Opportunities to Commercialize Life Science Applications in Less Developed Countries
- A Strategic Plan -

A Proposal
Submitted by the

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to
Bureau for Science and Technology
U.S. Agency for International Development

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I. Executive Summary

The objective of this proposal is to review AID-sponsored investigations in the life sciences to identify fields with near- to mid-term commercial potential. Based upon an analysis of promising technology developments, the Resources Development Foundation (RDF) will prepare a strategic plan for AID that will delineate commercialization pathways for near-term opportunities and will define an approach to enhance the commercial utility of ongoing AID-supported investigations.

RDF is a non-profit foundation that is working closely with the International Biotechnology Group (IBG) to establish viable life science-based enterprises in developing countries. IBG is a for-profit corporation created to manage an investment fund dedicated to developing country business ventures employing both classical and advanced biotechnologies. RDF will support the "threshold" costs associated with the identification of promising technologies and private sector players and the evaluation of potential business opportunities--costs typically not absorbed by investment funds. In the present instance, RDF will perform these functions within the domain of AID-supported development activities.

The project will carry out the following activities:

(1) Review existing documentation on AID-supported life science investigations
(2) Screen prospects to develop a short list of projects deserving in-depth investigation
(3) Conduct field investigations of priority projects
(4) Carry out a detailed evaluation of priority projects
(5) Perform a second screening based on evaluations
(6) Sponsor a roundtable to present and discuss lead projects
(7) Prepare the strategic plan

The work proposed would be carried out over a one-year period by RDF and IBG staff members. Outside consultants will be used only where specialized expertise is required.

RDF believes that the proposed project offers substantial benefits to S&T. The most important consideration is that the project will initiate a process that will proceed well beyond the scope of work and will ultimately realize the commercial application of AID-sponsored technology. This provides an opportunity to enhance the continuity of AID programs and this will, in turn, result in greater recognition for AID for its achievements. The resulting strategic plan should prove to be a useful reference for AID missions, R&D program planners and for private companies engaged in life science based enterprises. It is hoped that this project will form the basis for an enduring cooperation between AID and the LDC business community in the field of life science applications.

II. Background

The RDF/IBG Initiative

The Resources Development Foundation (RDF) is establishing a program for the transfer and commercial development of life science applications in Less Developed Countries (LDCs) in the fields of agriculture, bioenergy, environmental restoration and health. With principal offices located in Washington, D.C., RDF is a tax-exempt, non-profit organization chartered to help leverage more public and private resources in support of LDC development activities.

RDF's biotechnology project was initiated in mid-1985 with a feasibility study investigating the prospects for establishing investment funds (Funds) to promote joint ventures in the life sciences between developed and developing country firms. This phase was supported by the Rockefeller Brothers Fund in co-operation with AID when provided additional assistance with consulting services and was directed by a steering committee composed of representatives from biotechnology companies, investment and venture capital firms, international development agencies and foundations. After several meetings with the steering committee, a mission to Southeast Asia and extensive interviews by a team of consultants, a consensus emerged that profitable and appropriate ventures in the life sciences were possible in LDCs and could be of great benefit. However, conventional venture capital financing strategies would probably fail because of the many impediments that have to be overcome.

Therefore, it is necessary to also identify a not-for-profit organization (RDF) to work closely with a for-profit investment fund and support the "threshold" costs associated with the identification of promising technologies and private sector players and the evaluation of potential ventures. These costs are typically not supported by venture capital funds and are expected to be substantial for venture development in LDCs. The not-for-profit entity also will ensure that social and environmental considerations are adequately addressed in formulating new ventures.

The respective roles of the not-for-profit arm (RDF) and for-profit arm (International Biotechnology Group (IBG) are depicted in the flow chart on the following page. Non-profit sources and applications are clear, for-profit sources and applications are denoted by hashmarks and the overlapping area represents the targeted field of ventures where commercial (for-profit) interests and social (non-profit) interests intersect.

RDF is now a functioning organization with a permanent staff. Its funding will come from other foundations, international development agencies and corporate charities. RDF applies its funds in two principal ways. The first activity is support for project incubation. This addresses those activities that precede the creation of specific ventures such as market and infrastructure development, information collection and dissemination, training and the adaptation of technologies to LDC needs and conditions. Second, RDF will support certain IBG preinvestment activities, including technology assessment, financial analysis and other actions required to prepare venture prospectuses for consideration by the Funds.

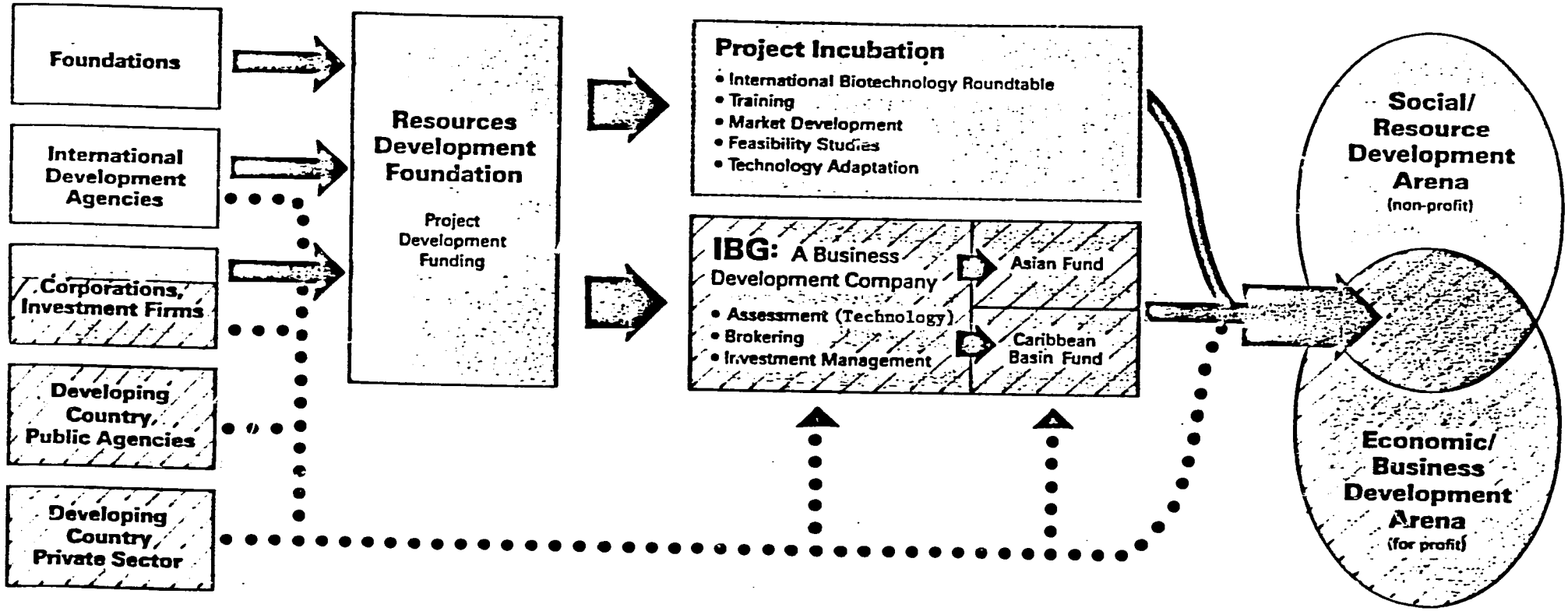
Funding for IBG will come from corporations and investment firms in developed and developing countries and through the investment arms of international development agencies and LDC public agencies. Financing from these sources will be used primarily to capitalize the Funds which will, in turn, invest in specific LDC ventures. IBG has been established with seed funding from RDF. Thus, by absorbing project incubation and venture development costs, RDF helps IBG attract capital by avoiding potentially high preinvestment and management costs. This should keep IBG competitive with domestic investment funds having lower risk profiles. A more detailed discussion of the RDF/IBG initiative is provided in Appendix I. RDF's legal counsel, a tax-exempt organization specialist, has issued a formal opinion that RDF's activities described in this proposal are consistent with its tax-exempt status.

This proposal is based upon guidance received from Mr. McPherson at an August 1986 meeting with project staff. the conclusions of the feasibility study were presented to the Administrator at that time and the team was instructed to submit proposals to the PRE and S&T bureaus to help support the next phase in implementing the program described above. A separate propcsal to PRE is currently under preparation by IBG to request assistance for the preparation of prospectuses for ventures already in the advanced stages.

AID Support for the Life Sciences

AID's assistance in creating the RDF/IBG initiative is based upon its long standing support for R&D in the life sciences of potential value to LDCs. R&D in the field of agriculture has promoted techniques for the propagation of superior crop varieties and tree species for silviculture and AID has been a leader in malaria and veterinarian vaccine development. The Program in Science and Technology Cooperation has supported innovative research in the bioconversion of organic materials into fuels, feeds and other useful products and the Biomass Systems and Technology project is investigating bioprocesses for

Establishing Biotechnology Enterprises In Developing Countries



the conversion of sugar industry wastes and rice hulls. Many of these investigations have afforded results with considerable commercial potential, if developed (see expanded discussion of opportunities in Appendix II).

Despite AID's achievements in advancing the life sciences, there is, as yet, no mechanism for translating these achievements into practical realities yielding positive long-term benefits for LDCs. Certain technologies, such as some advances in medicine, may always have to rely upon ongoing support from donor agencies to be applied. Many others could be introduced through private sector initiatives that would provide a self-sustaining mechanism for realizing economic gains. Also, the disaggregated nature of AID's investigations makes it difficult to recognize the considerable overall effort that has been devoted to the life sciences. If the scope of development activities was surveyed and consolidated into a coherent strategic plan, AID and other development agencies could both better recognize areas to improve their programs and be better recognized for their achievements to date. The proposal herein presented provides a means for consolidating AID's gains in the field of the life sciences and for translating those gains into tangible benefits for the countries it serves.

III. Project Description

Objective

The principal aim of the proposed project is to develop a strategic plan for the private sector implementation of life science technologies with near-term commercial potential in less-developed countries. The plan will form the basis for further action by RDF/IBG to actually implement mature technologies through private business ventures. The analysis will also include the formulation of recommendations to AID that would improve the commercial viability of investigations it now supports (e.g., through training programs) and would identify new areas of complementary R&D that the Agency might consider.

Approach

The strategic plan and associated recommendations will be developed through the following step-wise process:

(1) Review documentation concerning LDC life science technology development in the fields of agriculture, bioenergy, environmental restoration and animal and human health;
(2) Perform an initial screening to select a short list of projects with near-term commercial potential to investigate in depth;
(3) Conduct field visits to gather data on selected projects, product market potentials and country capabilities;
(4) Develop detailed technical, economic and market evaluations for candidate technologies based upon the information gathered during field visits;
(5) Perform a second screening to further refine the list of candidates to those that will be presented at the roundtable and included in the strategic plan;
(6) Sponsor a roundtable to provide LDC researchers and businessmen an opportunity to present their technologies and discuss their views regarding their commercial potentials and commercialization strategies;
(7) Prepare the final report to AID covering:
    (a) the strategic plan for the commercialization of near-term life science technologies,
    (b) recommended AID actions to enhance the commercial potential of AID-funded R&D.

The period of performance will be one year. Close contact with AID will be maintained throughout and AID representatives are expected to review progress at the conclusion of Tasks 2, 5 and 7 (draft report review prior to final revisions). AID will also be provided copies of all other written materials prepared in the course of the proposed study (e.g., literature review, field trip itineraries, evaluation results).

Task Descriptions

This section defines in greater detail the tasks outlined above.

Task 1 - Literature Review - This initial step will examine available documentation concerning LDC life science R&D and applications and will cast a broad net covering many sources to ensure that all worthwhile opportunities are taken into consideration. RDF has already accumulated extensive literature on life science technologies of potential value in LDCs. Examples of some of the possible near-term opportunities are provided in the discussion in Appendix II. Special effort will be devoted to the collection of additional information on AID-sponsored technologies. RDF will work closely with appropriate AID/W staff members (at S&T/AGR, SCI and S&T/EY and with the AID regional bureaus [ANE, AFR, LAC]) to identify relevant information sources. Also, several consultants to AID have conducted studies yielding information relevant to this project (studies for PPC by Carl Pray [Rutgers], John Barton [Stanford]). In addition to AID sources, information from BOSTID (Board on Science and Technology for International Development), NSF's International Division, USDA Office of International Cooperation and Development, the Office of Technology Assessment, the Industrial Biotechnology Association, CGIAR (Consultative Group on International Agricultural Research), and international development agencies (World Bank, FAO, OAS, ADB, IADB) pertaining to LDC life science applications will also be reviewed.

