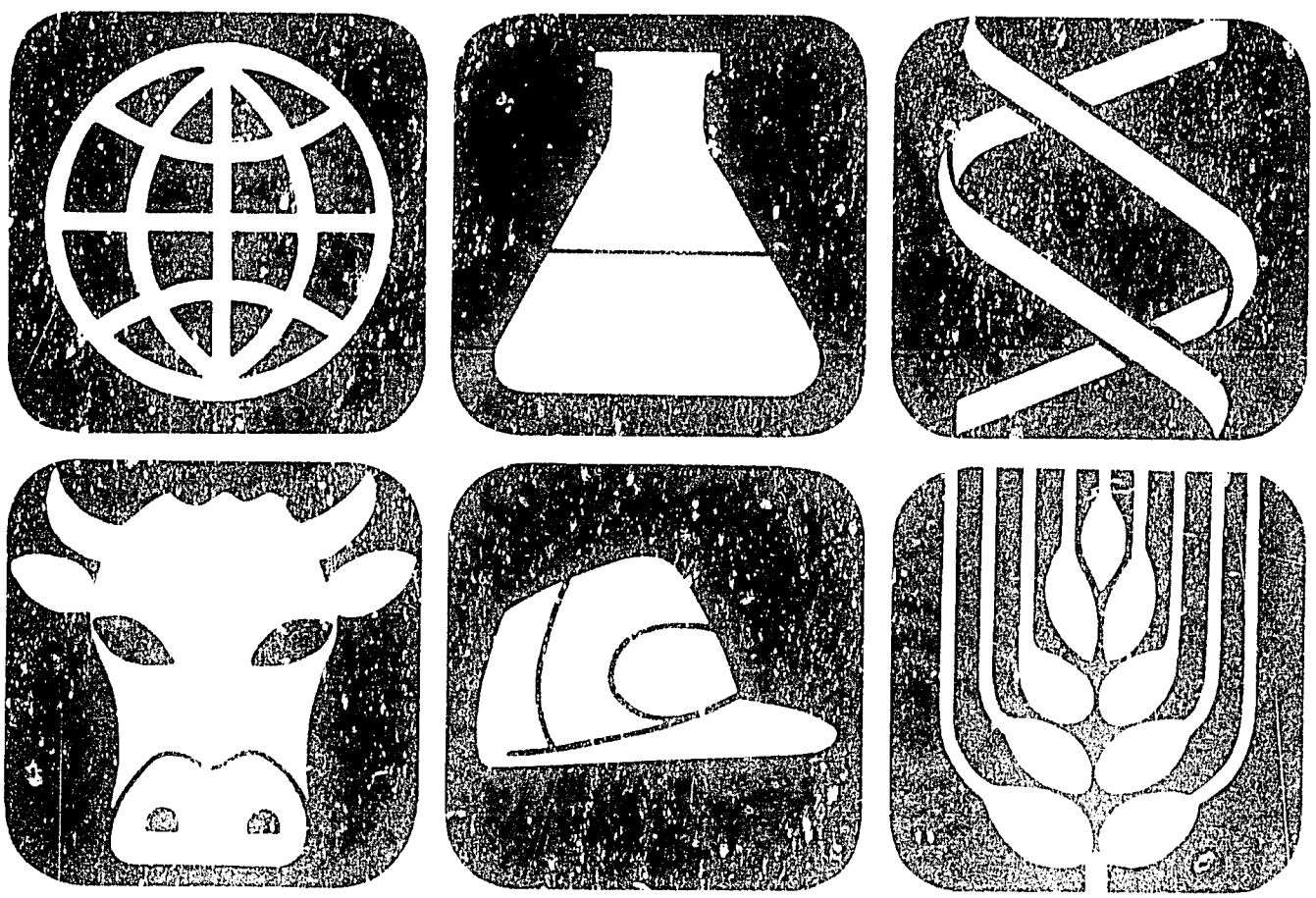
PN-AAZ-732.

Agency for International Development/Office for Agriculture/Bureau for Science and Technology

Strengthening Collaboration in Biotechnology: International Agricultural Research and the Private Sector

April 17-21, 1988
The Rosslyn Westpark Hotel
Arlington, Virginia



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STRENGTHENING COLLABORATION IN BIOTECHNOLOGY
APRIL 17-21, 1988
CONFERENCE OVERVIEW

	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY
8:00		Registration Coffee/Danish			
8:30		SESSION I	SESSION V	SESSION IX	SESSION XIII
9:00		Intro/ Overview	Molecular Technologies	Collaborative Research/ Commercialization	Commercialization/ Patents/ Tech Transfer
9:30					
10:00		BREAK	BREAK	BREAK	BREAK
10:30		SESSION II	SESSION VI	SESSION X	WORKSHOP 2
11:00		National Programs	Molecular Markers	Donor Agencies	-Biosafety -Wide Crosses/ Genetic Res. -Diagnostics
11:30					
12:00		LUNCH	LUNCH	LUNCH	
12:30					BANQUET
1:00					Wrap-up/ Closing Remarks
1:30		SESSION III	WORKSHOP 1	SESSION XI	
2:00		Plant Cell & Tissue Culture	-Vaccines -Cell Culture -Molecular technologies	Biosafety	
2:30					ADJOURN
3:00		BREAK		BREAK	
3:30		SESSION III con't, or SESSION IV	BREAK	SESSION XII	
4:00	Presenters/ Session Chair Meeting	Commercialization	SESSION VII	Pathology/ Diagnostics	
4:30			Wide Crosses		
5:00					
5:30					
6:00					
6:30	Registration				
7:00	OPENING RECEPTION		SESSION VIII	RECEPTION National Academy of Sciences	
7:30			Genetic Resources		
8:00					
8:30					
9:00					

Conference Program

Sunday, April 17, 1988

4:00-6:00 pm	**Meeting for Conference Presenters and Session Chairs** *Club Room*
6:30-7:30 pm	**Registration** *Shenandoah Room A & B*
7:00-9:00 pm	**Evening Reception** *Shenandoah Room A & B*

Monday, April 18, 1988

7:30-8:30 am	**Registration**
8:00-8:30 am	**Coffee and Pastry**

Session I: **Introduction and Overview** *Rosslyn B Room*

Session Chair: William Furtick, AID

8:30 am	**Conference Welcome and Strengthening Collaboration in Biotechnology: International Agricultural Research and the Private Sector, by** *Nyle C. Brady, Senior Assistant Administrator for Science and Technology, Agency for International Development, Washington, D.C.*
8:50 am	**Conference Overview by** *Joel Cohen, Biotechnology Specialist, Bureau for Science and Technology, Office of Agriculture, Agency for International Development, Washington, D.C.*
9:00 am	**Building Bridges of Research Collaboration Through the CGIAR System of Centers, by** *Richard L. Sawyer, Director General, Centro International de la Papa (CIP), Lima, Peru*
9:20 am	**Research Collaboration and Technology Transfer: The Public Sector and International Seed Companies by** *Donald N. Duvick, Senior Vice President - Research, Pioneer Hi-Bred International, Des Moines, Iowa*
9:40 am	**Discussion**
10:00-10:30 am	**Break**

