# BIOTECHNOLOGY RESOURCES IN CANADA AND THEIR APPLICATION TO DEVELOPING COUNTRIES

Prepared for the Agriculture, Food and Nutrition Sciences Division, International Development Research Centre, Ottawa

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MTL BIOTECH

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## 1. SUMMARY

Modern biotechnology is a continuum of techniques in biological science that promises great improvements in human nutrition and health in all countries of the world. The pace of research in biotechnology in North America, Europe and Japan is not only forcing international donors to state policies on biotechnology, but also guarantees that, unless developing countries have access to these new tools, the technological gap between rich and poor nations will widen rapidly.

Once the extravagant early claims for biotechnology are discounted, realistic forecasts based on a decade's experience in North America and Europe encourage immediate application to selected problems in Third World agriculture. This report recommends that IDRC consider funding collaborative research projects in such areas, and that Centre support for Ph.D. training in Canada reflect the longer term potential in such biotechnological areas as the identification of useful genes and their transfer between species.

Scientists in Canada's universities, Federal research laboratories and smaller private companies make up a large and rapidly growing pool of world class expertise in biotechnology. Many who are neither known to IDRC nor aware of IDRC's programs are nevertheless well suited to collaboration with their counterparts in the Third World for research and training. This report describes the work of some of these Canadian scientists against a background of biotechnology research and applications around the world, and suggests a strategy for putting their expertise to work for IDRC. This strategy will ensure the highest standard of research using a resource whose skills are markedly generic, and assumes not only an increased Centre capability in biotechnology, but also an improved relationship with Canada's research scientists.

## 2. RECOMMENDATIONS

### 2.1 Areas for immediate funding consideration

IDRC is already funding biotechnological projects by supporting plant tissue culture research. As a highly regarded international donor, the Centre should make this existing work part of a coherent policy on biotechnology by taking the lead in funding specific biotechnological research projects in areas where risk is moderate and the implementation of results predictable. Such areas are cell and tissue culture technique; transformation (DNA delivery) technology; genome mapping; stock identification; genetic conservation; and development of diagnostic probes.

### 2.2 Health Sciences applications of biotechnology

Because the vast majority of expertise in biotechnology is in medical schools, the Health Sciences Division of IDRC should consider carrying out an inventory of these resources.

### 2.3 Technology assessment and linkages

IDRC needs up to date access to international developments in biotechnology, and should use this information as an aid in fixing funding priorities.

An IDRC biotechnology resource group, whether in-house or contracted, can then take the first step in linking Canadian scientific expertise to developing country needs through case by case discussion of past and proposed projects, local needs and institutional capabilities with Associate Directors and their staffs at Regional Offices.

### 2.4 Areas for Ph.D. training

In areas with a longer term payoff, particularly the identification of useful genes and their transfer between species, IDRC should devote funds to Ph.D. training of developing country biologists in Canada so that they can acquire expertise that can be turned to specific projects in the future.

### 2.5 Bridging courses

IDRC should design and implement bridging courses in biotechnology aimed at informing researchers and administrators in developing countries about new developments and their potential application. Target groups for such training should include classical plant and animal breeders, agronomists, pathologists and veterinarians.

### 2.6 Dealing with research proposals in biotechnology

The Canadian research community wants a mechanism for predictable and professional adjudication of their proposals for international development work, and needs guidelines on how to prepare such proposals, and where and when to submit them. IDRC should consider options for peer review, as ultimately it is with the researchers' peer group that technical accountability should lie. IDRC should ensure that unsuccessful proponents are so informed within a reasonable and specified period, and that proponents be made aware of delays that may occur in making decisions. Speed is important in reviewing biotech proposals, because the techniques described and equipment requested may rapidly become out of date.

The Canadian research community in general needs to be better informed about IDRC's interests and policies, including past projects and areas where project proposals are welcome. Where researchers are invited by IDRC to submit proposals, the likelihood of eventual funding should be discussed beforehand, and there must be followup.

### 2.7 Dealing with the commercial nature of biotechnology

Because biotechnology can be profitable, IDRC, like all international donors, will have to develop innovative arrangements with researchers from Canadian universities, government laboratories and private companies, as well as with their counterparts in the Third World, for the development and diffusion of certain kinds of biotechnology. Doing so implies that project development must from the outset pay much closer attention to realistic mechanisms for implementing the results.

# 3. TERMS OF REFERENCE

## 3.1 Objectives and methods

This report was prepared for the Agriculture, Food and Nutrition Sciences division of IDRC between May and September, 1989. Major objectives were to identify and evaluate Canadian expertise in biotechnology; identify and assess potential applications to agriculture in developing countries; and provide recommendations that will assist the Centre in the development and application of a biotechnology policy.

Scientists in Canadian universities, Federal research laboratories and private biotechnology companies were contacted by telephone, and asked in a general way about their research interests and interests in international development work. We then visited the laboratories of researchers who seemed to have something to offer IDRC, and in most cases spent about an hour with each, discussing their work, its potential application to Third World problems, and their personal interest in becoming involved. In many cases we learned something about researchers' impressions of IDRC and its programs; in just as many cases researchers were completely ignorant about IDRC.

Our brief write-ups on researchers and their laboratories essentially reflect their degree of interest in IDRC's goals. Comments about IDRC, although frequent, are not attributed, partly because some were meant confidentially, but, just as important, because most of them fit a pattern that became familiar over the course of the study. We have tried to incorporate the spirit of these comments, which we believe reflect the attitude of Canada's scientific community, in recommendations for IDRC biotechnology policy.

## 3.2 Institutions covered

Our sample, and hence the "inventory" (Section 8) is far from inclusive. Many excellent resources are doubtless omitted, and the very rapid development of biotechnology expertise in Canada guarantees that the number of competent scientists in this area is increasing by the month. IDRC will find the inventory useful as a starting point. In all, we discussed biotechnological research and Third World development with over 200 scientists and visited three-quarters of those. The 38 institutions they represent include the following:

### 3.2.1 Universities and associated research centres

Memorial University of Newfoundland
Marine Sciences Research Laboratory
Dalhousie University
University of Toronto
Hospital for Sick Children, Toronto
Mt. Sinai Medical Centre, Toronto
University of Western Ontario
Queen's University
University of Guelph
McGill University
MacDonald Collecge
University of Ottawa
University of Saskatchewan
Veterinary Infectious Disease Organization (VIDO)
University of Calgary
University of Edmonton
University of British Columbia
B.C. Cancer Research Institute
Simon Fraser University
University of Victoria

### 3.2.2 Government research laboratories

Fisheries and Oceans Canada

Pacific Biological Station, Nanaimo
West Vancouver Laboratory

Agriculture Canada

Animal Disease Research Institute, Ottawa
Vancouver Research Station
Animal Research Centre, Ottawa
Plant Research Centre, Ottawa

National Research Council

Plant Biotechnology Institute, Saskatoon
Biotechnology Research Institute, Montreal
Atlantic Research Laboratory, Halifax
Division of Biological Sciences, Ottawa

### 3.2.3 Private companies

Alta Genetics Ltd., Calgary
Shaver Poultry Ltd., Cambridge
Semex Canada Ltd., Guelph

Helix Biotech, Vancouver
FMG Biotech, Vancouver
B.C. Research, Vancouver
International Broodstock Technologies, Vancouver
Microtek Research and Development, Victoria

## 4. DEFINITION AND CHARACTERISTICS OF BIOTECHNOLOGY

In this report the term "biotechnology" is used in its broadest context as "any technique that uses living organisms or substances from those organisms to make or modify a product, to improve plants or animals, or to develop microorganisms for specific uses". It is a continuum of technologies ranging from long established, relatively simple methods for the commercial use of microbes in biological nitrogen fixation and the collection, selection and production of beneficial strains of bacteria, to more sophisticated strategic research on the genetic engineering of plants and animals.

Modern biotechnology marries new techniques in molecular biology to cell biology and tissue culture. Recombinant DNA technology for genome manipulation, monoclonal antibody production for protein detection, cell fusion for creating new cell lines and cell and tissue culture for the rapid propagation of selected plant cells form the basis of genetic engineering.

It is essential to realize, particularly when research projects are being planned, that the elements of biotechnology cannot function in isolation, and it is precisely because biotechnology ranges from "low end' to "high end" technology - from, say, plant micropropagation to the creation of transgenic cattle - that definitions tend to break down. Generalizations are, nevertheless, useful when a subject is complex; in the case of genetic engineering, which forms such an important part of what is loosely termed biotechnology, such a crude simplification would characterize activities as recombinant DNA techniques and reproduction/propagation techniques: the former results in the creation of new and presumably better adapted cells and organisms, while the latter is concerned with disseminating these improved entities.

### 4.1 Recombinant DNA

The analysis of DNA composition allows us to rapidly measure the genetic distance between individuals, populations, or species and to determine the amount of genetic variability in a population. The ability to do this is highly useful in designing breeding programs for any organism from plants to cattle.

Once we can determine the amount of genetic variability in a population of organisms, we can then use this information rationally. The construction of detailed genomic maps using RFLP (restriction fragment length polymorphism) technology magnifies enormously the power of plant and animal breeders to select for desired traits in otherwise conventional breeding programmes, because the precisely located genetic markers in such a map are numerous and scattered over the entire genome.

Synthetic DNA probes, which are complementary to target gene sequences, serve as "hooks" to catch genetic markers specific to populations or individuals. These probes can be used for stock identification, for the detection of all classes of pathogens, and even as a novel and powerful tool for studying the natural history of an organism. Recent examples include specific probes for fisheries stocks whose ownership may be in dispute and, most conspicuously, diagnostic DNA probes for the detection of viruses, bacteria and other microscopic pathogens.

Astounding progress has been made in gene transfer techniques and expression systems in transgenic cells, but a major limitation remains in the need to identify and isolate suitable genes to transfer - namely, complex gene systems with appropriate molecular controls that determine agriculturally useful traits. Nevertheless, field testing of transgenic plants engineered for herbicide resistance is already in progress, and many other transformed organisms will become available within five to ten years.

**4.2 Reproduction/propagation techniques**

Modern biotechnology is interdisciplinary and applicable to all organisms in the evolutionary scale. It is not exclusively concerned with DNA manipulation. In livestock production for example, in addition to affecting many aspects of animal physiology and nutrition as well as facilitating the production of new vaccines for the control of infectious diseases, biotechnology is providing new techniques for embryo manipulation. In cattle, the reproductive potential of a single superior animal can be greatly multiplied by embryo splitting and cloning, and by embryo transfer technology. Superior stocks with specialized genotypes and rare breeds can be rapidly expanded; these genotypes can also be cryopreserved for wide distribution.

Successful genetic engineering of a particular plant species depends on cell and tissue culture technology in requiring efficient transformation and regeneration systems so that transformed single cells can develop into whole plants. Rapid in vitro micropropagation systems are being developed for the multiplication of new varieties of important crops, as are cryopreservation methods for germplasm conservation.

Reproduction/propagation technologies draw heavily on other disciplines, and success in using them requires grounding and support in such areas as basic cell biology, embryology, endocrinology, veterinary science and sterile technique. Propagation of superior cattle breeds by cloning, for example, will demand expertise in all of these fields.

## 5. AGRICULTURAL BIOTECHNOLOGY AND THE THIRD WORLD

Modern biotechnology holds great promise for alleviating poverty in the Third World. Many of its varied applications are concerned with basic human needs; in the West, its impact is already being felt in agriculture, fisheries, human health care, environmental protection, energy, mining and industry.

### 5.1 Limits to existing technology

In recent decades the Green Revolution has permitted per capita world food production to increase at a rate aproximately equal to that of population growth. Nevertheless there remain large deviations from these figures in many countries where net progress in reducing hunger and poverty is not evident. Limits for improving agricultural output with existing technology are associated with the progressively smaller increments obtained for each unit of expenditure on fertilizer and irrigation, and by physiological barriers which constrain crop and animal yields. Environmental considerations are also checking rapid agricultural expansion because further declines in forest and pasture land are unacceptable to many countries.

The substantial increases in food production required for the expanding Third World populations in the coming decades cannot be met using existing technology, and there is now widespread agreement that the next significant advances for enhancing productivity must come from biotechnology.

### 5.2 A realistic role for biotechnology

Initial excitement over the scientific possibilites of genetic engineering resulted in unrealistic expectations about its potential impact on agriculture. More conservative expectations now hold, largely as a result of ten years of research experience in industrialized countries. Innovative and efficient technology has enhanced the speed with which research can be done, and more realistic predictions about the production of useful end products in agriculture can now be made.

Biotechnology will have a significant impact on agricultural research and productivity by the beginning of the next century, and after that it will be an increasingly important component of new technology for crop and livestock production in industrialized and developing countries alike.

### 5.3 Can Third World countries do biotechnology research?

It is often argued that biotechnology research is sophisticated and costly, and that Third World countries can never compete. In fact, this argument is no more true for biotechnology than for any other kind of scientific research.

The complexity and cost of doing the most publicised kind of biotechnology, namely molecular biology, have in fact decreased dramatically. DNA sequencing and synthesizing technologies, to take only one example, have progressed so fast that operations that once took weeks can now be done in days. The human genome is expected to be sequenced within 5 years; this confident prediction would have been unthinkable 5 years ago. The requirement for radioactive tracers in molecular biological work, once a stumbling block for many countries, has now virtually disappeared. The major cost of doing molecular biology is now in buying restriction enzymes, and it is worth noting that IDRC has already explored the possibility of assisting one developing country in making its own enzymes (the project was eventually funded by another donor).

