr. Executive Director,

You may recall that an expert meeting convened by UNIDO in February 1981 examined the implications of genetic engineering for developing countries and recommended the creation of national capabilities of those countries in this field and primarily to contribute to that end, the preparation of a project report for the setting up of an International Centre for Genetic Engineering and Biotechnology.

Following this meeting, we participated in a series of missions, from August to October 1981, to 16 countries, developed and developing, and some international organizations to interact with high-level policy makers and the scientific and technological community to get their reactions to the idea of the Centre and the specific needs it could meet. Encouraged by the wide-spread interest in, and commitment to, the idea we met on the 15th and 16th October in Vienna to prepare a report for the setting up of an International Centre for Genetic Engineering and Biotechnology.

We have pleasure in forwarding our report to you herewith. We believe that this is a venture of great potential benefit to developing countries and we would therefore like to appeal to you and through you, to the decision-makers in developed and developing countries, to pursue this question as a matter of priority. Our full and continued co-operation will be available to you in this endeavour.

Yours sincerely

Prof. Carl-Göran Hedén (leader of the mission)

Prof. Herbert W. Boyer

Prof. Ahmad Bukhari

Prof. Ananda Chakrabarty

Prof. Saran Narang

Dr. Sheikh Riazuddin

Prof. Ray Wu

Organizations

AMBO	Asian Organization for Molecular Biology
CERN	Centre of the European Organization for Nuclear Research
CGIAR	Consultative Group on International Agricultural Research
EMBO	European Organization for Molecular Biology
FAO	Food and Agriculture Organization of the United Nations
ICGEB	International Centre for Genetic Engineering and Bio-technology
ICRO	International Cell Research Organization
ICSU	International Council of Scientific Unions
IFIAS	International Federation of Institutes for Advanced Study
MIRCEN	Microbiological Resource Centre
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNU	United Nations University
WHO	World Health Organization

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I. INTRODUCTION

1. Following a recommendation made by a group of experts on Genetic Engineering, meeting at UNIDO, Vienna, in February 1981[1/], concerning the possible setting up of an International Centre for Genetic Engineering and Bio-technology, UNIDO organized an expert mission to explore the official and professional reactions in selected countries to the idea of such a Centre, its scope and functions, the needs it could meet and especially the support it could give to national efforts.

2. The mission, which was headed by Prof. Carl-Göran Heidén, Karolinska Institutet, Stockholm, Sweden, included[2/] the following expert advisers: Prof. H. Boyer, University of California; Prof. A. Bukhari, Cold Spring Harbor Laboratory, Long Island; Prof. A. Chakrabarty, University of Illinois; Prof. S. Narang, National Research Council of Canada; and Prof. R. Wu, Cornell University. The mission was supported by the following UNIDO staff members: G.S. Gouri, K. Venkataraman, W. Kamel, E. Yakushin and J. Cramwinckel.

3. The mission met senior government officials, scientists and technologists in the countries visited by it and also briefly reviewed ongoing national and regional activities. Based on the overall results of the mission, the members of the mission adopted this report in a meeting held at Vienna on 15-16 October 1981. Within the constraints of available time and material the report has been presented in the form of a project report containing the essential elements for taking policy decisions. The annexes to the report contain details of countries visited, persons contacted and relevant background material.

4. The members of the mission wish to express their gratitude to the government officials, scientists and technologists who met the mission and to the UNDP Resident Representatives and the UNIDO Field Advisers for their excellent preparations and logistic support.

1/ See paragraph 66 of "Draft Report on Exchange of Views with Experts on the Implications of Advances in Genetic Engineering for Developing Countries", Vienna, 4-6 February 1981.

2/ The composition of the mission visiting various countries is contained in Annex III.

II. NEED FOR ICGEB

5. From the discussions held by the mission it is evident that in various countries visited there is a commonality of interest on the basic issues. There has been uniform recognition that scientific and technological advances in genetic engineering constitute breakthroughs offering a wide range of new opportunities and that they have dramatically enhanced the vast potential of bio-technology by investing it with new dimensions of versatility, efficiency and economy. It was generally realized that the impact that bio-technology will have on various economic activities including food, chemicals, pharmaceuticals, energy and environment, will involve a significant industrial dimension in terms of new products and processes and that industrial applications might well provide the motive force for further applications in other sectors. Moreover, it is anticipated that the technological and production structure of industry in the coming decades will be substantially altered by the creation of industries with low fossil energy demands and by considerable changes in a number of industry sectors such as food processing, chemical and pharmaceutical industries including fertilizers, pesticides, detergents and feedstocks; mineral processing, recycling and waste treatment, and not least the [illegible]ion of energy in large and small scale. While the time frame within which the changes will occur is subject to variable estimates, it is recognized that the starting point has clearly been passed. There is the pervasive feeling that unless timely action is taken, countries will stand to lose in the structural changes ahead. In view of this realization, the initiative taken by UNIDO for the establishment of an International Centre for Genetic Engineering and Bio-technology (ICGEB) and to consult with governments and the scientific and technological community in various countries was welcomed.

6. As a consequence, the mission encountered throughout an active interest in international co-operation in the field of genetic engineering and bio-technology. This interest stems from a variety of factors. Significant work is being carried on in a number of countries, and the range and speed of applications in genetic engineering and bio-technology could be considerably accelerated for the benefit of all countries by the interaction between the scientific and technological communities of various countries.

There is thus the recognition of the great scope for international co-operation. There is equally the awareness that the diversity of micro-organisms and the plant and animal life on earth is such that this "treasure chest" can be opened only by a continuous, substantial and co-operative effort.

7. There is also the recognition in several countries that national efforts, whether scientific and technological, industrial or commercial, would be considerably facilitated by international interaction. These efforts in most countries are taking place amidst several constraints. A great shortage of trained scientific and technological manpower in this field is common. The scientific and technological community in general is not only keen but feels that it is imperative to have opportunities for interaction and exchanges on an international scale and for greater exchange of information. In several developing countries visited, the need for advisory services on matters ranging from policy and institutional aspects to specific projects and disciplines is evident. In those countries another identified need pertains to the formulation and execution of R and D programmes and projects of common concern to several countries which those countries have neither the resources nor the capacity to take up individually.

8. The importance, potential and manifest, of genetic engineering and bio-technology and the need for international co-operation felt in this area, have confirmed and re-emphasized the recommendation of the expert meeting in February 1981[3/] for the setting up of an International Centre for Genetic Engineering and Bio-technology. In the light of the experience gained through the visits to, and discussions in several countries, the mission is convinced that only the setting up of such a Centre will ensure the critical mass of international action and effort consistent with the wide ranging potentialities and implications of genetic engineering and bio-technology.

9. The mission is aware of the general climate of opinion against proliferation of international institutions. In spite of such a climate, a desire was expressed in many of the countries visited for the setting up of a Centre for genetic engineering and bio-technology. Such a Centre will generate concerted action in this important field of scientific and techno-

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3/ Ibid.

logical advance whose potentials are enormous and whose implications are wide ranging. A measure of internationalization will promote on the one hand world-wide development of technologies, technology capacities and applications and on the other, the acceleration of international exchange of products and processes. By promoting awareness of the potentialities of this important area of technology which offers a variety of capabilities in solving current day problems, a well-endowed International Centre for Genetic Engineering and Bio-technology could play a significant role in advancing the world-wide frontiers in this field and in the accelerated transfer of technology.

10. In the view of the mission, the establishment of an International Centre will have other important benefits. It will ensure the accumulation and continuity of experience which will be freely accessible to all countries[4/]. At the same time the mission does not expect that the Centre will preclude any bilateral co-operation there is, or which may take place in future; minimize or substitute any institutional effort in particular sectors or disciplines that may be taking place at the national, regional or international levels; and hinder or replace commercial flows of technology. The mission believes that these processes may actually be helped and "opened up" by the general enhancement of the scope and capacity for applications that will result from the creation of the Centre.

11. The mission believes that the creation of the Centre will be the most practical and effective means of assisting, in an integrated fashion, the strengthening of national technological capabilities in this important field. The spin-off effects of an International Centre for Genetic Engineering and Bio-technology could in fact be considerable, not only in the developing parts of the world, but also in many small developed countries. For the former, given the general lack of infrastructure and financial resources to support an adequate R and D effort in this field, the Centre may well be the only means by which they can get a start in this field and ensure that optimal technology choices are made, local problems addressed and major natural resources fully utilized. As regards the latter, the small developed countries may well be aware of the benefits of transdisciplinarity which the Centre entails, but may not always be in a position individually

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4/ This was a major consideration in the creation of the International Centre for Theoretical Physics at Trieste, Italy.

to benefit from Descartes' guidelines: "If anyone wishes to search out the truth of things in serious earnest, he ought not to select one special science, for all the sciences are conjoined with each other and interdependent."

12. Actually the principles of the methods and techniques employed in the fields concerned form a body of knowledge which is so large and so dynamic that no single discipline (e.g. chemical engineering, bacteriology, virology, mycology, immunology, etc.) or problem area (food, fuel, vaccines, biological control agents, etc.) can be expected to carry its development. A unique feature of the Centre will be its transdisciplinarity[5/].