Task 2 - Initial Screening - The information assimilated in Task 1 will be refined into a listing of potential LDC life science applications currently under investigation. Each application will then be reviewed by an expert staff panel to identify those which have some near-term commercial potential (see descriptions in Personnel, screening criteria are defined in Methods). Available data on product (or process) economics will be reviewed but no new quantitative analysis will be conducted at this point. The definition of "near term" is liberal and will include technologies that can be as much as five years from commercialization provided that the path of remaining development is straightforward and plausible within a developing country context. RDF estimates that roughly two dozen potential opportunities will be identified that are worthy of further investigation in field visits. Selected applications will be subject to review and modification by AID representatives at this stage.

Task 3 - Field Visits - The short list of candidates developed in Task 2 will be employed to develop a precise itinerary of field visits. In addition to visits to AID-sponsored projects, activities funded by BOSTID and activities at the International Agricultural Research Centers (IARCs) are expected to figure heavily in the planned itinerary. Field visits are costly and it is important to define the scope of such missions as precisely as possible. Advance contact with investigators and government and private sector representatives will be made wherever such contacts can be identified. Visits by the RDF team will be co-ordinated with country AID missions. RDF is sensitive to the fact that outside interactions can be disruptive and can generate false hopes that impede the smooth functioning of incountry programs and will strive to keep a low profile and follow AID mission guidance in its interactions. AID mission representatives will be invited to participate in country project visits. It is difficult to ascertain, at this time, the exact nature of the field visits to be carried out. Promising applications are under development in the Latin American/Caribbean, African, and Asian regions and at least one field visit to each region is anticipated. However, the RDF/IBG program has already conducted a preliminary review of prospects and constraints in the different regions and believes that the Asian region constitutes the most promising theater for commercializing life science applications and one of the most active areas of AID involvement in the life sciences. RDF, therefore, anticipates three field visits to the Asian region of two to three men each.

The purpose of the field visits will be to gather additional information and RDF staff and consultants will not try to develop business ventures at this point. Information needed will include both technical data on the applications under development but data is also needed for the economic analysis of product (or process) potentials and to assess the market potentials of candidate technologies. Development status, private sector and government infrastructure for implementation, national policies, management capabilities, and other factors affecting the feasibility of commercial ventures in targeted countries must also be assessed. (Not more than six countries will be targeted for in-depth analysis of country capabilities and market potentials.) The following section on Methods describes the criteria and approaches that will be employed to evaluate candidate technologies.

Task 4 - Detailed Evaluations - Once the necessary information has been gathered, RDF staff members and consultants (where needed) will perform detailed evaluations of candidate technologies (10-12 such evaluations are anticipated). In many cases, there will be more than one country that is suitable for a candidate technology. (In fact, breadth of application is an important determinant of commercial potential.) The analysis will, therefore, evaluate both technology-specific and country-specific factors. Technology-specific factors include developmental status (commercial readiness), remaining development needs including adaptation to LDC circumstances, and process or product economics. Conceptual processes or production systems will have to be hypothesized in many instances to enable an economic analysis. Process economics can vary markedly from country to country depending upon relative labor, raw material and utility costs, infrastructure for equipment fabrication, tax structures, etc. It will be necessary to note the sensitivity of process economics to country of application and to report subcases for several countries where sensitivities are high. It is also essential to report the relative uncertainties of economic analyses since these are also likely to vary substantially.

Country-specific factors predominate in the assessment of political risks, policy environments and private sector and government infrastructure for technology commercialization. The level of expertise in a country's technical workforce must be assessed to determine training needed for technology implementation. Well qualified in-country management is essential for successful technology-based ventures. RDF is sensitive to the difficulties in fairly evaluating the capabilities of in-country personnel and recognizes that additional training often will be needed to augment existing expertise. RDF will seek to minimize the need for expatriate technical and management personnel in the potential ventures it formulates. Another important factor is the availability of in-country investment financing that can potentially leverage RDF/IBG and other outside investors.

The evaluation process will begin in the field since the best way of ensuring that all necessary information has been collected is by working with that information. The results of the proposed analyses will be presented as profiles for each application. Despite the use of quantitative analytical methods, reporting will concentrate upon substantive observations rather than concentrating overly on numerical results.

Task 5 - Second-Level Screening - Once each prospective application has been analyzed, it will then be possible to classify prospects according to their level of development. The portfolio of profiles will be rated according to the intrinsic merits of the technologies employed (degree of readiness projected markets and investment returns and will further define the relative potentials in alternative countries). The three principal technology categories are: (1) those about which ventures have been formed and that are now ready for commercial application, (2) those that are sufficiently well developed that venture formation should be initiated and (3) those requiring substantial additional development. Commercial readiness is a function of both the maturity of the technology and the degree to which business ventures exploiting that technology have been developed. Few life science applications now under investigation in LDCs are expected to have achieved commercial readiness. It is anticipated that most of the near-term applications selected earlier will be well understood technically but will not have yet been organized into business ventures. Finally, one can expect that some of the applications earlier identified as near term will not qualify upon closer examination.

The purpose of this step is to establish priorities regarding the subsequent treatment of the applications evaluated and is not intended to eliminate candidates from further consideration. All candidates surviving the initial screening are likely to have merit. However, RDF proposes to pull together the results of its analysis in the form of a roundtable conference in addition to the report that would be submitted to AID. Only the most promising and advanced technologies should be featured at the roundtable while all candidates should be addressed in the strategic plan that is subsequently prepared.

Task 6 - Roundtable - The most promising life science applications identified and analyzed in the course of this study will be selected for presentation at an International Biotechnology Roundtable. RDF, in cooperation with the BOSTID (Bureau of Science and Technology in International Development) staff of the National Academy of Science [and with the Industrial Projects Department of the World Bank] is sponsoring the first roundtable in late 1987 or early 1988. The roundtable is intended for representatives of AID/W and AID missions, international development agencies and other financing institutions and will focus on near-term commercial opportunities for the life sciences in LDCs

and on the mechanisms needed for establishing biotechnology-based enterprises. Presentations by LDC investigators and businessmen will be emphasized in the agenda. The purpose is to convey a realistic and substantive perspective concerning actual opportunities in this much talked about but poorly understood field. The roundtable will also offer technology proprietors a chance to cultivate the interest of development agencies that can assist their enterprises. Attendance is expected to be divided roughly equally between LDC investigators, corporate representatives and donor agency personnel.

Because the roundtable will effectively publicize those life-science based ventures presented, it is important that only mature technologies be featured and that emerging technologies still requiring further development be clearly identified as such. Premature efforts to commercialize immature technologies can be very destructive. RDF hopes to conduct this roundtable in conjunction with a biotechnology conference planned for Sri Lanka in December 1987 but this may be too soon after project initiation to be possible.

Task 7 - Final Report - Final report preparation will be the concluding step in the project and will consist of two principal elements. The first part will be a strategic plan that presents RDF's analysis of life science applications with near-term commercial potential. Technology profiles will review the developmental status, possible commercial applications and their market potentials, and projected investment returns (where such projections are possible). The most promising countries to target for each venture will be identified as will the preferred mechanism for technology commercialization. Approaches are expected to vary markedly from technology to technology. Profiles will be reported in sufficient depth to enable AID missions and other interested parties to judge whether further assistance is warranted but will not include pro forma financial analyses and other prerequisites needed for the preparation of full business plans. Individual profiles will be integrated into an overall strategy that emphasizes technologies with near-term commercial potential but that also addresses mechanisms for bringing emerging technologies into the commercialization process as they mature. An augmented role for the LDC private sector in advanced R&D will figure heavily in RDF's efforts to formulate an effective technology transfer strategy.

The second element in the final report will present recommendations concerning how development agencies can improve the commercial utility of R&D it now supports and how it can foster continuity in the process of technology conceptualization, development, and commercialization. The focus will be on approaches to enhance the effectiveness of existing program investments rather than proposing new commitments for development agencies to undertake. In many cases, funding from foundations and other sources can be found to supplement development agency resources. Examples of the types of things to be explored are:

Enhanced participation of the private sector in life science R&D and R&D program management (i.e., through greater participation on review committees, improved in-company R&D capabilities),

Applied training of LDC personnel in biotechnology companies and financial institutions in developed countries to prepare a foundation for the technology transfer process,

Specific technical support services that development agencies might provide that are important to ensure that potential ventures have adequate technical capabilities,

Components that could be introduced into workshops and symposia that will attract representation from LDC financial institutions and the private sector,

Development needs in allied fields (i.e., separations technology) that reduce the technology gaps currently impeding the commercialization of basic advances advances (e.g., novel fermentations).

A draft report will be submitted to AID for its review and modification prior to presentation of the final report.

Methods

There are two basic levels of evaluation to be undertaken within the proposed project. This first involves a screening based primarily upon technical considerations. The second level evaluation integrates technical, economic, and political factors into a more sophisticated judgment of venture potentials.

Initial Technology Screening

After the literature on LDC-based developments in the life sciences has been reviewed and discussed thoroughly with AID staff members, it will be necessary to sort through the various prospects and select those that may have near- to mid-term potential. In general, this will involve the following sequence of determinations:

(1) What are the specific process or produce applications arising from the subject technology (or technique)? (This may seem self-evident but is often poorly defined by technology proprietors.)

(2) Do the applications identified afford products or processes that fulfill LDC markets? If so, where?

(3) Do the applications identified meet LDC needs? (All other things being equal, it is desirable to focus on opportunities that also fulfill pressing social needs.)

(4) Are all elements needed for a given application fully developed? (Again, many technology proprietors feel that a breakthrough, e.g., a new fermentation organism, constitutes a new technology when key aspects such as fermenter design and product separation have not been resolved.)

(5) At what scale has the technology been demonstrated (laboratory, pilot, commercial)?

(6) What remaining development is required to achieve commercial readiness?

(7) What adaptation is required to render the technology applicable within a developing country context?

(8) Are there any special infrastructure requirements on the part of LDCs to make the technology applicable? (This will define infrastructure needs as opposed to the determination of infrastructure capabilities arising from subsequent field visits.)

(9) Has the technology and economic performance ever been independently evaluated? (Evaluations by technology proprietors are suspect.)

(10) Do technology proprietors hold or have access to all rights and permits needed to implement the technology?

(11) Are technology proprietors prepared to cooperate with others to implement their technologies? (Others include technical personnel in allied fields (i.e., engineers) and potential venture managers and financiers.)

These questions will be addressed as best as is possible without undertaking field visits. The field visits must remain focused on those prospects that pass muster initially if they are to be thoroughly addressed.

In-Depth Evaluations

The field visits will gather the additional information needed to perform the detailed evaluations. In general, the RDF team will apply the same investment criteria employed by the International Finance Corporation (IFC) and listed on the following page. They will focus first on the projects identified and second on gathering information on the country. The technical points already described will serve as a basis for assessing the technology status. For a viable venture, one must be able to control the technological risks. Every effort will be made to gain enough understanding to enable an independent engineering/economic analysis of the technology by the RDF team in addition to whatever analyses that may have been completed by others. Life cycle cost analyses will be performed on a computer using Lotus 1-2-3 software. A computerized database will thereby be developed that will allow the RDF team and AID sponsors to propose and easily investigate different scenarios. Both financial and economic rate of return calculations will be conducted to assess the return potentials to both investors and the country as a whole. To be attractive as a venture capital investment, a prospective venture should demonstrate an internal rate of return of 40% or better. These determinations will commence in the field to help ensure that all necessary data has been obtained and to enable the preliminary review with technology proprietors.

In order to carry out rate of return calculations, it will be necessary to know product (or process) market values within target markets. Indeed, a market analysis is essential for any kind of critical assessment of a technology's commercial merit. There are two levels to a market analysis: the global potential and country-specific characteristics.

Global potential refers to the overall breadth of the market for the technology and involves a determination of the number of countries where the technology can be applied. Clearly, applications that can be replicated in many countries are more attractive as ventures than those with only limited utility. However, global potential is meaningless unless a technology can gain a foothold and be proven out in at least one country.