Monday, April 18, 1988 con't

Session II: **National Programs in Biotechnology: Needs and Opportunities** *Rosslyn B Room*

Session Chair: Max Rives, CGIAR Secretariat

10:30 am **Biotechnology in Thailand: Present Status, Needs and Opportunities for International Collaboration by** *Yongyuth Yuthavong, Mahidol University, Bangkok, Thailand*

11:00 am **Biotechnology: New Approach for Agricultural Research and Training at CATIE by** *Victor Villalobos, Centro Agronomico Tropical de Investigacion & Ensenanza (CATIE), Turrialba, Costa Rica*

11:30 am **Discussion**

12:00-1:30 pm **Lunch**

Session III: **Applications of Plant Cell and Tissue Culture for Crop Improvement** *Rosslyn B Room*

Session Chair: Indra Vasil, University of Florida

1:30 pm **Use of Cell Genetics in Crop Improvement by** *David Evans, Vice President - Corporate Research, DNA Plant Technology Corporation, Cinnaminson, New Jersey*

2:00 pm **Tissue Culture Micropropagation and CIAT Biotechnology Research by** *William Roca, Director General, Centro International de Agricultura Tropical (CIAT), Cali, Columbia*

2:30 pm **Discussion**

3:00-3:30 pm **Break**

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Monday, April 18, 1988 Con't

Concurrent Sessions: Please Note You Have Two Choices of Sessions: Session III, con't in Rosslyn B Room or Session IV, Commercialization and Research Perspectives for Vaccines in the Dogwood Room

Session III: **continuation of Applications of Plant Cell and Tissue Culture for Crop Improvement** *Rosslyn B Room*

Session Chair: Indra Vasil, University of Florida

3:30 pm **Anther Culture Program at IRRI by** *F.J. Zapata, International Rice Research Inst. (IRRI), Los Banos, Philippines*

3:50 pm **Tissue Culture for Germplasm Management and Distribution by** *John Dodds, Tissue Culture Specialist, Centro International de la Papa (CIP), Lima, Peru*

4:10 pm **Utilization of Somaclonal Variation in Plant Breeding by** *William Scowcroft, Vice-President for Research & Development, Biotechnica Canada, Inc, Calgary, Alberta, Canada*

4:30 pm **Discussion**

Session IV: **Commercialization and Research Perspectives for Vaccines** *Dogwood Room*

Session Chair: George Shibley, APHIS/ USDA

3:30 pm **Commercialization and Research Perspectives for Vaccines by** *Charles Muscoplat, Executive Vice President, Molecular Genetics, Inc, Minnetonka, MN*

4:00 pm **Vaccine Development: The Role of Biotechnology, ILRAD and the Private Sector by** *John Doyle, Director of Research, International Laboratory for Research on Animal Diseases (ILRAD), Nairobi, Kenya*

4:30 pm **Discussion**

Tuesday, April 19, 1988

Session V: **Molecular Technologies for Crop Improvement :Viral and Pest Management** *Rosslyn B Room*

Session Chair: Malcolm Finlayson, Mycogen Corporation

8:30 am **Genetic Transformation for Virus Resistance: Needs and Opportunities in Developing Countries by** *Roger Beachy, Washington University, St. Louis, Missouri*

9:00 am **Genetically Engineered Insect Resistance in Crops by** *Ronald Meeusen, Manager, Agricultural Biotechnology, Rohm and Haas, Spring House, Pennsylvania*

9:30 am **Discussion**

10:00-10:30 am **Break**

Session VI: **Molecular Markers and Recombinant DNA** *Rosslyn B Room*

Session Chair: J.M.J. DeWet, ICRISAT

10:30 am **Applying Restriction Fragment Length Polymorphism to Plant Breeding by** *Michael Murray, Principal Research Scientist, Agrigenetics Advanced Science Company, Madison, Wisconsin*

11:00 am **Development and Field-Testing of Crops Improved Through Genetic Engineering by** *Xavier Delanny, Research Group Leader-Applied Genetics, Monsanto Company, St. Louis, Missouri*

11:30 am **Discussion**

12:00-1:30 pm **Lunch**

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Tuesday, April 19, 1988 Con't

Workshop I

Concurrent workshop sessions for Working Groups to meet around specific topic areas. Attendees are to self-select topic areas of interest to them. Objectives of the workshops are to:

* identify constraints in international agricultural research and then identify collaborative and commercial research that will address these constraints.
* consider the consequences of biotechnologies, develop recommendations for and interest in collaborative research, initiate links between the private sector and international agricultural research organizations and provide a list of suitable linkages with international donor organizations.

1:30-3:30 pm

A) **Vaccines** *Dogwood Room*
Resource Persons: Charles Muscoplat
John Doyle
Facilitator: T.D . Yilma, UC Davis
Reporter: Michael Burridge, University of Florida

B) **Cell Culture** *Club Room*
Resource Persons: Dave Evans
William Roca
Francisco Javier Zapata
John Dodds
William Scowcroft
Facilitator: Ronald Philips, University of Minnesota
Reporter: Oluf Gamborg, Tissue Culture for Crops Proj.

C) **Molecular Technologies** *Rosslyn B Room*
Resource Persons: Roger Beachy
Ronald Meeusen
Michael Murray
Xavier Delanny
Facilitator: Rita Colwell , University of Maryland
Reporter: David Edwards, Western Biotechnology

3:30 pm **Break**

Tuesday, April 19, 1988 Con't

Session VII: Facilitation of Wide Crosses Through Biotechnology
Rosslyn B Room

Session Chair: G.S. Khush, IRRI

4:00 pm **Use of Hormones and Ovule and Embryo Culture to Enhance Wide Crosses by** *J. Philip Moss, Principal Cytogeneticist, International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Andhra Pradesh, India*

4:30 pm **Alien Germplasm for Wheat Improvement Faciliated by Cytogenetic Manipulation and Use of Novel Techniques** *by A. Mujeeb-Kazi, Head, Wheat Wide Crosses, Centro Internacionla de Mejoramiento de Maiz y Trigo (CIMMYT), Mexico*

5:00 pm **Discussion**

Session VIII: Genetic Resources: Commercial Initiatives Linking Conservation, Evaluation and Utilization *Rosslyn B Room*

Session Chair: Trevor Williams, IBPGR

7:00 pm **Evaluation of Latin American Maize: International Cooperation on a Major World Crop Genetic Resource by** *Quentin Jones, Director, Latin American Maize Project (LAMP), Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland*