# 6. APPLICATION OF CANADIAN EXPERTISE IN AGRICULTURAL BIOTECHNOLOGY TO THIRD WORLD PROBLEMS

## 6.1 International policies on biotechnology in development

Canada has commissioned many internal studies and reports on biotechnology but has no official policy on biotechnology for developing countries; IDRC, as our instument for development research, must take this responsibility. The United States (USAID, the Rockefeller Foundation), West Germany (ATSAF) and The Netherlands (DGIS) have already developed, or are developing, policies on Biotechnology and the Third World. Most recently, the World Bank has collaborated with ISNAR and the Australian government on a study to determine the potential of biotechnology for increasing agricultural productivity and to explore how the Bank and other development agencies can best contribute to this effort.

## 6.2 Confronting biotechnology

Biotechnology is the modern approach to biological research. Many institutes have new appointments in molecular biology and the majority of established scientists are learning to use the tools of biotechnology in their work.

The ubiquity of biotechnology has got to recognized; the problem for IDRC is to take what the new developments have to offer without being carried away on the bandwagon. The bandwagon effect is certainly there, because biotechnology promises so much. Nevertheless, the reality is that recent developments in molecular biology have dramatically changed the way biological research is done, and even more importantly, the way biological science is taught. Scientists and students think differently, and the textbooks and journals they read look different.

## 6.3 The need for international partnerships and information exchange

Developing countries need immediate access to the new tools for the improvement of tropical crops and livestock. This implies building partnerships between industrialized and developing countries that allow transfer of new technology relevant to solving food production problems in the Third World. The present report reveals that there is a large pool of Canadian expertise in biotechnology available for such partnerships.

The key management problem in applying biotechnology to Third World agriculture is naturally in deciding which application should be given priority. First, it is necessary to identify the problems which have proved to be intractable to conventional approaches and may benefit from the new technology. However, since biotechnology includes a wide array of products, processes and research areas, solutions require the combined expertise of agricultural scientists and economists who understand the agricultural systems and the economic policies that affect these systems, the component crops and animals and the problems restricting their productivity, and modern biologists who see new ways to answer questions.

For example, crop improvement requires interdisciplinary cooperation between classical plant breeders, agronomists, pathologists and new cell and molecular biologists, because the widespread use of engineered plant varieties depends on the development of suitable agronomic characteristics and high yield.

### 6.4 Educating all of the partners in a biotechnology research project

In order for interdisciplinary research partnerships to work, funders of biotechnology in developing countries need to consider "bridging" courses in biotechnology to facilitate the successful introduction and integration of new technology into existing research and development programmes.

Agricultural scientists and research managers need to better understand the basic principles of genetic engineering and how to use the new techniques in their existing programmes. By the same token, it is also necessary for modern biologists to understand more of the agronomy and ecology of the target species and its pests and pathogens, because much of modern biotechnology is generic. The key components of recombinant DNA technology - identification and isolation of selected genes, DNA delivery and integration systems and the expression of new genetic information in recipient cells - can be similarly applied to bacteria, fish, crops and cows. This often means that the new molecular biologists have powerful technical skills that can operate quite outside any meaningful biological context. One need not know anything about fish biology to develop DNA probes for stock identification because the technology has universal application.

Many molecular biologists are looking for research problems on which to put their skills to work. IDRC can profit from this large pool of expertise, but should design projects with more than the usual care for practical implementation of the results. In the 1990s, good project planning will have to take into account the power of molecular biology and the enthusiasm of its practitioners, and temper these with input on natural history, social consequences and economic feasibility.

### 6.5 New IDRC strategies for dealing with biotechnology

#### 6.5.1 Soliciting and reviewing project proposals

Areas in biotechnology described in Section 7 should all be considered for IDRC support. Even so, the pace of development in biotechnology means that no list can be all inclusive. Rather than encourage proposals in a limited number of areas, IDRC should set up a system for rapid peer review of all biotechnology-related proposals so that Canadian scientists are encouraged to make linkages with their counterparts in developing countries and submit their ideas to IDRC. This way, IDRC will have broader access to Canadian expertise, and in the end will be able to fund on the basis of technical merit as well as on the basis of IDRC internal priorities. The pace of biotechnological development virtually guarantees that IDRC priorities will frequently be under review.

#### 6.5.2 Using graduate training to build competence

In some areas of biotechnology, developments are so rapid that, while the implications for Third World benefit are great, no one is sure what the specific benefits will be. This uncertainty translates into reluctance to fund highly specific projects in some areas. Thus, while IDRC can feel reasonably confident in supporting projects in micropropagation or in developing diagnostic DNA probes, it may wish to hold back on funding any part of a project whose goal is to produce transgenic cattle.

Our recommendation is that in such cases IDRC endorse the promise of biotechnology by supporting graduate, and particularly Ph.D., training in Canada in a laboratory where the technology is being rapidly advanced. The argument that such people will sink into an administrative morass on their return remains valid, but the alternative to building up a country's highly trained resources in the field of biotechnology guarantees that biotechnological solutions to their problems will eventually be sold to them with no input from them at all. The problem of trainees dropping out of the system can be minimized by emphasizing Ph.D. projects that are more basic than applied. In biotechnology, people first need the tools; the applications will follow.

### 6.6 International development using commercially oriented technology

It is now common for biotechnological research to be funded at least partly by industry, and lists of authors of scientific papers frequently include someone with ties to the marketplace. All Canadian researchers, whether at universities or in Federal government laboratories, are now officially urged to find industry funding for their projects, and alliances are forming all the time between growing biotech companies and university scientists. It is the stated policy of the Government of Canada to encourage private biotech companies with a product to develop and sell.

The biotechnological approach is now so powerful and pervasive that no research funding organization, whatever its mandate, can ignore it. For IDRC, where the top priority is assisting less developed countries to help themselves, the trick will be to put money, carefully and knowledgeably, into those areas where biotechnology can genuinely make a difference to the lives of thousands of people; but to do this, IDRC must confront the commercial aspect of biotechnology. Fortunately, there are many problems in Third World countries where a biotechnical solution is possible but does not represent a large enough market for all but the most specialized company to get into. IDRC can make alliances with such Canadian companies that are to everyone's benefit, but this may require a change in policy toward the ownership of technology that results from an IDRC project.

## 7. SPECIFIC APPLICATIONS OF BIOTECHNOLOGY OF INTEREST TO AFNS

This report is limited to applications of biotechnology in plant and animal agriculture - i.e., crops and animal production systems, fisheries, forestry and biological pest management, and describes Canadian expertise in the key areas where modern biotechnology is likely to have an impact.

In this report, the terms "agriculture" and "agricultural" are used broadly to include plant, animal and fish culture. We stress the generic aspect of biotechnology by grouping applications by technology rather than according to the organism that is ultimately grown.

The following sections describe both long and short term objectives in these areas that should be of interest to IDRC. No ranking is implied because all of the objectives included are important; the specifics of a proposed project will be fundamental in determining which area(s) IDRC should support. Reference is made to Section 8 for expertise in each area. These areas are:

Plant breeding
Fish breeding
Animal breeding, including embryo transfer technology
Diagnostics and vaccines
Agricultural mcrobiology
Biological pest management

### 7.1 Plant breeding

In plant agriculture and forestry, the major application of biotechnology is the development of new varieties with novel characteristics such as pest or disease resistance, herbicide or stress tolerance, or improved quality characteristics. Canadian expertise in crop improvement technology to be considered by IDRC includes applications of cell and tissue culture, transformation, and genome mapping techniques. Our major research organisms are cereals, forage grasses, Brassica and conifers, but the technology is generic and potentially applicable to tropical plants.

7.1.1 Cell and tissue culture techniques

7.1.1.1 Haploid production

One of the most useful methods developed for plant breeding is the production of haploid plants from both male and female gametophytic cells through the culture of anthers, microspores, ovaries and ovules. A positive in vitro response to culture conditions leads to the development of embryos and/or callus from which plants can be regenerated. Haploid plants can be used as pure breeding lines for hybrid cultivar development in highly heterozygous cross pollinating crops, and breeders can select for desirable genetic recombinants using homozygous lines established by chromosome doubling techniques. In Canada, doubled haploids are being used in breeding programmes for barley, wheat and canola.

Cultured microspores can be used in mutant isolation, and highly embryogenic isolated microspores offer great potential as recipient cells for the introduction of foreign genes. Selection for herbicide resistance in canola, for example, has been greatly simplified by the use of this technology.

Haploid production technology is not highly sophisticated; it can be modified for specific plants and can be easily applied and used in developing countries. Keller's group at Agriculture Canada's Plant Research Centre in Ottawa has a very strong programme in the production and utilization of haploids and is highly recommended for consideration in IDRC tropical crop breeding projects.

#### 7.1.1.2 Protoplast technology

The production of somatic hybrid plants depends on the successful integration of several technical procedures. These include the isolation of viable protoplasts, the induction of protoplast fusion, cell wall regeneration and cell division, the identification of hybrid cells and the regeneration of hybrid plants. Recent progress in in vitro culture techniques of important crop plants such as Brassica species has led to the production of several new hybrid plants with novel combinations of mitochondria and chloroplasts which encode cytoplasmic male sterility and herbicide resistance.

Somatic hybridization has widespread application as a means of producing new combinations of desired characteristics in plants - for example, the transfer of disease or herbicide resistance between sexually incompatible species such the transfer of triazine resistance from canola to alfalfa by researchers in Crop Science at the University of Guelph. Protoplast technology and reliable regeneration procedures should be developed for specific tropical crop plants in order to maximize the potential significance of somatic hybridization for crop improvement.

#### 7.1.1.3 Somatic embryogenesis

The application of tissue culture and genetic engineering techniques to crop improvement is dependent on the ability to regenerate plants from cultured tissues, cells and protoplasts. Plant regeneration in vitro occurs via somatic embryo formation or shoot formation.

In somatic embryogenesis, a new individual with a bipolar structure (i.e. a root/shoot axis) arises from a single cell in callus or suspension culture. These individuals can be induced to form in large numbers and subsequently coaxed to develop into whole plants. This technique is a means of propagating selected lines with a uniform consistent phenotype and has significant potential for forest trees and vegetatively propagated tropical root crops such as cassava. In addition, somatic embryos of selected cultivars can eventually be dehydrated, stored in a germplasm bank and exchanged by mail as artificial seeds. Somatic embryogenesis is an area that IDRC should monitor closely for development.

Artificial seed technology has been developed at the University of Guelph and Agriculture Canada's Plant Research Centre in Ottawa with somatic embryos of alfalfa cultivars. Desiccation tolerant somatic embryos are dehydrated to less than15% moisture, and can be stored for months without loss of viability and then germinated into whole plants. There are some problems to be solved, but this method is already being developed for other plants such as geranium, grapes, spruce and orchard grass.

#### 7.1.1.4 Micropropagation

The most basic and extensive use of tissue culture is in the clonal propagation of plants that may be difficult to reproduce by traditional means or that multiply slowly. Given knowledgeable and skillful technical help, improved techniques for rapid micropropagation using disease free callus cultures, cell suspensions, protoplast cultures or somatic embryos can be applied to oilpalm, cacao, aroids, tubers as well as forest trees at relatively low cost. Countries having a basic infrastructure for micropropagation technology should be particularly encouraged by IDRC to advance along the biotechnology gradient.

### 7.1.2 Genetic engineering techniques

Traditionally, plant breeders can only produce new varieties of crops by making sexual crosses between closely related organisms. The process is relatively slow and largely limited by reproductive barriers between species. The most exciting notion offered by genetic engineering is that DNA can be transferred from a cell of any one organism to another unrelated species and made to express itself in the recipient cells. This does not replace plant breeding but instead enlarges its productive horizons because of the immense potential it offers for crop improvement.

7.1.2.1 Transformation technology

Transformation technology has advanced rapidly in the past 5 years so that genes can now be delivered efficiently and effectively integrated into the recipient genome. Every plant biotechnology lab in Canada can use innovative methods based on Agrobacterium as a vector and/or direct physical insertion.

The Agrobacterium approach is limited to dicot plants such as tobacco, tomato and canola because the bacterium does not infect moncots i.e., most of the world's important agricultural crops. The technology is well established, however, and is now being routinely used to produce transgenic plants that are being studied for integration mechanisms, gene regulation and function, and the molecular basis of selective expression of gene families.

Physical insertion methods do not suffer from species limitations but require a sound tissue culture system for the target plant. Selected genes are transferred into protoplasts and the transformed protoplasts must be subsequently regenerated into transgenic plants. DNA is delivered into protoplasts through the plasma membrane by induced osmotic uptake using electroporation or chemical induction, or by direct puncturing of the protoplast using microinjection and particle bombardment. These methods are essentially a 'shotgun' introduction of DNA into the cytoplasm of target cells but significant integration into the recipient genome does occur and technical improvement is inevitable.

The Plant Research Centre, Ottawa and the Plant Biotechnology Centre, Saskatoon are particularly well equipped for teaching and research in transformation technology.

7.1.2.2 Genome mapping

Advances in the three key components of genetic engineering technology - identification and isolation of suitable genes, transfer of selected genes and expression in the transgenic organism - have not proceeded at equal rates, primarily because of the complexity of genetic systems. Engineering of herbicide resistance has been possible because a single enzyme step degrades glyphosate or phosphinotriazines whereas the engineering of drought tolerance, doubtless governed by numerous enzymatic steps, has not been yet been achieved. Finding the right gene to use is the key to successful engineering. A good example is the choice of human metallothionein gene which was transferred into rapeseed and tobacco cells using Agrobacterioum, integrated, and expressed to confer a heavy metal tolerance phenotype in the transgenic plants (Misra, University of Victoria).

The major limitation in genetic engineering remains the paucity of useful genes, but a powerful and simple application of recombinant DNA technology can be used to construct detailed genomic maps that can aid plant breeders as well as molecular biologists in selecting for multigenic traits. Restriction fragment length polymorphism (RFLP) is a method that uses restriction enzymes to locate markers throughout the genome and is actively being developed by several Canadian labs for barley (Molnar), Thai rosewood and Douglas fir (Carlson) and Ustilago (Kronstad). RFLP maps of rice (IRRI), potato (CIP/ENEA Italy) and beans (CIAT) are also being constructed at CGIAR centres.