It is well beyond the scope of this project to assess a technology's market potentials in every developing country. It is, therefore, necessary to limit the range of target countries to not more than six. For this reason, the project will concentrate on specific country potentials for nations in the Asian region (e.g., Thailand, Indonesia, and the Philippines), although better developed countries in the African (e.g., Zimbabwe) and Latin American/Caribbean regions (e.g., Dominican Republic' may also be targeted. The RDF team will not restrict itself to activities within the Asian region and will draw upon and visit worthwhile projects in Africa, Latin America and the Caribbean, but will limit the country markets it examines. Final selection of target countries will be made after initial project evaluation field visits and consultations with AID staff. Where the commercial potential of a project in an untargeted country has been sufficiently well developed already, such analysis will be reported along with the target country analyses.

Key parameters to be investigated in each target country are:

(1) Size of product market
(2) Product pricing in the market(s)
(3) Market elasticities
(4) Nature of market (e.g., import substitution or an export market, direct versus indirect product substitution, etc.
(5) Degree to which the market has been and could be developed
(6) The nature of competition in the market

The third key consideration is the characteristic of the countries other than markets that affect the potential viability of business ventures. Principal aspects include the following:

(1) Governmental stability
(2) Government policies concerning outside investments - policies concerning specific investments as well
(3) Government policies concerning the preservation of proprietary rights and other matters of international law
(4) Stability of macroeconomic policies, e.g., exchange rates, foreign exchange limitations, tax regulations, regulations concerning the expatriation of earnings and capital
(5) Credit worthiness of the government and leading financial institutions and businesses
(6) Current level of debt service
(7) Availability of debt and equity capital
(8) Technical infrastructure for research, fabrication, servicing and personnel training; capabilities of the educational system and of leading businesses
(9) Availability of qualified management - Are there in-country people who can effectively manage a proposed enterprise on a day-to-day basis?
(10) Existence of local entrepreneurs or businesses that are prepared to risk some of their capital in a proposed venture

Final Screening

If each of the considerations previously enumerated are addressed, a good perspective will have been developed for each prospective application under evaluation. One could attempt to utilize this information for further screening with a quantitative approach of assigning weightings to each criteria and then ranking candidates according to a numerical scale but this really contributes nothing to the decision-making process. The RDF team will, instead, rely upon the expert judgment of a panel of people experienced in life science technology commercialization to review and evaluate the prospects for each candidate application. The outstanding qualifications of the staff panelists are described in the Qualifications section and their collective judgment should provide the keen insight needed to put the analysis in its proper perspective.

IV. Justification

RDF believes that the proposed project will enhance the value of AID programs and will do so in a cost-effective manner.

Meeting AID and LDC Needs

In discussions between RDF and AID staff, the need for continuity in the fields where AID has supported R&D was repeatedly emphasized. Concern was expressed that advances such as the progress towards a malaria vaccine could be lost unless a mechanism is established for the "privatization" of vaccine production and marketing. The only alternative is to continue heavy donor agency support for the introduction of new vaccines and this would be a very costly process with no exit strategy to extricate agencies from continuing obligations. Given the finite resources of agencies such as AID, only a few beneficial products can be subsidized before that capacity is exhausted. Clearly, if a mechanism can be developed to facilitate the transfer of know-how from the laboratory into the private sector, a greater degree of continuity can be achieved. RDF is convinced that such transfers of life science technology can be greatly enhanced despite the few successful examples existing today. RDF believes that the failure of the technology transfer process is not due to any intrinsic commercial unattractiveness but is a result of the high initial costs of evaluating technologies, finding private sector players and accessing sources of financing. Supporting such costs often falls outside of the mandates of donor agencies and financial institutions. Indeed, RDF was created expressly for the purpose of filling this void in the commercialization process. Although elements of AID's life science programs have been previously examined, only RDF offers a comprehensive analysis and the unique ability to act on its recommendations.

The proposed project will also present a strategic analysis encompassing the full scope of life science research sponsored by the full network of development agencies including AID. The study will be valuable for a wide audience including AID/W and AID mission staff members, other donor agency personnel, R&D institution management and program planners and to private enterprises contemplating life science-related investments.

By enhancing continuity and coherence, the proposed project will improve the level of recognition that AID is accorded for its endeavors in the life science field. RDF's initial exploration of AID-funded activities has already identified significant advances in agriculture and medicine that can be attributed to AID support. In addition, RDF's priorities for life science technology/development (see Appendix II) were found to be remarkably consistent with those of AID's staff which also leads RDF to believe that an impressive list of AID-sponsored achievements can be recognized through this project.

The project can also yield significant benefits for the LDCs that AID serves. Since much of AID-supported life science R&D is conducted within developing countries, the project will enhance public awareness of LDC R&D capabilities. This will do much to overcome the erroneous impression held by U.S. businessmen and investors that LDCs totally lack the infrastructure to conduct life science R&D. The roundtable and strategic plan should also heighten awareness of the managerial resources available in LDCs.

If the project eventually succeeds in catalyzing the commercialization of life science technologies, then there would be enormous benefits in terms of improved technical infrastructure, better health care, improved environments, energy independence and more productive agriculture. The application of life science technologies is expected to greatly improve the profitability of cash crops, an area of comparative advantage in many LDCs.

Cost Effectiveness of the Project

A number of factors contribute to the project being an effective use of AID resources. The fact that the project will be cost-shared 50:50 with other RDF funders, primarily the Rockefeller Brothers Fund, is the foremost. Cost sharing will permit nearly three person-years of expert professional attention to be devoted to furthering the implementation of technologies that S&T believes are valuable to LDCs. RDF's professional staff has already expended considerable effort examining the prospects for commercial ventures in LDCs using life science technologies. This previous experience means that insights have already been gained that will enhance the effectiveness of the project and will reduce the effort needed to come up the learning curve on LDC life science applications.

AID's support for the project will have a catalytic effect in promoting the application of life science technologies. By providing the means to carry out this first crucial step, AID will set the stage for the subsequent steps of venture formulation, financing and implementation. Once specific countries and technologies have been targeted, RDF/IBG will look towards the regional and country AID missions to support remaining development needs and to PRE (Bureau for Private Enterprise) to support prospectus preparation and to contribute to the investment fund. [IBG is preparing a separate proposal to PRE for assistance with the costs for developing prospectuses for immediate commercial opportunities already identified by RDF/IBG. These opportunities are based upon business propositions presented to IBG by companies for consideration. While some subject areas overlap with areas currently under investigation by AID, prospectus development is done at an advanced stage of venture creation and lies beyond the scope of

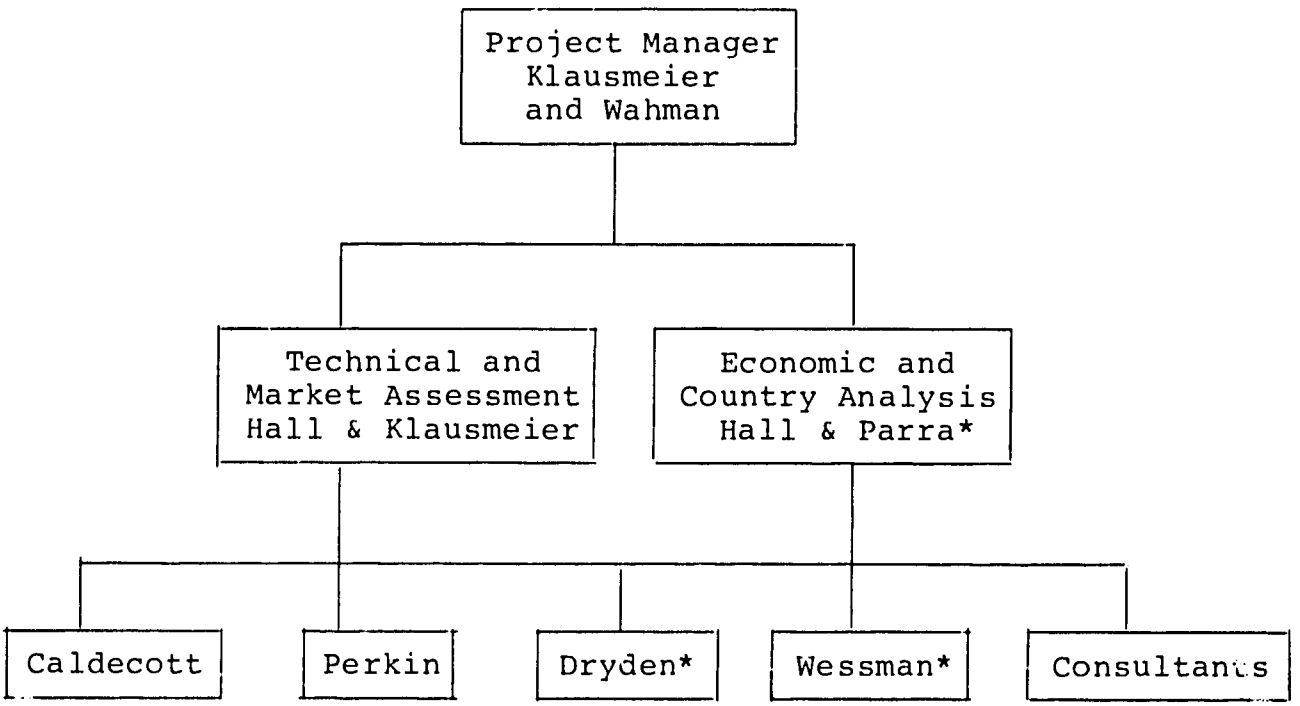
the analyses intended in the present proposal.] Thus, there is a well-defined exit strategy to govern the extent of AID obligations.

Many other private and public sector contributors will share in the costs and investments needed to implement LDC life science ventures. This will not only leverage AID financial support but will also make available the experience held by these contributors. For example, Monsanto has been active in the creation of the RDF/IBG initiative and has made a substantial contribution to RDF. Monsanto has also volunteered the services of staff members in conducting the search for prospective ventures and has offered to provide in-house technical training to LDC personnel. RDF staff members are also working closely with the Industry Department of the World Bank to establish an agronomic testing program to examine the effectiveness of several organic fertilizer products in Burundi and other African countries. The experience gained through this study could provide insights of value to AID's agriculture program. Thus, AID participation in the RDF/IBG initiative is as part of a vital community of public and private sector contributors where the potential for cross-fertilization is high.

V. Qualifications

Personnel

An outstanding roster of experts in life science applications has been assembled by RDF to conduct the proposed project. The relationships and roles of project staff are summarized in the following organizational chart:



*Retained through a subcontract to the International Biotechnology Group of which Parra, Dryden and Wessman are officers.

The following listing reviews each contributor's background and responsibilities (resumes are provided in Appendix III.).

William H. Klausmeier, Ph.D. - Dr. Klausmeier has degrees in biochemistry, organic and medicinal chemistry. His experience includes pharmaceutical process development research for Diamond Shamrock Corp.; industrial systems analysis and research management for Argonne National Laboratory; and has most recently served as President of Sylvatex, a consulting firm specializing in the technical assessment and economic analysis of developing country projects. Since joining RDF he has assumed lead responsibility for RDF's Project Development Fund, and will serve as the Project Manager of the proposed project. In addition to his managerial responsibilities, Dr. Klausmeier will share the responsibility for conducting technical and market assessments.

Robert J. Parra - Mr. Parra has degrees in engineering sciences and international economics. He has a distinguished record in international banking as a Vice President with Citicorp and served as the Lead Project Officer for the Office of Investment of the Bureau for Private Enterprise at AID. Most recently, he became a founding partner in the Washington Capital Markets Group, a Washington-based financial services firm specializing in developing country venture financing. Mr. Parra will share responsibility with Mr. Hall for economic and country analysis.

Tom Wahman - Mr. Wahman is currently the managing consultant of RDF. Over the past five years he has been responsible for creating several new organizations to advance development in LDCs and before that he served as the National Program Director at the Rockefeller Brothers Fund where he coordinated all RBF philanthropy at the national level.

Peter C. Hall - Mr. Hall has a degree in biology and has done graduate course work in ecology and chemistry. Before joining RDF, he worked as an industry consultant at SRI International where he concentrated on the technical assessment and market analysis of biotechnology industry products. He now serves as RDF's chief operating officer. In the proposed project he would share responsibility for both technical and market assessment and economic and country analysis components of the project.