7:20 pm **The Role of the International Legal System in Protection of Plans and Other Biotechnology Inventions by** *Stan Schlosser, Of Counsel Foley & Lardner, Shwartz, Jeffery & Schwaab, Alexandria, Virginia*

7:40 pm **Plant Genetic Resources Network in India by** *R.S. Paroda, Deputy Director General, Indian Council on Agricultural Research, New Delhi, India*

8:00 pm **Discussion**

Wednesday April 20, 1988

Session IX: **New Agendas for Collaborative Research and Commercialization** *Rosslyn B Room*

Session Chair: Gabrielle Persley, ISNAR

8:30 am **Focused Large Scale Cooperative Agricultural Research by** *Richard Baldwin, IFAR consultant, Minneapolis, MN*

9:00 am **CIMMYT's Collaborative Project with Molecular Markers and Agronomic Improvement : Role of Private Sector and Commercial Opportunities by** *Clive James, Deputy Director General - Research, Centro Internacional de Mejoramiento de Maiz & Trigo (CIMMYT), Mexico*

9:30 am **Discussion**

10:00-10:30 am **Break**

Session X: **Opportunities in Biotechnology for Donor Agencies** *Rosslyn B Room*

Session Chair: Dilbagh Athwal, Winrock, International

10:30 am **The Rockefeller Foundation's International Program on Rice Biotechnology by** *Gary Toenniessen, Associate Director, The Rockefeller Foundation, New York, New York*

11:00 am **Complexity of Biotechnology and Opportunities for Donors: Experiences in India by** *Kerri-Ann Jones, Biotechnology Adviser, USAID/New Delhi, India*

11:30 am **Discussion**

12:00-1:30 pm **Lunch**

Wednesday, April 20, 1988 Con't

Session XI: **Biosafety Concerns Regarding Agricultural Research**
Rossyln B Room

Session Chair: Joel Cohen, AID

1:30 pm **Designing Guidelines and Regulations for Safe Conduct of Agricultural Research by** *Sue Tolin, Virginia Polytechnic Institute and State University (VPI), Blacksburg, Virginia*

2:00 pm **Biotechnology and International Development: Strategies for Safety by** *Anne Hollander, Associate, The Conservation Foundation, Washington, D.C.*

2:30 pm **Discussion**

3:00-3:30 pm **Break**

Session XII: **Molecular Technologies in Pathology and Diagnostics**
Rosslyn B Room

Session Chair: John Nickel, CIAT

3:30 pm **Crop Disease Detection Through Biotechnology - Worldwide Applications by** *Richard Lankow, Director of Product Development, Agri-Diagnostics Associates, Cinnaminson, New Jersey*

3:50 pm **Immunassay Technology for the Diagnosis of Disease in Livestock and Developing Countries by** *Erwin Workman, V.P. Research & Development/Operations, AgriTech Systems, Ind., Portland, Maine.*

4:10 pm **Applications for Immuno-Diagnostics in Crop Improvement at ICARDA by** *Khaled Makkouk, Virologist, International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria*

4:30 pm **Discussion**

6: 00 - 7:30 pm **Reception: National Academy of Sciences - Hosted by** *Alan Woods, Adminstrator, Agency for International Development and Frank Press, President, National Academy of Science*

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6: 00 - 7:30 pm **Reception: National Academy of Sciences - Hosted by** *Alan Woods, Adminstrator, Agency for International Development and Frank Press, President, National Academy of Science*

Thursday, April 21, 1988

Session XIII: Commercialization, Patents and Technology Transfer
Rosslyn Room

Session Chair: Allen Stevens, Campbell Research

8:30 am	**One Company's Attempt to Commercialize an Agricultural Biotechnology Product by** *Peter Carlson, V.P. for Research and Development ,Crop Genetics International (CGI), Hanover, Maryland*
9:00 am	**A New Era of Government- Industry Cooperation in Research and Development by** *William Tallent, Assistant Administrator, Agricultural Research Service. U.S. Department of Agriculture, Washington, D.C.*
9:30 am	**Discussion**
10:00-10:30 am	**Break**

Thursday, April 21, 1988 Con't

Workshop 2

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* identify constraints in international agricultural research and then identify collaborative and commercial research that will address these constraints.
* consider the consequences of biotechnologies, develop recommendations for and interest in collaborative research, initiate links between the private sector and international agricultural research organizations and provide a list of suitable linkages with international donor organizations.

10:30-12:30 am

A) **Biosafety** *Dogwood Room*
Resource Persons: Anne Hollander
Sue Tolin
Facilitator: Henry Miller, FDA
Reporter: Bruce Umminger, OES, Dept. of State

B) **Wide Crosses/Genetic Resources** *Club Room*
Resource Persons: Abdul Mujeeb-Kazi
Quentin Jones
Phil Moss
Stan Schlosser
R.S. Paroda
Facilitator: Donald Plucknett CGIAR Secretariat
Reporter: Calvin Qualset, UC/Davis

C) **Diagnostics** *Shenandoah Room A & B*
Resource Persons: Richard Lankow
Erwin Workman
Khaled Makkouk
Facilitator: Frederick Bliss, University of Wisconsin
Reporter: Joyce Turk, AID/AGR

Closing Luncheon *Rossyln B Room*

12:30 pm **Wrap Up by** *Joel Cohen, Conference Coordinator*

Final Remarks by *Nyle C. Brady*

2:30 pm **Departure**

1

STRENGTHENING COLLABORATION IN BIOTECHNOLOGY: INTERNATIONAL AGRICULTURAL RESEARCH AND THE PRIVATE SECTOR

N.C. Brady. Senior Assistant Administrator for Science and Technology/A.I.D., 4942 New State, Washington, D.C. 20523

INTRODUCTION AND OVERVIEW

The United States Agency for International Development is commited to generating new technologies needed to ameliorate many of the unique problems in the developing countries, and to help the inhabitants of these countries to improve their lives.

Biotechnology is already being employed by A.I.D.-supported researchers to generate improved agricultural, health, family planning, and energy technologies. The Agency's strategy of involving the private sector in development assistance includes endeavors in this new field, particularly as efforts move from publically-funded basic research to private-sector development of commercially-viable applications.

To successfully implement this collaboration, such issues as regulation, patent rights, and biosafety must be considered by all parties involved including public- and private-sector scientists, and developing-country leaders. The mutual agreement and respect thus generated will open the door to truly fruitful collaboration.

This Conference is to provide a biotechnology dialogue among scientists and science administrators of the private sector, universities, and the international agricultural research centers. It is hoped that appropriate linkages for future collaboration will result.

