



ENVIRONMENTALLY AND SOCIALLY
SUSTAINABLE DEVELOPMENT

Work in progress
for public discussion

Biotechnology and Biosafety



A forum cosponsored by
AAAS, The Conservation Fund, CGIAR, FAO,
Governments of Norway and Sweden, ICSU,
IUCN, USNAS, Smithsonian Institution,
TWAS, UCS, UNDP, UNESCO, UNEP, UNIDO,
and The World Bank Group

Ismail Serageldin and Wanda Collins, Editors

Biotechnology and Biosafety

A forum cosponsored by
American Association for the Advancement of Science
The Conservation Fund
Consultative Group on International Agricultural Research
Food and Agriculture Organization of the United Nations
Government of Norway
Government of Sweden
International Council of Scientific Unions
Smithsonian Institution
Third World Academy of Sciences
Union of Concerned Scientists
United Nations Development Programme
United Nations Educational, Scientific and Cultural Organisation
United Nations Environment Programme
United Nations Industrial Development Organization
U. S. National Academy of Sciences
The World Conservation Union
The World Bank Group

Biotechnology and Biosafety was a forum associated with
The Fifth Annual World Bank Conference on
Environmentally and Socially Sustainable Development,
held at the World Bank, October 9–10, 1997

Ismail Serageldin and Wanda Collins, Editors

*The World Bank
Washington, D.C.*

Copyright © 1999
The International Bank for Reconstruction
and Development/THE WORLD BANK
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.

All rights reserved
Manufactured in the United States of America
First printing February 1999

This report has been prepared by the staff of the World Bank. The judgments expressed do not necessarily reflect the views of the Board of Executive Directors or of the governments they represent.

Cover photographs. Top: A peasant farmer in a northern volcanic area of Rwanda weeds potatoes grown on elevated beds. Bottom: A molecular virologist at the International Potato Center (CIP), Lima, loads an acrylamide "sequencing gel" to sequence the RNA of a potato virus; the resulting genetic fingerprint is in the background. Both photos by permission of CIP, one of the centers of the Consultative Group on International Agricultural Research (CGIAR).

Ismail Serageldin is vice president, Special Programs, at the World Bank. Wanda Collins is deputy director general for research, International Potato Center (CIP), Lima, Peru, one of the 16 research centers of the Consultative Group on International Agricultural Research (CGIAR).

Library of Congress Cataloging-in-Publication Data

International Conference on Environmentally Sustainable Development
(5th : 1997 : World Bank)

Biotechnology and biosafety : proceedings of an associated event of the fifth annual World Bank Conference on Environmentally and Socially Sustainable Development / Ismail Serageldin and Wanda Collins, editors.

p. cm. — (Environmentally and socially sustainable development)

ISBN 0-8213-4242-8

1. Biotechnology—Environmental aspects—Congresses. 2. Health risk assessment—Congresses. 3. Agricultural biotechnology—Congresses. I. Serageldin, Ismail, 1944- . II. Collins, Wanda Williams. III. Title. IV. Series: Environmentally and socially sustainable development series.

TP248.2.I579 1997

660.6—dc21

98-23586

CIP



The text and the cover are printed on recycled paper, with a flood aqueous coating on the cover.

Contents

Preface v

Acknowledgments vi

Abbreviations and Acronyms viii

PART I. BIOTECHNOLOGY AND BIOSAFETY 1

Setting the Stage

- Introductory Remarks and Stating the Problem *Ismail Serageldin* 1
The Scientific Scene *Werner Arber* 5
The Special Case of Agricultural and Food Biotechnology *Henry W. Kendall* 13
Discussion 16

The Promise and the Perils

- Overview *Christopher R. Somerville* 22
The Opportunities and the Risks *Robert B. Horsch* 25
Miguel A. Altieri 31
Discussion 39
Regulatory Framework Issues
Chair *Hamdallah Zedan* 44
Presenters *Desmond Mahon* 50
Timothy W. Roberts 53
Discussion 57

Reviewing the Evidence

- Panel 1 Are the Opportunities of Genetically Modified Organisms Being Fully Exploited?
Presenters *George Tzotzos* 60
Gabrielle Persley 62
Carlienne Brenner 63

Panel 2 Are the Risks of Developing and Releasing Genetically Modified Organisms Being Adequately Evaluated and Assessed?

Presenters	<i>Rita R. Colwell</i>	65
	<i>L. Val Giddings</i>	67
	<i>Rebecca Goldberg</i>	69
Discussion		72

Role of International Agricultural Research

Biotechnology and Biosafety in the CGIAR System:

An Efficient, Equitable, and Ethical Path	<i>Timothy G. Reeves</i>	75
Research Partnerships in Biotechnology: Role of the Global Forum on Agricultural Research	<i>Fernando Osorio Chaparro</i>	79
Perspectives from National Agricultural Research Systems	<i>Maria José A. Sampaiao</i>	91
Genetic Engineering: Addressing Agricultural Development in Egypt	<i>Magdy Madkour</i>	94
Discussion		99

Role of Public Policy

Presenters	<i>Vernon W. Ruttan</i>	105
	<i>Michel Dron</i>	108
	<i>George A. Lloyd</i>	116
Discussion		119

Recommendations for Action

Synopsis	<i>Wanda Collins</i>	122
Discussion		126
Wrap-up and Next Steps	<i>Ismail Serageldin</i>	128

**PART II. "ETHICS AND BIOTECHNOLOGY: REALITIES AND UNCERTAINTIES,"
EXCERPTED FROM *ETHICS AND VALUES: A GLOBAL PERSPECTIVE* 132**

PART III. *BIOENGINEERING OF CROPS: REPORT OF THE WORLD BANK PANEL ON TRANSGENIC CROPS* 153

Appendixes

A. Program	183
B. Presenters and Chairs	185
C. Cosponsors	189
D. Consultative Group on International Agricultural Research Secretariat and Centers	191

Preface

Biototechnology—the technique of using living organisms or their parts to make or modify products, improve plants or animals, or develop microorganisms for specific use—comprises an important and powerful set of enabling technologies with which to solve an array of problems. The power of these technologies is unlike any the scientific world of biology has yet seen, and they are responsible for a true biological revolution. The ability to move genes and groups of genes at will, to decipher, to “see,” and to manipulate the molecular codes that make us individuals, as well as to “demystify” the genetic makeup of organisms in nature—these tools are now spread before us.

The potential risks of biotechnology go well beyond those we face directly as humans. They go to the very heart of what makes our world survive: the ecosystems in which we live and the organisms, both plant and animal, that make those ecosystems function. New technologies as powerful as those of biotechnology carry with them the burden of making wise and informed decisions of how to use them by asking and answering questions about their safety and assessing what risks are acceptable to human society. It is up to all of us as scientists, policymakers, and concerned members of civil society to make those decisions.