The four following individuals will contribute their expertise to the technical and economic evaluations and will participate in field visits as needed. These individuals will also participate in the initial and secondary screening exercises and will review all products of the project.

Richard S. Caldecott, Ph.D. - Dr. Caldecott was the former Dean of Biological Sciences at the University of Minnesota and was Chairman of the feasibility study from which the RDF/IBG initiative originated. Dr. Caldecott continues to serve RDF as senior science advisor.

Gordon Perkin, M.D. - Dr. Perkin is currently Executive Director of the Program for Appropriate Technology and Health (PATH). PATH, along with several associated organizations, has been responsible for establishing several companies in Southeast Asia for the transfer of health technology. He has advised the RDF/IBG initiative concerning health-related biotechnologies and will continue to do so on the proposed project.

R. N. Dryden, Jr. - Mr. Dryden formerly served as the President of the biotechnology firm, Agrigenetics, which was recently bought out by Lubrizol. He now serves as Chairman of the newly formed IBG and will also advise the project concerning life science applications in agriculture.

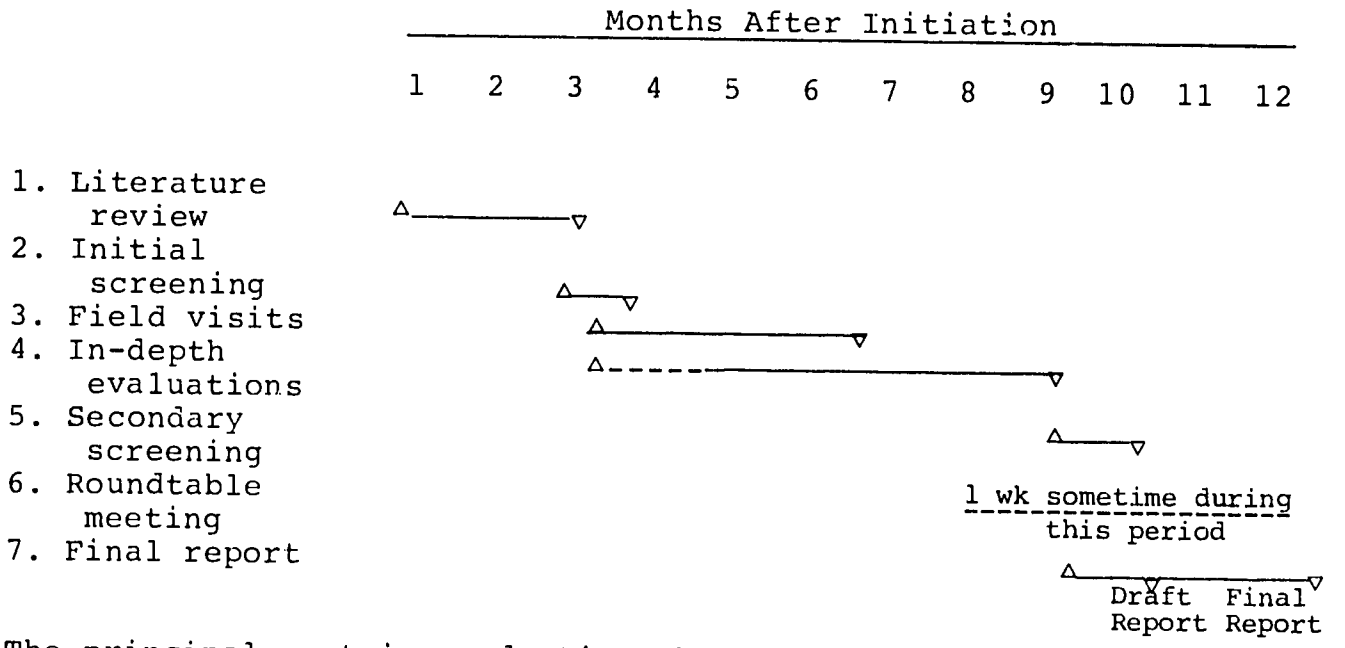
Gunnar Wessman - Mr. Wessman recently retired as the Chairman of the European pharmaceutical company, Pharmacia. He now serves as a senior advisor to RDF and IBG and represents RDF/IBG interests in Europe and Japan and will advise the project in the field of life science applications in pharmaceuticals and chemicals.

In addition to the above individuals, the need for consulting services are also anticipated to ensure the most expert analysis in the broad spectrum of disciplines covered by life science applications. Likely consultants include Dr. Donald Colbert, formerly Manager of Business Development at Repligen; Dr. Oskar Zaborsky, former Director of the Renewable Materials Engineering program at NSF; Dr. John Barton, a professor of international law at Stanford University; Mr. Steve Witt, a biotechnology consultant, Dr. Brian Hunter, an expert in aquaculture and nutrition; and Mr. Kenneth Stern, a chemicals market and technology analyst for Chem Systems, Inc.

VI. Milestone Schedule and Budget

The period of performance for the project is one year and tasks will be performed according to the following milestone schedule.

Project Milestone Schedule



The principal cost in conducting the project will be the manpower requirements. These are broken down by task in the following table:

Project Manpower Requirements
(Person-Months)

Task	Klausmeier	Hall	Parra	Wahman Caldecott Perkin Dryden Wessman	Consultants
1. Literature review	1	1			
2. Initial screening	½	½	½	1	
3. Field visits	2	2	2	3	1
4. In-depth evaluations	2	2	1	3	2
5. Secondary screening	½	½	½	1	
6. Roundtable meeting	1	1		1	
7. Final report	2	2		1	1
Totals	9	9	4	10	4

Project Budget

			$
Salaries			
Klausmeier - 9 mos @ $5,000/month	45,000		
Hall - 9 mos @ $5,000/month	45,000		
Secretarial (½ Staff time @ $2,200/mo)	19,800		
Total			109,800
Benefits - 8% of salaries			7,900
RDF Staff Advisors and Consultants			
Wahman - 3 mos @ 22 da/mo @ $260/da	17,160		
Caldecott - 3 mos @ 22 da/mo @ $260/da	17,160		
Perkin - 1 mo @ 22 da/mo @ $260/da	5,720		
Consultants - 4 mos @ 22 da/mo @ $260/da	22,880		
Advisors retained through a subcontract to International Biotechnology Group			
Parra - 4 mos @ 22 da/mo @ $260/da	22,880		
Dryden - 2 mos @ 22 da/mo @ $260/da	11,440		
Wessman - 1 mo @ 22 da/mo @ $260/da	5,720		
Total			102,960
Travel			
SE Asia, Project Evaluation Mission I India/Sri Lanka/Thailand			
Air fare $2,938* X 3 travelers	8,814		
Per diem			
Bombay, India $110/da X 7 X 3	2,310		
Colombo, Sri Lanka $84/da X 5 X 3	1,260		
Bangkok, Thailand $93/da X 10 X 3	2,790		
Miscellaneous In-country travel, communications, clerical assistance 10% of per diem)	636		
Subtotal		15,810	
SE Asia, Project Evaluation Mission II Philippines/Indonesia/Singapore			
Air fare $1,980* X 3 travelers	5,940		

Per diem		
Manila, Philippines $80/da X 10 X 3	2,400	
Jakarta, Indonesia $108/da X 7 X 3	2,268	
Singapore $111/da X 4 X 3	1,332	
Miscellaneous	600	
Subtotal		12,540
SE Asia, Country Evaluation Mission		
Philippines/Indonesia/Thailand/Sri Lanka		
Air fare $1,838* X 3 travelers	5,514	
Per diem		
Manila, Philippines $80/da X 7 X 3	1,680	
Jakarta, Indonesia $108/da X 7 X 3	2,268	
Bangkok, Thailand $93/da X 7 X 3	1,953	
Colombo, Sri Lanka $84/da X 7 X 3	1,764	
Miscellaneous	767	
Subtotal		13,946
Africa, Project Evaluation Mission		
(Assume Kenya, Zimbabwe, Nigeria for		
purpose of estimating costs)		
Air fare $3,256* X 2 travelers	6,512	
Per diem		
Nairobi, Kenya $92/da X 7 X 2	1,288	
Harare, Zimbabwe $66/da X 7 X 2	924	
Lagos, Nigeria $98/da X 7 X 2	1,372	
Miscellaneous	358	
Subtotal		10,454

Latin America/Caribbean - Project Evaluation Mission (Assume Jamaica, Colombia, Honduras, Mexico for purpose of estimating costs)		
Air fare $1,990* X 2 travelers	3,980	
Per diem		
Kingston, Jamaica $125/da X 5 X 2	1,250	
Cali, Colombia $79/da X 5 X 2	790	
Tegucigalpa, Honduras $101 X 5 X 2	1,010	
Mexico City, Mexico $65/da X 5 X 2	650	
Miscellaneous	379	
Subtotal		8,059

(*Air fares represent the lowest available rates for excursions of 14 days or more.)

Project Screening Meetings I and II (Assume Washington, D.C. venue, travelers from New York, Colorado, Minnesota, California and Sweden, 3-day meeting, 1-day travel.)		
Air fare		
$2,630 (for 5 travelers) X 2 trips	5,260	
Per diem		
$112/da X 5 travelers X 4 days X 2 trips	4,480	
Subtotal		9,740
Total for all travel		70,549

Roundtable meeting expenses		
(Colombo, Sri Lanka, 100 participants		
50% of expenses charged to this project)		
Conference Center		
$3,000/day X 3 days	9,000	
Meals		
$10/meal X 3 meals/day X 3 days	9,000	
Honoraria		
$500/speaker X 20 speakers	10,000	
Travel		
10 U.S. travelers X $2,200 ea	22,000	
20 LDC travelers X $2,000 ea	40,000	
Meeting announcements, communications, Conference agendas, organizational expenses	10,000	
Total for Conference	100,000	
Total charged to this project (50%)		50,000
Publication costs		
(Spiral bound, Xerox copies)		
Roundtable proceedings		
100 copies X $25/copy	2,500	
Final Report		
100 Copies X $25/copy	2,500	
Total		5,000
Legal expenses		
(confidentiality agreements, analysis of statutes, patent searches)		5,000
Overhead - 21% of RDF Salaries		23,058
Total Budget for Project		$374,267
Total Request from Science and Technology Bureau		$187,133

Appendix I

International Biotechnology Program

Establishing Life Science Enterprises In Developing Countries

A program to foster business development, involving the commercial application of biotechnology in the areas of agriculture, bioenergy, environmental restoration and animal and human health, is now being established for developing countries. Two separate but cooperating organizations are implementing the program--the Resources Development Foundation (non-profit) and the International Biotechnology Group (for-profit). Start-up operations in 1987 are being initiated through the establishment of the Southwest Asia Fund. This is an equity pool allowing co-investment with Asian partners in joint ventures matching commercial technology proprietors in developed countries with indigenous operating companies in Southeast Asia.

The Resources Development Foundation (RDF), a non-profit, tax-exempt organization incorporated in Washington, D.C., will initiate this program by leveraging public- and private-sector resources (scientific and technical, managerial, financial) in support of development activities on a worldwide basis. RDF will capitalize on the potential of biotechnology to help meet the developing world's rising demand for food and fuel, to improve human health, and to help in reducing environmental degradation. The focus is an appropriate technologies such as microbial fermentation, mammalian cell culture, aquaculture and other areas that can be commercialized on a relatively near-term basis. RDF will fulfill its development role by:

- funding technology adaptation and enterprise formation activities by for-profit companies operating in the economic/business development arena,
- and funding important pre-venture or project incubation activities in the social/resource development arena that are necessary for the successful commercialization of these projects, through non-profit channels.

Economic/Business Development Activities

RDF will establish performance contracts with for-profit, highly focused business development companies such as the International Biotechnology Group (IBG). These firms will implement the activities of RDF by undertaking projects leading to technology adaptation and commercial enterprise formation.

IBG was incorporated in Washington, D.C., as a technology transfer and business development company to identify appropriate biotechnologies that can be adapted by companies to meet local needs and take advantage of market opportunities in developing countries. To help in meeting the critical need for equity financing in developing countries, IBG is establishing and will manage the Southeast Asia Fund, an investment pool of equity and long-term capital that will be used in financing ventures in Southeast Asia that are primarily export oriented.

In addition to matching technology proprietors with existing operating companies through its Southeast Asia Fund investment program, IBG will operate a technology assessment, brokering and consulting service in international biotechnology on a fee-for-service basis. IBG will also assess the feasibility of establishing additional regional investment pools (e.g., in the Caribbean).