The genetic engineering of crops will not be commercially viable for another five or ten years but IDRC can help Third World countries prepare for their advancement at all technical levels by using Canadian expertise, and especially Canadian graduate training, to provide them with information, knowhow, and an understanding of the long term benefits offered by biotechnology.

### 7.2 Fish breeding

#### 7.2.1 Sex determination and control in fish

Preference for one sex over the other is common for most farmed animals, either on the basis of flesh quality or growth performance. Monosex culture is standard in the farming of Pacific salmon and becoming widespread in tilapia culture. Control of sex through hormonal manipulation is more applied endocrinology than biotechnology; gynogenesis, androgenesis and chromosome set manipulation are complementary, and more sophisticated, methods. Ed Donaldson's laboratory (Fisheries and Oceans Canada, West Vancouver) is the authority and recommended source of expertise on sex control in fish.

Although determination of sex is an extremely important objective in animal biotechnology (see below), only one laboratory in our survey group was actively working on the problem in fish (Vaisius, Memorial University, for chinook salmon). Once monosex culture is widely established in Third World aquaculture, sex specific DNA probes may also be of value. Although aquaculturists now have the ability to control sex of fish through hormonal manipulation and chromosome set manipulation, the use of sophisticated technology to detect individuals that have not responded to treatment may only make sense in highly intensive farming systems such as are found in the salmon industry.

7.2.2 Stock and strain identification

Ocean and inshore fisheries management often require that large numbers of fish belonging to the same population or strain be distinguished from morphologically identical batches. Traditional tagging of large numbers of fish will in many cases yield to identification of stocks based on similarities in DNA composition.

Knowledge of the degree of variability in any population vastly increases the chance of success of a selective breeding program. In aquaculture, where genetic improvement programmes are just beginning, broodstocks must be kept separate and can be genetically tagged once specific DNA probes are developed; an example is the need to rationalize the choice of strains of tilapias used in aquaculture, based on knowledge of their genetic makeup.

Measurement of genetic distance can also be a powerful tool in describing natural history in fisheries where this is not well known (see Brown and Smith, Simon Fraser University).

During the past two years the number of Canadian laboratories capable of developing stock I.D. probes for fish has greatly increased; note also that the generic nature of molecular biology means that one need not go to a fish laboratory to make these probes. The laboratories of Davidson and Carr (Memorial University) and Smith and Brown (Simon Fraser University) are particularly recommended.

7.2.3 Transgenic fish

The next few years will see rapid expansion of research on producing genetically engineered breeds of fish for aquaculture, with emphasis on growth rate, disease resistance, environmental tolerance and control of sexuality. As in all transgenic work there will be intense competition to develop better ways of inserting foreign genes into eggs or embryos. At present, many laboratories are trying to use sperm cells as a vector for foreign DNA; if this technique does not work, another will arise. Research will also be concentrated on gene expression, and there will have to be a solid, continuing effort at genome mapping that will ultimately enable us to link important production traits with gene complexes that can be transferred and expressed in another species.

Commercial benefits of transgenic fish, and the present dramatic successes with carp and salmon indicate that such organisms will be farmed within the next decade. IDRC should stay abreast of developments because they are inescapable. For the next two or three years, when technology will develop rapidly, the best way to do this will be to support Ph.D. training in leading Canadian laboratories. At present, Choy Hew's laboratory in Toronto is highly recommended for this training; Devlin's laboratory at Fisheries and Oceans in Vancouver will likely become the other centre for training and research once it has been running for a year or so. IDRC should also consider funding specific collaborative research projects in transgenic fish as these develop out of the initial graduate training linkages.

7.2.4 Cryopreservation and genetic conservation

Cryopreservation of gametes of fish and shellfish will be a useful hatchery tool as well as an important means of conserving valuable genetic material. Within the next decade, gene banks will be established for aquaculture. IDRC has already supported work in this area and should continue to do so; attention will have to be paid to determining the potential for transmission of disease with frozen gametes. Extension of the technology to oyster farming is also feasible and could be achieved in a two year project, but should only be pursued where IDRC is supporting intensive culture.

Cryomicroscope facilities and prior experience with fish gametes recommend Mike Ashwood-Smith's laboratory at UVIC for training and development of novel freezing protocols.

## 7.3 Animal breeding

7.3.1 DNA analysis as a measure of genetic distance

DNA sequence analysis is a new and powerful tool for assessing the degree of genetic variability (and hence the selection potential) in a population, and as such will have an important place in the design of breeding programs for cattle and poultry. This is something of a "service" area in biotechnology, and has not attracted the attention of the more glamorous animal breeding technologies such as embryo transfer. It is, however, of fundamental importance to developing breeding programs, and projects in this area should be supported as providing invaluable background information. Our survey turned up only two researchers interested in this area, both of them working with poultry (Cheng and Kuhnlein).

7.3.2 Multiple ovulation and embryo transfer (MOET)

MOET is a complex technology with many components needing research to improve the success rate and ease of use, and to apply it to more species. As a method for greatly increasing the fecundity of desirable breeds, MOET is already having an impact in North American and European farming, just as artificial insemination (AI) has for decades. The usefulness of MOET in Third World countries is the subject of a growing number of papers.

Any decision made by IDRC to fund research or training in this area should first and foremost consider the availability of suitable germplasm to be propagated by MOET. In most cases, of course, this is not known; the transplanting of North American breeds to Third World countries has proponents and opponents of equal repute.

The genetics of production traits in cattle are exceedingly complex; beef production, for example, is controlled by over 200 genes, and setting up high technology to disseminate an "improved" breed in areas where record keeping is practically nonexistent and inproved husbandry could have a significant effect on production may be a waste of money. On the other hand, MOET is here to stay, and there is a very high demand from Third World governments and scientists for training in the technology. Canada can meet this demand as its expertise in the area is second to none. IDRC's present conservative policy on ET is justified but should not rule out support of some components of this very complex technology; IDRC should consider an expert consultation on the application to MOET in the Third World within the next two years.

The field of embryo transfer is so strongly represented in Canada that IDRC has a choice of a number of groups interested in the technology as part of an overall livestock management strategy. These include the excellent resources at Guelph (Smith, Wilkie, Betteridge); Agriculture Canada (Gavora, Nagai, Marcus); University of Saskatchewan (Mapletoft, Murphy). Following are descriptions of MOET components, with recommendations for consideration by IDRC.

7.3.2.1 Design and implementation of breeding programs

This discipline can stand on its own, but is included in the present discussion as being a prerequisite for a successful MOET scheme. It includes assessment of local genetic potential and design of workable schemes for record keeping, including computer software. IDRC should turn to the Centre for Genetic Improvement of Livestock at Guelph (Charles Smith and colleagues) for an integrated approach, as well as to Jan Gavora's group at Agriculture Canada in Ottawa.

7.3.2.2 Follicular maturation and superovulation

Provision of large numbers of embryos for dissemination can be in vivo (superovulation) or in vitro. Both technologies require an improved understanding of follicular dynamics. Laboratories with experience in this area as well as international exposure are those of Downey (McGill), and Rajamahendron (UBC); Betteridge at Guelph is also an endocrinologist with research interests in this area which are well coordinated with the CGIL at Guelph.

7.3.2.3 Disease transfer

There is strong evidence that embryo transfer can be a very effective way of preventing the spread of disease in a cattle breeding programme. By the same token, certification of embryos for export (primarily from developed countries, but ultimately from Third World countries) requires proof that they do not carry disease agents. This "supporting discipline" is strongly represented in Canada at Agriculture Canada in Ottawa (Singh and Hare).

7.3.2.4 Manipulation of embryos

Activities associated with embryo transfer include in vitro fertilization, embryo splitting, cloning and cryopreservation. Success in transferring any of these technologies requires a firm grounding in veterinary medicine, endocrinology and immunology, and IDRC should consider supporting Canadian groups where all of this expertise is available. Leading specialist laboratories in Canada are those of Nagai and Marcus (cloning); Betteridge (splitting and cryopreservation); and Ashwood-Smith (cryopreservation). Work at Willadsen's laboratory (Alta Genetics Ltd. in Calgary) is highly regarded but commercially well protected.

Embryo manipulation is a good example of a field in biotechnology where rapid developments make the technology potentially attractive to Third World scientists and administrators, but lack of infrastructure makes application of the technology risky. In this situation IDRC should consider supporting Ph.D. training, rather than technical training, so that as the technology develops, Third World scientists can adapt it to their own conditions.

A peripheral technology that will be used in support of embryo manipulation and transfer is sexing embryos. Several laboratories in Canada are attempting to do this by developing sex-specific DNA probes. IDRC should consider projects involving this technology in cases where the species or breed in question does not represent a significant world market, as the technology has very high commercial value.

7.3.3 Genetic engineering: engineered rumen bacteria and transgenic animals

Two laboratories in Canada are working on modifying cattle rumen bacteria to metabolize coarse forage (Anne Gibbons, Guelph) and to synthesize supplementary amino acids (Frank Sauer, Agriculture Canada). The eventual development of transgenic poultry and cattle is the goal of a number of other laboratories, with improved disease resistance the most realistic end point in view of the relatively ferw genes controlling this group of traits. Research is, however, long term (as it is for fish), and involves much work simply to identify the genes responsible for desirable traits; in many cases nobody is even sure what traits are desirable.

Because transgenic animals will be introduced into production systems within the next decade, IDRC should monitor research developments closely. Over the next few years, graduate training in any of the laboratories described in Section 8 will be an effective way of providing Third World countries with skills that can be turned to their own problems as the technology matures.

## 7.4 Diagnostics and vaccines

### 7.4.1 Plant disease diagnostics

The major uses for modern diagnostics in agriculture are in research and development, regulation and crop management. Much of this technology is well developed and can be made available almost immediately for many crops and their pests and diseases in the Third World. Applications of immunology and molecular biology for crop management include accurate disease diagnosis, selection of pathogen free planting material and the detection and monitoring of pathogens in crops and soil.

Recent improvements in assay technology have made possible the development of sensitive, specific and easy to use immunoassays for the detection and quantification of microorganisms, chemicals and plant products.

Monoclonal antibodies (MABs) are now widely used commercially for improved diagnosis in human health care. In plant agriculture, MAB technology is a potentially powerful tool for disease diagnosis because MABs are highly specific, can be produced in large quantities, and can be used in simple, rapid diagnostic tests based on enzyme linked immunosorbant assay (ELISA) procedures. MAB technology is relatively robust, much simpler than recombinant DNA technology, and detects antigens at very low levels.

The immediate application of this technology in developing countries is feasible in the form of diagnostic kits designed for specific targets such as the one for potato leaf roll virus developed by the biotechnology group at the Agriculture Canada Vancouver Research Station. This kit is freely available to research institutions but is also being commercially marketed in Third World countries.

Nucleic acid probes have also been developed for detection of many plant pathogens. Their use, however, is limited by the presence of radioactive labels. Many labs are now developing stable and sensitive nonradioactive probes for easy field application.

The use of MAB diagnostics does not require sophisticated technology in developing countries - only purchasing power. At present it appears more efficient for most countries to use ready-made systems from industrialized nations, but long term investment in the internal development of agricultural diagnostics is more appropriate to the self actualization process that IDRC promotes.

Canada can provide technical training for foreign scientists in modern diagnostic technology at several well equipped institutions and provide on site assistance for the development of specific MAB and DNA probes to be used locally.

7.4.2 Fish disease diagnostics

Diagnosis of bacterial and viral diseases of fish can be achieved by developing DNA probes specific for the organisms, or by producing a monoclonal antibody that reacts only with the organism. Both approaches lend themselves to production of field kits for diagnosis, and both have obvious commercial applications that mirror the much larger market for diagnostics in veterinary and human medicine.

Canadian companies involved in developing diagnostic kits for fish diseases include Quadralogic Technologies (DNA), Helix Biotech (MAB) and Microtek (MAB). In the university research community, the laboratory of Allan Vaisius (Memorial University) is highly recommended both on the basis of its development of an IPN (infectious pancreatic necrosis) probe and on the willingness to become involved in comparable Third World projects. The laboratory of Bill Kay at the University of Victoria is recommended for developing diagnostics using the immunological approach.

7.4.3 Animal disease diagnostics and vaccines

Canadian laboratories active and recommended for collaboration are those of Michael Clarke (Western Ontario), Bruce Wilkie (Guelph) and Lorne Babiuk (VIDO). Wilkie is also interested in genetically engineering so-called "cassette vaccines", which are viral carriers with a range of antigenic determinants capable in theory of immunization against a number of different diseases. Research on cassette vaccines is long term; as with transgenics, IDRC should support Ph.D. training in this area before it supports full blown collaborative research projects.

7.4.4 Identification of pests using DNA probes

Nematodes parasitic on animals and plants present an unusual case where diagnosis is frequently difficult due to the problems of identifying species. Molecular biology is now being used to develop diagnostic probes for important nematode pests in the same way as viral and bacterial diseases are now being approached. IDRC should support straightforward molecular biological research of this type as lending itself well to international collaboration; the laboratory of Baillie (SFU) is recommended.

### 7.5 Agricultural microbiology

Potential applications in agricultural microbiology include the traditional methods for the selection and multiplication of beneficial microorganisms as inoculants to stimulate plant growth and reduce fertilizer use; the use of genetically engineered microorganisms as biological control agents; and the application of recombinant DNA technology to disarm pathogenicity in infectious organisms.

Molecular biologists working in this area are trying to understand the basic mechanisms regulating pathogen infection and factors determining host resistance in various cereal and forest diseases, and the engineering of organisms remains theoretical until genomic data gathering is complete.