How to maximize the potential of biotechnology while minimizing risk is a critical issue facing scientists and policymakers and was the topic of an intensive, two-day conference at the World Bank in October 1997. The event took as its starting point the findings of a panel of experts commissioned by the World Bank Group and led by

Nobel laureate for physics Henry W. Kendall. These findings, published by the World Bank in 1997 under the title *Bioengineering of Crops: Report of the World Bank Panel on Transgenic Crops*, are also presented in Part III of this report to provide the reader with essential background.

The “Biotechnology and Biosafety” conference, an Associated Event of the Fifth Annual World Bank Conference on Environmentally and Socially Sustainable Development, was open to the public. Participants represented a wide cross-section of stakeholders—academics, scientists, international and national research organizations, and representatives from the private sector and civil society. The special focus of debate was on how the promises of biotechnology can be realized for the benefit of the world’s poor, the environment, and the safe management of biotechnology products and processes. Because of the significant role of ethics and values in determining choices affecting environmental conditions, an Associated Event on this topic was held prior to the Conference. The proceedings of this Event, *Ethics and Values: A Global Perspective*, include the chapter, “Ethics and Biotechnology: Realities and Uncertainties,” which has been reprinted in Part II of this book as an easy reference to the readers.

This publication summarizes the wide-ranging, stimulating, and provocative presentations and discussions that took place during the meeting. While there are still dissenting opinions on some issues, there was surprisingly broad agreement on many others. In areas of divergent opinion this frank and open public discussion served to more clearly focus the debate and—just possibly—point the way forward.

Acknowledgments

Cosponsors

American Association for the Advancement of Science (AAAS)
The Conservation Fund
Consultative Group on International Agricultural Research (CGIAR)
Food and Agriculture Organization of the United Nations (FAO)
Government of Norway
Government of Sweden
International Council of Scientific Unions (ICSU)
Smithsonian Institution
Third World Academy of Sciences (TWAS)
Union of Concerned Scientists (UCS)
United Nations Development Programme (UNDP)
United Nations Educational, Scientific and Cultural Organisation (UNESCO)
United Nations Environment Programme (UNEP)
United Nations Industrial Development Organization (UNIDO)
U.S. National Academy of Sciences (NAS)
The World Bank Group
The World Conservation Union (IUCN)

This conference on Biotechnology and Biosafety was held as an Associated Event of the Fifth Annual World Bank Conference on Environmentally and Socially Sustainable Development (ESSD) and was hosted by the World Bank Group under the auspices of the ESSD vice presidency. In recognition of biotechnology's critical importance to science and society, the event was cosponsored by 17 organizations. The cosponsors, listed above, deserve a special expression of gratitude, having contributed to the organization of an outstanding event

that brought together many of the world's most distinguished specialists.

The governments of Norway and Sweden deserve a very special expression of appreciation for their financial support, without which the conference would not have occurred.

The World Bank Group also wishes to express gratitude to all who participated in this event by making presentations or by taking part in the debate. Special thanks are due to Wanda Collins and Sarwat Hussain, who organized the event; Joan Martin-Brown, who oversaw day-to-day organi-

zation of the entire ESSD Conference and affiliated events; and Lisa Carlson and other staff of the World Bank Group, the CGIAR Secretariat, the International Food Policy Research Institute (IFPRI), and all the others whose contributions made this event possible.

The background document for this conference was *Bioengineering of Crops: Report of the World Bank Panel on Transgenic Crops*, which was prepared by a panel of experts chaired by Professor Henry W. Kendall, Nobel laureate for physics

and chairman of the board of the Union of Concerned Scientists. Dr. Kendall and the entire panel deserve special acknowledgment for their outstanding contribution to the success of the conference. The panel's report, which includes a list of the panel members, is reprinted in this volume as Part III.

This proceedings was copyedited by Alison Raphael, desktopped by Gaudencio Dizon, and coordinated by Lisa Carlson, Alicia Hetzner, and Virginia Hitchcock.

Abbreviations and Acronyms

AGERI	Agricultural Genetic Engineering Research Institute (Egypt)
AIDS	Acquired immunodeficiency syndrome
APHIS	U.S. Animal and Plant Inspection Service
ARC	Agricultural research center
BSE	Bovine spongiform encephalopathy
BSO	Biological safety officer
Bt	<i>Bacillus thuringiensis</i>
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	International Maize and Wheat Improvement Center
CIRAD	Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement
COLCIENCIAS	[Colombia Sciences]
CONABIA	National Biotechnology Commission
CORPOICA	Colombian National Research Corporation
CTNBio	National Technical Biosafety Committee
DNA	Deoxyribonucleic acid
EMBRAPA	Brazilian Agricultural Research Corporation
EPA	U.S. Environmental Protection Agency
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FBEC	French Biomolecular Engineering Commission
FDA	U.S. Food and Drug Administration
GATT	General Agreement on Trade and Tariffs
GDP	Gross domestic product
GMO	Genetically modified organism
HRC	Herbicide-resistant crop
IARCS	International agricultural research centers
IBC	Institutional Biosafety Committees
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICSU	International Council of Scientific Unions
ICT	Information and communication technology
IFPRI	International Food Policy Research Institute

IITA	International Institute on Tropical Agriculture
IP	Intellectual property
IPM	Integrated pest management
IPR	Intellectual property rights
ISNAR	International Service on National Agricultural Research
IUCN	World Conservation Union
KARI	Kenyan Agricultural Research Institute
LMO	Living modified organism
MAI	Multilateral Agreement on Investment
MVs	Modern varieties
NAGEL	National Agricultural Genetic Engineering Laboratory (Egypt), now AGERI
NARS	National Agricultural Research Systems
NBC	National Biosafety Committee (Egypt)
NGO	Nongovernmental organization
OECD	Organisation for Economic Co-operation and Development
ORSTOM	French National Research Institute for Development Cooperation
R&D	Research and development
r-DNA	Recombinant deoxyribonucleic acid
RNA	Ribonucleic acid
TAC	Technical Advisory Committee
TRIPS	Trade-Related Aspects of International Property Rights
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
UPOV	Union for the Protection of Varieties
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
WHO	World Health Organization
WTO	World Trade Organization

PART I. BIOTECHNOLOGY AND BIOSAFETY

Setting the Stage

Introductory Remarks and Stating the Problem

Ismail Serageldin

February 22, 1997 was the day on which the international community was compelled to come to terms with the spectacular progress of biotechnology: Dolly the sheep was introduced to the world. Dolly's creation immediately focused attention on a branch of science that is little known and less understood by the public at large.

The promise and perils of biotechnology have developed a mystique of their own, and the world was soon buffeted by conflicting stories of the possible benefits of scientifically created superabundance and possible disasters that raised fears from Frankenstein's monster to Jurassic Park. More thoughtful concerns were expressed about the possible health or environmental effects of genetically modified organisms (GMOs), in addition to the ethical concerns of tinkering with nature.

We need to be more dispassionate. Let us disentangle the issues.

Biotechnology could help us to pursue the mission of environmental protection, poverty reduction, and food security by helping to promote a sustainable agriculture centered around smallholder farmers in developing countries. Although the first fruits of the new technology are already benefiting the commercial crops of the industrialized countries, there is no inherent reason why the tools of biotechnology could not be employed in pursuing the mission of environmentally and socially sustainable development.