Initially operating under contract to RDF, IBG is seeking technology licensing and funding arrangements with transnational corporations, dedicated biotechnology companies, investment firms and individuals and international development agencies.

Social/Resource Development Activities

RDF will sponsor non-profit, tax-exempt activities that directly facilitate the identification, transfer and adaptation of appropriate technology and the establishment of commercial enterprises. These project incubation activities will help to qualify projects for eventual commercialization by IBG and lower the investment risk to potential venture partners. More specifically, RDF will underwrite feasibility studies, business plans, training programs, international travel and other activities that maximize the chances for commercial success and optimize return for investors. Training programs will involve developing country venture partners and include:

- financial and business managers from local investment firms and
- scientists and technicians from local universities and private research laboratories.

RDF will maintain a Project Development Fund for the evaluation of the commercial potential of existing biotechnology-related projects funded by international development agencies and to provide funding for model biotechnology projects that show particular promise of leading to successful commercial ventures in developing countries on a near-term basis.

In addition to its primary activities as outlined above, RDF will help to sponsor other activities that foster the identification of business opportunities and the establishment of successful enterprises in developing countries. In late 1987, RDF is sponsoring the International Biotechnology Roundtable in cooperation with the Bureau of Science and Technology in International Development (BOSTID) of the National Academy of Science. The topic of the Roundtable is: "Establishing Biotechnology Enterprises in Southeast Asia."

In order to finance RDF's activities, contracts and grants are being provided or sought from private foundations and individuals, transnational corporations based in developed countries, and international development agencies.

Leadership Team

An outstanding core group of professionals has been assembled to enable RDF and IBG to implement their objectives.

Dr. Richard S. Caldecott - former Dean of Biological Sciences at the University of Minnesota and chairman of the RDF steering committee during its conceptual phase will continue as Senior Science Advisor.

R. N. (Sam) Dryden, Jr. - former President of Agrigenetics, and now Chairman of IBG.

Peter Hall - formerly an international biotechnology consultant with SRI International and RDF's Chief Operating officer, based in California.

Dr. William H. (Will) Klausmeier - specialist in the assessment of bioconversion and other biotechnology processes and RDF's Washington, D.C. representative.

Robert J. Parra - senior partner in Washington Capital Markets Group and former lead project officer of AID's Bureau for Private Enterprise, and now IBG's Treasurer and Chief Financial Officer.

Thomas W. Wahman - former Director of the national program of the Rockefeller Brothers Fund, for which he is currently an international program consultant, and now acting as interim managing consultant of RDF.

Gunnar Wessman - recently retired Chairman of Pharmacia and now senior advisor to RDF and IBG, representing their interests in Europe and Japan.

Next Steps

During 1987 this team will be responsible for implementing RDF and IBG activities. The primary tasks include the following:

- Preparing the prospectus for IBG's Southeast Asia Fund, securing lead public and private investors, and establishing the initial enterprises.
- Presenting RDF proposals to secure contributions from international development agencies, transnational corporations, foundations and individuals in the United States, Europe and Japan.
- Identifying lead personnel and an office location in Southeast Asia.
- Hiring Chief Executive Officers for RDF and IBG.
- Developing business and operating plans for RDF and IBG.
- Broadening Board of Directors for RDF and IBG.
- Conducting International Biotechnology Roundtable.

Appendix II

Overview of Life Science Applications in Developing Countries

The Technologies

For the purposes of this discussion, biotechnology is defined as the application of life science-based techniques and procedures to produce products and processes of commercial value. The biotechnologies of primary interest are those that are immediately applicable or relatively near-term and can be readily adapted for use in developing country commercial ventures. Appropriate biotechnologies with significant potential to provide immediate or near-term commercial benefits in developing countries include plant cell culture, immobilized enzymes, microbial fermentation, mammalian cell culture, hybridoma technology, and elements of recombinant DNA technology. Other life science-based technologies such as conventional plant breeding, mammalian germ plasm manipulation (e.g., artificial insemination, superovulation, embryo transfer, twinning), algae culture and aquaculture are also under consideration. Table 1 shows initial estimates of the development timetable for such technologies in developing countries.

Biotechnology as defined holds much promise for helping to meet the continuing need in the world for food, fuel, and value-added commodities, as well as providing new approaches for environmental restoration and the improvement of human and animal health. These technologies should afford the following benefits to consumers:

- Availability of products that are new in the marketplace,
- Expansion of value and availability of existing products that are currently in short supply,
- Reduced cost of products, resulting from more economical methods of production,
- Safer and better quality products,
- The use of raw materials that are more readily available and less expensive than those currently used, and
- Bringing to the marketplace new products that were not previously available.

Table 1

Estimated Timetable for Biotechnology
Commercial Development in Developing Countries

Technology	Near-Term (0-5 Years)	Medium-Term (5-10 Years)	Long-Term (>10 Years
Aquaculture	X		
Immobilized Enzymes (Biocatalysis)		X	
Biomass Conversion	X		
Hybridoma Technology	X		
Macroalgae Culture	X		
Mammalian Cell Culture	X		
Mammalian Germ Plasm Manipulations	X		
Microalgae Culture		X	
Microbial Fermentation	X		
Plant Cell Culture	X		
Recombinant DNA (regulatory proteins, enzymes, vaccines, probes)	X		
Recombinant DNA (microbial systems)		X	
Recombinant DNA (plants)			X

Successful commercial use of technology in developing countries will help to improve the standard of living of the inhabitants and also will help to reduce the widening economic disparity between them and the inhabitants of developed countries. At this time, of particular importance in overcoming this disparity is the application of those life science technologies that can help to augment food production in areas where a comparative advantage exists (Table 2).

The following sections describe more specific immediate and near-term applications of life science technology in developing countries.

Agriculture

Self-sufficiency in food production is essential for long-term economic growth. A recent World Bank study of an irrigation scheme in Malaysia found that each dollar of extra rice production generated $0.75 of extra demand elsewhere in the economy. Improvements in agricultural crops and technology can not only reduce foreign exchange lost for food imports, but also can generate additional foreign exchange by increasing cash crop exports.

There is a continuing need in developing countries for agricultural crop varieties affording increased yields, improved food quality and reduced production costs. Improvements in agricultural productivity in developing countries through the introduction of proven technologies have already been demonstrated. The agricultural productivity of peasant farmers in some Asian countries has increased dramatically in recent years due to the availability of improved crop varieties. The introduction of drought-resistant crops, as well as new water management and low-cost farming techniques also can help immensely.

New innovations in plant cell and tissue culture can help to realize these goals because they facilitate the genetic modification of commercially valuable crops by providing a means of rapidly propagating improved or disease-free planting stock. Crop yields can be increased by using this technology to develop plants with resistance to pests and environmental stress or by increasing plant productivity. Food quality can be improved by enhancing the nutritional value of cultivated crops. Food costs can be lowered by developing crops with reduced dependence on intensive agricultural inputs and by developing varieties with improved harvesting and processing characteristics.

Table 2

Immediate and Near-Term Applications of Biotechnology in Important Commercial Sectors in Developing Countries

	Commercial Sector			
Technology	Agriculture for Food	Human Health	Animal Health & Nutrition	Energy
Aquaculture	X			
Immobilized Enzymes (Biocatalysis)	X			X
Biomass Conversion	X			X
Hybridoma Technology		X	X	
Macroalgae Culture	X		X	
Mammalian Cell Culture		X	X	
Mammalian Germ Plasm Manipulations			X	
Microalgae Culture	X		X	X
Microbial Fermentation	X	X	X	
Plant Cell Culture	X	X	X	
Recombinant DNA (regulatory proteins, enzymes, vaccines, probes)		X	X	

Table 2 (continued)

	Commercial Sector	
	Biomass Production	Value-Added Commodities
Technology		
Aquaculture	X	
Immobilized Enzymes (Biocatalysis)		X
Biomass Conversion	X	
Hybridoma Technology	X	X
Macroalgae Culture	X	X
Mammalian Cell Culture		
Mammalian Germ Plasm Manipulations		
Microalgae Culture	X	X
Microbial Fermentation	X	X
Plant Cell Culture	X	X
Recombinant DNA (regulatory proteins, enzymes, vaccines, probes)		

In addition to the genetic improvement of existing agricultural crops, plant cell and tissue culture holds promise for the development of new crop varieties with desirable characteristics. The techniques will be particularly helpful in the improvement of cereals, roots and tubers, vegetables, fruits, oilseeds and forage crops as well as in preserving valuable germ plasm necessary for continued improvement of existing varieties.

Among the specific plant cell and tissue culture techniques now under development for crop improvement are:

- o Clonal propagation of disease-free planting stock,
- o In vitro mutagenesis based on somaclonal variation and selection to expand the variability of important crop species,
- o Protoplast culture and fusion to develop novel combinations of genetic material, and
- o Haploid culture to assist in the development of new hybrid varieties.

The use of plant cell and tissue culture to develop genetically improved crop varieties is in many ways an extension of earlier successes in plant improvement obtained during the Green Revolution in many developing countries. The Consultative Group on International Agricultural Research (CGIAR) and the associated network of research centers (IRRI, CIAT, IITA, ICRISAT and 9 other centers) was primarily responsible for the Green Revolution and, with U.S.AID support, has continued to take the lead in introducing life science applications in agriculture to LDCs. AID has funded the establishment of germplasm banks to maintain and propagate genetic diversity and in vitro clonal propagation technology has now been used for propagating disease-free planting stock of several dozen different LDC agricultural crops. The IARCS (International Agricultural Research Centers) are also employing this technology to rapidly develop improved hybrids of these plants.

IRRI is using tissue culture techniques to develop salt and aluminum-resistant cultivars of rice, wheat, oat, millet, tomato and carrots. AID-supported research has shown that in rice, the salt tolerance trait is inheritable and remains stable in regenerated progeny. Several cytologically stable derivatives of groundnut lines with desirable agronomic traits (growth, habit, yield, earliness) and with disease tolerance have been developed recently at ICRISAT by incorporating wild species genes into locally adapted groundnuts. Two disease-resistant lines have been in field tests for several years and one high yielding line has now advanced to regional field trials in India. CIAT-supported research has developed black seeded bean varieties that

are higher yielding and resistant to golden mosaic virus. Virus resistance also has been successfully bred into several high yielding rice varieties. CIAT has also developed techniques for improving the yields of crops such as cassava through the application of mycorrhizal fungi and AID-sponsored research in Honduras has examined the potentials of Bacillus thuringensis and other microbial insecticides. A number of these advances have reached a point where they can serve as bases for commercial ventures in LDCs. AID-sponsored programs have also supported the training of LDC personnel essential for effective technology transfer.

Plant cell and tissue culture techniques are already in use by a number of companies to develop new plant varieties in developing countries. For instance, Plantek International, a joint venture between NPI (Salt Lake City, UT), Tata (India), Sumitomo Corporation, Kyowa Hakko (both of Japan), and Intraco Ltd. (Singapore) is developing improved varieties of a number of crop species in Indonesia, Malaysia, Thailand and other Southeast Asian countries. Transnational seed companies such as Pioneer Hi-bred International, Inc. and Cargills and local seed companies in India, the Philippines and other developing countries are using conventional plant breeding techniques to develop improved hybrids. Crop Genetics International now markets disease-free sugarcane planting stock in developing countries. Such companies are increasingly using plant cell and tissue culture and sophisticated techniques such as isoenzyme analysis and gene mapping in their work.

Alternative Food Technologies

Other biotechnologies with near-term potential for increasing both the quantity and quality of food resources in developing countries include:

- aquaculture,
- algae culture,
- biomass conversion, and
- microbial fermentation.

Aquaculture of vertebrates (fin fish) and invertebrates (e.g., shrimp, oysters) from both freshwater and marine sources is an economically viable source of food protein in many developing countries. In many of these countries, fin fish and shell fish species are a major source of food for domestic consumption as well as a commodity for export. Aquaculture also addresses the problem of overexploited coastal resources.

Pilot cage culture projects for groupers and snappers are underway in Malaysia. Oyster and shrimp culture is growing rapidly in the Philippines and Thailand. About 90% of the green mussels consumed in the Philippines are cultured. Worldwide, about 5% of all seafoods consumed are now cultured and the demand for cultured products is expected to exceed 20% over the next 20 years.