13. The mere networking of existing institutions will not have the desired effect by itself. Institutions are yet to be established in many developing countries and those that exist primarily cover one discipline or other and do not necessarily bear a transdisciplinary character. Networking, if it is to extend beyond information exchange and occasional contacts, has to be complemented by other organized efforts, substantive programmes and financial support. Thus the effort required in this field warrants more than networking. In saying this, it is not the intention of the mission to minimize the valuable work being done in selected aspects or areas by some of the institutions that exist or to exclude networking and the utilization of ongoing experience from the function of the Centre. What is emphasized however is that networking is not a substitute for an International Centre.

14. The mission considers that a major factor in favour of the establishment of a Centre and indeed its major asset is the uniform expression of interest and commitment in various countries visited[6/]. The comments on the proposal to establish a Centre have ranged from "timely" to "excellent", in some cases followed by indications of interest in hosting such a Centre and in some others tempered by concerns about the possibility of attracting high calibre staff and the feasibility of effective co-operation in an area of

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5/ See also in this connection Annex II.

6/ See Section III below for more details.

significant competitive potential. The mission feels that these concerns do not detract from the establishment of the Centre but rather argue for its careful design and effective functioning.

15. The ICGEB would have to provide an intellectually challenging and stimulating environment and the working conditions should be such as to prevent frustrations due to lack of essential materials or inadequate services.

16. The question of competitive potential in this technological field is a double-edged one. On the one hand, the creation of the Centre and the increasing levels of awareness and capabilities it will generate will increase the scope for trade in products and processes. On the other, the point can also be seen as a forceful argument on the part of the developing countries in favour of the creation of the Centre to obviate a situation where the already visible trends towards "secrecy and monopoly" could result in excessive costs and limitations of access in the flows of technology. Moreover, it should be noted that there is a "non-competing group" of technologies viz. those relevant and specific to the conditions of developing countries, which may not be developed due to the absence of market pull, but which are needed to improve the living standards of the developing countries. The development and application of such technologies will be possible only through national and international efforts which the ICGEB can generate.

III. INDICATIONS OF COUNTRIES' INTEPESTS AND COMMITMENT

17. As indicated earlier, the mission has had discussions with almost one hundred senior government officials, scientists and technologists in the course of visits to 15 countries[7/].

18. The mission noted that the priorities of countries vary, as also their approaches towards regional co-operation. For a meat producing country, like Argentina, it is natural to regard the potential of cloned bovine growth hormone as interesting, and to see the curtailment of its red-meat export - due to foot and mouth disease outbreaks - as a serious problem that should be addressed by its genetic engineers. After all, the losses amount to about US $ 2 billion a year, and the protective virus component can now be produced by bacteria that are easy to store in anticipation of outbreaks and also safe to handle on a large scale, once the need for a particular mixture of vaccine emerges. In Brazil, on the other hand, there is a natural focus on genetically improved strains for the production of industrial alcohol and on new energy-saving methods for its purification. Oil-producing countries, like Kuwait and Saudi-Arabia, would wish to explore the potential microbial fodder production (SCP), tertiary oil recovery and the microbiological management of oil spills. Finally, many African countries, like Tanzania, would benefit greatly by special efforts in bio-technology, i.e. from methods suitable for decentralized fuel, food and fertilizer production. However, there is a wide range of problems that have so much common interest for developing countries that they would deserve special attention in the choice of topics for research training at ICGEB: improved biofertilizers, decomposition of "hard" biocides, phytochrome gene for plant genetics and drugs and pharmaceuticals for tropical diseases, etc.

19. Most government representatives in developing countries expressed a very positive attitude to the proposed Centre, particularly as a measure which could lead to a further strengthening of national and regional activities in this field. In some instances, governments offered host facilities and also indicated the possibility of substantial support.

7/ In addition, Prof. Hedén had informal talks in Canada, Switzerland and U.K. with regard to ICGEB. Also, discussions were held with senior officials of Pakistan during their visit to the UNIDO Secretariat.

Several developed countries expressed interest and willingness to participate in the training activities of ICGEB, and some also offered host facilities, including financial support for the Centre. In this connection the mission feels that the choice of a location would require further negotiations with potential host countries. Another consideration is that countries not visited during the mission may also express interest in the Centre.

20. As for the scientific and technological community the support for the idea of a centre was overwhelming. It was so even in countries where considerations of a competitive advantage might have been expected to temper the attitudes. Willingness to participate in the training and research activities of ICGEB was expressed by all. However, the degree of their participation would obviously be strongly influenced by the standard of excellence of the Centre. If it showed leadership in the development and practical use of genetic engineering, and if it also provided modern facilities for example in the optimization and scale-up of fermentations, there would be no problem in attracting prominent experts. In many instances those might then later associate the activities of their own laboratories with the ICGEB programmes. However, a subcritical effort might rapidly erode ICGEB's attraction as a centre of excellence.

21. From the discussions in developing countries, it was obvious that ICGEB must provide facilities that stimulate the cross fertilization between advanced knowledge on the one hand and simple needs and resources on the other and permit the expression of indigenous creativity. Many examples of cross fertilization mentioned in the course of the visits indicated that ICGEB might develop a unique interest profile that could attract scientists from many parts of the world.

IV. SCOPE OF THE CENTRE'S ACTIVITIES

22. A range of opinions have been advanced with regard to the scope of the Centre's activities.

23. One view is advocated by those (including the leader of the mission) who point out that biology is now in the same situation as physics half a century ago, but with the important difference that the capital-intensity is much less than that is normally associated with high energy physics and atomic energy research. Also the leadtime between discovery and industrial application in bio-technology is likely to be dramatically reduced as a consequence both of scale factor effects and of a widespread concern for the environment. When these observations are coupled with awareness of the magnitude of various global problems and of the increasing gap between rich and poor countries, it becomes natural to visualize a CERN-type organization for bio-technology providing unparalleled resources for sequence analysis, gene synthesis, vector design and pilot plant work, involving all sorts of micro-organisms and tissue cells (including fastidious pathogens). Such a Centre, with facilities for pushing foward the frontiers of instrument development and computer applications in areas like numerical taxonomy and process optimization, would certainly have no problem in attracting high-calibre staff and stimulating R and D contracts. However, the establishment costs would also be high.

24. An idea of the scope of the Centre's activities might be obtained by comparing the infrastructure which one industrial country - Federal Republic of Germany - found necessary in order to support the overall development in the fields of genetic engineering and bio-technology in a national context, namely the Stöckheim laboratories of the "Gesellschaft für Biotechnologische Forschung" which was established in 1975. The physical facilities (14000 m^2) would today cost about US $ 40 million, out of which US $ 15 million would be for the buildings. An annual budget of nearly US $ 12 million supports a staff of 249 people, 92 of which are for infrastructure support (technical services: 46, administration: 25, scientific equipment services: 21). Out of the research staff 42 work on metabolites and structure analysis, 33 on genetics and microbial physiology, 20 on process technology, 19 on cellular mechanisms, 18 on enzyme engineering and 16 in the culture collection. These figures should be seen in the context of all other

facilities available in German industry, universities and governmental establishments in the Federal Republic of Germany. Since the Stöckheim laboratories are short of space of microbiology, genetic engineering and enzyme technology, it is planned to expand the facilities for about US $ 13 million in the next few years. Consequently it seems reasonable to conclude that ICGEB would ideally require an investment of no less than US $ 50 million. The annual budget would probably have to be around US $ 15 million. Since seminars, courses, visiting scholars, staff travel, information management, communications and other international services, which the Stöckheim laboratories do not provide, would have to be included.

25. Considering the facts that a single firm (Hoechst) now invests US $ 50 million in genetic engineering in the Boston area and that the International Rice Research Institute in the Philippines operates with an annual budget in excess of US $ 22 million, the figures mentioned above should be seen as an indication of the level of financial commitment needed for the developing countries to keep pace with the advances in this field. On the other hand, if one would like to see the technology gap between the rich and the poor countries, and if the ICGEB would be used as a platform for co-operation on long-range goals such as nitrogen fixing grains, then the figures mentioned might have to be substantially increased.

26. This case might be expanded into a scenario when the basic structure would be supplemented with a corporation aimed at a rapid exploitation of the results in order to generate an income that could for instance be used for marketing the services of ICGEB. This activity, which would provide both a testing ground for UNIDO's efforts in technology transfer and a breeding ground for developing country entrepreneurs, could involve many administrative innovations, such as the participation of international financial institutions and a portion of the shares of the corporation being used to attract and involve scientific expertise. Perhaps the corporation could also establish a Foundation for technology transfer to further the socio-economic development of developing countries. In this way the scenario could be regarded as a pilot experiment for future international initiatives related to the "problematique" of development.