2

THE CGIAR CENTERS BUILDING- BRIDGES OF COLLABORATION THROUGH BIOTECHNOLOGY

R.L. Sawyer. Director General- Internat. Potato Center

The success of the research centers of the Consultative Group for International Agricultural Research is dependant on the collaborative bridges established with cells of expertise in the developed and developing world in both the public and private sector. The bridges of collaboration are particularly important as the new tools of biotechnology are becoming available. The international agricultural research centers can help make sure that these new tools mainly emerging from research in industrialized nations do not pass by the needs of the developing world for solving priority problems in food production. The need for bridges of collaboration in modern day biotechnology can help speed the move towards a global research approach to agriculture.

3 RESEARCH COLLABORATION AND TECHNOLOGY TRANSFER: THE PUBLIC SECTOR AND INTERNATIONAL SEED COMPANIES.

D.N. Duvick. Pioneer Hi-Bred International, Inc., Des Moines, IA. 50309.

International agricultural research organizations (IAROs) and international seed companies (ISCs) have the goal, in common, of serving farmers in third world countries. Both types of organizations are learning how to utilize biotechnology as an aid to plant breeding, and as a source of new products for agriculture. By recognizing complementarities, the two kinds of organizations can maximize progress in applying biotechnology to the needs of developing country farmers. IAROs typically will have greater capability in development of basic breeding stocks and in the basic research needed as an underpinning to applications of biotechnology; ISCs in general will have greater capability in the application stages of research and development, such as seed production and distribution, or variety and hybrid selection and testing for local adaptations. However, both types of organizations also have many skills in common. A major difference is that ISCs usually can serve only those segments of agriculture in developing countries that use hybrid seeds and have cash to pay for the seeds, whereas IAROs can and do serve all categories of agriculture in developing countries. Knowledge of this different client base should allow for realistic assumptions about expected results from collaboration between IAROs and ISCs in application of biotechnology to plant breeding for the benefit of farmers in developing countries. Also important: national research organizations in several of the developing countries have capabilities in biotechnology. They may wish to collaborate with IAROs or ISCs.

4 NATIONAL PROGRAMS IN BIOTECHNOLOGY FOR THAILAND AND OTHER SOUTHEAST ASIAN COUNTRIES : NEEDS AND OPPORTUNITIES.

Yongyuth Yuthavong Director, National Center for Genetic Engineering and Biotechnology, MOSTE, Bangkok 10400, Thailand

Growing awareness of potential impact of new biotechnology ranging from genetic engineering to bioprocess engineering led many developing countries to set up national programs to further the advancement and utilization of the technology. In Thailand, the National Center for Genetic Engineering and Biotechnology (NCGEB) was created in 1983 to serve as the center for policy and planning in biotechnology, for support of important research, development and technology transfer projects in designated institutions, and for linking these institutions with the private sector. Specific biotechnology areas were supported from laboratory stages up to pilot scale, with emphasis on transfer and utilization of genetic engineering and biotechnology in various fields and on strengthening of basic infrastructure in relevant disciplines. The National Center has 4 affiliated laboratories, including pilot plants, and over 30 projects in 9 institutions in the network. Recently the Science and Technology for Development Program, created with the assistance of USAID, has also devoted a part of its substantial funding to support various biotechnology research projects. The current programs and projects in Thailand will be discussed with special emphasis on agriculture and in relation to needs and opportunities for US-Thai collaboration, which can serve as a good model for other developing countries.

5 BIOTECHNOLOGY: NEW APPROACH FOR AGRICULTURAL RESEARCH AND TRAINING AT CATIE.

V.M. Villalobos. Head of Tropical Crop Improvement
CATIE, Turrialba, Costa Rica.

The importance of applied biotechnology to agriculture is recognized in Latin America. National programs have been established to resolve problems in the multiplication of desirable genotypes, elimination of virus, genetic improvement, and germoplasm conservation. Although there has been considerable adoption of biotechnology in the region, research and training centers such as CATIE, can play a more decisive role in the use of these techniques.

CATIE is promoting research in biotechnology for tropical species in: genetic improvement, *in vitro* conservation, and micropropagation of superior genotypes. Also encourage its transference to national programs and private industry in Central America.

The Genetic Resources Unit at CATIE is widly recognized, particularly for their collections of coffee and cocoa. Tissue culture techniques combined with conventional methods of plant improvement will permit more rapid solutions to the problems of these species. Also, under CATIE's new structure, plantain research will expand using *in vitro* techniques. Cryopreservation has already been initiated in *Musas*. Root and tuber crops, are also being studies. Morphogenic studies and field evaluation of virus-free plants are in progress.

CATIE's educational activities will multiply the impact of the research program in biotechnology through the region, via its masters program and short courses offered to professionals from the national research centers and to private industry.

6 USE OF CELL GENETICS IN CROP IMPROVEMENT

David A. Evans, Vice President-Corporate Research
DNA Plant Technology Corporation, 2611 Branch Pike,
Cinnaminson, New Jersey 08077

Over the past several years, a collection of techniques have been developed that permit development of new crop varieties. These emerging technologies will play a significant role in agricultural improvement in the next twenty years. Recent progress in cell genetics has opened the door to: (1) large-scale and rapid propagation of genetically uniform plants from elite materials; (2) the selection of novel and improved varieties using somaclonal variation; (3) the development of new parent lines via anther culture; and (4) the development of new hybrids between different cultivars and species by means of protoplast fusion. The critical hurdle for application of these technologies is efficient plant regeneration via cell culture. It is expected that, by the Year 2000, a wide range of crops will be affected by these advances in biotechnology.

7 TISSUE CULTURE MICROPROPAGATION AND CIAT BIOTECHNOLOGY RESEARCH.

W.M.Roca* and B. Nolt**. Biotechnology Research Unit* and Cassava Program**. CIAT, A.A. 67-13, Cali-Colombia.

In vitro propagation is widely used for clean planting material production. Recently, similar techniques have been developed for in vitro conservation and international exchange of germplasm. In Latin America, two IARCs apply these techniques to cassava and potatoes, and among national institutions, micropropagation stands out as the most utilized technique, according to a recent study carried out by CIAT with over 100 institutions in 23 countries. However, there is a need for low-input micropropagation technologies suitable for tropical, small farming conditions. On the other hand, current limitations in the diagnosis of viruses, require the development of rDNA-based techniques. Similarly biochemical/molecular techniques should be crucial in monitoring genotypic stability of *in vitro* cultures at propagation cycles and long-term conservation.

CIAT Biotechnology Research Unit serves as a linkage between CIAT commodity programs and advanced research institutions for the application of emerging technologies. Current efforts include running an *in vitro* active gene bank for cassava, development of plant regeneration from somatic and gametic tissues of cassava and beans, application of anther culture to rice breeding and protoplast culture to forrage legumes. In addition, research for developing molecular genetic markers and gene transfer techniques for cassava and beans are underway. Several collaborative projects with developed labs., in a network approach, provide upstream back up to this program.