Extensive research efforts are currently underway around the world on a wide range of vertebrate and invertebrate species. There is a significant demand for technology to optimize culture conditions and ensure maximum productivity, including control of spawning, larval settlement and metamorphosis, growth enhancement, and improved hatchery and feeding techniques. Understanding the hormonal mechanisms of spawning is proving valuable in improving the reliability of larvae production and in avoiding destructive techniques such as eyestalk ablation to induce spawning. Feed costs can constitute up to 60% of shrimp production costs and the development of low cost feeds via algae culture or other microbial transformation of organic wastewaters is a fruitful area for development. U.S.AID has actively supported aquaculture development through its missions in the Philippines, Thailand, Honduras, Jamaica and Ecuador. Collaboration with organizations such as SEAFDEC (Southeast Asian Fisheries Development Center) has done much to disseminate aquaculture know-how and numerous small farmer cooperatives have been created to spearhead expansion in production.

Microalgae culture holds potential as a source of organic fertilizer feeds and specialty chemicals and is capable of extremely high acreage productivities in developing countries. Algae culture is especially appropriate for developing countries because a tropical climate is needed for year-round operation. In addition to aquatic algae culture, some blue-green algae are free living, autotrophic organisms capable of growing and multiplying on the surface of soils. They are capable of fixing atmospheric nitrogen and liberate a portion of the fixed nitrogen into the soil as ammonia and organic nitrogen compounds. Algae culture can also become an important source of protein, fatty acids, pigments and other specialty biochemicals. Although current culture techniques are too costly for commodity applications, simplified systems using organic waste nutrients and operating year round might eventually reduce production costs to below 40¢/lb.

Cyanotech (Woodinville, WA) has developed technology for growing heterocystous blue-green algae on a large scale in culture ponds and for producing an inexpensive dried preparation that can be stored for prolonged periods without loss of viability. The Oceanic Institute in Hawaii has conducted

extensive investigations into the low-cost culture of protein-rich Spirulina (70% protein) in shallow raceways using manure elutrate and distillery slops as nutrient sources. The Tennessee Valley Authority has also been active in exploiting slops as a source of nutrients for algae and aquaculture. The Program in Science and Technology Cooperation recently funded a joint Israel/Thailand project culturing Spirulina on starch plant effluent and is investigating techniques to enhance the production of high value constituents such as gamma-linolenic acid.

Microbial fermentation, in combination with sophisticated screening and selection can be used to produce improved microbial inoculants. Micro-organisms such as Anabaena (in symbiosis with Azolla) and Rhizobium have been applied to fix nitrogen in agriculture for some time.

These microbial products can be added directly to the soil to enhance the uptake of nitrogen, phosphorus and other nutrients by plants or that can be used in the production of organic fertilizers for later addition to the soil. Expertise is now being developed in microbial ecology and molecular biology that potentially could be transferred to developing countries where the need for effective, low-cost fertilizers is significant. One U.S. firm has been developing a process in India for converting slops and sugar mill filter mud waste into an organic fertilizer enriched in N, P, K nutrients (8-8-8).

Microbial fermentation technology is also being applied to the development of microbial pesticides. Significant progress has already been made in developed countries that potentially could be transferred to developing countries to lessen their dependence on chemical pesticide use. The microbial pesticide, Bacillus thuringensis (B.t.), already is used to combat gypsy moth and the development of B.t. strains to combat other pests has already extended investigations into Honduras and the Philippines, and the World Health Organization is developing B.t. strains to combat mealy bug in Africa. In addition to being costly import items, chemical pesticides are creating significant environmental pollution and human health care problems in these countries. Although B.t. is also expensive, innovations in the production and delivery of microbial pesticides should realize dramatic reductions in their cost.

Microbial fermentation can also be used to produce antibiotics for use in livestock as therapeutic agents, as prophylactics to prevent disease, and as growth promoters. The extent of the potential for antibiotic production in developing countries for use in livestock will depend on the degree to which they adopt intensive farming methods.

Biomass conversion of agricultural and food processing wastes is proving to be a successful technology in the large-scale production of organic fertilizers (compost) in developing countries. Cereal straw production in Asia has been estimated at 800 million metric tons annually. Residues from cassava, banana, citrus and coffee in these regions account for an estimated 124 million tons, with sugarcane residues accounting for 83 million tons. The potential for the production of low-cost fertilizers from sugarcane waste is tremendous and there is a need for such organic fertilizers because of the ongoing deterioration of soils in many developing countries. This need is also driven by the high cost of inorganic fertilizers which must be imported. The U.S. firm, Fabcon Incorporated, now markets a composting starter and equipment for producing organic fertilizer from sugar mill and agricultural wastes. Although composts have limited markets because of high distribution costs, Fabcon has developed a phosphate fertilizer based on composting with phosphate rock which has proven to be an effective substitute for chemical phosphate fertilizers in the Philippines, Pakistan, Barbados and Kenya. Also, common and exotic mushrooms are currently grown throughout Asia on various composted substrates.

Human Health

Biotechnology holds tremendous potential for the development of therapeutic agents, vaccines and diagnostic products. Microbial fermentation, mammalian cell culture, plant cell culture, and recombinant DNA methods can be used to produce a number of important biologically derived therapeutic products. Of these technologies, microbial fermentation will result in the most immediate commercial opportunities in developing countries. The current world market for antibiotics (derived ultimately from fermentation) is in the neighborhood of $6.5 billion at the dose form level. Because of their medical value and importance for the economic and social well-being of all countries, self-sufficiency in basic antibiotic production is a development goal in some of the more advanced developing countries. Production technology is already available from a number of sources for the older natural and semisynthetic penicillins, aminoglycosides, erythromycin, rifampicin and the tetracyclines. India, Indonesia and Thailand are already making headway in this area. Research is also underway in Indonesia involving the microbial conversion of steroid precursors.

Recombinant DNA technology will be used by pharmaceutical companies based in developed countries to produce such necessary products as human growth hormone and insulin for developing country markets on a limited scale. However, with the exception of vaccines and nucleotide probes, there is little chance that this technology will play a role in indigenous production in these countries for some time.

Mammalian cell culture and most recently, recombinant DNA technology are important in the production of vaccines. Bacterial, viral and parasitic pathogens result in much human suffering throughout developing countries. A significant number of these pathogens can effectively be combatted through the use of vaccines currently available or under development.

Recombinant DNA technology is being used to develop cloned antigenic determinants that can be produced by bacterial fermentation and hold promise for the development of safe, effective and inexpensive vaccines for numerous disorders prevalent in developing countries. Monoclonal antibodies may prove useful in developing passive vaccines against malaria and other disorders. Among the high priority disorders for which there is a good probability that biotechnology will result in relatively near-term advances in vaccine development are bacterial respiratory diseases, bacterial enteric diseases, dengue hemorrhagic fever, Japanese encephalitis, rabies, malaria, hepatitis B, chlamydial infections, and leishmaniasis. Other important diseases that are the targets of immunization programs are poliomyelitis and childhood gastroenteritis (rotavirus).

In June 1986, hepatitis B vaccine from recombinant yeast developed by Smith Kline Beckman was first introduced in Singapore and Malaysia as ENGERIX-B. This was the first market introduction of a recombinant human vaccine. The product answers a real need for safe and effective vaccines to protect against a major health problem. The hepatitis B virus is carried by 10-20% of the Asian and African population and as many as 200 million individuals around the world have the disease. With support from U.S.AID, Merck had assisted the Serum Institute of India in the development of a production capability for measles, rabies and Hepatitis B vaccines and Indonesia is currently contemplating a venture for the production of hepatitis B vaccine. Although Genetech had been aggressively developing a vaccine for malaria, it had terminated its research in this area because of the many complexities associated with the multiple variants of malaria that exist. Fortunately, U.S.AID has assumed a leadership role in continuing the effort to develop the diagnostic aids and tailored vaccines needed to effectively combat malaria on a region-by-region basis.

Plant cell and tissue culture can potentially be used to develop genetically improved plant varieties that are the source of important medicinal chemicals. Developing countries cultivate numerous medicinal plants to produce raw materials important to local as well as transnational pharmaceutical companies. In addition to the large number of plant extracts important in local, indigenous medicine, plant-derived compounds important in world pharmaceutical markets include atropine, catharanthus alkaloids, cinchona bark alkaloids, digitalis and other cardiac

glycosides, opium alkaloids, pilocarpine, and the rauwolfia alkaloids. Potential improvements could be made in plant growth characteristics and medicinal product yield and quality.

Diagnostic products represent the medical industry segment that will be most radically transformed by biotechnology. Immunodiagnostic products based on monoclonal antibodies produced via hybridoma technology are playing a major role in the detection and monitoring of disease states and drug levels. In 1985, the world market for these products was already an estimated $250 million and is growing at over 20% annually.

The ready availability of inexpensive monoclonal antibody-based diagnostic tests in developing countries will help in determining ovulation and pregnancy, detecting parasitic and other infectious diseases, determining the state of the immune system, detecting cancers, and monitoring metabolic disorders. For a country with the medical infrastructure, such tests could be indispensable in the improvement and expansion of health care. Diagnostic aids can also be important in countries with a shortage of physicians since they could facilitate the use of para-professionals in disease diagnosis and treatment.

Animal Health and Nutrition

Disease and malnutrition take a heavy toll on livestock in developing countries. Biotechnology is now beginning to afford a number of products to combat disease and to improve the performance of economically important species.

Mammalian cell culture can potentially be used to produce growth hormone and is now used in vaccine production. Hybridoma technology is now being used both to produce monoclonal antibodies for a passive vaccine against scours (neonatal diarrhea) in cattle as well as diagnostic tests. Recombinant DNA technology is now being used by a number of developed countries to produce vaccines against scours and a pseudorabies vaccine for swine. Among the other high priority animal diseases for which biotechnology could result in relatively near-term vaccine developments are bacterial and viral respiratory diseases, African swine fever, and hemotropic diseases (e.g., babesiosis and anaplasmosis). Other disorders for which vaccination is important include foot and mouth disease, anthrax, brucella and Newcastle disease. Achieving important nutritional goals such as enhanced milk production will depend heavily upon the effective control of disease and on herd improvement.

Because of the existence of clear, unmet needs and potentially large markets in some developing countries as well as the possibly lower regulatory barriers, animal vaccines represent a less risky commercial development opportunity than human vaccines.

Mammalian germ plasm manipulations such as artificial insemination as well as superovulation, cryopreservation, twinning and other techniques involved in embryo sexing and transfer are now under development and hold tremendous potential for improving livestock reproduction in developing countries. Artificial insemination is the most practical of these techniques for immediate or near-term application in most of these countries. Artificial insemination extends the use of male gametes and permits a superior animal to sire thousands of offspring. The technology associated with embryo transfer will remain comparatively expensive and impractical for some time compared with alternative methods (e.g., artificial insemination) for improving breeding herds. (Nevertheless, an embryo transfer facility is now reported in operation in the Philippines as a joint venture between Philippine Genetics, Inc. and Grenada International.)

Diagnostic products based on monoclonal antibodies and nucleotide probes will be important for the further refinements in this area. Eventually, life science-based techniques in areas such as sex regulation, maturation of oocytes in vitro, oocyte fusion, cloning, unisex parentage, and interspecies embryo transfer may be developed. This will not occur however until they can be made cost effective and the infrastructure of developing countries is able to support it.

In producing food crops, by-product residues suitable for feed applications actually equal or exceed the edible food components. Animal wastes can also be recycled via bioconversion processes to provide effective, low-cost methods for conserving nutrients for refeeding. More complete and efficient utilization of agricultural and food processing wastes for animal feed can be greatly enhanced by biotechnology and can expand the nutritional resources available in developing countries.

The use of physiochemical treatments (e.g., steam, alkali) to disrup resistant structures and subsequent aerobic fermentation to enhance protein content is becoming commonplace. For instance, the use of lignocellulosic forestry and agricultural residues to produce high quality animal feeds to replace imported soybean cake is currently under consideration in Indonesia. Sugarcane-based distilleries in Brazil are converting residues into animal feed for local farmers. The Caribbean Industrial Research Institute in Trinidad has developed a process for animal feed utilizing sugarcane, fish processing wastes and

manure. Upgrading of coffee pulp and cassava waste to produce a protein-enriched feed is underway in Belize, Cuba, Mexico and Guatemala. This field provides one of the best potential areas for South-to-South technology transfer and many AID missions have actively supported such efforts.