The most useful contribution they can currently make to developing countries is to provide training in the theory and technical skills aimed at specific disease problems requiring new biotechnology for solution.

### 7.6 Biological pest management

Release of natural enemies of insect pests is a strategy that has attraction for Third World application because breeding of the pest control agent can be done locally. The Centre for Pest Managemet at Simon Fraser University (Mackauer, Webster, Rutherford) has international experience using insect and nematode control agents. Semiochemicals (insect communication chemicals) are proving to be powerful tools in pest mangement as well; John Borden's laboratory at SFU has already suggested to IDRC a research program aimed at a pheromone control strategy for an important Southeast Asian pest.

Novel pesticides derived from plants or marine organisms have potential application worldwide. Environmental concerns over the continued use of synthetic pesticides will result in further development in this area during the next decade. Canada has world-leading resources in identification and preliminary testing of such compounds (Towers, Arnason, Borden).

IDRC support for the identification and testing of natural compounds should reflect several realities. First is the realization that many plant-derived biocontrol agents are potentially harmful to operators - for example, photosensitization is a common side effect.

The relative lack of safety registration requirements in Third World countries should not be an excuse for inadequate testing. Second, although local manufacture and distribution of plant derived pesticides is an attractive goal, the reality is that local entrepreneurs will only be interested where there is profit, and local extension networks must be in place where there is likely to be none. Either way, post-project implementation must be a factor right from the start.

## 8. CANADIAN SCIENTISTS WHOSE WORK HAS POTENTIAL APPLICATION TO THIRD WORLD PROBLEMS

To assist the several divisions within AFNS in gaining a broad idea of Canadian biotechnological resources, the following inventory is classified according to plant, fisheries and animal applications. As already noted, the inventory is not comprehensive, and should be considered a starting point only.

### 8.1 Forest biotechnology

**Carl J. Douglas,**
Department of Botany,
University of British Columbia,
6270 University Boulevard,
Vancouver B.C. V6T 2B1
Tel: 604-228-2618

Assistant Professor. Plant molecular geneticist; postdoctoral fellow at Max Planck Institute and University of Washington, Seattle. Research mostly mainline molecular biology.

NSERC project on application of biotechnology for the improvement of cultivated poplar clones - objective is to study the control of phenylpropanoid metabolism during pathogen infection and secondary growth to create and/or screen for improved poplar cultivars.

Well equipped and active lab; technology transfer capability and enthusiasm.

**John K. Carlson,**
Biotechnology Laboratory and Forest Sciences,
3220-6270 University Blvd,
University of British Columbia,
Vancouver, B.C. V6T 1W5
Tel: 604-228-4733

Plant geneticist with five years of experience at Allelix. Assistant professor. Well equipped new laboratory.

Overall objective at UBC is the application of molecular genetics and plant biotechnology to forestry for plant improvement and understanding developmental gene expression. Recently initiated projects include: genome mapping of Thai rosewood, Pseudotsuga menziesii, Chamaecyparis nootkatensis; somatic embryogenesis of P. menziesii and Camellia spp.; development of transformation systems for conifers (NSERC).

Two proposals under consideration: development of genomic map for P. menziesii (NSERC); micropropagation of C. nootkatensis (IRAP).

Strong interest in Third World afforestation projects, knowledgeable about international biotech scene. Has Philippine connections and was involved in 1985 Allelix/IRRI proposal to IDRC for the development of new rice varieties. Has six graduate students and associates working on projects. Three CIDA students from Thailand on CIDA grants inherited from another professor.

Capable of effective technology transfer and training of scientists.

**Gary Hicks,**
Biology Department,
Dalhousie University,
Halifax Nova Scotia B3H 4J1
Tel: 902-424-3563

Telephone interview only; was absent for prearranged meeting in Halifax and instead represented by summer assistant Marc Chiarot. Has not made further contact with MTL.

Teaches plant anatomy; was doing tissue culture of ornamentals but according to Mr. Chiarot, is no longer supported by NSERC. Looking for funds to develop micropropagation techniques and somatic embryos of Picea varieties and Abies spp Some collaboration with R. Cervelli at Nova Scotia Research Centre. Indicated interest in tropical conifers on telephone but has not provided details. Only individual doing plant tissue culture at Dalhousie.

Small laboratory, basically equipped; uses communal growth room and transfer facilities.

Summer student Balsam fir project two months old in June 89.
New Masters student, part time, starting September 89.

**Patrick von Aderkas,**
Department of Biology,
University of Victoria,
P.O. Box 1700,
Victoria BC V8W 2Y2
Tel: 604-721-8926

Postdoctoral research on genetic improvement of conifers with Jan Bonga, Canadian Forestry Service, Fredericton. Successful induction of regeneration in haploid embryogenic cultures of Larix decidua.

Current research focus as part of Forest Biotechnology Centre is the clonal propagation of improved conifer seed stock. Projects for

Western forest tree species such as L. occidentalis and Pseudotsuga menziesii include the development of micropropagation systems; induction of haploid and diploid embryos; suspension and protoplast working cultures; homozygous lines by fusion of haploid cells to create effective multiplication systems with optimal yield and propagule quality.

Well equipped lab in new Science and Technology building.

**Santosh Misra,**
Biochemistry/ Forest Biotechnology,
University of Victoria,
P.O. Box 1700,
Victoria, B.C. V8W 2Y2
Tel: 604-721-8928

Trained as plant molecular biologist. While at Biotechnica introduced human metallothionine gene into Brassica napus using Agrobacterium tumefaciens. Looking for water tolerance markers in mature viable somatic embryos of Pseudotsuga menziesii and Picea glauca in order to develop genetic probes for screening transplants. Well equipped lab in new Science and Technology building. One graduate student starting September 89.

Interested in biotechnology transfer to developing countries; numerous contacts in India.

**Chris Chanway,**
Department of Forest Sciences,
270-2357 Main Mall,
University of British Columbia,
Vancouver, B.C. V6T 1W5
Tel: 604-228-6019

Assistant professor. Ecophysiologist with agriculture background - UBC Plant Science. Postdoctoral work at Plant Biotechnology Institute, Saskatoon. Research programme on conifer physiology just begun.

Experienced in free-living soil bacteria that will colonize plant roots and increase yields and interested in the potential interaction between soil bacteria and mycorrhizae applied to poor soils sites.

No particular interest in development projects.

**William Vidaver,**
Department of Biological Sciences,
Simon Fraser University,
Burnaby, B.C. V5A 1S6
Tel: 604-291-4475

Professor. Research interests in plant physiology and photobiology; biophysical and ecophysiological aspects of photosynthesis; plant tissue culture and micropropagation in B.C. conifer species and tropical forest trees.

Impressed by research capability in the Institute of Tropical Biology, Bogor - can potentially apply plant tissue culture techniques for improvement of sambala cultivation. At Ambon University, East Java, minimally equipped basic tissue culture lab devoted to identifying and maintaining endangered cassava cultivar genomes.

Interested in collaborative projects using biotechnology. SFU well equipped for molecular biology; active in development of Indonesian academic expertise.

**Lin Kemp,**
Department of Biological Sciences,
Simon Fraser University,
Burnaby, B.C. V5A 1S6
Tel: 604 -291-4475

Cell biologist with recent interest in molecular biology. Developing projects on tissue culture and genomic analysis of hemiparasitic dwarf mistletoe; micropropagation and tissue culture of conifers.

**Lewis Melville,**
Department of Botany,
University of Guelph,
Guelph, Ontario N1G 2W1
Tel: 519-824-4120

Research associate of R. K. Peterson. Interested in information transfer of mycorrhizae technology for Third World reforestation projects. Wants to make electronic conference on agroforestry available to developing countries e.g. computer network connection between Guelph and Bogor.

No followup with MTL.

**Ben C.S. Sutton,**
Forest Biotechnology Centre,
B.C. Research,
3650 Wesbrook Mall,
Vancouver, B.C. V6S 2L
Tel: 604-224-4331
Fax: 604-224-0540

Head of Forest Biotechnology group at B.C. Research Corporation, a private company engaged in contract work. Activities include development of clonal propagation, somatic embryo and artificial seed technology for Picea species; development of embryos using mature tissue from selected individuals; transformation and regeneration of Picea and Pseudotsuga for transfer of specific Bt toxin genes; analysis of nuclear genome markers to separate Picea races in seed lots (BC Science Council); development of commercial bacterial inoculant for forestry ( IRAP with Allelix).

Lab well equipped, group interested if technology is appropriate for them. Needs 120-130% overhead covered in contracts.

**Martin Hubbes,**
Department of Forestry,
33 Willcocks Street,
Toronto, Ont. M5S 3B3
Tel: 416-978-6512

Forest pathologist working on Dutch Elm pathogen. Projects include: induction of mansonones by Ophiostoma ulmi in callus cultures of Ulmis pumila; identification and mapping of virulence genes in Ophiostoma by morphological, biochemical and molecular markers; biocontrol of termites using parasitic nematodes.

Very keen on development projects. Has two students from Harbin working on Dutch elm disease.

**Louis Zsuffa,**
Department of Forestry,
33 Willcocks Street,
Toronto M5S 3B3
Tel: 416-978-6512

Forest geneticist. Involved in development projects with CIDA and IDRC in China and Costa Rica. Projects include: genetic characterization of some white pine species and hybrids; development and selection of stock clones in Salix; establishment of isozyme markers for identification of important poplar hybrids and clonal varieties.

Currently has 3 PRC scientists and 1 student. Enthusiastic about collaborative projects.

**David J. Gifford,**
Department of Botany,
University of Alberta,
Edmonton, Alberta T6G 2E9
Tel: 403-492-5463

Telephone conversation only. Assistant Professor. Major research interest is in the improvement of conifer seed viability in nurseries by studying the biochemical mechanisms that control germination. Also developing somatic embryogenesis protocols for Pinus species as an alternative to zygote germination.

Interested in applying technology to Araucaria species in Brazil.

**John Hoddinott,**
Department of Botany,
University of Alberta,
Edmonton, Alberta T6G 2E9
Tel: 403-492-4587

Interested in forest technology transfer to Third World. Projects include: factors which enhance cultivation of tree seedlings; carbon partition in aluminium tolerant wheat cultivars; regeneration of hardwood forests; light quality effects on forest growth and reestablishment

Department plant growth facilities are extensive and made available to other research institutes. Improving current plant tissue culture facilities.

### 8.2 Plant biotechnology

**John E. Thompson,**
Chair,
Department of Horticultural Science,
University of Guelph,
Guelph, Ontario N1G 2W1
Tel: 519-824-4120

Post harvest lipid physiologist particularly interested in membrane deterioration and disassembly during senescence. Six new hires in HortScience in last 18 months, all molecular biologists.

Cautious about Third World projects but wants to evaluate individual proposals for department. Not informed about development problems and not much thought given to potential Third World applications of biotechnology.

**Jim Tsujida,**
Department of Horticultural Science,
University of Guelph,
Guelph, Ontario N1G 2W1
Tel: 519-824-4120

Telephone conversation only. Not interested in MTL visit. Developing commercial application of dehydrated somatic embryos of geranium for industry. Beginning work on artificial seeds for commercial celery. Postdoctoral fellow Albert Marsolais experienced in development of hybrid seed production from somatic embryos.

Does not see how somatic embryogenesis technology and artificial seed development can be applied to Third World agriculture.

**Steven Rothstein,**
Department of Molecular Biology and Genetics,
University of Guelph,
Guelph, Ontario N1G 2W1
Tel: 519-824-4120

NSERC/Allelix Plant Molecular Biology Research Chair. Telephone conversation only. Interests include isolation, characterization and regulation of nitrate assimilation genes; isolation of self-incompatibility alleles in Campestris (with Allelix); formation of free radicals in senescence.

Highly regarded researcher but not interested in practical application for development projects.

**Vern I. Shattuck,**
Department of Horticultural Science,
University of Guelph,
Guelph, Ontario N1G 2W1
Tel: 519-824-4120

Breeder of cruciferous vegetables and parsnips for disease resistance. Does not consider himself knowledgeable in biotechnology but interested in helping to train and provide technical support in collaborative Third World projects.

**Vince Souza-Machado,**
Department of Horticultural Science,
University of Guelph,
Guelph, Ontario N1G 2W1
Tel: 519-824-4120

Professor. Teaches course in tropical/subtropical agriculture and gives seminars on small farmer problems. Uses basic tissue culture technology to improve potato propagation methods in developing countries: minitubers for field planting developed from meristem cultures; microtubers developed and stored in vitro for transplant.

Informed about status of potato problems in South America, South East Asia, India. Very practical application of low level biotechnology for small farmers.

**Wally D. Beversdorf,**
Chair,
Department of Crop Science,
University of Guelph,
Guelph Ontario N1G 2W1
Tel: 519-824-4210.

Uses microspore cultures for protein and oilseed crop breeding.

Organized two week workshop on microspore culture for Chinese rapeseed breeders (IDRC). Success was due to preplanning and effective two-way communication - both elements critical to collaborative development projects.

**J. Derek Bewley,**
Chair,
Department of Botany,
University of Guelph,
Guelph Ontario N1G 2W1
Tel: 519-824-4210.

Generally interested in physiology and biochemistry of seed development, dormancy, germination processes and stress responses of plants, with particular interest in mechanism and regulation of desiccation tolerance in somatic embryos. Botany department not particularly strong in molecular biology.

Interested in collaborative projects with developing countries and training in basic research.

**K. Peter Pauls,**
Director,
Plant Biotechnology Centre,
University of Guelph,
Guelph Ontario N1G 2W1
Tel: 519-824-4210.

Development of tissue culture technology for crop improvement. Works on protoplast, microspore cultures of alfalfa and Brassica species. Interested in application to tropical crops e.g. applying alfalfa somatic embryo and artificial seed technology to cassava for vegetative propagation and hybrid development; developing microspore cultures and homozygous breeding lines; tissue culture technology for virus screening.