8 BREEDING FOR RICE VARIETIES TOLERANT TO ADVERSE CONDITIONS THROUGH TISSUE CULTURE

F.J. Zapata, Tissue Culture Specialist, Plant Breeding Dept, International Rice Research Institute (IRRI), Manila, Philippines

Conventional breeding techniques have so far been successful in narrowing the gap between potential and actual yields. As land devoted to agriculture is becoming less and less, the best option in the future may be to produce crops in less suitable land and environment. Development of crops suited to adverse conditions such as salt, drought and cold is then an alternative to improve crop productivity.

The development of rice varieties takes several years through conventional breeding. Innovative breeding techniques such as anther and isolated pollen cultures considerably shorten the breeding cycle since these methods allow the immediate fixation of homozygosity from heterozygous materials. Somatic cell future, on the other hand, is utilized in the production and selection of mutants, as well as in the production of somatic embryos for its possible use as artificial seeds, while protoplast culture is important in gene transfer technique and somatic hybridization for incorporation of various resistances from wild into cultivated species. The utilization of various tissue culture techniques for rice improvement, especially in the development of lines and varieties for adverse conditions at IRRI, will be discussed.

9 TISSUE CULTURE FOR GERMPLASM MANAGEMENT AND DISTRIBUTION.

J.H. Dodds. Tissue Culture Specialist.
International Potato Center, P.O. Box 5969, Lima, Peru.

Potato and sweet potatoes are two basic food crops whose germplasm is normally maintained and distributed in both clonal and seed forms. Both crops when maintained clonally in the field are subject to degeneration as a result of pathogen infections. Tissue culture techniques are enabling CIP to transfer the clonal germplasm collections of these two crops to *in vitro* storage. The phytosanitary status of the collection is also enhanced by tissue culture pathogen elimination methods (coupled to appropriate pathogen testing techniques).

Germplasm of clonal accessions after appropriate pathogen testing can then be distributed to national programs in *in vitro* form. There are a number of methods for in vitro germplasm distribution, however, all of these allow the movement of germplasm of high phytosanitary quality thus assisting in compliance with International quarantine agreements. The other major advantage to the use of pathogen-tested in vitro plants is there increased yield when used in seed schemes. Tissue culture now plays a critical and principal role in the maintenance, improved phytosanitary quality and distribution of potato and sweet potato germplasm. The use of tissue culture techniques by national programs, i.e. micropropagation is also allowing rapid introduction of new varieties, of high health quality to potato and sweet potato farmers.

10 ANALYSIS AND UTILIZATION OF SOMACLONAL VARIATION IN PLANT BREEDING

W.R. Scowcroft, Biotechnica Canada Inc., Calgary, Alberta, Canada

Eukaryotic genomes are in a dynamic state of flux. This is most apparent in higher plants cultured *in vitro*, where the amount of variability generated is extensive. Genetic and molecular analysis is providing some understanding of the events which give rise to somaclonal variation.

In wheat, variants which have been analyzed at several loci indicate that chromosomal rearrangements play a significant role in generating the variation.

In maize, a new functional electrophoretic variant at the *Adh-1* locus has been characterized as resulting from a single nucleotide substitution. An analysis in maize has also shown that cell culture greatly enhances the activation of transposable elements.

For plant improvement, the enhanced frequency of genomic rearrangements during culture provide a new option to introgress alien genes from wild relative into domesticated crops. Somaclonal variation provides enhanced levels of genetic variability for *in vitro* selection. Somaclonal variation can also have a significant impact on the recovery of genetic transformants.

11 COMMERCIALIZATION AND RESEARCH PERSPECTIVES FOR VACCINES

Charles C. Muscoplat. Molecular Genetics, Inc. 10320 Bren Road East, Minnetonka, MN 55343

Biotechnology has promised a revolution in the development of animal health care products. Products envisioned include, growth hormones to improve effiency of livestock production and vaccines and monoclonal antibodies to treat and/or prevent infectious diseases. Beginning in 1980, many laboratories around the world began ambitious programs to genetically engineer subunit vaccines and prepare monoclonal antibodies. Numerous attempts at producing subunit vaccines against most major classes of viruses was difficult if not impossible. Reasons for this apparent failure are as yet unclear and may remain so for some time to come. Alternatives to subunit vaccines, which are being attempted by many laboratories are things such as; (i) cloning specific genes into vaccinia virus vectors, (ii) genetically altering native viruses by deletion of virulence genes, and (iii) producing native protein subunit vaccines through the use of improved separation techniques, specifically through the use of monoclonal antibodies. However, there is a real need for new vaccines for diseases which are as yet not controlled by any existing vaccine or product. For these diseases, the need and the challenges are great.

12 VACCINE DEVELOPMENT: THE ROLE OF BIOTECHNOLOGY, ILRAD AND THE PRIVATE SECTOR.

J.J. Doyle, Director of Research, ILRAD, P.O.Box 30709, Nairobi, Kenya.

Development and application of a new vaccine based on components of an infectious organism has the following stages. The first is the identification, isolation and characterisation of potential protective antigens. The second is production of sufficient quantities of the antigens to allow initial testing of their ability to induce protective immune responses. The third is the development of a suitable form of vaccine which is easy to manufacture, stable under a wide range of environmental conditions, easy to apply and gives long periods of protection without the need for revaccination. Finally there is the testing of the vaccine under field conditions to confirm its efficacy and determine the reasons for any apparent vaccine failures.

In the course of developing a novel vaccine against the economically important protozoan parasite of cattle, *Theileria parva*, ILRAD has identified the stages where ILRAD and the private sector each have comparative advantage, including the various uses of the new biotechnologies. A collaborative program has been developed, taking into account such issues as patent rights, to ensure that such a vaccine can be devised, tested, produced and applied in the most economic manner, so as to ensure its eventual adoption by the livestock owners in the regions of East and Southern Africa affected by this disease.

13 GENETIC TRANSFORMATION FOR VIRUS RESISTANCE: NEEDS AND OPPORTUNITIES IN DEVELOPING COUNTRIES

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The application of plant genetic transformation to crop improvement has been demonstrated through the production of plants that are resistant to viruses, insects and several different herbicides. Recently completed field tests of transgenic tomato plants carrying these new traits demonstrated high levels of efficacy for each gene. My laboratory has been instrumental in implementing the application of resistance to tobacco mosaic virus infection in transgenic plants, as well as in identifying the cellular and molecular mechanisms responsible for the trait. An overview of the results of these studies will be presented.

Because of the nature of virus diseases and their spread and the lack of resistance to many such diseases, there has been widespread interest in applying these technologies to a large number of disease situations in ex-U.S. situations. We have undertaken to establish collaborative research programs with Kasetsart University, Thailand, to control indigenous viruses and the Rockefeller Foundation to control rice tungro disease. In concert with Dr. Claude Fauquet (ORSTOM) we are currently attempting to form an international working group to apply similar technical approaches to improve cassava plants. These and other examples serve to illustrate the need for collaborative interactions between scientists who develop important technologies and scientists in developing countries who need the technologies.