Macroalgae is commonly used as a source of animal feed in developing countries and microalgae can be cultured in human and animal wastewaters, thus providing a level of wastewater treatment. The algae, containing 45-65% protein, can be harvested and processed for animal feed. Much of the development in this area has occurred in India, the Philippines and Singapore. Finally, plant cell and tissue culture will be used in developing genetically improved plant varieties used in feeding livestock. For instance, the use of Leucaena leaf meal as a feed protein source would benefit from the development of varieties lacking the toxin, Mimosine.

Energy

Developing countries rely on bioenergy in the form of wood, dung, straw, and animal and human power to meet 50% of their basic energy needs. This energy is used almost entirely for the production, processing, and preparation of food. In many developing countries, a large percentage of the time of rural families is spent searching for fuel, at the expense of other productive activities. If additional energy sources were more readily available, agricultural output and postharvest processing could be significantly improved.

Demand for fuel has led to the decimation of forests and declining wood supplies and high-yielding strains of cereal grains that produce less straw reduce the amount of agricultural waste available as fuel. Because of the rising demand for fuels and reduced fuel supplies in developing countries, economic prosperity will depend on the more efficient use of traditional fuels, substitution by alternative fuels and better management of natural resources. For developing countries dependent on oil imports and where substantial biomass is available from agricultural, human, and food processing wastes, energy from biomass conversion is a primary development goal. Appropriate technology is available involving anaerobic fermentation (digestion) of agricultural and other wastes to generate biogas (mainly methane) and the hydrolysis and fermentation of cellulose-, starch-, and sugar-containing materials to ethanol.

For instance, an anaerobic digestion system based on manure from animals fed in confinement could be cost effective if the herd size is large enough. The biogas produced could be used to replace a portion of the fuel currently consumed by stationary engines that generate power or drive mechanical equipment on remote farms. At the same time, the fertilizer value of the manure input is preserved in the digester sludge which can be used as fertilizer in place of manure. Digesters for biogas production have been in use in some developing countries for years. A biogas plant using primarily human wastes supplied gas to several hundred households in Baroda, India, for several decades and was abandoned only when the area was connected to the municipal sewage system. A similar plant in the Dadar suburb of Bombay is still in operation. In China, about 7 million digesters have been constructed.

Even with these successes, the conditions under which the technology is successful are restricted. Biogas production requires capital investment, a plentiful and reliable source of substrate and a level of technical competence to obtain enough gas to justify the effort. Often successful projects are part of integrated systems in which the gas collected is a by-product of nutrient conservation and waste treatment efforts rather than the principal objective. AID has been providing technical assistance to a number of agribusinesses in the Philippines, Thailand and India in the design of aqueous effluent digester systems for distilleries and starch plants.

Brazil is leading the way in developing ethanol as a supplement to replace gasoline, as well as a feedstock for ethylene, butanol, acetic acid, and vinyl acetate manufacture, while several other developing countries have more modest programs. Brazil has already demonstrated the ability to produce large quantities of ethanol (14 billion liters per year) at a cost substantially below the cost of ethanol production in developed countries. The Brazilian firm, Dedini, has pioneered commercial-scale continuous fermentation technology using a special yeast developed by Alfa-Laval of Sweden, that is tolerant to high osmotic pressures. The development of a yeast that is more tolerant to ethanol would immediately improve the productivity of the 700 distilleries that now exist in developing countries. The application of biotechnology is also expected to render the enzymatic hydrolysis of abundant lignocellulosic materials to fermentable sugars commercially viable. U.S.AID in collaboration with the Tennessee Valley Authority is actively investigating technology for the hydrolysis and fermentation of rice hulls and other abundant agricultural residues and has supported investigations into improved applications for distillery by-products.

In order for such development to be successful, a range of issues must be addressed. Perhaps even more important than the availability of appropriate bioconversion technology per se are issues relating to biomass availability and cost, as well as storage and distribution issues that will determine whether any given biomass energy project will be economically feasible.

Biomass Production

Wood use for fuel and construction purposes in developing countries is dependent on a supporting ecosystem that is being disrupted in many areas by population growth and increased cultivation. Where wood resources are overused without replanting, serious soil erosion has occurred further limiting biomass production. In Thailand and the Philippines, as in many other developing countries, forests are being removed by loggers and farmers or are flooded as a result of power dam projects. There is concern in these countries that the deforestation is rapidly removing the habitat required for other important resources such as medicinal plants.

Plant cell and tissue culture has the potential for speeding up the time required for developing improved tree species. This technology could be very important in reforestation efforts, providing fast-growing varieties of commercial value that are resistant to environmental stresses. It is already being used in the United States and elsewhere to develop genetically defined plant species for reintroduction into ecologically disturbed areas.

U.S.AID has supported innovative investigations into improved fast-growing tree species (i.e., leguminous tree developmetn at the Niftal project in Hawaii) and into better clonal propagation techniques for rapidly generating planting stock. The S&T Biomass Systems and Technology program has extensively analyzed the potential of high biomass yielding cane varieties ("energy" cane) for making more bagasse available for energy applications. Brazil is now using tissue culture techniques for improving Eucalyptus which is now grown for charcoal production and several African countries are investigating the potential of fast-growing grasses as alternative fuel sources and soil stabilizers.

Additional areas where biotechnology can contribute to the development and protection of renewable resources in developing countries include:

- Aquaculture and macroalgae culture to replenish valuable coastal marine and freshwater fisheries resources,
- The use of microbial fermentation and microalgae culture in developing genetically modified microbes for the treatment of wastewater,

- The use of genetically modified microbes to degrade persistent organic contaminants in the environment, and

- The development of monoclonal antibodies for diagnostic products used to detect toxic residues in the environment.

Value-Added Commodities

There is a tremendous need for new technology in developing countries for the production of specialty chemicals and commodity products. Because of the increasing debt burden experienced by developing countries, it is necessary that they develop their own products to substitute for expensive imports, and also develop value-added products for export in order to acquire foreign exchange. A major reason for the stagnating economies in many developing countries relates to depressed prices and declining demand for many of the commodity products they depend on for export earnings. This is nowhere more apparent than in the sugarcane industry. Cuts in sugar import quotas by major consumer nations such as the United States have resulted in the closing of many sugar mills around the world.

Biotechnology can play a major role in the production of value-added commodities for export by developing countries to help offset this trend. These products include those on which developing country economies currently depend as well as new, currently undeveloped, product areas that can help to expand their economic base. Included are:

- Use of biocatalysis (immobilized enzymes or microbes) and microbial fermentation to produce commercially important specialty chemicals such as amino acids, food additives and medicinal chemicals. The potential for biotechnology in this area is perhaps greater and more diverse than in any other industry sector, at least in the long term. In developing countries, there are potential near-term opportunities for bioprocesses used in the production of large-volume amino acids, vitamins, and steroids. In most cases, process economics will not favor the production of relatively large-volume, but low-value commodity chemicals via biotechnology in developed countries. However, in some developing countries there may be cases where bioprocesses for the production of certain commodity chemicals from renewable feedstocks (including even lignocellulose) will make economic sense. Success in this area could depend much more on bioprocess engineering and economic considerations than on further innovations in the life sciences per se.

- Use of hybridoma technology to produce monoclonal antibodies for use in immunoaffinity chromatography to purify peptides and other molecules from bioprocesses. Immunoaffinity chromatography is important in research labs in addition to commercial production processes. These reagents could find use in both the domestic and export markets.

- Macroalgae culture (the cultivation of commercially valuable seaweeds) is important in a number of developing countries to produce food and feed items, fertilizer, and especially phycocolloids and other specialty chemical products such as agar, alginates and carrageenan. The Marine Colloids Division of FMC Corporation cultures and processes seaweeds in the Philippines to produce hydrocolloids for the food processing industry. FMC is also working with the government and local firms in Indonesia to develop an alternate source of cultured seaweeds for their Philippine processing facility and also to develop improved varieties. The Philippines are already an important source of carrageenan-bearing seaweeds, accounting for more than one-half of the world supply. Protoplast fusion, somatic hybridization, and other genetic modification procedures are under development around the world and are likely to result in immediate and near-term improvements. Among the modifications sought are faster growing varieties, higher product yields, more desirable products, herbivore resistance, increased protein content and environmental adaptability.

- Development and cultivation of flowers and other ornamentals using plant cell and tissue culture techniques in conjunction with conventional plant breeding. A number of development opportunities could potentially grow from such a venture, involving improved or automated micropropagation, green house, and processing techniques.

- Development and cultivation of commercially valuable tree varieties using plant cell and tissue culture. Such activity would be in support of the existing lumber industry and contribute to reforestation efforts (see Biomass Production).

- Development and cultivation of improved varieties of estate crops (e.g., rubber, oil palms, coffee (using plant cell and tissue culture in conjunction with conventional plant breeding. Biotechnology is already being employed to develop varieties yielding products of greater value including oil palms (optimal fatty acid yield and fruit conformation), cotton, coffee and cocoa. Companies commercializing this technology for oil palms in Southeast Asia include Unilever (UK), Sime Darby (Malaysia) and DNA Plant Technology Corporation (Cinnaminson, NJ). Sime Darby, using technology from International Plant Research Institute (San Carlos, CA), is in the process of expanding output from 60,000 trees per year.

Appendix III

Resumes

WILLIAM H. KLAUSMEIER

RESUME

NAME:	William H. Klausmeier
POSITION:	President, Sylvatex Corporation Manager, Resources Development Foundation Project Development Fund
CITIZENSHIP:	U.S.A.
EDUCATION:	Ph.D. Medicinal Chemistry University of Michigan MS Organic Chemistry University of Maine BS Biochemistry Penn State University
LANGUAGES:	French, German, Spanish, Russian
AREAS OF EXPERTISE:	Process Development Technology Assessment Processing for Natural Products Organic Synthesis Radio diagnostic labeling Technical Venture Evaluation

PROFESSIONAL EXPERIENCE

SYLVATEX CORPORATION
December 1983-present

President of Sylvatex, a technical services firm located in Burke, Virginia.

Recent assignments and projects include:

--Preparation of appraisal and bid package for two distilleries in Guyana for Czernikow, Ltd.

--Management assistance to the Biomass Users Network on behalf of the Resources Development Foundation

--Assessment of alcohol and feed production alternatives for the Philippine Islands

Initiation of a World Bank project in Mali for alcohol fuel production

--Identification of World Bank priorities in bioenergy R&D

--Feasibility analysis of prospective distillery sites in Honduras for U.S. AID

--Evaluation of the Technology Development Component of the First Brazilian Alcohol Program for the World Bank

--Evaluation of the role of the U.S. Department of Energy in biotechnology R&D

--Served as Executive Director of the Biomass Energy Research Association

--Creation of a fund to promote international joint ventures in biotechnology for the Rockefeller Brothers Fund

--Surveyed worldwide developments in the field of alcohol fuels for the U.S. Department of Energy

--Evaluation of an additive for increased alcohol concentrations in gasoline blends for the World Bank

--Evaluation of numerous project proposals for the World Bank, the Rockefeller Brothers Fund, U.S. Agency for International Development and the U.S. Department of Energy.

ARGONNE NATIONAL LABORATORY
January 1983-October 1983

Biomass Research Program Manager responsible for:

--The identification and development of experimental biomass research projects

--The management of ongoing research in fermentation, thermochemical conversion and environmental control technology

March 1981-January 1983

Industrial Systems Analyst responsible for:

--The technical and economic evaluation of federally funded biomass and synfuel research programs

--Investigation of new innovations in R&D that may have practical applications.

DIAMOND SHAMROCK CORPORATION
January 1979-March 1981

Research Chemist
responsible for:

--Development of a new process for Vitamin D manufacture

--Development of a novel process for the synthesis of Vitamin D metabolites

--Start-up troubleshooting for a calcium pantothenate plant

--Development of a new technique for the radio-bromination of steroids.