Department is particularly well equipped for tissue culture.

**Bryan D. McKersie,**
Department of Crop Science,
University of Guelph,
Guelph Ontario N1G 2W1
Tel: 519-824-4210.

Assistant Professor. Member of team applying artificial seed technology to alfalfa for: mass propagation of parental self-sterile lines for commercial hybrid production; long term storage of germplasm; international transport of disease free clones.

Lab focus is on production of synchronized somatic embryos and subsequent desiccation technology. Process under patent consideration.

Enthusiastic about applications of technology.

**Ken J. Kasha,**
Department of Crop Science,
University of Guelph,
Guelph Ontario N1G 2W1.
Tel: 519-824-4210.

Cytogeneticist interacting with plant breeders interested in: production of haploids in cereals using anther and microspore cultures and chromosome elimination techniques; transformation of barley microspores using particle guns; development of molecular probes for chromosomes; gene isolation and cloning of barley genes.

Interested in collaborative projects - discussing possible research areas with INTA.

**James N. Kronstad,**
Biotechnology Laboratory,
6174 University Boulevard,
Vancouver, B.C. V6T 1W5
Tel: 604-228-4732

Plant/Forest Biotechnology group. Assistant professor. Molecular geneticist, studied Bacillis thuringiensis crystal protein genes, expression of heterologous proteins in yeast.

Interested in regulation of Ustilago maydis and U. hordei dimorphic pathogenicity: understanding B locus genes controlling formation of infectious dikaryons in order to engineer nonpathogenic strains; begin construction of RFLP maps of Ustilago.

Not immediately interested in applied molecular biology - wants to understand fundamentals of smut gene function and regulation.

**Danielle Donnelly,**
Department of Plant Science,
MacDonald College of McGill University,
21, 111 Lakeshore Rd.,
Ste. Anne de Bellevue, Quebec H9X 1C0
Tel: 514-398-7856

Plant tissue culture expert with interest in micropropagation. Associated with CIDA Egypt project through MacDonald college; has a student there and trained two visitors.

Very strong interest in establishing potato tissue culture in Egypt, including a certification program for virus-free strains. Research needed to scale up tissue culture procedures and ensure stability in long term culture; also must asist Egypt in becoming self sufficient in producing antiserum for field checks for viral recontamination.

Strongly motivated and recommended for further IDRC collaborative research.

**Dan C. W. Brown,**
Agriculture Canada,
Plant Research Centre,
Ottawa K1A 0C6
Tel: 613-995-3700

Research Scientist. Developmental biologist working on alfalfa. Current projects include: heritability of somatic embryogenesis trait; understanding biochemical and molecular changes during induction of embryogenesis and subsequent development; application of somatic embryogenesis in the micropropagation of select germplasm for hybrid development.

Part of the artificial seed group, working on the regeneration and tissue culture of dehydrated alfalfa somatic embryos.

**Brian L. Miki,**
Agriculture Canada,
Plant Research Centre,
Ottawa K1A 0C6
Tel: 613-995-3700

Research Scientist. Molecular geneticist interested in gene expression. Lab produces transgenic plants using Agrobacterium and microinjection transformation technology with emphasis on specific targetting and integration.

Current projects include: development of transformation systems and construct vectors for Brassica napus; engineering of herbicide tolerance in canola via Agrobacterium-mediated gene transfer; identification, isolation and characterization of gene expression in canola microspore cultures; isolation and genetic engineering of acetohydroxyacid synthase (AHAS) genes in Arabidopsis and Brassica.

Has recieved many requests from Third World students for technology training. Well equipped lab, active group, many collaborators. Enthusiastic about potential practical applications of current biotechnology.

**Bin Huang,**
Agriculture Canada,
Plant Research Centre,
Ottawa K1A 0C6
Tel: 613-995-3700

Scientist from the Peoples' Republic of China associated with Allelix. Expert in direct DNA transformation techniques. Developing microinjection technology for using canola microspore cultures. Very knowledgeable and highly skilled.

**Ken C. Armstrong,**
Agriculture Canada,
Plant Research Centre,
Ottawa K1A 0C6
Tel: 613-995-3700

Research Scientist. Cytogeneticist working on cereals. Current projects include: detection and identification of alien chromatin incorporated into crop species using genome specific repetitive DNA probes, RFLPs and isozyme differences; development of physical gene maps; development of chromosome specific DNA probes for gene isolation.

**Wilf A. Keller,**
Agriculture Canada,
Plant Research Centre,
Ottawa K1A 0C6
Tel: 613-995-3700

Research Scientist. Heads Plant Biotechnology Programme at Plant Research Centre. Lab works with Brassica. Developed microspore culture system. Specific projects include: production and utilization of haploid canola and tropical oilseed cultures; development of efficient regeneration techniques for haploids and/or doubled haploids from microspore-derived embryos; development of efficient and reliable technology for Brassica protoplast regeneration; transfer of selected traits from wild crucifers to canola and mustard by somatic hybridization; in vitro induction and selection of herbicide resistance genes using mutagenized microspores and protoplasts.

Well equipped lab has had numerous visiting foreign scientists. Haploid culture easily transferred and desirable for plant breeding in Third World. Development and transfer of technology for tropical oilseeds funded by IDRC.

**M. Keith Pomeroy,**
Agriculture Canada,
Plant Research Centre,
Ottawa K1A 0C6
Tel: 613-995-3700

Research Scientist, experienced lipid biochemist. Using microspore culture system to: determine fatty acid composition of lipids from developing embryos grown under varying conditions; characterize lipid biosynthesis in Brassica embryos; modify fatty acid composition in developing Brassica embryos.

Has realistic long range objectives for genetic engineering technology.

**George Fedak,**
Agriculture Canada,
Plant Research Centre,
Ottawa K1A 0C6
Tel: 613-995-3700

Cytogeneticist interested in disease resistance in wheat and barley. Projects include: intergeneric hybridization in cereals to transfer disease resistance and stress tolerance traits from wild and ancestral species to cultivated wheat and barley; characterization of RFLP markers for resistant genes in barley; collaboration with David Miller on Fusarium vomitoxin resistance in cereals.

Interested in hosting foreign postdoctoral fellows.

**Steve J. Molnar,**
Agriculture Canada,
Plant Research Centre,
Ottawa K1A 0C6
Tel: 613-995-3700

Research scientist who applies molecular biology to genetic assessment in plant breeding. Currently developing RFLP map for barley.

Interested in developing nonradioactive and dotblot oligomer probes for rapid and simple field screening by breeders and farmers. Technology particularly suitable for Third World.

**Michael M. Oelck,**
Agriculture Canada,
Plant Research Centre,
Ottawa K1A 0C6
Tel: 613-995-3700

Visiting scientist from Hoechst, Frankfurt. Agronomist and plant geneticist who is looking for herbicide resistance in Brassica and other vegetables.

Detoxification of phosphinotriazine as a single enzyme reaction and resistant plants are produced by using Agrobacterium infected microspore cultures to mutate and select for resistance to LPPT.

**Robert Murgita,**
Director,
Office of Biotechnology,
Dawson Hall,
McGill University,
853 Sherbrooke West
Montreal Quebec H3A 2T2
Tel: 514-398-3914

Did not appear for previously arranged meeting in June. Has not since returned telephone messages. The Biotechnology Centre is reported to consist of an interdisciplinary group of molecular biologists.

**Barid B. Mukherjee,**
Chair,
Biology Department,
McGill University,
1205 Avenue Docteur Penfield,
Montreal, Quebec H3A 1B1
Tel: 514-398-6403

Professor. Department has strong ecology and molecular biology groups. Biotechnology is emphasized in Plant Science.

Enthusiastic about Chinese students and research scientists and the strong infrastructure in Indian laboratories. Supportive of applied Third World projects.

**Paul A. Horgen,**
Director,
Centre for Plant Biotechnology,
University of Toronto,
Department of Botany,
Erindale Campus, Mississauga Ontario L5L 1C6
Tel: 416-828-5424.

Professor classicially trained in fungal genetics, recently acquired expertise in biotechnology. Works on commercial Agaricus breeding biology and genetics.

Centre has 25 associates from botany, forestry, engineering and industry. Projects include development of transgenic crop plants resistant to viruses; nonradioactive assay for virus and viroid detection in potatoes; marker for drought resistance in pine seedlings; gene transfer system for commercial mushroom; use of somaclonal variation for genetic improvement of tomato; molecular cloning of genes associated with cold hardiness; induction and evaluation of haploid and dihaploid lines in willow and poplar species; selection of insect parasitic nematodes for pest control.

Interested in applied collaborative projects for the centre.

**John P. Williams,**
Department of Botany
St. George Campus,
University of Toronto,
Toronto Ontario M5S 1A1
Tel: 416-978-3540

Lipid biochemist primarily interested in the molecular basis of cold tolerance in plants. First director of Centre for Plant Biotechnology at the University of Toronto. Very supportive of biotechnology research.

**Trevor A. Thorpe,**
Department of Biology,
University of Calgary,
2500 University Drive NW,
Calgary, Alberta T2N 1N4
Tel: 403-220-6126

Professor in Plant Physiology Research Group, halftime as Associate Dean. Has considerable experience in international projects, foreign scientists and students, and is active as a consultant with IDRC. Major interest is in the application of tissue culture technology.

Currently advising University of Costa Rica IDRC project on the micropropagation of Peach palm and Xanthosoma virus detection and phytosanitation procedures.

Wants continued participation in development projects and is prepared to provide training, research collaboration and technology transfer. Prefers to work with countries that have strong research infrastructure such as Cuba and Costa Rica.

**Keith E. Denford,**
Chair,
Department of Botany,
University of Alberta,
Edmonton, Alberta T6G 2E9
Tel: 403-492-3484

Phytochemist. Did not appear at prearranged meeting.

**Greg J. Taylor,**
Department of Botany,
University of Alberta,
Edmonton, Alberta T6G 2E9
Tel: 403-492-2598

Assistant professor. Studies the physiology and biochemistry of metal phytotoxicitity to: identify mechanisms that confer aluminum and manganese tolerance in wheat cultivars and in Phaseolus suspension cultures; isolate and identify protein produced by plant under metal stress; identify tolerant cultivars of important crops.

Has a PRC postdoc (CIDA) working on tolerance mechanisms. Enthusiaistic about training and technology transfer in collaborative projects.

**David D. Cass,**
Department of Botany,
University of Alberta,
Edmonton, Alberta T6G 2E9
Tel: 403-492-3248

Professor. Cell biologist who has helped developed a technique that may be used for in vitro fertilization in wheat and corn.

Technology has considerable application in international agriculture: live sperm cells from pollen protoplast cultures can now be fused with somatic cells to produce gametosomatic hybrids; transformed microspore cells can be used to integrate specific genes into the hybrid e.g. glyphosate resistant gene.

Interested in collaborative projects and technology transfer, particularly to PRC.

**Warren Steck,**
Director,
Plant Biotechnology Institute,
110 Gymnasium Road,
Saskatoon, Saskatchewan S7N 0W9
Tel: 306-975-4191.

Primary emphasis at PBI is research on biotechnology for higher plants. There are 6 projects based in one of 3 laboratories: Plant Cell Technology, Plant Gene Technology and Biological Chemistry. These are:

methods development in molecular genetics for genetic transformation e.g., transfer of herbicide resistant genes to canola;

application of biotechnology to legumes - to identify and characterize genes controlling agriculturally important traits of egumes and associated microorganisms;

tissue culture, micropropagation and genetic engineering in conifers to improve growth rates, increase disease resistance and stress tolerance;

crop biotechnology applied to monocots e.g., selection of herbicide resistant and frost tolerant varieties in spring wheat; development of in vitro wheat regeneration systems for genetic manipulation experiments;

development of synthetic plant growth promoters; applications of plant and plant derived semiochemicals for crop protection from insects; modification of phytochemical phenotypes through DNA technology;

development of new plant cell bioreactors and use in production of pharmaceutical metabolites.

PBI's research facilities for plant biotechnology are excellent and its scientists collaborate with researchers all across Canada, Europe and Brazil. PBI is interested in technology transfer and collaborative research projects with Third World countries.

**John P. van der Meer,**
Assistant Director,
Atlantic Research Laboratory,
1411 Oxford Street,
Halifax, Nova Scotia B3H 3Z1
Tel: 902-426-4927
Fax: 902-426-9413

Institute has a large new molecular genetics group interested in genetic characterization of marine algae with known potential commercial value and alge which are at key junctions in current evolutionary theory.

Projects include development of plasmid as vector for genetic engineering of red algae; tubulin gene structure, regulation and expression in brown and red algae; development of herbicide resistant genes needed for alga culture; cultivation of diatoms as a source of biological silica; isolation and characterization of bioactive toxins from marine organisms.

Lab has new and sophisticated equipment for molecular biology. Interacts with PRC Developmental Biology Institute in Beijing which has a strong aquaculture programme but limited facilities for marine algae molecular biology and genetics.

**Michael Smith,**
Director,
Biotechnology Laboratory,
University of British Columbia,
6174 University Boulevard,
Vancouver, B.C. V6T 1W5.
Tel: 604-228-2838

Molecular biologist experienced in chemical sysnthesis of nucleic acids and the use of DNA fragments as tools for gene isolation, nucleic acid sequence determination and site specific mutagens in genetic engineering. Research emphasis in Biotechnology Laboratory is in heme protein engineering.

UBC's Biotechnology Laboratory has 3 areas of activity: molecular biology, fermentation and process engineering and plant /forest biotechnology. Ten new faculty have been appointed recently and aim to eventually produce disease resistant conifers, new varieties of agricultural crops, strategies for treating crop diseases, and more economical procedures for producing monoclonal antibodies.

Lab facilities in all 3 areas are new and well equipped.