Biotechnology could be used to introduce environmentally friendly resistance to disease and pests. It could help develop hardier plants with resistance or tolerance to drought, salt, and herbicides. Plant characteristics could be genetically altered to adjust maturation speed, increase transportability, reduce post-harvest losses (such as shelf-life), water content, and stem size. All of these aspects are of great relevance to poor farmers in low-potential environments.

Biotechnology is also relevant to the poor because it is seen to be scale-neutral. Unlike mechanization, for example, it has no intrinsic bias against the smallholder farmer. But the complexity of managing refuge areas in Bt transgenic crop plantings shows that it is not as easy to transfer as might appear at first blush, unless seed mixes prove adequate to the task.

In the case of livestock, so essential for the smallholder farmer, biotechnology provides the most important defense against disease, such as vaccines for east coast fever in east Africa.

The biotechnology revolution is here. It is relevant to the problems of the world and to the work of the World Bank Group and the Consultative Group on International Agricultural Research (CGIAR). But for many of us it raises important questions relating to ethics, intellectual property rights, and biosafety. Let me say a brief word about each of the two first sets of issues—which are not the topic of this conference—and then try to frame the issues for the remaining discussions on biosafety.

The Ethical Issues

Not everything that is technically feasible is ethically desirable. For some, transgenic tinkering with nature raises fundamental issues, which must be respected. Conversely this must be weighed against the possible benefits that biotechnology, with adequate safeguards, can bring to the poor and the environment.

These issues were scrutinized yesterday at a special session that dealt with ethical issues in development; they were also the topic of a workshop held in Brazil under the auspices of the CGIAR Genetic Resources Policy Committee some months ago. Such discussions constitute a major step forward in disentangling the issues and, hopefully, creating a consensus as to the domains that we should pursue and those that we should eschew. There will always be areas of disagreement on such controversial issues, but to the extent that they are thoroughly debated we should all be wiser for hearing each others' point of view.

Intellectual Property Rights

There is no question that intellectual property should be protected. The results of recognition of IPR are increased rewards to the creative and mobilization of resources for research that would not occur if protection were not there. However proprietary science is beginning to pose some problems of access for some of the poorer countries and for those needing to use processes for the purpose of producing public goods.

Balancing the need of private investors to have IPR to recoup their investments and the needs of the poor and future generations to have access to relevant science and suitable products is the real problem posed by IPR in this new biotechnology revolution, which is not only producing undreamed-of breakthroughs, but also is creating a totally new environment for science—a domain of proprietary science with a whole new set of issues to address. I do not propose to address these here.

Safety Issues

Nobody would argue that we should not be on the lookout for the safety of the public, especially

in developing countries where there has been inadequate attention to issues of product safety in the past. But that should not translate into the rejection of all types of activities that are labeled biotechnology out of fear or ignorance. The correct balance has to be established when weighing the benefits against the risks of biotechnology.

Fear exists that transgenic plants will turn into weeds; or that biotechnology will provide paths for new genes to move into wild plants that become weeds; or that it will create new viral strains from virus-containing transgenic crops. In addition there is concern regarding possible health or environmental impacts of these transgenic organisms in food crops.

Such concerns are real. They must be examined dispassionately, and we are gathered here today in this important seminar, cosponsored by the most distinguished scientific bodies in the world and key international bodies, to do just that. We are here to assess scientific evidence on the safety of biotechnology applications in agriculture, which should constitute another step in disentangling the issues.

Possible Actions

I believe that this conference should lead to two types of results.

First, a collective judgment, a consensus, on the range of acceptable approaches to the issues of biosafety for both biotechnology research and application. I look to this gathering to replicate in a small way the achievements of the Asilomar conference a generation ago. At that time the uncertainty surrounding the new science of recombinant DNA research attracted much media attention, which shed more heat than light. Scientists met at Asilomar in California and established a set of guiding principles, based on the best available science, to create appropriate protocols for research and the levels of protection appropriate for different kinds of research. It is interesting to see that this set of voluntary guidelines, based on a scientific consensus and subsequently adopted by many institutions, has served the world well for over a quarter of a century.

Second, a specific set of decisions that each of us intends to pursue in the institutions where we

work, which have a role in promoting the adoption of the kind of biosafety measures that this consensus will underline.

For the first, I await the results of your deliberations. For the second, I can say something about the World Bank Group and the CGIAR, subject to modifications that may arise from the deliberations in the coming two days.

The World Bank Group and the CGIAR

For the World Bank Group I am happy to endorse the recommendations of the Kendall Panel Report, entitled *Bioengineering of Crops*. I propose to urge the Bank to act in accordance with its recommendations. In fact, I am happy to note, some of the panel's recommendations are already being implemented.

- *Support of Developing World Science*

The Bank should direct attention to the need for liaison with and support for the developing world's agricultural scientific community.

We will support the newly emerging Global Forum for International Agricultural Research. We will continue to support the regionally based National Agricultural Research Systems (NARS).

- *Research Programs*

The Bank should identify and support high-quality research programs dedicated to exploiting the favorable potential of genetic engineering for improving the lot of the developing world.

The recently approved loan for agricultural research in Brazil is a model of our willingness to move in this direction.

- *Surveillance and Regulation*

The Bank should support the implementation of formal, national regulatory structures in its client nations by seeing to it that these structures retain their vigor and effectiveness through the years and by providing scientific and technical support to the client nations as requested. The Bank should support, in each developing country, the deployment of an early warning system to identify any troubles that may arise and to sig-

nal successes and introduce improvements in adapting new strains.

We will look into this.

- *Investment in International Agricultural Research Centers*

The Bank should increase its support for research in biotechnology and related areas at international agricultural research centers, because these centers are in the best position to ensure that high-quality, environmentally sustainable agricultural products and processes are developed and transferred in developing countries.

Our support for the CGIAR will continue.

- *The Agricultural Challenge*

The Bank should continue to give high priority to all aspects of increasing agricultural productivity in the developing world, while encouraging the necessary transition to sustainable methods.

This is at the heart of our new rural development strategy and the new emphasis that President James D. Wolfensohn has placed on rural development.

For the CGIAR I am happy to report that the Technical Advisory Committee has just appointed two panels, one to look at biosafety issues and one to look at IPR and the practice of proprietary science. We await their views for a debate on the topic at the annual meetings of the CGIAR later this month. Yet one can still advance some thoughts for consideration. The principles that should guide the actions of the CGIAR can be articulated, fully recognizing that the devil is in the details and that the application of the principles is where the difficulties will lie.

The CGIAR must play a role in ensuring that:

- Access to the potential benefits is guaranteed for the poor and the environment
- The risks of biotechnology are appropriately addressed and adequate biosafety provisions are made for developing countries that want to benefit from this additional tool.