ROBERT J. PARRA

RESUME

NAME:	Robert J. Parra
POSITION:	Partner: Washington Capital Markets Group International Biotechnology Group
CITIZENSHIP:	U.S.A.
EDUCATION:	MA International Economics Georgetown University BS Engineering Sciences U.S. Air Force Academy
LANGUAGES:	English, Spanish
AREAS OF EXPERTISE:	Project Finance Financial Engineering Equity/Credit Markets Debt Swaps Venture Capital Agroindustry Tax-Oriented Financing Privatization Programs

PROFESSIONAL EXPERIENCE

WASHINGTON CAPITAL
MARKETS GROUP
September 1984 - Present

Partner with Irving S. Friedman in the "Washington Capital Markets Group," a financial services firm located in Washington, D.C.

Current assignments and projects include:

--Involved in the development, financing and operation of the $40MM Santa Maria Development Company ("SMDC") in Azores, Portugal

(SMDC will be an investment promotion vehicle for the Azores attracting light assemblers from the U.S., Canadian, and Brazilian toy, garment and electronic industries)

--Organizing, with the Siam Commercial Bank in Thailand, a venture capital company that would specialize in investment in, and promotion of, U.S. agro-industrial technologies suitable for transfer to Thailand

--Involved in the early stages as a financial consultant to the Government of Panama with respect to their Privatization Program, envisaging divestiture of up to twenty-eight government parastatals

--Organizing with Skylon Industries of New York, the establishment of three garment assembly plants in Barbados, Grenada, and Dominica

--Early stage involvement in several projects under development in Indonesia, Panama, Dominican Republic, Azores/ Madeira, Ecuador, Pakistan

	emphasizing venture capital, agroindustry, and/or investment promotion.
AGENCY FOR INTERNATIONAL DEVELOPMENT Bureau for Private Enterprise Washington, D.C. August 1982 - September 1984	Political Appointee, Director, Office of Investment, responsible for: --Recruiting and hiring personnel to staff $100MM Revolving Fund approved by the U.S. Congress in 1983 --Supervising the structuring and implementation of 19 foreign private sector projects, many of which possessed unique blend of commercial viability, development impact and replication potential.
CITICORP SUBSIDIARIES Citicorp Industrial Credit (CIC) San Francisco, California from 1980	Vice President and General Manager Directed the transformation of CIC in the 16-state western region to one which competed with independent finance companies in marketplaces that were "downstream" from the traditional ones. Most significant achievement included the approval in New York of a special program to loan $100MM to tax oriented limited partnerships, an activity never before undertaken by Citicorp or any of its subsidiaries.
Citibank N.A. New York, N.Y. from April 1975	Vice President, responsible for establishing management process to monitor, assess risks, and control the distribution of short- and long-term exposure in 103 foreign countries.

Citicorp Leasing Int'l Ltd. London, U.K. from January 1972	Resident Vice President, in charge of a unit of transactors, responsible for the packaging of cross border transactions involving the financing of ships and aircraft with risk syndication: --of debt, to export credit agencies (e.g., Eximbank, ECGD, COFACE, etc.) --of equity, to U.K. corporations seeking tax-oriented returns. Unit earned $1MM pretax in 1974 after losing money for a period of years.
Citibank, N.A. from June 1968	Manager, Arrendequipos, S.A. from 1970-72 in Venezuela, during the start-up years of a locally incorporated leasing company. Pretax profit at the end of this initial three-year period was $830M; 1968-70, in Ecuador as Trainee and Assistant Manager; 1967-68, in New York taking in-house course work, e.g., accounting, corporate finance, financial engineering.

THOMAS W. WAHMAN

RESUME

NAME:	Thomas W. Wahman
POSITION:	President, Tabor-Wahman, Ltd. Managing Consultant, Resources Development Foundation
CITIZENSHIP	U.S.A.
EDUCATION:	Bachelor of Arts Dartmouth College Master of Divinity Union Theological Seminary
AREAS OF EXPERTISE:	Establishing new for-profit and non-profit corporations, programs and projects in several different fields

PROFESSIONAL EXPERIENCE

TABOR-WAHMAN, LTD. (TWL)
April 1980 - Present

President of TWL, a for-profit company specializing in the creation of new for-profit and non-profit corporations, programs and projects

Recent clients and projects include:

--For the Rockefeller Brothers Fund, lead responsibility in creating American Farmland Trust, New York City Housing Partnership, International Biotechnology Group, Resources Development Foundation, Citizens Participation Project, Development Training Institute

--For the Rockefeller Brothers Fund, Rodale Press, Control Data Corporation and Midwest Technology Development Institute, shared senior responsibility for the design and funding of major domestic and international policy and implementation projects in agriculture, resource development, environmental protection, equal rights and opportunity, enfranchisement, and technology transfer and adaptation

ROCKEFELLER BROTHERS FUND
July 1968 - March 1980

Director, National Program

Responsible for:

--Coordinating all RBF philanthropy at the national level

--Reviewing grant proposals and recommending grant awards for policy and implementation projects in several fields, including: housing, economic development, manpower, equal opportunity and equal rights, health, community organization and development

--Creating Winrock International Livestock Research and Training Center, National Rural Center and Winthrop Rockefeller Foundation

--Preparing program authorizations and guidelines for new areas of philanthropy within the RBF

NEW YORK FOUNDATION
May 1966 - June 1968

Associate Director

Responsible for:

--Reviewing proposals and recommending grant awards in several fields

METROPOLITAN URBAN SERVICE TRAINING INSTITUTE
September 1965 - April 1966

Consultant

Responsible for:

--Community organization liaison

NEW YORK UNIVERSITY
September 1963 - August 1965

Coordinator of Civil Rights and Religious Activities

PETER C. HALL

RESUME

NAME:	Peter C. Hall
POSITION:	Chief Operating Officer and and Biotechnology Program Director, Resources Development Foundation
CITIZENSHIP:	U.S.A.
EDUCATION:	BA Biology Alfred University
LANGUAGES:	English
AREAS OF EXPERTISE:	Technology Assessment Identification and Evaluation of New Business Opportunities Market Analysis

PROFESSIONAL EXPERIENCE

RESOURCES DEVELOPMENT FOUNDATION
September 1986 - Present

Recent assignments and projects include:

--Overall coordination of program activities

--Development of program goals and objectives

--Established and head West Coast office

--Identification of technologies and business areas of primary interest

--Identification of funding sources

--Presentation of program goals and objectives to potential founders

SRI INTERNATIONAL
1975 - 1986

International Biotechnology Advisor

Recent assignments and projects include:

--Assessment of the impact of new microbial and enzymatic production processes on the production of phenylalanine, tryptophan, and threonine, for Lafarge Coppee (Orsan)

--Author of the 1983, 1984, and 1985/86 Biotechnology Update reports for SRI's Biotechnology Program

--Author of The Role of New Biotechnologies in the Genetic Modification of Higher Plants, for SRI's Biotechnology Program

--Evaluation of biotechnology-related business diversification and entry opportunities for a number of U.S., European, and Japanese firms.

Determination of potential market opportunities involving a wide range of new, biotechnology derived products, for a number of U.S., European, and Japanese firms.

--Development of entry strategies for chemical and other companies contemplating entry into the pharmaceutical business as basic producers

--Evaluation of new business opportunities involving manufacture and sale of cephalosporin antibiotics for Eastman Kodak Company

--Evaluation of markets for fluorinated medicinal chemicals and intermediates used to produce them, for Allied Corp.

--Evaluation of new pharmaceutical dose form delivery systems for a number of multinational pharmaceutical companies

--Contributing author to SRI's Health Industries Handbook

--Evaluation of bulk medicinal chemical markets and business opportunities on a worldwide basis.

R. N. DRYDEN, JR.

RESUME

NAME:	R. N. Dryden, Jr.
POSITION:	President Plant Biological Systems, Inc.
CITIZENSHIP:	U.S.A.
EDUCATION:	BA Economics Emory University
LANGUAGES:	English
AREAS OF EXPERTISE:	Agricultural Biotechnology Biotechnology Industry Matters Finance Tax-Oriented Financing Research and Development Partnerships Mergers and Acquisitions International Joint Ventures Venture Capital

PROFESSIONAL EXPERIENCE

PLANT BIOLOGICAL SYSTEMS, INC.
March 1986 - Present

President. PBSI is located in Boulder, Colorado, and is active in venture formation of companies utilizing advances in biological technologies as they relate to agriculture.

Current assignments and projects include:

--Organizing, with a major U.S. venture capital firm the structuring, financing and directing of a new plant science oriented biotechnology company formed by spinning out a research group from a multi-national corporation.

--Involved in the establishment and direction of a new plant science company in Holland involving the Dutch Government as well as private venture capital.

--Involved in the formation of the U.S. operating arm of Agricultural Genetics Corporation (AGC).

AGC is the agricultural biotechnology company organized by the British Government to commercialize developments of the U.K. Agricultural Research Council labs.

--Serving as a retained advisor to several U.S. and European firms with interests in biotechnology.

AGRIGENETICS CORPORATION
January 1982 - February 1986

President, Chief Executive Officer and Director responsible for:

--The overall direction of the company with special emphasis on the corporate structure and finance. Sales grew from $30MM in 1981 to over $100MM in 1986 with over 1000 employees worldwide.

--Raising in excess of $110MM of capital.

AGRIGENETICS RESEARCH CORPORATION
January 1981 - February 1986

Chairman and Founder, responsible for:

--Establishment of $55MM research and development partnership in plant biotechnology.

--Negotiation of over 30 research contracts with 26 research institutions in the U.S. and overseas (U.K., Holland, Germany, Switzerland and Australia).

--Establishment of internal research and development strategy and organization.

UNION CARBIDE CORPORATION
March 1975 - December 1980

Associate, Mergers and Acquisitions

--Involved in analyzing and partial responsibility for the worldwide restructuring of $1.2 billion of corporate assets.

This involved the negotiation of divestitures, acquisitions and joint ventures in industry sectors including chemical and plastics, ag chemicals, metals and technologies such as electronics and biotechnology.

These transactions involved extended location in Europe, South America and Japan.

INDUSTRIAL BIOTECHNOLOGY ASSOCIATION

Co-Founding Director and Treasurer.

RICHARD S. CALDECOTT

RESUME

NAME:	RICHARD S. CALDECOTT
POSITION:	Assistant to the President for Federal Relations, University of Minnesota Senior Science Advisor, Resources Development Foundation
CITIZENSHIP:	U.S.A. (Naturalized, 1954)
EDUCATION:	Ph.D. Genetics State College of Washington MS Genetics State College of Washington BSA University of British Columbia
LANGUAGES:	English
AREAS OF EXPERTISE:	Genetics Molecular Animal and Plant Biology Research Administration Technical Consultation in Genetics, Plant and Animal Biology, Radiation Biology University and Government Administration

PROFESSIONAL EXPERIENCE

UNIVERSITY OF MINNESOTA 1954 - Present	Served the university in many capacities including: --Assistant to the President for Federal Relations --One of four founders of a corporation dedicated to the development of biological systems for degrading toxic and other wastes - Biotrol --Dean of the College of Biological Sciences Chairman, McKnight Foundation Committee on Molecular Plant Biology --Member of Board of Directors, Argonne Universities Association
U.S. ATOMIC ENERGY COMMISSION 1960 - 1963	--Served as geneticist for U.S. AEC investigating genetic effects of radiation --Consulted to the International Atomic Energy Commission on radiation effects --Earlier (1955) served as delegate to International Atoms for Peace Conference --Served on NAS-NRC Subcommittee on Radiation Biology (1963-71)
BROOKHAVEN NATIONAL LABORATORY 1953 - 1954	Served as Radiation Biologist
UNIVERSITY OF NEBRASKA 1951 - 1953	Held post of Assistant Professor

GUNNAR WESSMAN

RESUME

NAME:	GUNNAR WESSMAN
POSITION:	Industry Consultant and Senior Advisor, International Biotechnology Group
CITIZENSHIP:	Sweden
EDUCATION:	M.Eng. Chemistry and Chemical Engineering Royal Institute of Technology in Stockholm

PROFESSIONAL EXPERIENCE

1980 - 1985	Pharmacia AB, Sweden 1984-85 - Chairman 1980-84 - President and CEO
1975 - 1979	Uddeholm AB, Sweden President and CEO
1970 - 1974	Perstorp AB, Sweden President and CEO
1964 - 1969	AB Stadex, Sweden in the Dutch Scholten-Henig Group President
1958 - 1963	The Borrier Group, Sweden Divisional Manager
1954 - 1958	Unilever, Sweden Project Leader
1951 - 1954	AB Bofors Nobelkrut, Sweden Production Engineer