14 GENETIC ENGINEERING OF INSECT RESISTANT CROPS

Ronald L. Meeusen

Each year pests destroy enough of man's food and fiber crops to feed and clothe over one-fifth the population of the planet. To reduce these loses researchers have spent decades developing chemical pesticides and breeding resistant crops, but additional tools are badly needed.

One such tool will be reviewed today. Crops have now been genetically engineered to resist major insect pests by introducing into their genomes a bacterial gene which produces a natural, non-toxic and biodegradeable protein insecticide.

While this exciting technology has already proven itself in the laboratory and two seasons of field trials, several issues yet cloud its future for world agriculture. The cost of this type of research is over 10x that of traditional crop breeding, yet patent protection in many countries remains weak or non-existent, reducing the incentives for such innovative solutions to agricultural problems. Moreover, the investment needed for regulatory approvals is at best uncertain, further discouraging rapid deployment of such environmentally desireable technologies.

These problems and their current status will be reviewed.

15 APPLYING RESTRICTION FRAGMENT LENGTH POLYMORPHISM TO PLANT BREEDING

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Restriction fragment length polymorphism (RFLP) provides a tool to assist plant breeders in the management of variation produced through genetic recombination. The reassortment of parental chromosomal segments in progenies which result from recombination has been a black box to breeders who must deal at the organismic level of variation. RFLP makes it possible to tag and follow the reassortment of economically valuable chromosomal segments through succeeding generations. Consequently, the odds of success in producing new, agronomically superior or specialized varieties will be improved significantly. RFLP markers can also provide precise genetic fingerprints for the determination of evolutionary, pedigree, and identity relationships.

16 DEVELOPMENT AND FIELD TESTING OF CROPS IMPROVED THROUGH GENETIC ENGINEERING.

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Following the introduction into plants of foreign genes responsible for tolerance to herbicides, insects and viruses, and the demonstration of their activity in laboratory and greenhouse conditions, a new step has been taken towards the practical use of engineered traits with the first field tests of transgenic tomatoes. Field testing allowed for the first time a thorough evaluation of the agronomic potential of the engineered genes, and showed that transgenic plants do not differ from the original cultivar, except for the introduced gene. The test demonstrated that bioengineered plants can be grown safely without conferring any undue risk to man or the environment. A continuing collaboration between government agencies and private and public research organizations will help gradually remove the obstacles towards the full release of bioengineered plants in the environment, so that their benefits can be applied to agriculture.

17

Use of hormones and ovule and embro culture to enhance wide crosses.

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One aim of biotechnology is to transfer genes into cultivated plants from related species from which they have diverged. The barriers which have evolved to maintain this natural divergence include failure of pollen germination or growth, fertilization, and embryo abortion.

These barriers can be overcome by treating flowers and developing fruits with growth hormones, and culturing hybrid embryos. In wide crosses in *Arachis*, (groundnut or peanut), treating flowers with gibberellic acid at the time of pollination increased fruit initiation (peg formation) from less than 10 percent up to over 80 percent, and prolonged the time before the developing peg and embryo degenerated. Treating the peg with auxins extended the life of the peg and increased pod production from 17 percent to 40 percent. The size of the ovules was also increased, but mature seeds were not formed.

Embryos were too small to dissect so ovules were excised and cultured on filter paper bridges. Some embryos grew and could be excised and cultured, but many embryos were abnormal. These were excised and cultured to promote callus formation, and subsequent subculturing promoted shoot formation. Shoots were rooted, or grafted onto cultivated seedlings of cultivated groundnut.

18

ALIEN GERMPLASM FOR WHEAT (*Triticum aestivum* L.) IMPROVEMENT FACILITATED BY CYTOGENETIC MANIPULATION AND USE OF NOVEL TECHNIQUES.

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Practical alien genetic transfers in the Triticeae have been predominantly for simply inherited traits. The potential for methodology application to complex polygenic systems is probably higher in the Triticeae than in most other groups. Gene transfer methodology mechanisms incorporate use of (i) chromosome 5B mechanism, (ii) *Triticum aestivum* or *T. turgidum* x *Agropyron* spp. based partial or complete synthetic genomes, (iii) general or specific wheat x alien chromosome-induced translocations, (iv) high intergeneric recombinant sources, and (v) interspecific hybridization involving *T. araraticum*, *T. monococcum*, *T. tauschii* and *T. urartu*. This phenomenal cytogenetic flexibility offers remarkable opportunities for alien gene transfers and incorporation of homoeologous, introduced segments in the best location in the recipient wheat chromosomes. Novel techniques exist or are being developed to complement wheat cytogenetics, diversify polyhaploid-based stable wheat euploid production through intergeneric hybridization, establish diagnostic markers for detection of alien introgression, and yield greater precision for callus culture methodology as it may influence intergeneric hybridization amongst the Triticeae. The short-term (5 to 7 years) interspecific and long-term (10 to 12 years) intergeneric hybridization objectives demand critical scrutiny of collaborative or base-located projects that are budget efficient and focussed towards demands for world food production.

19 EVALUATION OF LATIN AMERICAN MAIZE: INTERNATIONAL COOPERATION ON A MAJOR WORLD CROP GENETIC RESOURCE.

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There is general agreement that probably most of the genetic diversity of maize (*Zea maize* L.) has been collected. Taxonomic, or characterization, studies have led to the definition of about 300 races of maize. Members of a race share highly heritable characters so the concept is useful in providing a means for classifying maize germplasm and for studying patterns of variation and presumed relationships. Evaluation studies are designed to elucidate the nature and extent of influence environmental factors may have on units of genetic diversity. It is evaluation data that permits maize breeders to select germplasm that will be of most help in reaching breeding goals.

Essentially equally important in generating good evaluation data is the accurate recording and reporting of that data for utilization by maize breeders and other scientists whenever and wherever the need arises. It is available and useful data that provides the greatest support for the costly, but necessary tasks of rescuing, maintaining, and evaluating our crop genetic resources.

20 THE ROLE OF THE INTERNATIONAL LEGAL SYSTEM IN PROTECTING PLANTS AND OTHER BIOTECHNOLOGICAL INVENTIONS

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Many of the world's technologically advanced countries have established legal systems for the protection of biotechnological inventions, including plants and plant breeding. The major treaties regulating the international legal system are now under examination. The exact nature of the future modifications in the system cannot, of course, be predicted, but it seems certain that rights in the form of plant breeders' rights and patents will be strengthened. This strengthening will benefit the public as recipients and future users of new technology.