This means intensifying certain things we have been doing. It means adding to our critical mass of scientific effort in the area of biotechnology, but not at the expense of the heartland issues of

people-centered policies, inclusion of the farm community, natural resource management, and biodiversity. Let us always remember, too, that biotechnology is a tool to be used in conjunction with other tools, not an end in itself.

Envoi

We often speak of partnerships, of the complementary roles played by the public and the private, the national and the international, the formal and the informal, the farmer and the scientist, nongovernmental organizations and NARS, and the synergies that we have to cap-

ture for the benefit of creating a better world—free of hunger and misery, dedicated to the dignity of people, especially the poor and the future generations from whom we have borrowed this planet. Can we define ways in which this can be accomplished in the domain of biotechnology? Can we create adequate safeguards for use of this powerful new technology? Can we find ways to marry the interests of all these actors? I think that we can. I think that this conference will be a major step in that direction.

The time for action is now. Let us move forward with all the deliberate speed that practical wisdom would dictate.

Wrap-up and Next Steps

Ismail Serageldin

First, I would like to say a profound thank you to the people who organized this event, specifically Wanda Collins and Sarwat Hussain, and more generally Joan Martin-Brown, who has been the impresario of the multiplicity of events this week, as well as Lisa Carlson and many other staff members from the CGIAR Secretariat, the World Bank Group, the International Food Policy Research Institute, and others who have worked so patiently, along with our cosponsors, to made this event possible.

It has, indeed, been a compelling two days and, if nothing else, serves as an interesting starting point. There are actually some 16 different organizations, including conservation groups, scientific groups, international agencies, and bilateral agencies that agreed to cosponsor this event, which speaks to the importance that we all attach to this issue.

I think that we have done reasonably well in trying to disentangle a number of the issues, including an effort to start with the more general ethical issues and then deal separately with legal regimes. But the comment that Alexander McCalla made at the end about World Trade Organization (WTO) and nontariff barriers brings back the whole issue of links between the WTO, other conventions, legal arrangements, and intellectual property rights, which is a topic that deserves a separate, in-depth discussion in its own right.

The decision was to confine this particular discussion to the safety issues related to biotechnology, and I feel that we have made considerable advances.

Sometimes there is a fear of setting reductionism up too much as a straw man, because many of the top scientists in the world would not adhere to the view of reductionist science. Roger Penrose, for example, who is a mathematician, wrote a beautiful essay in a book called *Nature's Imaginings* in which he shows why even the structure of mathematics, which due to its inherent structure is assumed to be the most reductionist, recognizes that there are things that remain outside of the reductionist approach.

In many instances we use the concept of reductionism as an artifact; the problems are too complex, and we try to bring them down to a more comprehensible level. I am fond of pointing out that on one level human beings are nothing more than three buckets of water and a handful of minerals held together by chemical reactions. That extreme reductionist view has served us extremely well in medicine, bringing about enormous advances in treatment and longevity of human beings.

Yet it is a view that misses the difference between a Mother Teresa and a Hitler, or between a Mozart and a Stalin. It fails to take into account everything that we refer to as a human being. In the same way no doctors or medical practitioners would assume that this reductionist view is the entire totality of human beings, even though they find it convenient to do so.

In some ways there has also been a tendency—perhaps less so in this group than in others—to hold up economics as a discipline as being reductionist in an unacceptable way, by reducing

a society to the sum of its economic and financial transactions, which is equivalent to reducing a human being to three buckets of water and a handful of minerals.

I think there is something there of value. But I sense that the other side of that equation is really concern for the complexity of the interactions and synergistic effects present in the idea of understanding an ecosystem in its entirety, not just its individual organisms, and that takes a more holistic approach to sort out.

This is a debate that has also permeated the Convention on Biological Diversity, as one of protecting species or entire habitats in ecosystems, and that is where I think we need to have a larger discussion. I have spent much time debating with colleagues on how to bridge the differences between microbiologists and ecologists in their general perception of life.

I think we need to engage others in discussing this. Miguel Altieri said earlier that science is too serious to leave to the scientists, paraphrasing a famous leader talking about war being too serious to be left to the generals. Nevertheless there is a scientific basis and a scientific viewpoint for dealing with ecological interactions as well.

But we are not just about settling perceptions in science; we are also about trying to move forward with realities. With every passing minute we have 200 additional people on the planet, three per second. They will be demanding food, nutrition, shelter, housing, and habitats, and enormous pressure is going to be coming upon us. It is important that actions are being taken. Delaying action is an action. It is a choice. It is not postponing a choice; it *is* a choice.

The balance is between perception and reality. The tradeoffs are there and they are inescapable. They will require that we try to find ways of dealing with the disagreements that we have. Val Giddings, I think, rightly pointed out the disagreements about what is acceptable risk. Even if you have defined the level of risk, what is acceptable?

Acceptable risk is not really a scientific issue, but rather a social and political issue. We accept airlines as being safe, yet planes do crash. So there is a level of risk. We can build in a redundancy system and a second. There is no end to how far we can go, but it is implicit that at certain points

choices are being made about levels of acceptable risk, and they vary.

Defining the level of acceptable risk is not an issue that can be determined by science. Science may be able to help determine the magnitude of the risk or the probability of its occurrence, but ultimately the choices have got to be there. It is in that context that I think Wanda Collins' comment reminding us about the question of choice between things that have already passed acceptable risk is especially pertinent.

I would like to add two other dimensions to our concern, since much of what drives me and my colleagues is concern with the poor and the impoverished in the developing world. The first is that discussions of standards must always be weighed with the interests of those who do not have voice in many of these debates in mind. We need to remember that. We should not allow the noxious practices of dumping toxic materials on them. We should not allow the sale of expired medicines to developing countries or other practices of which we are fully aware.

At the same time we also must be concerned about the pressures of the counter-factual. For example, in another domain I have worked for many years on issues of accessibility to water and sanitation. When governments insisted that they would have a certain level of service—now, mind you, this is not risk, this is service, levels of service—the net result was that they rationed out a lot of people. They ended up having subsidized water running from the taps of the middle class, while very large numbers of poor people had no access to water. Women had to travel for five hours a day to get water; children were playing in the filth, causing all sorts of diseases. Meanwhile the claim was that: “We cannot reach those people because we are trying to provide water at a certain standard.” That is counter-factual: we are trying to reach everyone, but our self-imposed standards do not actually allow us to reach the people who need it most.

In the same way I think that we have to look at a range of approaches capable of improving the productivity and income of the poor, including and only in part—and here I concur with Wanda Collins—the issue of biotechnology, which is being seen only as a subsidiary to that larger problem.

On the ecological side is the issue of pressure on habitats, which is important because debates around the Green Revolution still continue today. But at the same time it is important to know that if we had not had significant yield increases, we would have had 300 million more hectares under cultivation, and the net result of that in terms of additional forests destroyed and additional species lost would have been very severe—plus the fact that there would have been colonization of the hillsides, erosion of the soil, and a lot of other negative consequences.