**Bob C. Miller,**
Vice President, Research,
Department of Microbiology,
University of British Columbia,
Vancouver, B.C. V6T 1W5

Professor. Research microbiologist who is politically informed about biotechnology and widely connected with the established scientists in Canada.

### 8.3 Plant disease diagnosis

**Biotechnology Group,**
Agriculture Canada,
Vancouver Research Station,
6660 NW Marine Drive,
Vancouver B.C. V6T 1X2
Tel: 604-224-4355

Research emphasis is on development of agricultural diagnostic probes for viruses. Group meeting with Dick Hamilton, Bob Martin, Peter Ellis, Rick Stace-Smith, Deanne Rochon, Andrew Wieczorek and H. Pepin.

Activities include development of: monoclonal and polyclonal probes for major plant viruses to aid certification of virus-free plants; field kits for identification of virus free clones; diagnostic kit for potato leaf roll virus (PLRV) - now marketed commercially; polyclonal and monoclonal diagnostic tests for Phytophora; nonradioactive probes for field diagnosis; virus resistant transgenic plants.

Well equipped station with a Monoclonal Antibody Facility which provides technical training and advice on MAB projects. Currently active in Peru (CIDA), training and setting up of central and regional MAB facilities. Negotiating for project on development of MAB and cDNA diagostic probes with IITA (IDRC).

## 8.4 Fisheries and aquaculture

### 8.4.1 Stock and strain identification

**Steven Carr,**
Department of Biology,
Memorial University of Newfoundland,
St. Johns's, Nfld. A1B 3X9
Tel: 709-737-4776
Fax: 709-737-4569

Systematic biologist presently applying recombinant DNA techniques for stock identification in cod fishery. Has developed a direct sequencing PCR technique for mitochondrial DNA that is faster and more informative than restriction enzyme techniques; currently processing 24 fish per day.

Works in collaboration with Willy Davidson of Dept of Biochemistry (see below). Together with Davidson, should be considered a competent resource for training and/or research on fisheries stock identification using DNA. A basic scientist interested in applying techniques to Third World problems but needing assistance in identifying problems and collaborators.

**William Davidson,**
Department of Biochemistry,
Memorial University of Newfoundland,
St. Johns's, Nfld. A1B 3X9
Tel: 709-737-4468

As for Steven Carr above, a basic biologist with much to offer in developing DNA technology for stock identification in fish. No Third World contacts but recommended as an excellent, well regarded scientist with the right personality for international collaboration.

**Mike J. Smith,**
Institute of Molecular Biology and Biochemistry,
Department of Biological Sciences,
Simon Fraser University,
Burnaby, B.C. V5A 1S6
Tel: 604-291-4475

Senior faculty member. Invertebrate biologist (starfish, octopus) with interest in gene flow patterns accompanying resettlement of oil spill areas. His work has implications for ownership of offshore fisheries stocks. Work involves study of migration patterns and associated genetic diversity.

Brief consulting experience in S.E. Asia several decades ago. Interested in working on Third World problems but not to exclusion of basic research.

Laboratory equipped for PCR.

**Jim R. Brown,**
Institute of Molecular Biology and Biochemistry,
Department of Biological Sciences,
Simon Fraser University,
Burnaby, B.C. V5A 1S6
Tel: 604-291-4475

Ph.D. student under Mike Smith and Andrew Beckenbach. Dissertation research analyzes mitochondrial DNA to study genetic variation in West Coast sturgeon populations using DNA amplification by PCR and DNA sequencing. Has identified eight clonal lines based on mtDNA divergence, described phylogenetic relationships between poorly delineated species. By linking mtDNA homologies with age data, has deduced important life history information, e.g., frequency of spawning. His results demonstrate the power of genetic analysis in that they are based on approximately 100 samples only. Technology could be applied to Third World fishery resources where natural history information is lacking but vital for effective management (e.g., milkfish).

Co-supervisor Beckenbach is a population geneticist also familiar with analysis of mtDNA variation (not interviewed).

**Jon Wright,**
Department of Biology,
Dalhousie University,
Halifax, N.S. B3H 4J1
Tel: 902-424-6468

Basic molecular biologist interested in genome organization and taxonomy of teleost fishes. Recently joined Dalhousie and presently active in helping to organize their new, Provincially funded Gene Probe Laboratory. Interested in developing DNA probes for fish stock identification; current research on Atlantic species, also collaborating with Brendan McAndrew (Stirling University) to develop reference library of tilapia DNA using Stirling's "pure strains". Studying sexual maturation in tilapias and salmon in collaboration with Department of Biochemistry.

No international experience or contacts other than through association with Roger Doyle.

**Ruth Withler,**
Fisheries and Oceans Canada,
Pacific Biological Station,
Hammond Bay Rd.,
Nanaimo, B.C. V9R 5K6
Tel: 604-756-7000

Classical geneticist with background in using electrophoretic markers for fish stock identification but now beginning to apply DNA technology to problems of herring and salmon stock I.D. Most experience is with mitochondrial DNA, although working against limits to the amount of variability in salmon mDNA. Hiring to expand her laboratory's capabilities for stock ID using DNA technology as part of DFO expansion of expertise in this area (see also Devlin, below).

**8.4.2 Disease diagnosis and sex determination**

**Allan Vaisius,**
Ocean Sciences Centre,
Memorial University of Newfoundland,
St. John's, Nfld A1C 5S7
Tel: 709-726-6681
Fax: 709-726-7711

Extremely well trained molecular biologist (Max Planck Institute); was at prestigious NRC Division of Biology in Ottawa before coming to MSRL. Now applying molecular genetics to fisheries problems.

Current example is development of sex specific DNA probes for screening broodstock populations of monosex chinook salmon to eliminate any genetic males. This test requires only a very small blood sample (10 ul), and has potential application to sexing tilapias, where there are similar problems of eliminating genetic males from sex reversed broodstock.

Very interested in developing DNA probes for diagnosis of warmwater fish viral diseases in collaboration with Third World researchers, has already made diagnostic clone for infectious pancreatic necrosis virus (an important disease of salmonid fishes). Work on viral diseases lends itself well to Canada-Third World collaboration - culturing the virus and isolation of the DNA in the country of origin and subsequent sequence analysis and production of a diagnostic probe in Canada.

Noted that specialized skills of virologists are usually applied to medical problems, and that good students must be attracted away to work on fisheries applications. A highly motivated and capable researcher looking beyond the domestic applications of his work; ideal personality for Third World collaborative work. Strongly recommended for future IDRC involvement in fisheries and veterinary applications of molecular genetics.

**Bill Kay,**
Department of Biology,
University of Victoria,
P.O. 1700,
Victoria, B.C. V8W 2Y2
Tel: 604-721-7211

Former Chairman of an active and well regarded department. Senior immunologist with strong interest in practical development of diagnostics and vaccines. Favors live, attenuated vaccines for inclusion of all antigens.

Philosophy for diagnostics is to base not on DNA probes but on simpler technology using monoclonal antibodies bound to beads. Has used this technology to develop cheap, stable kits for diagnosis of several diseases of salmonid fishes (vibriosis, furunculosis, bacterial kidney disease). Interested in applying technology to viral and bacterial diseases of fish and cattle (e.g., salmonella). Stresses that monoclonal technology lends itself well to collaborative research and training and, being less sophisticated than DNA technology, can reasonably be furthered in Third World countries following conclusion of any collaborative research.

An energetic and very highly regarded researcher; formed Microtek Research and Development with Trevor Trust (also of same Department) to develop and market diagnostics and vaccines. Well acquainted with pros and cons of publicly funded development of marketable biotechnology; could make a major contribution through UVIC or Microtek. General Manager of Microtek is Steve Newman, also an immunologist (Microtek Research and Development Ltd., P.O. Box 2460, Sidney, B.C. V8L 3Y3).

**Terry Owen,**
President,
Helix Biotech Scientific Ltd.,
215-7080 River Rd.,
Richmond, B.C. V6X 1X5
Tel: 604-270-7468

Helix Biotech is a small, successful research, development and manufacturing company specializing in diagnostic kits based on enzyme immunoassay (EIA) technology. Products are aimed at the clinical, veterinary and aquaculture markets. Examples include EIA tests for bacterial disease in salmon, and a heat and pregnancy test for cows.

Focus is strongly commercial, with an interest in developing technology arising from applied research done in house and elsewhere. Cow heat and pregnancy test has been developed in collaboration with Rajamahendron of UBC Animal Science (see below).

Strong interest in manufacturing and distributing products in other countries. An excellent source of practical expertise and training in manufacturing and quality control, and in taking research results through to development of a viable product.

**Larry Albright,**
Department of Biological Sciences,
Simon Fraser University,
Burnaby, B.C. V5A 1S6
Tel: 604-291-3193

Immunologist already under IDRC contract for training of researchers from Philippines. Interested in general protocols for vaccine development. Not visited.

**8.4.3 Sex control; applied endocrinology and genetics**

**Ed Donaldson,**
Fisheries and Oceans Canada,
West Vancouver Laboratory,
4160 Marine Dr.,
West Vancouver, B.C. V7V 1N6
Tel: 604-666-7928

Section Head, Centre of Disciplinary Excellence in Biotechnology and Genetics in Aquaculture. Well known to IDRC and CIDA through advisory involvement in numerous fisheries projects. Laboratory a world leader in research on teleost reproduction and genetics, and application of research results to practical fish culture. Notable expertise in sex control in fish through manipulation of hormonal environment or chromosome sets; sex control technology has had a major practical impact on farming of Pacific salmon. Also a leader in applied research on growth acceleration in fish (cf recent hiring of Devlin, above, to pursue growth enhancement through insertion of foreign DNA).

Note that ability of laboratory to produce transgenic fish is greatly strengthened by expertise in sex control: integration of these technologies potentially significantly reduces the amount of time needed to produce a pure breeding population of transgenic fish.

Extensive international experience in S.E. Asia, China, S. America. Laboratory a frequent host to scientific visitors from Third World countries; highly recommended as integrated source of expertise and training.

**Nancy Sherwood,**
Department of Biology,
University of Victoria,
P.O. Box 1700,
Victoria, B.C. V8W 2Y2
Tel: 604-721-7143

Known to IDRC through milkfish project (Philippines). Studies the molecular biology of neuropeptides related to growth and reproduction, with emphasis on fish. Interested both in basic biology of peptide sequence homologies and practical applications in fish culture; has field experience in S.E. Asia.

Thai graduate student has made catfish DNA library for screening with DNA probes specific to salmon and chicken gonadotropin hormone releasing hormone; eventual aim is to locate the gene for GnRH in fish. Laboratory makes use of UVIC Dept of Biochemistry Micro Sequencing Centre for determining peptide sequences; DNA probes are made in collaboration with University of Calgary.

Experienced in international collaborative projects.

**Michael Easton,**
International Broodstock Terchnologies,
567 W. 23d St.,
N Vancouver, B.C. V7M 2C1
Tel: 604-988-3532
Fax: 604-669-9385

Private consultant in statistical analysis, experimental design and fisheries population genetics. Specializes in development of broodstock programmes; has consulting arrangement with FMG Integrated Biotechnical Laboratories Ltd, who supply capability in developing DNA probes for fish stock identification.

**Larry Crim,**
Ocean Sciences Centre,
Memorial University of Newfoundland,
St. John's, NFLD A1C 5S7
Tel: 709-726-6681
Fax: 709-726-7711

Already well known to IDRC through SEAFDEC milkfish project, as is coworker on that project Nancy Sherwood of University of Victoria. Emphasized need for significant research and training in Canada as part of collaborative projects. Recommended training periods greater that three months, and for at least five years to complete Ph.D. in light of almost certain coursework inadequacies.

**8.4.4 Cryopreservation and genetic conservation**

**Michael Ashwood-Smith,**
Department of Biology,
Univeristy of Victoria,
P.O. Box 1700,
Victoria, B.C. V8W 2Y2
Tel: 604-721-7130

Well-trained, highly regarded senior low-temperature biologist. Considerable international but no Third World research experience. Recent term appointment in U.K. In Vitro Fertilization clinic.

World authority on freezing and thawing of a variety of biological systems. Laboratory equipped with modern cryomicroscope that allows viewing of intracellular freezing events; invaluable tool for developing cryopreservation protocols for plant and animal cells and tissues.

Equipment, experience and expertise recommend laboratory for research collaboration and training.

**8.4.5 Transgenic fish**

**Garth Fletcher,**
Ocean Sciences Centre,
Memorial University of Newfoundland,
St. John's, NFLD A1C 5S7
Tel: 709-726-6681

Senior physiologist; well publicized collaborator with molecular biologists Choy Hew and Peter Davies in development of transgenic Atlantic salmon carrying antifreeze gene from winter flounder. Visited China with Hew. Pursuing commercialization, although much further research and development is required before such transgenic animals are proven economical.

His role in transgenic fish research has been in inserting the gene into fish eggs (by microinjection, although other methods are also being tried), and in monitoring expression of the gene through successive generations. Stresses the long term nature of genetic engineering research in fish, but points to spectacular increases in growth rate of carp transgenic for human growth hormone.

At present the most experienced in Canada in practical insertion of genes into fish, although other researchers are rapidly entering the field (e.g., see Vielkind and Devlin/Donaldson, below). An excellent resource for training and research collaboration. Very interested in involvement in Third World research projects; expressed common desire to be better acquainted with specific problems where he could make a contribution.

**Choy L. Hew,**
Department of Clinical Biochemistry,
University of Toronto,
Banting Institute,
100 Collecge St.,
Toronto, Ont. M5G 1L5
Tel: 416-978-6505

Senior molecular biologist interested in molecular biology and gene expression in fish (was at Memorial University Dept. of Biochemistry before joining University of Toronto). Research applied to biological antifreeze proteins, fish pituitary hormones, and gene transfer for improved freezing resistance and growth in fish. Many professional connections in S.E. Asia and China, including research and teaching experience at Xiamen University and Institute of Oceanology, Academica Sinica. Collaborator with Garth Fletcher and Peter Davies on transgenic Atlantic salmon.