27. Much as ambitious plans, such as those outlined above, have great appeal, the mission recognizes the practical problems of funding and implementation and would like to set an initially feasible goal, beyond which expansion may be considered sometime in the future. The subsequent parts of this report are based on this feasible goal. While the development of the Centre to its full maturity will naturally span a period of time, the mission would emphasize that the nature and magnitude of the Centre's efforts should from the beginning be such as to create a credibility and an impact in this field. The proposals made below are considered by the mission to be the critical mass necessary for this purpose.

28. In addition, the mission expects the Centre to fully utilize and mobilize on-going efforts in this field and to maintain contacts with concerned international and regional organizations within and outside the United Nations system. In order to be effective, the Centre should have active contacts with the industry and the productive sectors in developed and developing countries.

V. FUNCTIONS OF THE CENTRE

29. The Centre will serve as a high quality institute where scientists and technologists from the developing and developed countries can work together. The mission envisages that the Centre will make fundamental contributions to genetic engineering and bio-technology and will directly help to develop the capabilities of scientists and technologists from the developing countries. These scientists and technologists should then be provided with the necessary means and materials to use their creativity to the benefit of their societies. The primary function of the Centre will be to stress research and development efforts through which scientists and technologists from developing countries will also be trained. The Centre should have the following functions:

(a) Research and Development

30. The Centre should provide facilities for several groups of scientists and technologists to work on problems at the frontiers of genetic engineering and bio-technology. Not only new ideas and new solutions to problems would emerge from such a group of imaginative

scientists and technologists but young scientists and technologists from developing countries will acquire the requisite skills and capabilities in this field. The research efforts will focus on problems of general and specific interest to the developing countries.

31. The Centre will have its own facilities for pilot plants. In addition it will promote R and D being undertaken elsewhere through problem identification, project formulation, assistance in securing financing and promoting co-operative projects. The Centre could also undertake contract research, as appropriate.

(b) Training

32. The Centre should have training programmes to build technological and scientific manpower in genetic engineering and bio-technology so that the developing countries can form multidisciplinary core groups which can carry out sustained research and development activities. Particular attention should be paid to training in genetic engineering techniques, basic and applied research of a problem - oriented nature and pilot plant activities. The Centre should have facilities for intensive training programmes to be given by leading scientists.

33. The Centre should offer fellowships to young scientists and technologists from the developing countries to work in well equipped laboratories in genetic engineering and bio-technology. The Centre should also be able to arrange training [illegible]s in different countries, in effect helping the scientists in the developing countries to set up their laboratories.

(c) Promotion of Co-operation

34. The Centre should promote interaction among the scientific, technological and industrial community through programmes of exchange of scientists and technologists among countries.

35. It should provide facilities for scientists and technologists of high calibre from developed and developing countries spending up to one year in the Centre pursuing specific activities.

36. The developing countries can strengthen their science and technology capabilities by collabbrating with each other. The Centre should devise ways to promote such collaboration.

37. The Centre should promote the networking of national and regional institutions engaged in genetic engineering and bio-technology so as to mobilize their efforts in the service of the developing countries.

(d) Advisory services

38. The services will be organized by the Centre with the help of its own staff and by employing outside experts. The services should support, on request, national activities pertaining to policy and plan formulation, institution building, training of manpower, R and D, problem-identification, identification of projects and programmes suited to the national needs and scientifically most feasible; assistance of a problem-solving and trouble-shooting nature; and follow-up of activities of trainees.

(e) Meetings

39. The Centre should be used as a venue for meetings that bring together eminent scientists and technologists from the developing and developed countries. The Centre should also arrange meetings in which scientists from different fields, engineers, computer experts, etc., can come together with molecular biologists. Furthermore, the Centre should also arrange meetings and promote conferences which can be attended by industrialists and decision makers from different countries.

(f) Information

40. The Centre should promote the flow and exchange of scientific and technological information in the fields of genetic engineering and bio-technology. The Centre should also devise schemes by which the laboratories in the developing countries can obtain quickly the relevant journals and books.

(g) Access to critical laboratory materials

41. The Centre should arrange or advise on the supply of critical laboratory materials needed for R and D in the developing countries.

VI. WORK PROGRAMME

42. A detailed work programme can be drawn up only after the actual establishment of the Centre. It should be emphasized that only an effective work programme can produce a useful impact and invest the Centre with the excellence it should acquire. Some guidelines for this purpose are given below. They will also help to estimate resource requirements.

Research and Development

43. A detailed goal-oriented R and D plan for implementation by the Centre and by promotion elsewhere should be drawn up by the Board of Scientific Directors after reviewing on-going R and D activities and identifying scientific and technological problems common to developing countries and requiring urgent attention. Priority attention may be given in the initial years to R and D and pilot plant activities in areas such as:

(i) tertiary oil recovery from petroleum wells;

(ii) energy, and fertilizer from biomass, in particular using genetically manipulated bacteria;

(iii) improvement of fermentation techniques, particularly of relevance to least developed countries;

(iv) development of improved human and animal vaccines;

(v) improved agricultural products using phytochrome genes; and

(vi) drugs and pharmaceuticals for tropical deseases.

44. All research and development projects administered by ICGEB should involve the participation of one or more scientists from developing countries, even when initiated and funded by an industrialized country. The projects would be selected by the Board of Scientific Directors on the basis of the following criteria:

(i) the magnitude of the local need and the potential global impact of the project;

(ii) the technical and scientific feasibility of the project; and

(iii) the potential of the project to trigger R and D activities and industrial implementation in the initiating country.

Training

45. The Centre should be able to train in the first five years some 100 scientific and technological personnel in its own premises. In addition it should aim at arranging the training of some 300 personnel in various institutions world-wide in the same period.

46. A primary objective must be to give advanced training to individuals who have the potential to create innovation groups for industrial activity in their home countries. This type of training should be such that it would open the road to a wide range of applications, and it definitely presupposes participation in active research projects. This should be supported by high-level seminars and be supplemented with the type of fellowship - and associateship programmes that have been pioneered by the International Centre for Theoretical Physics at Trieste.

47. The fellowships should be awarded to nationals from and working full-time in developing countries and should permit continued advanced training of and research by ICGEB-trainees. If the sending country is to benefit from the research experience in the fellowship programme the trainee must:

(i) have an adequate basic education adopted to his background and goal-orientation;

(ii) be given adequate working conditions on returning home after completing his training abroad.

In order to prepare the trainee for his research work both through advanced university courses and through specialized curricula, the Centre should be able to draw upon the resources of a major university or group of universities.

48. To ensure that the trainee becomes an active participant in his country's development process it might be advisable to consider the introduction of a tripartite agreement between the Centre, the responsible organization in the sending country and the trainee himself.

49. Such an agreement should define:

(i) A long-range goal defined by the sending country in agreement with the Director of the Centre and in consultation with the Board of Scientific Directors, as required:

(ii) A short-range training goal normally based on two years of training overseas and three years of R and D work at home. The ICGEB fellow should also have an opportunity to spend six weeks to three months per year at the Centre or elsewhere, to maintain research contacts and to keep their R and D activities up to date; and

(iii) A commitment made by the sending country which should declare its interest to provide adequate local facilities and its plans to exploit the "know-how" generated, and any important inventions made, in the course of the trainee's work.

50. Associateships should be awarded to senior scientists from and working in developing countries, permitting those scientists to spend, at a time of their choice, six weeks to three months per year at ICGEB. The stay of the associates at the Centre would be designed to keep them in the mainstream of modern genetic engineering and bio-technology and stimulate their research and training when they return home. No salary may be paid to associates, the home institution being expected to grant them paid leave of absence. However, travel expenses and a subsistence allowance should be paid by ICGEB.

Promotion of co-operation

51. The Centre should be able to invite eminent scientists and technologists to spend some 3 to 12 months in the Centre to enhance its overall capacity. In addition it should organize exchange programmes among countries to strengthen national level activities.

52. In regard to networking, the Centre will in particular encourage scientists and institutions in developing countries to initiate joint efforts in solving common problems thus promoting effective action at the regional level. In cases where a national centre in the network is faced with a challenging problem beyond its scientific and technological capacities to solve it, the Centre may help by apportioning the relevant project in different parts and distributing them to other R and D institutions (including the facilities in the ICGEB and the developed world).

Advisory Services

53. The Centre should be able to organize a number of missions in developing countries in the first five years to assist national level action at the request of the countries. Each mission may consist of two or three experts and may range from two to six weeks.

Meetings

54. The Centre should organize expert group meetings and workshops on selected problem-oriented topics based on the expressed needs and priorities of the developing countries. Twenty meetings are proposed for the first five years. In addition, the Centre should promote and participate in international technical conferences, as required.

Information

55. A system of information flow should be designed, using existing data bases and information services to the extent possible. National focal points for receipt and supply of information should be identified. A library should be built up, particularly to sustain a bio-informatics programme. The Centre may consider at a later date publishing a high quality technical journal or books, besides information material for general dissemination.