So we need to balance these issues—the needs and demands versus the risks. None of these choices are easy. Many of them are not going to be scientific choices, but rather societal choices. On this point I join our colleagues from the Third World Network who spoke about the need for greater information sharing and transparency in public debate, and I hope that this event has contributed to that.

Disagreement about benefits is easier. To the extent that we can prevent fraudulent claims and safeguard with scientific scrutiny against fraudulence and incorrect claims, then the question as to who is making the claims of benefits (of course, mostly these are people on the industry side) is whether they are willing to bet their money that this will prove economically viable. If the benefits are there, farmers will use the technology and it will be economically viable. If not, the technology will disappear.

Our job as decisionmakers and informed people is to ensure that the prices are real and that they incorporate the full environmental and social costs. Because to the extent that you have distorted prices or hidden subsidies, decision-making about whether or not the alternative choices are more beneficial and more economical would be unsound and distorted. Therefore incorporation and internalization of the externalities becomes essential.

It seems to me, finally, that there are two points that can pull us together in terms of movement. If we look at everything that is being done and discussed in biotechnology, we can go from a level of comfort to less and less comfort. The highest level of comfort would be the use of genetic markers, tissue culture. It is mainstream. Nobody worries about it. It is being done very well.

Second is movement within the same species, wheat and wheat. We take genetic material from one wheat and put it into another wheat. We could probably produce the same result by conventional breeding over a longer period of time and, therefore, there is not much of a problem there in terms of acceptance.

Third would be closely related species. It happens in nature and it happens to conventional breeding programs. Triticale is the result of a cross between wheat and rye, so we are still fairly close to conventional techniques, even if we used a transfer technique that enabled us to do it more quickly and the gene to express itself. But, fundamentally, we are not breaching much of what could be achieved at a slower pace in a conventional manner.

Then we get into more complex areas of moving from organisms where the transfers would not likely occur, including, for example, the biotechnology gene coming from a bacterium into a plant. Then you enter into suggestions of entire restructuring of the genome and changing the architecture of plants by putting traits together.

I think we can start by building partnerships where people feel a common comfort level and then work outwards from that. To the extent that additional evidence comes in, additional safeguards are employed, and the comfort levels of people are satisfied, then we can move with all deliberate caution on all of these problems.

That requires us, finally, to add two more things to make it feasible to have an effective follow-up. One is to work on clusters of specific problems, and I think Wanda Collins' comment about black Sigatoga in bananas is a very pertinent one. Next week I will be meeting with a group of people from industry, developing countries, and research institutions to discuss whether such a partnership is feasible around the issue of black Sigatoga in bananas, and whether such a partnership could also benefit plantains, which would benefit some very poor people in another commercial crop, even if it also benefits the desert banana, which is a commercial export crop.

To determine whether or not this is feasible, we will have to bring in the lawyers. It seems that nothing can be done without lawyers nowadays, but that is part of the bane of proprietary science and many other things. But lawyers also

have fashioned wise constraints that keep us free, so I hope that the lawyers will live up to that lofty and noble description of their profession.

And that, of course, is where we need to move towards a partnership. Partnership, we said, moves beyond the dialogue of the deaf toward a learning relationship. Yes, but it also has to be a definition and understanding of what it is that each one of us brings to the table. What we bring to the table is different knowledge, different perspectives, different abilities, so this is where we will have to work together.

In that working together around specific clusters of problems in specific projects, I take up Miguel Altieri's appeal to the noble forum: when you have the ability to say let us fuse our efforts around a specific problem, and in so doing you go on a journey, not just for the discovery of the other but also for discovery of the self. That is our goal in partnerships, and that is what will allow us to finally reach mutual agreement on more issues.

I have always been an optimist, and I am convinced that we will be able to forge the partnerships that we have been talking about in a

manner that will benefit the poor generations to come and the environment as a whole.

I am also optimistic that we will be able to raise additional funds if they are required, but to do so will require that we define more accurately the scope of the interventions for which these funds need to be raised. I hope it will not be at the expense of some of the other activities that we want to undertake.

It is with these notes that I would like to leave you, with a deep vote of thanks to each and every one of you that have taken time from your busy schedules to share with us your concerns, your visions, your knowledge, your experience, your expertise, your fears, and your hopes. For in the end there is nothing that exists today that was not once before imagined, and there is nothing that will exist in the future that we will not ourselves imagine.

The future is very much what we will make of it, and I believe that by our thoughts and our actions we are creating the future right now, this instant, in this room, in the very crucible of our minds, by defining the limits of the possible.

Panelist's Remarks

Ismail Serageldin

Few technological changes have caused as much debate as the recent changes in biotechnology (Bt). Unfortunately, much of this debate has been dominated by the sensational and the visceral, and little coverage in the media has been truly deliberative, rigorous, or based on scientific evidence in framing the issues.

Defining the Problem

I would like to define the scope of the topic first by limiting it to agricultural biotechnology, that is, the bioengineering of crops, especially food crops, and livestock, fish and trees. These activities are distinct from the bioengineering of medicines for human health. Medical bioengineering does not seem to elicit the same criticism as agricultural bioengineering. Critics of biotechnology do not seem to address their critiques to medical research, on the grounds that the resulting medicines or treatments would help people in distress.

Nevertheless, it is important to remember that most people who do not object to medical uses of biotechnology, while objecting to its use in agriculture, take that position because they place a value on reducing human suffering and prolonging human life, which is held to be intrinsically worthwhile. This argument, which I believe emanates from a correct system of values (that is, one in which minimizing human suffering and prolonging human life is held to be positive), is important to retain as we move to the domain that we will discuss here, namely,

agriculture, especially in developing countries. It is relevant to hold that thought because the issue of better food production in the developing world involves many of the same arguments, even though the debate in the North is largely among people whose most likely nutritional problem is obesity, not hunger. The hungry in the Northern industrial societies are largely the marginalized, and they do not participate in the debate to ban or not to ban genetically modified organisms (GMOs)!

The second delineation of the problem relates to what we mean by biotechnology. Biotechnology is a continuum of tools that has only recently evolved into the part that bothers critics: the transformation of the genetic makeup of organisms by recombinant techniques, especially when we introduce the genes of other species into the target species—for example, introducing the Bt gene from a bacterium into a plant.

Transforming the genetic makeup of a variety of plant through genetic transfer from another variety of the same species should not pose much of an ethical problem. In fact it would simply be an accelerated way of achieving by biotechnological means that which we could achieve through conventional breeding programs and therefore should not pose ethical or safety problems for anyone not opposed to the latter.

We might arguably extend this acceptance to the bioengineered product of a genetic transfer between closely related plants, such as wheat and barley. Here we are already tinkering with

nature, but the boundary with the conventional “natural” breeding system is so close that, for many, that also would be acceptable. The result of such a gene transfer is unlikely to significantly modify or denature the plant. Triticale is such an interesting cross.

Beyond that we get on the slippery slope leading to the design of new plant types, based on the assemblage of desirable traits from individual plant species or even from other organisms. Are we now “playing God,” with the likely results of the “sorcerer’s apprentice”? That is part of this discussion.