International seed breeding centers should take advantage of plant breeders' rights and patent systems. These centers should acquire foreign origin technology by license or purchase, in order to avoid wasteful duplicative research. In addition, they should acquire exclusive legal rights in their own countries. They could even introduce the profit motive in their research, to provide an additional source of research funding. The acquisition of foreign rights by seed breeding centers should not be overlooked. Joint ventures and other business relationships with technology-rich companies and countries deserve consideration, but such relationships require the possession of legal rights or agreement about their distribution.

21 PLANT GENETIC RESOURCES NETWORK IN INDIA

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The Indian gene centre holds rich genetic diversity of crop plants. Several land races, wild and weedy materials provided many useful genes for increasing productivity of a large number of crops. Much of the variability still remains unexplored and holds great promise for future. India took a lead in genetic resources activities in early forties and during the last four decades a viable genetic resources network got established under the National Bureau of Plant Genetic Resources, New Delhi. created by the Indian Council of Agricultural Research in 1976. The Bureau has a nationwide network of germplasm collection and evaluation centres. It also has the mandate for exchange, quarantine and conservation of plant genetic resources in the country. Being the nodal agency, Bureau has established effective linkages with International organisations, national research institutions and the Private Sector engaged in crop improvement activities. In the process, systems have been devised to cater to the needs of all concerned rather more effectively. An attempt has, therefore, been made to enlist the existing network on plant genetic resources in India and efforts being made to further strengthen the same to make it still more effective. Also the past achievements and future plans have been discussed and suggestions offered for possible improvements in the existing systems so that genetic resources are managed well for posterity, as well as to meet present needs of our society.

22 FOCUSED LARGE SCALE COOPERATIVE AGRICULTURAL RESEARCH.

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A novel mechanism has been suggested for tackling agricultural research opportunities that are too large, too complex, too orphaned, or are considered impossible to achieve with the resources and procedures presently available to individual research institutions. The proposed mechanism provides focus, planning, coordination and supplemental funding needed for "Manhattan type projects" related to agriculture.

The basic difference between this mechanism and other research networking systems is that it provides a specific objective focus within a time focus as was done, for example, for the "Moon landing program", i.e., within ten years send men to the moon and return safely to Earth.

Numerous agricultural research projects with such focus are being considered, e.g., a) hybrid soybeans with 20% yield advantage by the year 2003, b) cassava with 50 mg% of vitamin A equivalent by 2001, or c) practical biological nitogen fixation for wheat by 2005.

Networking, per se, is not a new concept in agricultural research. The novel part of this proposal is its emphasis on a tight focus on the objectives within a time frame. Participants should logically include appropriate research cooperators from the public and private sectors, basic and applied, domestic and international. In the past there has apparently been no "convenor or initiator" of such broadscale complex projects. The newly formed International Fund for Agricultural Research could be that "catalyst". Implications of such prospects are profound and exciting.

23 CIMMYT'S COLLABORATIVE PROJECT WITH MOLECULAR MARKERS AND AGRONOMIC IMPROVEMENT ROLE OF PRIVATE SECTOR. COMMERCIAL OPPORTUNITIES.

Clive James, Deputy Director General-Research. CIMMYT,Mexico

CIMMYT has responded to the CGIAR/TAC priority for upstream research by a decision to establish a biotechnology lab in CIMMYT Mexico in 1988. One of the thrusts of the biotechnology program will be the use of molecular probes (restriction fragment length polymorphisms RFLPs) as genetic markers in maize. The molecular genetic markers will be used to determine linkages with genetic factors controlling quantitative traits, which are difficult to manage in the current breeding programs e.g. insect resistance. CIMMYT has already secured access to a suite of probes from the University of Missouri, which can be made available to participants in an international network. Concurrently, CIMMYT has initiated a proposal to establish an international network of public and private institutions to develop a joint program of work on maize, where network participants have common goals and objectives and share information materials and results. Each participating lab or group would have the responsibility of generating information relative to one trait of interest and sharing the data with the other participants.

24 THE ROCKEFELLER FOUNDATION'S INTERNATIONAL PROGRAM ON RICE BIOTECHNOLOGY

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The Rockefeller Foundation has long supported plant breeding aimed at improving the productivity of major crops of the developing world. Recent advances in molecular and cellular biology are expected to increase the efficiency of plant breeding and make it possible to achieve objectives unattainable through conventional breeding. Since 1985 the Foundation has funded a comprehensive and vertically integrated research network designed to assure that powerful new genetic improvement technologies are developed for rice and made available for use by rice breeding programs in developing countries. The decision to focus on rice was based on its importance as the staple crop which determines the nutritional and economic status of millions of people, and the observation that no other private or public sources of support in the developed world were committed to generating the knowledge base necessary for the genetic engineering of rice. Initially, Foundation funds were used to introduce rice research at several of the world's leading plant biotechnology laboratories, to establish a wide hybridization program at IRRI and an expanded rice anther culture capability at CIAT, to help build capacity in developing country rice breeding programs to use biotechnologies, and to undertake a systematic assessment of rice improvement priorities, thereby establishing specific goals for the program. Promising results will be reviewed. Currently, emphasis is placed on identifying and supporting research that addresses priority goals and on building rice biotechnology research capability in the developing world.

25 COMPLEXITY OF BIOTECHNOLOGY AND OPPORTUNITIES FOR DONORS: EXPERIENCES IN INDIA.

K.A.Jones. Biotechnology Advisor/USAID/New Delhi.

The potential biotechnology offers has been recognized worldwide. Viewed in its entirety, this area presents a complex picture which must be addressed for ultimate success - i.e., useful products. Complexity has been revealed as developed countries proceed though the process of moving products from the laboratory to the market.

In developing countries, the situation will be similar. Additionally, the process of steps needed to develop biotechnology products and move them to the end user is even less well established in these countries. This complexity should not be viewed as an obstacle to development programs. Rather it provides a unique opportunity for creative approaches and policy discussions in an area which cuts across traditional sectors (e.g. health and agriculture) and interest groups (scientists and entrepeneurs).

India has long been a strong supporter of science and technology and the country's enthusiasm for biotechnology is a natural continuation of this policy. USAID/New Delhi is working to develop programs that target specific needs in the Indian biotechnology process. These programs cover a range of possibilities providing continuity by building on established programs and providing support for critical junctures in product movement.

26 DESIGNING GUIDELINES AND REGULATIONS FOR SAFE CONDUCT OF AGRICULTURAL RESEARCH.

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Plant and microorganisms modified by biotechnology research with potential applications for agriculture have been been developed through research conducted in compliance with the NIH Guidelines for Research with Recombinant DNA Molecules. These organisms are then evaluated in small scale field tests, as is traditional for agricultural research. In the United States currently, such field tests require approval at the Federal level by the Environmental Protection Agency by the U. S. Department of Agriculture's Marketing and Inspection Service. The effect of these regulations on research and development of agricultural biotechnology products, and approaches to develop generic guidelines to ensure regulatory decisions are based on sound science and lead to safe conduct yet unimpeded research will be discussed.