Access to critical laboratory materials

56. The Centre should develop a system for arranging critical supplies to developing countries of chemicals, equipment and materials like restriction enzymes. As a first step it should draw up a feasible and practical plan of what it could usefully do in this regard. This activity might get a start by arranging an efficient system for the rapid and economic supply of critical materials like restriction enzymes (for DNA cleaving, splicing and copying) and radioactive nucleotides with high specific activity (for DNA sequencing) to genetic engineers in developing countries[8/].

VII. ORGANIZATION AND STAFFING

57. In order to assist the operation of the Centre the following structure is recommended:

Policy direction

Board of Governors

58. The Board of Governors would consist of about 20 members drawn

8/ The mission thanks Dr. Riazuddin for his note submitted to it on the establishment of enzyme production centres in developing countries.

from the participating countries on the basis of equitable geographic distribution. Its role would be to decide on general policy and financial matters including mobilization of resources for the effective operation of the Centre. In regard to scientific and technical matters it should act as required on the recommendation of the Board of Scientific Directors. The Board of Governors may meet once a year.

Board of Scientific Directors

59. This Board should consist of about ten eminent scientists and technologists, with the Director of the Centre acting as its Member Secretary. It should be responsible for formulating and overseeing the implementation of the work programme. All substantive, scientific and technical matters will be within its purview. It should meet twice a year.

60. The detailed rules concerning composition, tenure and procedures of the Board of Governors and the Board of Scientific Directors should be elaborated before the establishment of the Centre.

Staff of the Centre

61. The staff of the Centre should consist of a Director, Deputy Director for administration and a staff of scientists and technologists; technicians; clerical personnel; and other staff. It is recommended that the staff be built up gradually, to reach its full strength by the third year of operation. (For details see cost estimates in Annex I).

62. The key to the success of the Centre will be the Director, who must be an established scientist with organizational skills, enthusiastic about the Centre's purpose, and capable of recruiting an outstanding staff. The Director and staff must be committed to the organization and its objectives.

63. The scientific and technological staff should consist of teams of molecular geneticists, biochemists, microbiologists, protein and nucleic acid chemists, bio-engineers, computer specialists, etc. organized in five units but interacting with each other.

(i) Molecular Biology and Biochemistry Department for separation and purification of macromolecules, for protein and nucleic acid sequencing and for nucleic synthesis.

(ii) Microbiology and Molecular Genetics Department with facilities for microbial genetics and physiology, numerical taxonomy and culture collection work. A physical containment laboratory, level P-3 should be available.

(iii) Advanced Bio-technology Department to be responsible for a pilot plant with fully instrumented 10-100-1000 litre fermentors and equipment for harvesting, fractionation and purification to scale. In regard to research, it should concentrate on the application of computer and materials science to the design and evaluation of equipment specially relevant to developing countries.

(iv) Bio-informatics Department to act as a communication node, sequence library and depository for important unpublished research data and reference materials.

(v) General Services Department for administrative matters of the Centre including units for training programmes including fellowships and associateships; procurement storage and maintenance; and external services including science and technology policy and patent questions (it is assumed that UNIDO in co-operation with other concerned organizations will continue to play an active role in this area and in technology assessment and transfer).

64. It is recommended that UNIDO consider providing supporting services for personnel and financial matters to the Centre in its initial years.

VIII. FINANCIAL REQUIREMENTS

65. On the basis of the tentative work programme and organizational structure and staffing of the Centre as outlined above, a five year budget outline is presented in Annex I. The capital expenditure, exclusive of land and buildings, is estimated at about US $ 9.5 million. The cost of land and buildings would vary with the location. Operating expenditure for a five year period is estimated at about US $ 29 million. These estimates are based on 1981 prices.

66. In the nature of things, estimates of this type cannot be completely precise but the figures above represent the order of magnitude of resources that are needed. The mission emphasizes that the figures mentioned above represent the minimum requirement if the Centre should make an impact of the type envisaged in the report. Considering that bio-technology, by all estimates, is expected to lead to a multi-billion dollar industry, not to speak of the beneficial impact it could have on the quality of life, the resource recuirements of the Centre are, in the opinion of the mission, modest indeed.

67. Judging from the positive interest shown by many of the countries visited the mission believes that finances of the magnitude indicated will be forthcoming. Accordingly, it is envisaged that the Centre be financed by voluntary contributions from participating countries and aid and donor agencies. Specific activities and projects could also be financed by multilateral and bilateral sources.

IX. SOME ASPECTS ON THE LOCATION OF ICGEB

68. Considering the interest expressed in hosting the Centre by several countries during its visits the mission would like to make a few observations on some aspects of the location of the Centre.

69. The mission has been pleased to note that a large number of highly qualified scientists have expressed their willingness to participate in and devote some of their time to the activities of the Centre. However,

the extent to which they actually do would depend on the location and facilities of the Centre. If well known visiting scientists are to be encouraged to spend a year of sabbatical or more, the Centre would have to provide physical facilities that would be comparable to the ones the visiting scientists would leave. Also, the visiting scientists would be concerned with the availability of amenities, educational opportunities, etc., for their families. Experience with several international research centres shows that an agreeable environment can be attractive. Due attention should be given to these factors since the competition from industry for the best brains in genetic engineering is fierce.

70. The factors to be considered include:

- Basic infrastructure: access by air and surface travel, telecommunications, international contacts, electronic and instrument services, mechanical services, pilot plant facilities, reliability of water and power supply, customs facilities, etc.
- Industrial environment: contacts with industry, universities and other R and D facilities.
- Social infrastructure: living costs, housing, climate and health environment, schooling, etc.
- National commitment at the governmental and academic levels; freedom to communicate and travel.

71. It would be presumptuous for the mission to make site-recommendations after just a few days visit to each country. It is presumed that UNIDO will in due course discuss and negotiate the matter with interested countries for host facilities and financing of the Centre.

X. RECOMMENDATIONS

72. The mission recommends:

(i) An International Centre for Genetic Engineering and Biotechnology (ICGEB) should be established on the lines suggested in the report.

(ii) UNIDO should follow up its initiative, pursue the question of establishment of the Centre vigorously and continue to fully and actively associate itself in this activity.

(iii) It should continue to associate the leading experts in the field in the setting up of the Centre.

(iv) It should initiate further consultations with interested United Nations agencies such as FAO, UNESCO, UNU and WHO and other international organizations such as AMBO, EMBO, ICRO and IFIAS.

(v) It should mobilize resources to create a small unit with a full-time project co-ordinator who would pursue the several activities leading to the establishment of the Centre.

(vi) It should carry out negotiations with interested governments and convene a meeting of participating governments where they could announce their participation and financial contributions and formally establish the Centre.

ANNEX I

COST ESTIMATES

for the Establishment of an International Centre
for Genetic Engineering and Bio-technology

	1981 prices US Dollars
A) Fixed Cost (excluding buildings, land and utilities)	
Laboratory Equipment and Materials	
(a) Molecular Biology and Biochemistry Department	
- Protein analysis and sequencing equipment	50,000
- Nucleic analysis and sequencing equipment	60,000
- Nucleic acid synthesis equipment	40,000
- Separation and purification equipment	1,000,000
- Chemicals materials and other basic equipment	1,150,000
- Mass spectrometer-gas chromatography	300,000
Sub-total	2,600,000
(b) Microbiology and Molecular Genetics Department	
- Basic and P-3* lab equipment	150,000
- Refrigeration equipment, thermostat shakers etc.	50,000
- Chemicals, materials, glassware	200,000
- Media kitchen	50,000
- Electronic microscope	150,000
Sub-total	600,000
(c) Advanced Bio-technology Department	
Pilot Plant	
- Fermentation Section with data logging and full instrumentation	3,800,000
- Harvesting and Disintegration to Scale Section	500,000
- Purification, Refrigeration and Drying Section	200,000
- Others Experimental equipment and expendable	150,000
Sub-total	4,650,000
Carried forward	7,850,000

* physical containment laboratory level 3 (P-3)

	1981 prices US Dollars
Brought forward	7,850,000
(d) Bio-informatics Department	
- Computer and terminals	150,000
- Library including basic textbooks and journals	150,000
- Microfiche laboratory	25,000
- Miscellaneous equipment	10,000
- Computer programming	25,000
Sub-total	360,000
(e) General Services Department	
- Mechanical and wood workshop equipment	120,000
- Electrical workshop equipment	50,000
- Materials and spare parts	50,000
- Transportation	40,000
- Office machinery and furniture	400,000
- Conference equipment	60,000
Sub-total	720,000
Supporting Engineering Costs (installation, trial etc.)	600,000
Total	9,530,000

B. Operational costs for five years

(US Dollars in '000s)

I. Staff[9/]

		Year 1	Year 2	Year 3	Year 4	Year 5
1 Director (D-2 level)		126	126	126	126	126
1 Deputy Director (Administration)		109	109	109	109	109
Scientists and Technologists	No.	10	20	30	30	30
	cost	914	1,828	2,742	2,742	2,742
Technicians	No.	10	20	30	30	30
	cost	300	600	900	900	900
Clerical Personnel	No.	10	15	20	20	20
	cost	300	450	600	600	600
Manual worker	No.	10	10	15	15	15
	cost	230	230	345	345	345
Total per year		1,979	3,343	4,822	4,822	4,822