The other, related problem that people have is with the idea of cloning, or the forced asexual reproduction of an organism that naturally reproduces sexually. This qualification is necessary because the critics of biotechnology generally, and of cloning specifically, obviously have no difficulty with the reproduction of plants through cuttings, a practice as old as civilization.

With the domain of the discussion delineated in this manner, the issues can be usefully grouped into ethical issues relating to:

- Tinkering with the natural order of things
- The likely risks associated with the new technology, which may well far transcend the actual users of the products of that technology
- The patenting of life forms.

Against this set of issues we must address the potential benefits that would be forgone if we do not use biotechnology to address the problems of the world today. This moral calculus must be undertaken if we are to chart an ethical course on this complex set of issues.

Tinkering with Nature

There is a profound distrust about people taking it upon themselves to change the natural order of things. One can argue, rightly, that by our very presence on this planet we are changing the natural order of things, and that our increasing numbers, ever-more powerful technology, and insatiable appetites for consumption and pollution are indeed affecting nature, mostly in negative and potentially dangerous ways. Witness global warming and biodiversity loss.

Yet, against this general proposition we must set the welfare of the human species. Any moral

argument must include human welfare, regardless of whether one assumes that human beings are a privileged species or not. There is no reason to argue for the welfare of animals if one is not going to extend the same argument to human beings. Indeed, it is instructive that the first legislation to protect children against the abuses of child labor was sponsored by the Society for the Prevention of Cruelty to Animals!

It is difficult to argue that hunter-and-gatherer societies living “in harmony with nature” should be encouraged to stay as they are, even if that means enormous infant mortality rates and short life expectancies. Humane treatment would mean improving diet, education, and health. The resulting reduction in infant mortality and increases in consumption are likely to put pressure on the natural system. The questions then become how to handle that pressure, how to ensure that the patterns of development that are adopted are sustainable. Even arguing from a human-centric point of view, surely it does not make sense to undermine the ecosystems on which our long-term survival depends.

Biotechnology fits into the class of tools that humans are mastering for the potential benefit of humanity, and that holds both promise and perils that should be weighed intelligently, on the basis of the best available evidence, to determine whether, when, and how it should be used. Viewed thus, the matter becomes a simple calculus of the potential benefits and potential risks associated with the new technology.

However, let me add some qualifiers to the argument. We must recognize that the ethical issue of purposively changing the natural order of things is qualitatively different from trying to survive as best we can in this world in which we find ourselves. A course of action that tinkers with the natural order of things is equivalent if and only if it can be demonstrated that there is no alternative to pursuing that course, and that it has enough unique benefits in improved living conditions for human beings to outweigh the moral questions it raises.

Stated thus, the issues become propositions that can be elucidated by the best available scientific evidence about the issues of agriculture, poverty, food security, sustainable development, and the potential of alternative means to

reach the goals of food security for all in an ecologically sustainable world system. Here the evidence is mixed: the challenge of ensuring food security is profound, and the likelihood of meeting it without recourse to the bioengineering of crops is remote. Indeed, some authors, ranging from Henry Kendall and David Pimentel to Lester Brown and Hal Kane, have cast doubt on the world's ability to feed its growing population in a sustainable fashion under any scenario.

However, I do not take that view and would argue that we do have the chance to develop and intensify agriculture to meet that challenge. I would not argue that enhancing food security is possible if the potential use of biotechnology in this enterprise is prohibited. Remember that if we fail to reach the goal of sustainable agriculture for food security in the developing countries, it implies enormous misery for an enormous number of human beings. That distributive and income policies are equally important in ensuring food security does not in any way diminish the need to have the production side in hand. The production side is necessary but not sufficient to meet the challenge of hunger. Its absence makes discussion of income or redistributive policies largely academic.

If this position is defensible, then the question becomes one of managing the safety and other aspects of the technology, not proscribing it a priori. On the other hand, if the goal of sustainable agriculture for food security in developing countries can be achieved by other means, then the ethical argument against tinkering with nature remains intact for those who support it.

We must always remember that not all that is technologically feasible is ethically desirable.

Ethical Issues of Safety

In the case of biotechnology that would lead to releasing genetically modified organisms into nature, the issues of safety acquire a different level of concern. Is there a risk that we would affect the very ecosystems on which we all depend? What if these scientific efforts produce "super weeds" or "super viruses" that have a broad impact on many? Again the question is one of evaluating the scientific evidence and assessing to the best of our ability the likely risks.

Clearly, it is not possible to entirely exclude certain classes of risk, any more than one would be able to exclude the risk of an asteroid hitting the earth or of being struck by lightning. Yet these risks are considered so remote that one goes through life ignoring them. I am not saying that the potential risks of releasing genetically modified organisms into the environment are in the same class of probability as asteroids or lightning. However, the discussion should not start with the premise that any potential risk, no matter how remote, would automatically veto the potential application of a technology. After all, in a case much closer to everyday life, we could ask whether people would be willing to accept a technology that contributes to global warming, kills about 50,000 people a year and maims another 500,000 in the United States alone, and adds nothing vital to our lifestyles except the convenience of personalized fast travel. Yet no one would be able to persuade the average person to agree to ban the automobile.

So we come back to assess the real risks of biotechnology in terms of how to ensure its safe use so that its benefits can accrue safely to the many who need it. This is the topic of a two-day symposium, entitled "Biotechnology and Biosafety," starting tomorrow in which a large number of distinguished authorities will participate (Serageldin and Collins 1998).

Patenting of Life Forms and Other Issues of Patenting

The third broad area of ethical issues involved in biotechnology is that of patenting. One of the ethical questions raised is whether the patenting of life forms is acceptable. There is no direct answer, but the ownership of animals and plants, as well as the right to own a particular breed, is recognized. It could be argued that allowing ownership rights to other life forms is a matter of degree. After all, the varieties of flowers or livestock are themselves owned and sold, and breeding of horses and other show animals is recognized. So what is more offensive in patenting, that is, establishing an ownership claim on, a gene or gene sequence, than in asserting ownership of a whole plant or animal or a variety thereof?

The difference lies in the idea of owning a “building block of life” rather than the living creature itself. The assumption is that the building block can then be part of many other living things. This is an issue that I still struggle with and cannot easily define to my satisfaction.

Nevertheless, the issue is one that affects many people, and we should strive to understand their qualms and to accommodate them. No legislature can function if it does not have the broad support of the majority of the population, and the views of the minority today could well be those of the majority tomorrow. However, such a transformation is best achieved by education and scientific evidence, not by assertive preemptive action by a vocal minority.

Why do I say this? Because the lessons of history teach us so. A comparison between the United States’ experience of its failed banning of alcohol (prohibition) and its effective quasi banning of smoking is instructive. Efforts to reduce smoking benefited from a protracted education campaign that resulted in a significant shift in popular attitudes; the banning of alcohol did not. The substance of that education campaign was scientific evidence increasingly linking smoking to a plethora of health issues.