27 BIOTECHNOLOGY AND INTERNATIONAL DEVELOPMENT: STRATEGIES FOR SAFETY.

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Private companies, international research centers, and development assistance agencies share the intent and the ability to transfer genetic engineering technology to developing countries. However, historical experience has shown that the mere transfer of technology to developing countries is not necessarily beneficial. Specific products need to be assessed for safety within the cultural and environmental context of the countries where they will be used.

Public assistance agencies and research centers have an explicit mandate to ensure their activities are safe from a scientific, social, and economic standpoint. Private companies do not. However, strong public pressures in the U.S. and in developing countries are likely to compel all public and private institutions to develop and adopt strategies to systematically address technical risks (e.g. environmental and health effects), and socio/economic risks (e.g. distributional and political implications). Very few companies and agencies involved in genetic engineering transfer have such strategies at this time. This paper provides concrete steps and considerations to help these institutions develop effective and foresighted safety strategies.

28 CROP DISEASE DETECTION THROUGH BIOTECHNOLOGY — WORLDWIDE APPLICATIONS.

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Diagnostic products for agriculture are among the first truly practical applications arising from those techniques we term biotechnology. Crop diseases are responsible for significant yield losses worldwide; although intensive efforts reduce yield losses, additional yield increases from improved disease management are possible. Diagnostic products can contribute to effective disease management in a number of ways:

- Provide accurate disease diagnosis with a minimum of laboratory equipment.
- Permit detection of disease before disease symptoms develop.
- Provide a means to monitor disease levels throughout the growing season.

Recently, Agri-Diagnostics has developed products which allow the rapid and accurate detection of fungal plant pathogens in foliage, roots, stems, seeds, fruit, grain, and soil. Detection and monitoring of fungi during the growing season will help reduce crop losses through the increased use of integrated pest management in disease control:

- Preplant determination of soil-borne pathogens will guide disease management practices such as: crop selection, variety selection, and fungicide seed treatment.
- Pathogen levels can be monitored to determine the need for fungicide applications.
- Pathogen levels will guide fungicide selection, rate, and timing of application.

Biotechnology-based crop disease diagnostic tools can be designed to be very simple to use which will allows their use at sites remote from laboratories. Simplicity of use will extend the availability of disease monitoring to the entire range of growers from the highly mechanized to the less sophisticated. In contrast to other biotechnologies, immunodiagnostic techniques can be readily applied to major yield-limiting diseases such as rice blast, resulting in practical applications within a relatively short period.

29 IMMUNOASSAY TECHNOLOGY FOR THE DIAGNOSIS OF DISEASE IN LIVESTOCK AND DEVELOPING COUNTRIES

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Developments in immunodiagnostic technology have dramatically impacted our ability to diagnose disease over the last ten years. Increased usage of this technology reflects the tremendous strides that have been made in assay development as a function of new instrumentation, new developments in solid phase chemistry, and biotechnology. Enzyme and fluorescence-based immunoassay systems are replacing radioimmunoassays and various agglutination and tissue culture methodologies. The use of monoclonal antibodies has given rise to improvements in sensitivity, specificity, and ease of use. The latest immunoassay systems, which incorporate recent technological advances, provide improved sensitivity and specificity, yet are simple enough to be performed in the veterinary clinic or out in the field. Concentration Immunoassay Technology (CITE™) is one example of this new generation of enzyme immunoassays. This type of technology provides the proper mix of accuracy and ease-of-use characteristics appropriate for the diagnosis of animal diseases in developing countries.

30 APPLICATIONS OF IMMUNO-DIAGNOSTICS IN CROP IMPROVEMENT IN ICARDA REGION.

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Immuno-diagnostic use has been integrated as an important component in virology and microbiology research at ICARDA, where research efforts focus on improvement of cereals and legumes for food and forage. The autecological capability of polyclonal techniques, particularly fluorescent antibody and ELISA, makes possible investigations into the critical areas of *Rhizobium* behavior in soil, and especially *Rhizobium*-plant interactions in the rhizosphere. Polyclonal antisera have been effectively used for detection and field surveys for a number of plant viruses, but more recently developed barley yellow dwarf virus (BYDV) monoclonals have proved useful in identification of PAV, RPV and MAV types. The narrow specificity of monoclonals is useful in detecting variability, but makes them inappropriate for field surveys where some field isolates could go undetected. Specificity of PAV monoclonals originating from different laboratories was found to differ.

Future application of immuno-diagnostic techniques at ICARDA will include detection of bean leaf roll virus, which affects a number of legume crops, and seed-borne pathogen testing for various viruses, fungi and bacteria. ICARDA will work to develop and provide kits for use by national program scientists in the West Asia - North Africa region, as well as train individuals to use the techniques.

31 FROM INVENTION TO COMMERCIALIZATION OF A NOVEL BIOPESTICIDE

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Crop Genetics International Corporation is an agricultural biotechnology company developing a family of genetically engineered microbial pesticides, InCide™ product, which can be inoculated into seeds and plants. These pesticide-producing microorganisms are designed to reside and function in a plant's vascular system and provide protection to the life of the plant.

The first products under development are insecticides designed to protect corn form major insect pests. CGI is seeking regulatory approval to field test in 1988 its first corn insecticide product in the United States and France. CGI believes that applications of its InCide microbial delivery system may include other insecticides and fungicides which protect cotton, soybeans, rice, wheat and other crops as well as new products which enhance the growth of major crops.

The Company's crop protectants and growth enhancers are expected to reduce significantly the costs and environmental hazards associated with conventional externally applied products.

I will outline CGI's experiences as we move this technology to the market.

32 A NEW ERA OF GOVERNMENT-INDUSTRY COOPERATION IN RESEARCH AND DEVELOPMENT

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The Federal Technology Transfer Act of 1986 (PL 99-502) authorizes Federal laboratories to work more closely with industry through Research and Development (R&D) Cooperative Agreements. Executive Order (EO) 12591 issued by President Reagan April 10, 1987, mandates that Federal laboratories will take advantage of the opportunities presented by the new law to achieve more effective technology transfer. Key provisions of PL 99-502 permit up-front commitments regarding exclusive licensing of inventions generated in the course of the cooperation and require that Federal inventors receive at least 15 percent of the revenue from such licensing. As of the end of calendar 1987, USDA officials had signed R&D cooperative agreements with 7 companies, and negotiations were underway with 35 more.

Both 99-502 and EO 12591 stipulate that business units located in the U.S. are to be given preference in cooperative research agreements with Federal laboratories, but neither excludes cooperation with foreign firms. For the latter, guidelines are being prepared that will take into account such factors as subsidiaries or facilities in the U.S. and reciprocal treatment of U.S. firms by the foreign government in question.