Total for five years: 19,788

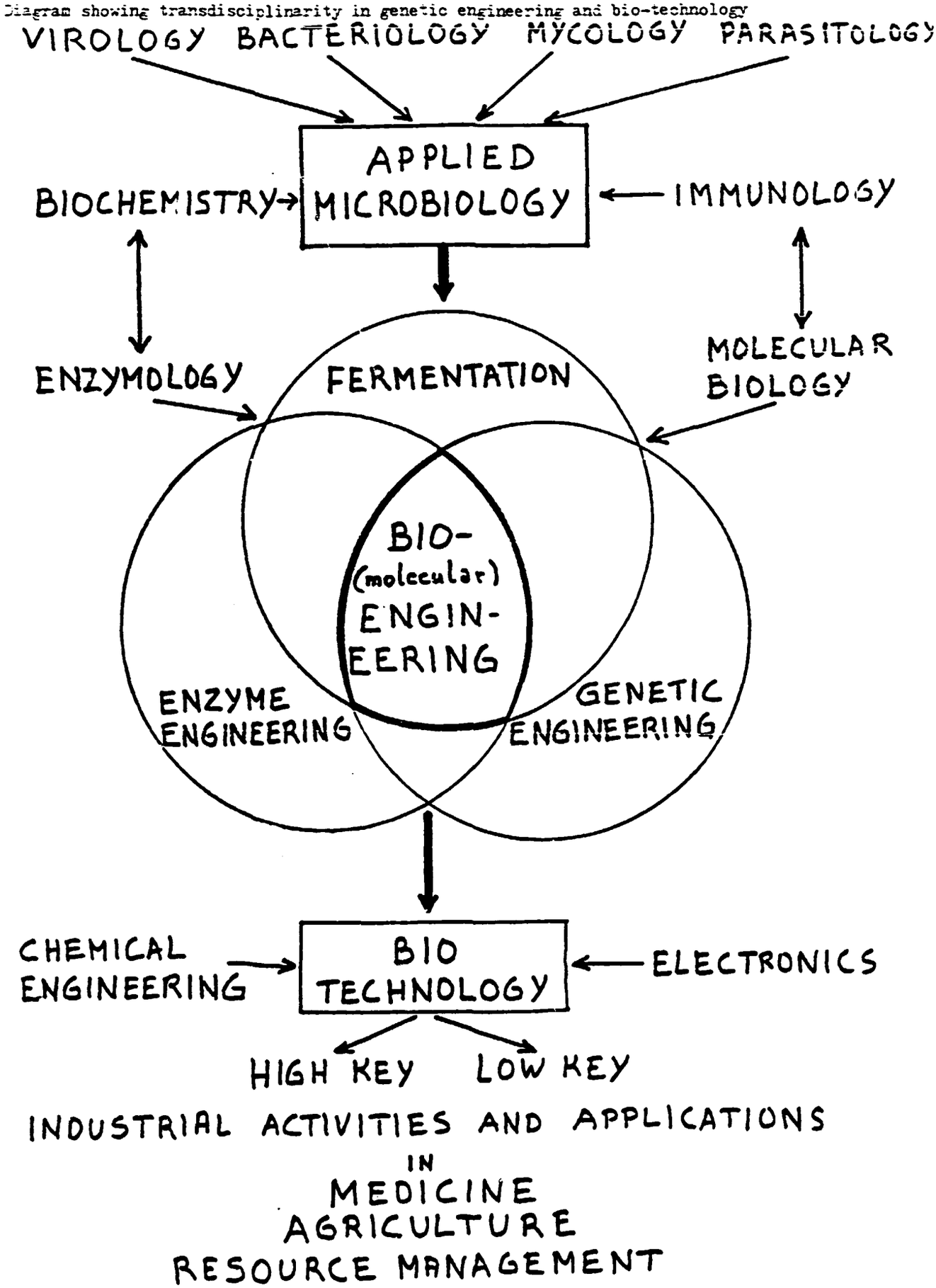
9/ Calculated on the basis of U.N. Vienna salaries. Costs will vary according to location.

II. Operational activities	1981 prices US Dollars
- Visiting scientists (200 man months)	1,600,000
- 20 Expert Group Meetings and Workshops (one week x 15 persons)	500,000
- Advisory Services (150 man months)	2,100,000
- Associateship	750,000
- Training 100 researchers (20/year)	2,250,000
- Information material	750,000
- Purchase of spare parts, chemicals and office material	1,250.000
Total for five years	9,200,000
Total operational costs for five years	28,988,000

N.B. It is assumed that fixed and operating costs of utilities will be met by the host country.

ANNEX II

Diagram showing transdisciplinarity in genetic engineering and bio-technology



ANNEX III

DETAILS OF MISSION VISITS

MEXICO

Mission members: Prof. Carl-Göran Hedén, Mission Leader
Prof. A.M. Chakrabarty, Expert Adviser
Mr. Nafa Hamel, Industrial Development Officer,
Development and Transfer of Technology Branch/UNIDO

MEXICO CITY - 3 August

National Autonomous University of Mexico (UNAM), Biomedical Research Institute:

Dr. K. Willms	- Director of the Institute
Dr. J. Marcheli	- UNAM Science Co-ordinator
Dr. J.A. Bolivar	- Head, Molecular Biology Department
Dr. R. Quintero	- Head, Bio-engineering Department
Dr. G. Soberón Acevedo	- Senior Investigator Department of Molecular Biology

National Laboratories for Industrial Development (LANFI):

Dr. F. Viliesid	- Bio-engineer (fermentation)

MEXICO CITY - 4 August

National Council for Science and Technology (CONACYT):

Dr. A.R. Araiza	- Director International Affairs

National Polytechnical Institute (IPN):

Dr. C. Casas Campillo	- Head, Department Biotech. Bio-engineering

MEXICO CITY - 5 August

United Nations Development Programme:

Mr. D. Jiménez	- Resident Representative
Mr. F. Fajnzylber	- Senior Industrial Development Field Adviser - UNIDO

Ministry of External Affairs:

Lic. J.A. Soberanis	- Director General, International Technical Co-operation

INDIA

Mission members: Prof. S. Narang, Expert Adviser
Mr. G.S. Gouri, Director
Division for Industrial Studies/UNIDO
Mr. K. Venkataraman, Special Technical Adviser
UNIDO Technology Programme

NEW DELHI - 7 August

Department of Science and Technology:

Prof. M.G.K. Menon - Secretary

Jawaharlal Nehru University:

Prof. Mayudamma - Vice-Chancellor

Indian Institute of Technology:

Prof. T.K. Ghose - Prof. of Chem. Eng.

NEW DELHI - 8 August

Planning Commission:

Dr. M.S. Swaminathan - Member

ARGENTINA

Mission members: Prof. C.-G. Hedén, Mission Leader
Prof. H. Boyer, Expert Adviser*
Mr. W. Kamel, Industrial Development Officer,
Development and Transfer of Technology Branch/UNIDO

BUENOS AIRES - 7 August

United Nations Development Programme:

Mr. C. del Castillo - Deputy Resident Representative

Ministry of Public Health and Environment:

H.E. Brigadier (R) A.E. Argüelles - Minister

Center for Animal Virology:

Dr. Latorre - Assistant Director

BUENOS AIRES - 10 August

National Institute for Industrial Technology:

Mr. J. Gomez Artero - Director-General

Eng. R. Henning - Head, International Relations

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* Prof. H. Boyer joined the Mission on 10 August.

Food Technology Department:

Dr. R. Macchi	- Director
Dr. A. Kuck	

Dairy Technology:

Doz. M. Bressanello	- Director
Lic. S. Tesone	

Department Meat Research:

Dr. C. Dabove	- Director
Eng. N. Prok	

Planning Secretariat:

Vice-Commander Mr. Jorge Mr. Jorge Bonnesserre	- Director-General, International Technical Co-operation

LA PLATA - 10 August

Governorate of Buenos Aires Province:

General Oscar Bartolomé Gallino - Governor

Commission for Scientific Research of Buenos Aires Province (CIC):

Dr. J.J. Gagliardino	- President
Dr. A.J. Arvía	- Vice-President
Dr. Renom	- Administrative Secretary
Dr. J.H. Comin	- Director

BUENOS AIRES 11 August

Ministry of Industry:

H.E. Mr. Eduardo V. Oxenford	- Minister

Under-Secretariat of Science and Technology:

Dr. V. Olguín	- Co-ordinator International Relations

National Council for Scientific and Technical Research (CONICET):

Eng. J.S. Candolfo	- President
Dr. N.O. Ciarrapico	- Head International Relations
Dr. H.M. Torres	- Expert, mol. biol.
Eng. L.E. Rocha	- Expert, electronics