In the same spirit should we not marshal the resources of science to assess the substantive claims of the contrarian view, be it for or against the patenting of life forms, to explain the difference between that and outright ownership of animals and plants?

There is another side to the patenting story. It raises another set of ethical issues that I would like to put before this assembly. These include the progressive monopolization of knowledge and the increasing marginalization of the majority of the world’s population. Concomitantly, selective focusing research and applications of new biotechnologies skew their benefits to the potential markets of the rich and exclude the concerns of the poor.

The issues operate at two levels:

- Privatization of the scientific research enterprise and the meaning of proprietary science in the coming century
- Proprietary aspects of biotechnology in terms of both process and product.

On the first, I am concerned by a growing gap in knowledge between the North and South, which is exacerbated by the privatization of the knowledge enterprise. Elsewhere, I have called this an emerging *scientific apartheid*.

But the problems posed by the new environment of proprietary knowledge are different. They lead to the hoarding of information, and they are changing the character of the scientific research enterprise, especially in the universities, with their claim of promoting the advance of knowledge and its diffusion. The race to publish is being replaced by the race to patent.

Increasingly, the proprietary climate that governs research on genome mapping and the patenting of genes and gene sequences has recreated the world of the mapmakers of the 15th and 17th centuries, eloquently evoked by Daniel Boorstin:

Geographic knowledge, a product of discovery, was a precious international currency, coveted by everyone, easily stolen, and valuable to hoard. Anybody’s new bit of information about an easy passage or a treacherous shore could be added to anybody else’s in the race for gold and glory....

In this grand universal enterprise of discovery, all scientists, explorers, and navigators were collaborating willy-nilly, intentionally or unintentionally. Collaboration, while necessary, was both desired and feared. All realized that they were working toward the same end, a more accurate map of the earth. And their efforts bore fruit. (1994, pp. 20–23)

In both examples the issue is not that the research efforts do not bear fruit, but that the climate of that research becomes more like the competitive and secretive climate of military research, and less like the open and participatory climate of the research university that we have come to know in this century. This proprietary research culture threatens the open partnerships of science that were established from the 18th century onward.

The emergence and rapid dominance of this proprietary science pose difficult issues for institutions of higher learning in countries such as

the United States. Here the need to maintain a not-for-profit status and retain the 501c(3) tax deduction is at odds with the pursuit of lucrative and interesting research with the giants of the private sector. They also pose questions about ensuring the ready accessibility of knowledge, surely a function of the university.

Equally powerful is the claim of the private sector that if it is to mobilize and invest large sums in research, it must be able to recoup its investment. To do so, the protection of intellectual property rights (IPR) is the key. From the view of the investor simple justice would demand that intellectual property rights be respected.

So we have an ethical dilemma posed by the conflict between two desirable ends—two competing claims to a just and fair treatment. The way out of this dilemma is to recognize the domains of the claims more precisely. Public goods should be left to the public, and *the private goods that aid in achieving these public goods should be treated differently* than the private goods produced by the private sector directly for the end user.

This is a subtle argument, but an important one. In the past institutions such as the International Agricultural Research Centers (IARCs) supported by the Consultative Group for International Agricultural Research had access to the basic science and could apply it to the problems of the poor. The results were available to all for free, a public good. Today, this is no longer possible because the patenting of both process and product continue unabated.

I would not mind if private companies patented the products that they choose to sell. However, I do mind if their patents prevent the IARCs from using the same basic scientific processes to make products of interest to the poor—products that the private sector patenters are not going to make precisely because of their public goods nature. Surely, there is an ethical question here, not just a legal one.

Of course, this does not argue for abolishing patenting or nationalizing private research. It argues for an imaginative approach that recognizes the interests of the vast majority of the poor in the world today.

This is not a hypothetical question. Look at pharmaceuticals, an areas in which the private sector has dominated research for a long time and

patenting is increasingly enforced around the world through the trade-related intellectual property (TRIPs) agreements under the World Trade Organization (WTO) rules. What do we find?

Malaria today affects some 200–400 million human beings, severely affects some 10 million persons, and kills about a million people annually. Yet, there is no significant private sector research for a malaria vaccine. Why? Because malaria is not a disease of the industrial countries, and because the millions of people affected are poor and live in very remote areas, making them an unattractive market. Compare this to the research being done on AIDS. It is plentiful and, it is hoped, is leading to a real cure for this devastating disease. But the cure will cost at best between US\$5,000 and US\$10,000 per patient. With enormous luck the cost could be brought down to US\$1,000 per patient. This is an enormous advance, but one that will leave the vast majority of very poor AIDS victims in such countries as India, Rwanda, and Uganda with no accessible treatment.

I do not say this to fault the private sector companies. They are doing what they are supposed to do. I fault the public bodies that use the enormous presence of the private sector in medical research to justify a retreat from the pursuit of what are essentially public goods in the classical economic definition of the term. Biotechnology in agricultural research poses many of the same problems. We should recognize the importance of public goods research to accompany and complement the massive private sector research. In this context we must reassess the ethical aspects of preemptive patents and the patenting of process as well as product. New ways of collaborating with the private sector while respecting its right to intellectual property rights protection must be found to access the process side of the biotechnology work for public goods research.

Envoi

I have argued for defining more narrowly the scope of the discussion, limiting it to the issues of biotechnology in agricultural research. I have tried, wherever possible, to isolate the issues that could be framed as scientific questions,

allowing us to assess the evidence and make informed decisions based on a cost-benefit or risk assessment, from the issues where the problems are inherently normative and the arguments are based on values. The difference between these approaches is the same as that between an argument against surrogate motherhood based on religious or other ethical values and one based on the safety of the procedure for the mother or the fetus. The safety argument is one that can be resolved in scientific terms, subject to another set of decisions about how much risk is acceptable. The ethical is not debatable in the same terms. So it is with some of these questions of biotechnology and patenting.

Whatever the difficulties, the ethical debate is one that we must all join in seriousness and in depth. There are few technologies on the market today that are more transformative. There are few that pose as many serious questions for our consciences and our minds, even when we circumscribe the debate as narrowly as I have tried to do here.

So let us go forth into these new domains with open minds and sensitive hearts, combin-

ing skepticism with concern and compassion. Let us be firm in the determination to do good and to remember our responsibilities toward the poor and the marginalized and the future generations of human beings as well as other species. And let us adopt an inquisitive posture that will also remember that issues such as these are never settled, but must be constantly reviewed and weighed in the light of new developments and new evidence. Only in this way will we be able to tackle our problems and, perhaps, also fashion the wise constraints that will set us all free in the truest and most profound sense of the word.

Reference

- Boorstin, Daniel J. 1994. *Cleopatra's Nose: Essays on the Unexpected*. New York: Vintage Books.
- Serageldin, I., and W. Collins. 1998. *Biotechnology and Biosafety*. Proceedings of an Associated Event of the Fifth Annual World Bank Conference on Environmentally and Socially Sustainable Development, "Partnerships for Global Ecosystem Management: Science, Economics and Law," Washington, D.C.: World Bank.