Hew's laboratory at the Hospital for Sick Children is state of the art and is frequently host to visitors from Third World and other countries. His laboratory is the world leader in isolating and inserting genes for economically important characteriestics in fish. In this rapidly expanding field, fish growth hormone gene cloned in his laboratory is expected to out perform human growth hormone gene when inserted into fish; industrial collaboration (with FMG Integrated Biotechnical Laboratories, Vancouver) is also being pursued to produce salmon growth hormone in bulk for potential topical application.

Other applications of expertise in his laboratory could include regulation of reproduction by genetically suppressing action of gonadotropin hormone (potential application to tilapia culture); compare this approach to the conventional endocrinological one considered by Dick Peter's laboratory at the University of Alberta, in which regulation of tilapia reproduction will be attempted through applying a gonadotropin releasing hormone antagonist.

Laboratory has formidable resources, and Hew is personally committed to Third World collaboration as a representative of Canadian fisheries expertise.

Attempted to organize, but did not receive funding for, a practical training workshop on fisheries biotechnology at Xiamen University, China (1988; Unesco/CIDA Assistance Program). Competence, credibility and outlook all recommend highly for IDRC collaboration.

**Peter Davies,**
Department of Biochemistry,
Queen's University,
Kingston K7L 3N6
Tel: 613-545-2983
Fax: 613-545-6612

Basic molecular biologist interested in gene expression; collaborating with Garth Fletcher and Choy Hew on production of transgenic Atlantic salmon and commercialization of related technology. Few international contacts; presently feels adequately funded by NSERC and MRC. Prepared to assist IDRC if asked; can also apply his expertise to increased frost resistance in plants through transfer and expression of antifreeze protein genes.

**J. Vielkind,**
Cancer Research Institute,
University of British Columbia,
601 W. 10th Ave.,
Vancouver, B.C. V5Z 1L3
Tel: 604-877-6010

Basic molecular geneticicist interested in effects of DNA insertion and expression of foreign DNA; ultimate object is to understand expression of melanoma gene in a cell line. Using zebra fish and medaka (small tropicals) as models; has developed technology for microinjection of foreign DNA (human metallocyanin promoter gene) into zebra fish embryos to produce a stable line of transgenic fish.

Has trained visitor from National University of Singapore in gene microinjection; could be considered source of expertise for this technology although does not seem strongly motivated in applied aspects of his work.

**Bob Devlin,**
Fisheries and Oceans Canada,
West Vancouver Laboratory,
4160 Marine Dr.,
West Vancouver, B.C. V7V 1N6
Tel: 604-666-7935

Molecular geneticist recently joined Ed Donaldson's Centre of Disciplinary Excellence (CODE) for Biotechnology and Genetics in Aquaculture (see above). Overall responsibility within the group is to develop technology for producing transgenic fish, withn emphasis on Pacific salmon species. Will start by inserting DNA constructs obtained from other laboratories; in longer term, laboratory will engineer its own. Initial focus on insertion of growth hormone genes.

Well trained; joining a highly regarded group.

### 8.5 Animal production systems

#### 8.5.1 DNA probes for disease diagnosis; engineered vaccines

**David Thomas,**
National Research Council Canada,
Biotechnology Research Institute,
6100 Royalmount Ave.,
Montreal, Quebec H4P 2R2
Tel: 514-496-6156
Fax: 514-496-6232

Head of Molecular Genetics at BRI. Associated with IDRC as advisor to proposed biotechnology project in Lahore (see correspondence with Aung-Gyi, IDRC). Applied interests include mapping of immunogenic sites in human and animal disease.

**Michael Clarke,**
Department of Biology,
University of Western Ontario,
London, Ont N6A 5B7
Tel: 519-661-3454

Microbiologist/immunologist interested in using DNA technology to develop diagnostic and therapeutic agents in cattle. Particular interest in the molecular biology of trypanosomes. Has collaborative association with ILRAD (graduate student funded by CIDA to work there; current research visit from senior ILRAD scientist). CUSO background in Africa. Very interested in further Third World collaborative work.

**Bruce Wilkie,**
Department of Veterinary Microbiology and Immunology,
University of Guelph,
Guelph, Ont N1G 2W1
Tel: 519-824-4120

Present Chairman of Department and Director of Animal Biotechnology Centre (Guelph-Waterloo Biotech). Veterinary immunologist interested in development of genetically engineered "cassette" vaccines carrying a range of antigenic determinants and amenable to mass vaccination using respiratory or oral route.

Experience in establishing College of Veterinary Mediciine in Malaysia for CIDA; ILRAD contacts. Receives numerous enquiries from Third

World countries for training in biotechnology as a discipline. Suggests Third World countries need basic training in laboratory animal science. Very interested in research collaboration, particulalrly with ILRAD.

**8.5.2 DNA analysis as a measurement of genetic distance**

**Urs Kuhnlein,**
Department of Animal Science,
MacDonald College of McGill University,
21, 111 Lakeshore Rd.,
Ste. Anne de Bellevue, Quebec H9X 1C0
Tel: 514-398-7799

Shaver Poultry Chair in biotechnology; collaborates with David Zadworny. Using DNA fingerprinting in poultry as a model for animal breeding; attempting to measure genetic differences between individuals and populations. Have shown that DNA fingerprinting accurately reflects inbreeding and genetic distance between strains, and permits correct assignment of individuals to breeding populations.

Interested in assessing variability of available gene pool and hence the selection potential of a breeding population. More distant applications of technology are in identifying and ultimately transferring genes responsible for disease resistance.

Conservative on potential for application of molecular biology to animal breeding through gene transfer.

**K.M. Cheng,**
Department of Animal Science,
University of British Columbia,
Vancouver, B.C. V6T 1W5
Tel: 604-228-2480

Avian population geneticist using DNA fingerprinting to determine variation in local populations; (basic interest is in male competition in reproduction, and DNA fingerprints useful in determining paternity). Applications of his work for local breeding programs; visits Indonesia as part of CIDA-SFU project to provide advice on genetic consequences of preserving local chicken populations.

### 8.5.3 Embryo manipulation, breeding strategies and transgenic animals

**Jan Gavora,**
Animal Research Centre,
Agriculture Canada,
Ottawa, Ont. K1A 0C6
Tel: 613-993-6002

Chairman of Biotechnology Program, which includes 24 scientists working in four main areas:

1. Genetic evaluation and biometrics
2. Rumen fermentation. Engineering of rumen bacteria to synthesize supplementary amino acids; at stage of testing engineered bacteria in artificial rumens. Contact Frank Sauer; Ron Teaser.
3. Embryo manipulation. Work of Nagai and Marcus (see below) to develop cloning by nuclear transfer. Developing collaborative ties with Betteridge at Guelph to increase survival of reimplanted embryos. Group member Paul Fiser (see below) has cryobiological expertise for freezing studies.
4. Molecular genetics. Avian and dairy cow projects. In chickens, similar interests to Kuhnlein (McGill) for developing DNA fingerprinting as a measure of genetic distance. His own personal interest in engineering of disease resistance in cases where single genes may confer resistance (not case in production traits, which are normally polygenic). Suggests collaboration with ILRAD for study of trypanotolerance in local N'dama breed, with potential eventual tranfer of resistance to more productive breed. Maintaining an ongoing population of transgenic mice to become familiar with possible generalized deleterious effects of gene transfer in subsequent generations.

His group starting a Centre for Preservation of Animal Genetic Resources, to develop technology (Fiser), develop databases and assist in evaluation of local breeds. Highly regarded scientist with strong interest in development work; recommended for IDRC collaboration.

**Jiro Nagai,**
Animal Research Centre,
Agriculture Canada,
Ottawa, Ont. K1A 0C6
Tel: 613-993-6002

Head of team developing cloning procedures for cattle, one of only three research groups in the world successful so far (for research approach, see Marcus, below).

Dedicated and conservative concerning application of biotechnology in developing countries; no personal Third World research experience. In development of cloning, stresses need to consider genetic constitution of cloned embryos, as cloning itself is a technique developed by reproductive biologists.

Transfer of cloning biotechnology implies competence in many associated disciplines, including sterile technique; endocrinology; veterinary expertise for recovery and transfer of embryos; sterile manipulation of embryos; cell culture; progesterone assays for determining pregnancy.

Laboratory should be considered an important resource for training and consultation on cloning and associated technologies.

**George Marcus,**
Animal Research Centre,
Agriculture Canada,
Ottawa, Ont. K1A 0C6
Tel: 613-993-6002

Member of world-leading research team developing cloning technology for cattle. Approach differs fundamentally from embryo splitting, which severely limits the number of copies; his group's technique implants nuclei from early embryos into activated eggs from which the nucleus has been removed. In this technique there appears to be no limit to the number of copies that can be made.

An invaluable source of training expertise; recognizes potential problem of losing genetic diversity using clonal propagation.

**Paul Fiser,**
Animal Research Centre,
Agriculture Canada,
Ottawa, Ont. K1A 0C6
Tel: 613-993-6002

Cryobiologist with experience on developing freezing methods for boar semen. Now working on problem of freezing cattle embryos that have been split; also developing methods for short-term supercooling of cattle ova (useful as a research tool).

Laboratory has video-equipped cryomicroscope (only other one in Canada is with M.J. Ashwood-Smith at University of Victoria).

No Third World experience; laboratory available for training.

**Elizabeth Singh,**
Reproduction Section,
Animal Diseases Research Institute,
Agriculture Canada,
Food Production and Inspection Branch,
801 Fallowfield Rd.,
P.O. Box 11,300, Station H,
Nepean, Ontario K2H 8P9
Tel: 613-998-9320

Member of a research group working in the general area of transmission of disease via sex products and embryos. Group includes W.C.D. Hare (below). Carries out experiments to determine likelihood of embryos becoming infected with, and passing on viral and bacterial diseases; methodology can be used both to establish safety of embryos for export (certification) and to justify using embryo transfer as a way of limiting the spread of disease both locally and internationally.

Laboratory well regarded; personally interested in Third World work.

**W.C.D. Hare,**
Reproduction Section,
Animal Diseases Research Institute,
Agriculture Canada,
Food Production and Inspection Branch,
801 Fallowfield Rd.,
P.O. Box 11,300, Station H,
Nepean, Ontario K2H 8P9
Tel: 613-998-9320

Senior researcher working with Singh (above). Additional interest in molecular biology through postdoctoral fellow Cyril Lutze-Wallace, who is looking at DNA probe technology for sexing embryos (see also efforts of Willadsen, Betteridge). Well versed in problems of international certification for semen and embryo transport. Interested in training students and post docs in his laboratory.

**Charles Smith,**
Department of Animal and Poultry Science,
University of Guelph,
Guelph, Ont N1G 2W1
Tel: 519-824-4120

NSERC-Semex Chair in Animal Breeding Strategies, Centre for Genetic Improvement of Livestock. Students in Thailand and Philippines working on genetics of small herds. Classical geneticist interested in design and implementation of breeding programs, including choice and evaluation of local, regional and international stocks, design of crosses, establishment of Multiple Ovulation and

Embryo Transfer (MOET) technology using nucleus breeding units, and training of local personnel. Design of breeding schemes employs computer simulation for recording data, estimating breeding values, selection and mating, and results in software for local use.

Interested in genetic conservation of local breeds.

Highly regarded senior reseacher; recommended as excellent potential collaborator as part of Centre for Genetic Improvement of Livestock team approach, along with Centre Director Ted Burnside and Brian Kennedy.

**Keith Betteridge,**
Department of Biomedical Sciences,
University of Guelph,
Guelph, Ont N1G 2W1
Tel: 519-824-4120

NSERC-Semex Senior Industrial Research Chair in Animal Biotechnology. Developmental embryologist working on manipulation of cattle embryos to advance the use of embryo transfer. Work includes splitting, improvement of cryopreservation technology, sexing of embryos and improvement of superovulation. Interested in cryopreservation of cattle ova.

Gets many requests for short term training in ET, but feels advanced training in reproductive technology often wasted due to lack of background in basic endocrinology. Has worked in Cuba and China, and is very interested in collaborative research through IDRC. Laboratory very well equipped for embryo manipulation and cryopreservation (hiring another cryopreservation expert), as well as for studies on in vitro maturation. Amenable to a coordinated approach with other Canadian specialists in embryo transfer and manipulation (e.g., Mapletoft, below).

Work as part of the Animal Biotechnology Centre at the University of Guelph forms tools for implementation by Smith and colleagues at the Centre for Genetic Improvement of Livestock (above).

**Alan Wildeman,**
Department of Molecular Biology and Genetics,
University of Guelph,
Guelph, Ont N1G 2W1
Tel: 519-824-4120

Molecular biologist recently joined faculty as NSERC-Semex Junior Industrial Research Chair in Animal Biotechnology. Basic biologist interested in regulation of transferred genes and mechanisms of action of mammalian tumor viruses; potential application of his work is in Semex interest in transgenic cattle. Carrying out fundamental research in how genes can best be introduced and expressed.

Fully committed with no time for international work at present.

**Bonnie Mallard,**
Department of Veterinary Microbiology and Immunology,
University of Guelph,
Guelph, Ont N1G 2W1
Tel: 519-824-4120

Recent graduate interested in genetics of disease resistance; using major histocompatibility complex (MHC) as marker. Developing DNA probes for MHC in swine. Interested in developing breeding programs with specific attention to disease resistance. Committed to practically oriented research, and interested in international collaboration although has not had time to develop contacts.