BRAZIL

Mission members: Prof. C.-G. Hedén, Mission Leader
Prof. H. Boyer, Expert Adviser
Mr. W. Kamel, Industrial Development Officer,
Development and Transfer of Technology Branch/UNIDO

BRASILIA - 12 August

United Nations Development Programme:

Mr. P. Könz	- Resident Representative

National Council for Scientific and Technological Development (CNPq):

Dr. J. Duarte	- Scientific Director
Dr. O.J. Crocomo	- Coll. of Agr., University of Sao Paulo
Dr. J.S. Furtado	- Soc. for Microbiology
Dr. R. Brentani	- Department Oncology, University of Sao Paulo
Dr. R. Montandon	- Co-ordinator
Dr. V. Palma	- Head EMBRAPA of the Planning Ministry

MONTE CLAROS - 12 August

Biobras - Biochimica do Brazil S.A.:

Dr. M.L. dos Mares Guia	- Director
Dr. J. Thiemann	- Director Fermentation Research

SAO PAULO - 13 August

University of Sao Paulo, Medical Faculty:

Prof. F.J.S. Lara	- Expert, mol. genetics
Dr. S.S. Diogenes	- Expert, microbiol.
Dr. R. Brentanni	- Expert, oncology
Dr. L.L. Villa	- Expert, oncology

LORENA - 14 August

Ministry of Industry and Commerce:

Dr. I. Vargas	- Secretary for Industrial Technology
Dr. C. Monaco	- Sector Co-ordination

U.S.A.

Mission members: Prof. C.-G. Hedén, Mission Leader
Prof. A.M. Chakrabarty, Expert Adviser
Mr. W. Kamel, Industrial Development Officer,
Development and Transfer of Technology Branch/UNIDO

SAN FRANCISCO - 17 August

University of California (S.F.), Medical School, Department Biochemistry and Biophysics:

Dr. W. Rutter	- Chairman, Head of Department
Dr. W. Goebel	- University of Würzburg (on sabbatical leave)

SAN FRANCISCO - 18 August

Stanford University, School of Medicine:

Dr. S. Falkow	- Chairman, Department Med. Microbiology

University of California, Berkeley:

Dr. M. Calvin	- Department of Chemistry

WASHINGTON D.C. -19 August

Department of State:

Mr. F. Dorough	- Dep. Dir., Office of Science and Technology Support
Mr. E. Kovack	- Dep. Dir., Office of Advanced Technology, Bureau of Oceans and International Environmental and Scientific Affairs
Mr. D. Fantozzi	- UNIDO Desk Officer

Department of Commerce:

Mr. L. Felker	- Dep. Dir., Co-operative Generic Technology Programme
Ms. A. Wickham	- Office of Food and National Resources
Ms. E.M. Robertson Ms. E. Bunten-Mines	- Planning Office of the National Bureau of Standards

Associated Universities:

Dr. A. Hollaender	- President

WASHINGTON D.C. - 20 August

Environmental Protection Agency (EPA):

Mr. T.J. Lepine	- Office for International Programmes

National Science Foundation:

Dr. B. Bartocha	- Director, Division of International Programmes
Messrs. M.T. Caiesla R.R. Ronkin	- Division of International Programmes
Dr. H. Lewis	- Director, Division of Biology
Mr. L.G Mayfield	- Deputy Director, Division of Chemical and Process Engineering
Dr. D. Nasser	- Director, Genetic Biology
Mr. H.T. Huang	- Expert, applied biology

National Academy of Sciences:

Dr. M. Dow Ms. K. Bell	- Board on Science and Technology for International Development
Dr. M. Greene	- Executive Secretary, Committee on Research Grants
Dr R. Housewright	- Executive Director, American Society for Microbiology
Mr. M. Phillips	- National Academy of Engineering
Mr. R. White	- National Academy of Engineering
Mr. E. Nightingale	- Institute of Medicine

Agency for Development:

Mr. J. Daley	- Head of Section

Congress of the United States; Office for Technology Assessment:

Dr. G. Kolsrud	- Programme Manager
Mr. G.M. Karny	- Attorney

CAMBRIDGE, Mass. - 21 August

Harvard University:

Dr. F. Ausubel	- Department of Biology

Massachusetts Institute of Technology:

Prof. A.J. Sinskey Prof. C. Cooney	- Department of Nutrition and Food Science

UNITED REPUBLIC OF TANZANIA

Mission members: Prof. A.M. Chakrabarty, Expert Adviser
Mr. J. Cramwinckel, Assoc. Industrial Development Officer
Development and Transfer of Technology Branch/UNIDO

DAR ES SALAAM - 27 August

United Nations Development Programme:

Mr. S. Renien	- Senior Industrial Development Field Adviser

National Chemical Industries:

Mr. H. Kitilya	- Assistant Manager

National Scientific Research Council:

Prof. H.Y. Kayumbo	- Director General

DAR ES SALAAM - 28 August

Muhimbili Medical Center:

Dr. Mhalu	- Acting Head, Microbiology Department
Dr. F. Douglas	- Head Department of Pharmaceuticals

DAR ES SALAAM - 29 August

H.E. Mr. W.-K. Chagula	- Ambassador Extraordinary and Plenipotentiary Permanent Representative

EGYPT

Mission members: Prof. A.I. Bukhari, Expert Adviser
Mr. J. Cramwinckel, Assoc. Industrial Development Officer
Development and Transfer of Technology Branch/UNIDO

CAIRO - 31 August

United Nations Development Programme:

Mr. G.L. Pennacchio	- Resident Representative

CAIRO - 1 September

National Research Center:

Dr. Kamel	- President
Dr. Mohie Abdel Samie	- Laboratory for Microbial Chemistry and Enzymes

Dr. Asem Mohammed Ali - Laboratory for Genetics
Dr. Sohair Amer - Laboratory for Genetics
Dr. Hassan El-Nahass - Laboratory for Cell Biology
Dr. Mohamed El-Foly - Laboratory for Plant Physiology
Chem. Eng. Adel Abdel-Daiem - Laboratory for Semi-industrial Research
Dr. Abdel-Moneim El-Rifai - Laboratory for Natural Products
Dr. Ettedal Wissa - Laboratory for Biochemistry

CAIRO - 2 September

Academy for Scientific Research and Technology:
Dr. M. Bahoa El Din Fayez - Vice-President

SAUDI ARABIA

Mission members: Prof. C.-G. Hedén, Mission Leader
Prof. A.I. Bukhari, Expert Adviser
Mr. J. Cramwinckel, Assoc. Industrial Development Officer, Development and Transfer of Technology Branch/UNIDO

RIYADH - 5 September

United Nations Development Programme:
Dr. Ibrahim Adly - Resident Representative
Dr. Zuheir Amin - Assistant Resident Representative

RIYADH - 6 September

Ministry of Planning:
H.E. Dr. Hussain Abduhla Mansour - Deputy Minister

Saudi Institute for Science and Technology:
Dr. Rydha Obeit - Managing Director

KUWAIT

Mission members: Prof. C.G. Hedén, Mission Leader
Prof. A.I. Bukhari, Expert Adviser
Mr. J. Cramwinckel, Assoc. Industrial Development Officer, Development and Transfer of Technology Branch/UNIDO

KUWAIT CITY - 8 September

Ministry of Public Health:
H.E. Dr. Nael Al Nageeb - Under-Secretary

Maternity Hospital, Genetic Centre:
Dr. Sulaiman Al Othman - Department Head

Kuwait Institute for Scientific Research (KISR):

Dr. Mohammed M.S. Al-Falah	- Deputy Director General Division of Administration, Finance and Support Services
Dr. Fikry I. Khalaf	- Acting Head, Environmental Sciences Department
Dr. Adel F. Halasa	- Director, Division of Petroleum, Petrochemicals and Materials
Dr. Nazar A.R. Hussain	- Acting Director, Division of Food Resources Head, Mariculture and Fisheries Department
Dr. Safat M.A. Moustafa	- Head, Division of Engineering, Department of Energy

KUWAIT CITY - 9 September

United Nations Development Programme:

Dr. Ibrahim Othman	- Resident Representative
Mr. Ali H. Al-Zatari	- Programme Assistant

Kuwait University, Faculty of Science, Department of Microbiology:

Dr. A. Kabarity	- Cytogenetics Laboratory
Dr. Maher M. El-Shinnawi	- Bacteriology Laboratory
Dr. Najat Al-Sarré	- Plant Physiology Laboratory
Dr. Redha Al-Hasan	- Algology Laboratory
Dr. A.K. Sallol	- Appl. Microbiology Laboratory
Dr. M.A. Ghannoum	- Bio-deterioration Laboratory
Dr. Ali M. Jafri	- Virology Laboratory

Kuwait Foundation for the Advancement of Science:

Dr. Adnan Ageel	- Director General

PHILIPPINES

Mission members: Prof. C.-G. Hedén, Mission Leader
Prof. A.I. Bukhari, Expert Adviser
Mr. J. Cramwinckel, Assoc. Industrial Development Officer
Development and Transfer of Technology Branch/UNIDO

MANILA - 11 September

United Nations Development Programme:

Dr. E.I. Pluhar	- Senior Industrial Development Field Adviser/UNIDO

University of the Philippines, National Institutes of Bio-technology and Applied Microbiology (BIOTECH):

Dr. M.G. Padolina	- Executive Deputy Director

Ministry of Energy:

Dr. W.R. de la Paz	- Director, Bureau of Energy Development

Energy Research and Development Center (ERDC):

Dr. Ibarra E. Cruz	- Director

LOS BAÑOS - 12 September

Ministry of Science:

H.E. Mr. Emil O. Javier	- Minister President, Science Development Board,

University of the Philippines, National Institutes of Bio-technology and Applied Microbiology (BIOTECH):

Dr. E. del Rosario	- Project Leader Biofuels
Dr. Priscilla L. Sanchez	- Assistant Professor, Department of Food Science and Technology
Dr. I. Manguiat	- Project Leader, biological nitrogen fixation, Soil Microbiology Laboratory
Dr. R. de la Cruz	- Project Leader, rhizosphere microbiology, Soil Microbiology Laboratory
Mr. M. Ortega	- Special Assistant to the Deputy Executive Director

LOS BAÑOS - 14 September

University of the Philippines:

Dr. Elias E. Escueta	- Chairman, Department of Food Science and Technology
Dr. Ricardo R. del Rosario	- Pilot Production, Biofuels
Dr. Mercedes Umali-Garcia	
Dr. Juanita C. Mamanil	- Nitrogen Fixation and Mycorrhiza Laboratory, College of Forestry
Dr. R.B. Aspiras	- Department of Soil Science

International Rice Research Institute (IRRI):

Dr. I. Watanabe	- Head, Microbiology Department

MANILA - 14 September

National Institute for Science and Technology:

Dr. Vedesto José	- Commissioner
Dr. Romeo V. Alicbusan	- Executive Secretary, SE Asian Network for Applied Microbiology

Center for Non-conventional Energy Development:

Dr. Ernesto M. Terrado	- Deputy Director
Dr. Ernesto S. Pangelman	- Programme Co-ordinator
Dr. Rufino H. Ibarra	- Specialist, solar energy
Dr. Aldwin C. Santos	- Specialist, biofuels

University of the Philippines, National Science Research Centre, Diliman, Manila:

Ms. Gloria Henriques	- Director
Dr. R. Uyenco	- Specialist, SCP-production
Dr. B. Gonzales	- Specialist, instrument maintenance

Veterinary School, Department of Microbiology:

Dr. H.A. Molina	- Director
Dr. C. Capulo	- Research Assistant

CHINA

Mission members: Prof. C.G. Hedén, Mission Leader
Prof. R. Wu, Expert Adviser

BEIJING - 17 September

United Nations Development Programme:

Mr. A. Sissingh	- Senior Industrial Development Field Adviser/UNIDO

Academia Sinicao:

Dr. Fen De Pei	- Vice-president Biological Sciences
Mr. Gin Tong Chao	- International Bureau

Institute of Genetics:

Mr. Tong Kezhong	- Director
Dr. J.W. Okyang	- Specialists, plant tissue culture
Dr. Chen Zhenghua	
Dr. Pai Ying-Lin	- Specialist, ribosome genetics

Institute of Microbiology:

Ms. Xue Yugu	- Director
Dr. Xu Hao	- Specialist, microbiotechnology
Dr. Xang Wangnien	
Dr. Jiang Shugin	- Specialist, mol. genetics
Dr. Qiao Baoyi	- Specialist, binding site studies

Dr. Fang Rongxiang	- Specialist, plant virology
Dr. Kaiyn Yang	- Specialist, enzymology
Dr. Yu Maoxiao	- Specialist, phage research
Dr. Mang Ke-Oriang	- Specialist, plant plasmids

SHANGHAI - 18 September

Academia Sinicao:

Dr. Tsao Tien Chin	- Deputy Director
Mr. Xing Fu	- Specialist, genetic engineering
Dr. Liu Xinyuan	- Specialist, interferon induction
Dr. Chen Changying	- Specialist, DNA synthesis
Dr. She Wei-Ming	- Specialist, plant genetics
Dr. M.S. Tsai Ming-Jie	- Specialist, genetic engineering
Dr. Aushi-Zhon Dr. Qian Bin	- Specialists, hepatitis B. genetics

SHANGHAI - 19 September

Academia Sinicao; Institute of Cell Biology:

Dr. Yao Zhen	- Director
Dr. L.C. Sze	- Specialist, chromosome structure of eucaryotes
Dr. Kuang Da Ren	- Specialist, molecular yeast genetics
Dr. Shae, Shih-Kung	- Specialist, holography
Dr. Yao Fei Long	- Specialist, NA synthesis

Fudan University, Intitute of Genetics:

Dr. T.C. Sheng	- Deputy Director
Dr. T.T. Liu	- Specialist, human molecular genetics
Dr. I.G. Tsai	- Specialist, rice genetics
Dr. C. S. Li	- Specialist, mol. genetics
Dr. Zhang-Sun Fu Dr. Ite Pei-Fu	- Specialists, foot and mouth virus genetics

SHANGHAI - 21 September

Ministry of Health, Chinese Academy of Medical Sciences, Institute of Basic Medical Sciences:

Dr. Wu-Kuan Yun	- Deputy Director
Dr. Chou Xi-Chang	- Specialist, cloning of genes for antibiotics
Dr. Qiang Bo-Qin	- Specialist, hepatitis B. cloning for diagnostic antigen

Institute of Biophysics:

Dr. Tson-Chen Lu	- Deputy Director
Dr. Chen Shen	- Specialist, nucleic acid structure and function
Dr. Li Han-Chien	- Specialist, M-RNA structure
Dr. Yan Mao Gong	- Specialist, polynuclestide synthesis and labelling
Dr. Jiang Maii-Yian	- Specialist, RNA recombination
Dr. Hua Ling	- Specialist, RNA synthesis
Dr. Li Yu Huan	- Specialists, radiation protection
Dr. Li You-Hua	

Academy of Sciences:

Dr. Chang Chih Ye	- Deputy Vice-President Biological Sciences (Institute of Zoology)
Dr. Yeu Yugu	- Institute of Microbiology
Dr. Li Jin Zhao	- Institute of Biophysics
Dr. Wu Zhichun	- Division of Biological Sciences
Dr. Guo Xingxian	- Division of Biological Sciences
Dr. Tong Kezhong	- Institute of Genetics

SHANGHAI - 22 September

Peking University, Department of Biology:

Dr. Chen Te-ming	- Director
Dr. Tsien Tswen-ran	- Specialist, microbiology
Dr. Du Gin-Zhu	- Specialist, amino-acid analysis
Dr. Ru Bin-Gen	- Specialist, amino-acid sequence analysis
Dr. Lee Ling-Yuan	- Specialist, restriction enzyme preparation
Dr. Ma Shu-Yi	- Specialist, mitochondrial DNA sequencing
Dr. Shang Ke-Kang	- Specialist, Metazoan tissue culture
Dr. Wang Shu-Yun	- Specialists, cancer immunology
Dr. Wang Tsun-Chin	
Dr. Lin. Jin-Hu	- Specialist, gene-regulation

IRELAND

Mission members: Prof. C.G. Nedén, Mission Leader
Mr. G.S. Gouri, Director,
Division for Industrial Studies/UNIDO
Mr. W. Kamel, Industrial Development Officer,
Development and Transfer of Technology Branch/UNIDO

DUBLIN - 24 September

Department of Foreign Affairs:

H.E. Mr. J. O'Keefe	- Minister for State

Industrial Development Authority (IDA):

Mr. J. Lyons	- Executive Director
Mr. Lowery	- Manager Industries Division
Mr. M. Foley	- Manager, Development Co-operation Unit
Mr. D.P. Hanna	- Manager, Development + Service Industries Div.
Dr. M. Greene	- Project Executive

Trinity College:

Dr. W. Watts	- Provost
Dr. G. Dawson	- Prof. Genetics
Dr. E. Cunningham	- Prof. Animal Genetics
Dr. J. Arbuthnott	- Prof. Microbiology
Dr. D. McConnell	- Specialist, genetics

University College Dublin:

Dr. T. Murphy	- President
Dr. P.N. Meenan	- Dean, Faculty of Medicine
Dr. J. Masterson	- Prof. of Medical Genetics
Dr. M. Geoghegan	- Prof. of Industrial Microbiology
Dr. W. Fogarty	- Associate Prof. of Industrial Microbiology
Dr. F. Hillery	- Specialist, virology

National Board for Science and Technology:

Dr. N. Gilliat

GALWAY - 25 September

University College Galway:

Dr. C. O'hEocha	- President
Dr. L.K. Duncan	- Prof. of Microbiology
Dr. P. Pottrell	- Prof. of Biochemistry
Dr. J.P. Gosling	- Specialist, immunoassays

Dr. M.P. Coughlan	- Specialist, cellulases
Dr. J. Greally	- Specialist, monoclonal antibodies

Institute for Industrial Research and Standards:

Dr. M. Kierstan	- Director

LIMERICK - 25 September

National Institute for Higher Education (NIHE):

Dr. G. Anderson

European Research Institute (Ireland):

Dr. D. O'Neill	- Chief Executive Officer

CORK - 26 September

University College:

Dr. T. O'Ciardha	- President
Dr. T.F. Raftery	- Vice-President Prof. of Agriculture
Dr. S. Doonan	- Dean of Science Prof. of Biochemistry
Dr. M.F. Murphy	- Dean of Science Dairy Science Department
Dr. C. Daly	- Appl. Microbio Genetics, food and dairy microbiology
Dr. F. O'Gara	- Specialist, molecular genetics of nitrogen fixation
Mr. M.P. Mortell	- Registrar

FRANCE

Mission members: Prof. C.-G. Hedén, Mission Leader
Mr. W. Kamel, Industrial Development Officer,
Development and Transfer of Technology Branch/UNIDO

PARIS - 28 September

Ministry of External Affairs, Bureau of International Organisation

Mr. E. Berg	- UNIDO Desk Officer

Ministry of Research and Technology (Délégation Général à la Recherche Scientifique et Technique - DGRST):

Mr. Douzou	- President

National Institute for Agronomic Research (INRA), Toulouse:

Mr. Durand - Director

Institut Pasteur:

Mr. Dedonder - Scientific Director

PARIS - 29 September

UNESCO:

Mr. E. DaSilva - Microbiology Programme

Ministry of Research and Technology - DGRST:

Mr. J.D. Cordjman - Counsellor for International Affairs

PARIS - 30 September

Ministry of External Affairs:

Mr. Jacques - Head, Department of Technical Development

Mr. L. Champenois - Deputy Head

including associates:

Ms. Debey

Mr. Laget

Mr. Poncet - Operation Division

Ministry of Co-operation and Development:

Mr. de la Fournir for H.E. Mr. Cot

National Technical Research Association (ANRT):

Mr. P. Sinet - Director, International Affairs

Université Paris Sud, Orsay, Institute for Microbiology:

Dr. J.C. Patte

Circuit de Centres d'Etudes et de Recherche de Chimie Organique Appliqué de CNRS (CERCOA), Thais:

Dr. M. Sicsic

Ecole Nationale Supérieure de Mines de Paris:

Mr. P. Lafitte - Director
President - Association Sophia - Antipolis

FEDERAL REPUBLIC OF GERMANY

Mission members: Prof. C.-G. Hedén, Mission Leader
Mr. W. Kamel, Industrial Development Officer,
Development and Transfer of Technology Branch/UNIDO

HEIDELBERG - 2 October

European Molecular Biology Laboratory (EMBL):

Sir John Kendrew	- Director-General (until March 1982)
Dr. L. Philipsson	- Director-General (from March 1982)

University of Heidelberg:

Prof. Schalle	- Head, Department of Microbiology
Dr. H. Bujard	- Head, Department of Genetics

STOCKHEIM/BRAUNSCHWEIG - 5 October

Association for Bio-technological Research (GBF):

Dr. K. Kieslich	- Scientific Director
Dr. J.H. Walsdorff	- Head, Planning Department
Dr. R. Radloff	- Public Relations Section
Dr. J. Collins	- Head, Genetics Department
Dr. H. Wagner	- Director of Department

BONN - 6 October

Ministry for Research and Technology:

Dr. Binder	- Director, Biological Research and Technology Unit
Dr. H. Keune	- Specialist, Bio-technology
Dr. Kirst	- Specialist, Appl. Plant Physiology

Ministry for Economic Co-operation:

Dr. H.J. Walch	- Head, Technology Development Unit
Dr. E. Killinger	- UNIDO Desk Officer

Ministry for Agriculture:

Dr. R. Jördens	- Head of Section

JULICH - 6 October

Institute for Bio-technology at the Nuclear Research Establishment:

Dr. E.-A. Witte	- Project Co-ordinator
Dr. Sahm	- Senior Scientist
Dr. C. Vandrey	- Senior Scientist

FRANKFURT AM MAIN - 7 October

Association for Technical Co-operation (GTZ):

Dr. Fredichsen	- Head, Plant Production Department
Mr. M.K. Rudolph	- German Appropriate Technology Exchange (GATE)
Dr. P. Pluschke	- Specialist, Energy
Mr. K. Zimmermann	- Specialist, Energy

UNION OF SOVIET SOCIALIST REPUBLICS

Mission members: Prof. C.G. Hedén, Mission leader
Mr. E. Yakushin, Industrial Information Officer, Industrial Information Section/UNIDO

MOSCOW - 8 October

All-Union Institute of Protein Synthesis:

Mr. R.B. Katrush	- Director
Mr. L.Y. Lebedev	- Head, Department for Foreign Relations of the Directorate of the Microbiological Industry of the USSR (DMI)
Ms. L.N. Aganesova	- Deputy Head, Department of Foreign Relations
Mr. V.S. Pitersky	- Scientific Researcher
Mr. V.I. Seregin	- Deputy Director of the Main Directorate of Microbiological Industry of the USSR

PUSHCHINO - 9 OCtober

Academy of Science, Institute of Biochemistry and Physiology of Micro-organisms:

Mr. G.K. Skryabin	- Director and Chief Scientific Secretary
Mr. A.A. Baev	- Head, Department for Molecular Biology and Genetics of Micro-organisms
Dr. V.K. Eroshin	- Head, Department of Microbiological Technology
Dr. M.V. Ivanov	- Head, Laboratory of Biogeochemistry
Dr. V.I. Tanyashin	- Head, Laboratory of Genetic Enzymology
Dr. L. Tikhomirova	- Specialist, Vector Design
Dr. V. Gorokhov	- Specialist, Sulphur Cycle

ITALY

Mission member: Prof. C.G. Hedén, Mission Leader

ROME - 14 October

Food and Agriculture Organization of the United Nations:

Mr. O. Brauer	- Director, Plant Protection Division
Mr. L. Chiarappa	- Plant Protection Division
Mr. W.H. Barreveld	- Agricultural Industries Division
Mr. R. Dudal	- Land and Water Development Division
Mr. C. Palmborg	- Forest Resources Division
Mr. A. Bozzini	- Crop and Grassland Production Service
Mr. W. Kossila	- Animal Production Science
Mr. J. Rendet	- Animal Production Science
Mr. B. Müller-Haye	- International Agricultural Research Development Centre
Mr. A.R. de Ravenell Terama	- Liaison Office for Interagency Affairs

GLOSSARY

Amino acids - The building blocks of proteins. There are 20 common amino acids; they are joined together in a strictly ordered "string" which determines the character of each protein.

Biomass - Plant and animal material.

Bio-technology - The collection of industrial processes that involve the use of biological systems. For some of these industries, these processes involve the use of genetically engineered micro-organisms.

Clone - A group of genetically identical cells or organisms asexually descended from a common ancestor. All cells in the clone have the same genetic material and are exact copies of the original.

DNA (deoxyribonucleic acid) - The genetic material found in all living organisms. Every inherited characteristic has its origin somewhere in the code of each individual's complement of DNA.

Enzyme - A functional protein that catalyzes a chemical reaction. Enzymes control the rate of metabolic processes in an organism; they are the active agents in the fermentation process.

Fermentation - The biochemical process of converting a raw material such as glucose into a product such as ethanol.

Genetic engineering - A technology used at the laboratory level to alter the hereditary apparatus of living cell so that the cell can produce more or different chemicals or perform completely new functions. These altered cells are then used in industrial production.

Hormones - The "messenger" molecules of the body that help co-ordinate the actions of various tissues; they produce a specific effect on the activity of cells remote from their point of origin.

Monoclonal antibodies - Antibodies derived from a single source or clone of cells which recognize only one kind of antigen.

Nucleic acid - A polymer composed of DNA or RNA subunits.

Nucleotides - The fundamental units of nucleic acids. They consist of one of the four bases - adenine, guanine, cytosine, and thymine (uracil in the case of RNA) - and its attached sugar-phosphate group.

Pathogen - A specific causative agent of disease.

Plasmid	- Hereditary material that is not part of a chromosome. Plasmids are circular and self-replicating. Because they are generally small and relatively simple, they are used in recombinant DNA experiments as acceptors of foreign DNA.
Protein	- A liner polymer of amino acids; proteins are the products of gene expression and are the functional and structural components of cells.
Restriction enzyme	- An enzyme within a bacterium that recognizes and degrades DNA from foreign organisms, thereby preserving the genetic integrity of the bacterium. In recombinant DNA experiments, restriction enzymes are used as tiny biological scissors to cut up foreign DNA before it is recombined with a vector.
SCP	- Single Cell Protein
Tissue culture	- An in vitro method of propagating healthy cells from tissues, such as fibroblasts from skin.
Vector	- An infectious agent that requires a host cell in order for it to replicate. It is composed of either RNA or DNA wrapped in a protein coat.