**Rob Etches,**
Department of Animal and Poultry Science,
University of Guelph,
Guelph, Ont N1G 2W1
Tel: 519-824-4120

Past Chairman. Avian physiologist and endocrinologist interested in genetic engineering of chickens by injection of transgenic cells into blastoderms. Unique approach can make use of bank of transgenic cells already genetically modified for disease resistance (often single gene traits). Potential application in countries with national poultry breeding programs (Malaysia, Sri Lanka, India). Collaborating with molecular biologist Anne Gibbons (see below) on transgenic chicken project.

No Third World experience.

**Anne Gibbons,**
Department of Animal and Poultry Science,
University of Guelph,
Guelph, Ont N1G 2W1
Tel: 519-824-4120

Molecular biologist interested in developing DNA probes for diagnosis of viral diseases. In early stages of project to engineer superior rumen bacteria enabling cattle to degrade coarse forage.

**Lorne A. Babiuk,**
Associate Director,
Veterinary Infectious Disease Organization,
124 Veterinary Road,
Saskatoon, Saskatchewan S7N 0W0
Tel: 306-966-7465
Fax: 306-966-7478

VIDO has strong programme in the application of biotechnology to animal health specifically in the development of vaccines against a variety of infectious diseases of livestock. Their programmes include: various management schemes for controlling infectious diseases; identification and cloning of important proteins of disease causing organisms for mass vaccine production; use of biotechnology and immunology to enhance growth and reproductive capacity in animals.

Dr. Babiuk is very interested in collaborative research, technology transfer and training programmes with developing countries. VIDO is associated with the University of Saskatchewan and trains graduate students and postdoctoral fellows. Has attempted to establish training and technology transfer projects with INTA in Argentina.

**Bruce D. Murphy,**
Director,
Reproductive Biology Research Unit,
College of Medicine,
University of Saskatchewan,
Saskatoon, Saskatchewan S7N 0X0
Tel: 306-966-8035
Fax: 306-966-8040

Professor of Obstetrics and Gynecology who collaborates with R. Mapletoft and L. Babiuk in immunomodulation of fecundity, development of immunity against gonadotropin releasing hormone, and the development of vaccines for immunocastration.

Interested in the use of biotechnology for reproductive enhancement in mammals: analysis and manipulation of embryos for cloning; insertion of new genes for desirable economic traits; screening for genetic abnormalities.

Dr. Murphy was an IDRC Fellow in Mexico and has most recently spent six months managing 22 projects in reproductive research in 11 Latin American countries for IAEA of the UN. Believes in international development and wants to assist in collaborative research projects. Has considerable insight and perspective about conducting science in Third World.

**Reuben J. Mapletoft,**
Department of Herd Medicine and Theriogenology,
Western College of Veterinary Medicine,
University of Saskatchewan,
Saskatoon, Saskatchewan S7N 0W0
Tel: 306-966-7149.

Professor. Major research interest is in embryo technology: in vitro fertilization for cloning; embryo transfer techniques; sex determination using DNA probes; development of probes for screening desirable traits in embryos.

Very enthusiastic about development projects but also has practical and realistic expectations about limitations and accomplishments. Knowledgeable about veterinary practices and animal agriculture in India, Indonesia, Chile, Argentina, PRC. Most recently consulting for INTA in Argentina and is preparing a joint proposal in embryo research with INTA. Has had students from PRC who were trained in embryo transfer technology.

Interested in collaborating with Alta Genetics.

**Steen Willadsen,**
Research Director,
Alta Genetics,
Site12, Box 12, RR4,
Calgary, Alberta T2M 4L4.
Tel: 403-239-8882

Associated with the University of Calgary. Alta Genetics specializes in cattle breeding by using advanced biotechnology and the Research Unit is fully equipped for modern embryo transfer. Embryo transplantation techniques effectively enhance reproductive performance in valuable donors. Research objectives include: cryopreservation of selected embryos; cloning of embryos by blastomere separation and nuclear transplantation; development of DNA probes for embryo sex determination; genome mapping and engineering of select traits.

Alta Genetics has trained several groups of scientists in embryo transplantation technology.

**Bruce Downey,**
Department of Animal Science,
MacDonald College of McGill University,
21, 111 Lakeshore Rd.,
Ste. Anne de Bellevue, Quebec H9X 1C0
Tel: 514-398-7794

Present Chairman of Department. Worked on CIDA Egypt project to increase productivity in small cattle and buffalo herds; also training in AI. Next phase of project is to implement a program of genetic improvement. Stresses need to improve record keeping and husbandry before training in biotechnologies. Research interests include control of follicle maturation applied in vitro to provide large numbers of embryos.

Interested in supervising Third World student course work, with degree research in home country.

**Jeffrey Turner,**
Department of Animal Science,
MacDonald College of McGill University,
21, 111 Lakeshore Rd.,
Ste. Anne de Bellevue, Quebec H9X 1C0
Tel: 514-398-7796

Molecular geneticist interested in developing bovine mammary cell culture to produce economically important transgenic proteins. Shares well equipped laboratory with Kuhnlein (see belowe); equipped for PCR. Potential Health Science application in producing lactose free milk by inserting lactase genes into bovine mammary cells; this biotechnological solution to lactose intolerance in very early stage of development.

No Third World contacts; orientation practical, commercial.

**Ray Peterson,**
Department of Animal Science,
University of British Columbia,
Vancouver, B.C. V6T 1W5
Tel: 604-228-4593

Cattle geneticist with consulting experience in China and New Zealand. Interested in design of cattle breeding schemes with particular attention to record keeping and performance evaluation. Continuing research interest in developing technique of "metabolic profiling" for prediction of performance based on a system of histochemical tests. Has African student.

**R. Rajamahendron,**
Department of Animal Science,
University of British Columbia,
Vancouver, B.C. V6T 1W5
Tel: 604-228-4593

Sri Lankan endocrinologist with veterinary training; recently joined UBC. Has visited most S.E. Asian countries; attended Philippines training course in embryo transfer. Zambian graduate student.

Main interest is in improving and applying embryo transfer technology. Developing ultrasound imaging technique for improving success in superovulation. Potential research projects include superovulation and embryo transfer in buffalo; interested in supervising graduate research on embryo transfer that could later be applied to this problem in India, Malaysia or the Philippines. Wants eventually to set up an international training centre in ET technology. Developed progesterone assay now being marketed as a field pregnancy test by Helix Biotech (Vancouver). Knowledge of S.E. Asia and interests in development work recommend for consideration once established at UBC.

**Bob Gowe,**
Shaver Poultry Breeding Farms Ltd.,
P.O. Box 400,
Cambridge, Ont. N1R 5V9
Tel: 519-621-5191
Fax: 519-621-9407

Director of Research; used to direct Agriculture Canada Animal Disease Research Centre. Biotech research interests at Shaver channelled through McGill research chair (presently held by Kunhnlein); biotech advances developed in a university would be marketed worldwide by Shaver. Stresses need for infrastructure in Third World poultry management - breeding schemes based on identified parents; record keeping; husbandry.

**Morris Freeman,**
General Manager,
Semex Canada,
130 Stone Rd. West,
Guelph, Ont. N1G 3Z2
Tel: 519-821-5060
Fax: 519-821-7225

Semex Canada is the export arm of Canada's artificial insemination (AI) and embryo transfer (ET) industry, and maintains close research and funding ties with the University of Guelph through contributing to industrial research chairs (see Smith, Betteridge, and Wildeman, below). Sponsors the International Livestock Management Schools, which provide training for other countries, including Third World countries, in AI and ET. Executing agency in several CIDA projects, including one with the New Delhi dairy board for genetic improvement in water buffalo; most such projects include a training component.

Given the strong connection with respected researchers at University of Guelph and present CIDA activity, very interested in further collaborative research with Third World countries where this is outside the CIDA mandate.

### 8.5.4 Biological pest management

**Murray B. Isman,**
Department of Plant Science,
University of British Columbia,
2357 Main Mall,
Vancouver, B.C. V6T 2A2
Tel: 604-228-2329
Fax: 604-228-6394

Associate Professor. Studies effects of natural products on insects. Does not use molecular biology.

Activities include NSERC/CRD project with Safer Ltd. and University of Ottawa (J.T. Arnason) to develop azadirachtin as an insectidical compound; phytochemistry of host resistance in canola varieties; pharmacokinetics of natural products in insects; antifeedants as natural insecticides.

Not interested in acquiring more funding or in the potential application of biocontrol agents in developing countries.

**John T. Arnason,**
Department of Biology,
University of Ottawa,
30 Somerset E.,
Ottawa K1N 6N5
Tel: 613-564-3458

Associate Director of Ottawa-Carlton Plant Insect Relations Group. Interested in biochemical and physiological ecology of natural and agroecosystems, plant-pest interactions, resistance mechanisms in cultivated plants, international agriculture projects. Active in IDRC projects past and present.

Numerous collaborative projects include photoactivated mosquito larvicides and botanical pesticides (Thailand, Philippines);

phytochemical resistance in maize (Zimbabwe, Mexico); activity and analysis of medicinal plants (Mexico, Indonesia).

Well equipped facility. Experienced and enthusiastic in development projects.

**Bernard J.R. Philogene,**
Dean,
Faculty of Science,
University of Ottawa,
Ottawa K1N 6N5

Entomologist collaborating with Arnason (above). Interested in plant-derived antifeedants and insecticides, plant-insect relationships and pesticide use in developing countries.

Major IDRC project in the Philippines on new botanical insectides.

**David Baillie,**
Department of Biological Sciences,
Simon Fraser University,
Burnaby, B.C. V5A 1S6
Tel: 604-291-4475

Senior geneticist with active laboratory devoted to molecular biology of nematodes. Part of NIH international team to sequence genome of nematode Caenorhabditis elegans (the "new Drosophila" of genetics). Has published with John Webster (see below).

Molecular biological tools used in his lab important for identification of nematodes and for development of diagnostics. Example of application in agriculture: restriction fragment length analysis of DNA to identify specific race of plant pathogen as aid in developing resistant cultivar.

Since classical taxonomic identification of nematodes is so difficult, tools available in his lab to develop specific DNA probes would be useful in Third World countries where plant and animal parasitism by nematodes is important, particularly because analysis can be done on frozen samples, and nematodes need not be cultured. He therefore offers rapid and reliable separation of closely related species, subspecies and strains.

Baillie has had students from Guyana, Libya and India; a current student is now at the London Tropical Disease Institute developing DNA probes for nematode identification in diagnosis. He is interested in helping with Third World problems and would welcome more students from Third World countries for training. His own main interest, however, is in basic genetic research.

**Russell Nicholson,**
Department of Biological Sciences,
Simon Fraser University,
Burnaby, B.C. V5A 1S6
Tel: 604-291-4107

Associate Professor. Biochemist interested in mode of action of established insecticides, and development of novel pesticides from natural sources. Working on pyrethroid-like toxin from a marine dinoflagellate. Just joined Department, and still accumulating equipment, but interested in overseas collaboration.

**John Borden,**
Centre for Pest Management,
Department of Biological Sciences,
Simon Fraser University,
Burnaby, B.C. V5A 1S6
Tel: 604-291-3646

Director of the Chemical Ecology Research Group (five faculty members and associated support), which focusses on semiochemicals (message-bearing chemicals used in communication systems by insects and plant pathogens). Group has close association with Phero Tech Inc., Vancouver, for commercialization of research results. Isolation, identification and synthesis projects of the group (completed or in progress) include honey bee pheromones, grain and bark beetle pheromones, forest defoliator pheromones, weevil pheromones, dipteran sex and aggregation pheromones, cockroach repellant pheromone, psyllid sex pheromone, plant rooting stimulants, weevil repellents.

Group and personal capabilities clearly with many applications to Third World agriculture. Attended IDRC workshop on botanical pesticides (1986). Presently has graduate student from Philippines isolating aggregation and repellent pheromones of Heteropsylla cubana, responsible for serious losses in giant ipil-ipil in S.E. Asia and the S. Pacific (see letter to M. Loevinsohn, IDRC, 15 June 1989).

Very interested in research and training collaborative projects; type of research and group approach lends itself well to collaboration. Well acquainted with commercialization process through past dealings with Phero Tech Inc.

**John Webster,**
Centre for Pest Management,
Department of Biological Sciences,
Simon Fraser University,
Burnaby, B.C. V5A 1S6
Tel: 604-291-3336

Senior faculty member working on plant-nematode interactions; work has application to IDRC programs in pest management (see correspondence with IDRC's M. Loevinsohn concerning possible projects in pest control in India, Thailand, Malaysia). Presently developing research projects identified through SFU activities for CIDA in Indonesia.

**Tom Rutherford,**
Centre for Pest Management,
Department of Biological Sciences,
Simon Fraser University,
Burnaby, B.C. V5A 1S6
Tel: 604-291-4105

Research Associate to John Webster (above). Research on nematodes as control agents in plant disease, acting by way of release of immunosuppresant bacteria. Steinernema sp. easy to rear at cottage industry level; visited China (FAO) to train local farmers in rearing and aplication to control cotton pest. Available in similar advisory capacity to IDRC, not as collaborative researcher.

**Manfred Mackauer,**
Centre for Pest Management,
Department of Biological Sciences,
Simon Fraser University,
Burnaby, B.C. V5A 1S6
Tel: 604-291-4808

Director of Centre for Pest Management; works on biological control of pests through release of natural enemies. Concerned with genetic aspects of released organisms and maintaining quality control in release programs. Has Ethiopian student (IITA funding).

**Neil Towers,**
Department of Botany,
University of British Columbia,
Vancouver, B.C. V6T 1W5
Tel: 604-228-3338

Well known to IDRC through Thai piscicide project. Senior, highly respected researcher with very extensive international experience as collaborator, invited lecturer, advisor and host to scientists and trainees from Third World countries. Interests centre on phytochemicals as therapeutic and pesticidal agents; laboratory equipped for extraction, isolation, identification and bioassay of a wide range of bioactive compounds.