Discussion

Ismail Serageldin: Klaus Leisinger said some very important things that I hope we will focus on. One was that if we are concerned about the inadequacy of public resources, one of the ways to tackle that is to increase public investment in research that the private sector is not going to do. There is a balance between the two: there are some things that the public sector will do, and there are some things that the private sector needs to do.

Miguel Altieri highlighted the set of what he referred to as the kinds of biotechnology that should be done, and he was happy that the Novartis Foundation is funding some of that, working in the Sahel. But we cannot expect that the Novartis, which is a profit-making institution, would necessarily invest its money in doing that kind of research, except through the removal from commercial considerations.

The second point of concern is that we need to try to resolve the degrees of risks that really are associated with that question. Over the next two days some very distinguished people will be addressing that. Professor Werner Arber, the president of the International Council of Scientific Unions and a Nobel Prize winner for research in enzymes, will be our opening speaker tomorrow, and Henry Kendall, of the Union of Concerned Scientists, and a Nobel Laureate in physics, also will be speaking. The question of just how much risk there is, and how we can guard against it—that is a separate set of issues which we can also

address. But it will take time, and we have two whole days for that, tomorrow and the day after.

Audience comment: I was very interested in the comment on how Ciba-Geigy is handling this issue of licensing, allowing the Consultative Group on International Agricultural Research access to licenses. I have experience with a somewhat different system, which we have practiced within the Biofocus Foundation. Many private companies with which we have been in touch have accepted it without hesitation. We favor patenting, but we also say that the license fee should be tied to the GNP per capita in the country where the intellectual property right is practiced. That may be a variety of the same approach that you take.

Pat Mishey: I am taken by the question that you raised of the biotechnology being driven by market forces, rather than concern for the common good of poverty and hunger alleviation. I would like that addressed. And the question of who is responsible and accountable when things go wrong? And what about the precautionary principle, to prevent harm? How can we hold companies accountable for the prevention of harm? Is the burden on the people to deal with a disaster after it happens, or is the burden on the companies to show, in advance of applying the technology, that it will do no harm?

Audience comment: It is not the companies that are responsible for the mess that we are in, or the multinationals, but rather our whole economic system, which is incompatible with ecological well-being.

Gabby Balsheart: I have two questions. First, do consumers want genetically manipulated organisms in their food? Second, do small farmers in developing countries want the seeds that they cannot use any way they want to?

Klaus Leisinger: On the last questions first, I am very much in favor of open labeling, because then consumers have the choice. If they want to buy a tomato, they should be able to see whether it is a “normal” one or a flavor-saver, and then they can make the choice.

Do the farmers in the developing countries want genetically engineered varieties? They want varieties that bring them an economic benefit. If a farmer with one or two hectares can feed his or her family with one variety and cannot feed his family with the other variety, his choice will be obvious, and he will not care about whether that variety was modified by traditional methods or by genetic engineering.

Miguel Altieri, I can give you, for free, the results of our 12 years’ research on striga. If you intercrop with cowpeas, the striga goes down by 85 percent without any chemicals being used. The choice is not between the most modern biotechnology and traditional technologies. There must be technological pluralism. The right mix very much depends on the circumstances. It depends on the time. Ten years from now more than 50 percent of the people in developing countries will be urban people who cannot produce food for themselves. Then we might have to look at a dual agriculture, where part of the food is mass produced, and we have to do anything that is possible to help the marginal farmer to survive. And to bring up this Manichean picture—it is either bad or good—this is simply not my perception of the world. Do farmers buy things they do not benefit from? Is the propaganda of the multinationals so powerful that they can overcome the economic judgment of farmers? If so they must be very different from the farmers we have in Switzerland or Germany.

Last but not least, and I do not want to be unfriendly or politically incorrect, but I have heard a lot of this diffused uneasiness about our economic system not being fit for the survival of humanity. Well, about eight years ago we had another system collapse. So there are not too many alternatives. The political task is to make the market economy socially compatible and ecologically sustainable. There are no instant solutions. For many countries this will be a matter of trial and error, which is going to be developed over many years. One element that was mentioned by Ismail in the morning session will produce a lot of progress—let us try anything to make prices tell the ecological truth. Once it is no longer possible to externalize ecological costs, then all of a sudden it will be the consumers’ choice.

Last, if we put the burden of proof about risks on those who innovate, we will not have any more innovation. Because we can never guarantee that we have not missed a risk during the research stage. We have to use the best available knowledge to minimize the probability that severe risks may emerge. That is the precautionary principle today. Most companies cease producing products that show ecological incompatibility in the early stages.

Lori Thrupp: I found it very interesting that both Dr. Serageldin and Dr. Leisinger pointed to the fact very lucidly that, to use your exact words, “there are no technological solutions to social and political problems.” And that was preceded by a very strong point which many of us have acknowledged for many years, that the root of food insecurity is largely related to social and political factors. Food production, therefore, is not sufficient, we acknowledge that.

Yet it seems ironic that we come back repeatedly to funding, to investing tremendous amounts of funds from the private sector and the public sector in purely technological solutions. If we are looking at issues that are largely related to distributional questions, to ensuring sustainability over the long term, which requires a change in paradigm, of production, related to the sort of model of science and of society that Miguel alluded to, then why do we come back repeatedly to look for technological solutions? I am not deny-

ing that there is a food insecurity issue, or that we do not need more production. But I think that we are looking for the wrong solution by investing huge sums of money into largely technological solutions. I wonder if some of you might want to address that?

Ismail Serageldin: This discussion is focusing on biotechnology because that is the issue before this panel. The issue of biotechnology as a technology raises many issues of a visceral nature, of an ethical nature. This is not to say that other issues are not important: the bulk of the World Bank's investments in agriculture, which are running at US\$3.5 billion a year, in support of maybe a total of US\$7 billion of spending by the developing countries, is largely not in technology. Out of that there may be a couple of hundred million that are going to technological improvements. The bulk of it is going to issues from land reform to rural roads to agricultural credit to access—a whole range of issues, changing the prices that you were talking about.

Second, and I tried to emphasize this point, the fact that we recognize that the distributional issues are absolutely essential does not remove the fact that the production side is extremely important. Everybody agrees on the demand side—that we will need roughly twice as much production of food on this planet within a generation and a half, partly due to population growth, partly due to income growth. Before we worry about the distributional aspects, if we do not have the overall balances, we know who is going to be squeezed out. It will not be the rich who will go hungry, it will be the poor. That was Amartya Sen's major observation: that people who focus only on the production side and who say that if the balances are in place then everything takes care of itself are not correct, a point that Norman Myers reminded us of.

This conversation is not a total picture, but it is focusing on one subset of it. In that light we are not denying the importance of all these other aspects.



THE WORLD BANK

1818 H Street, N.W.

Washington, D.C. 20433 USA

Telephone: 202-477-1234

Faexsimile: 202-477-6391

Telex: MCI 64145 WORLDBANK

MCI 248423 WORLDBANK

World Wide Web: <http://www.worldbank.org/>

E-mail: books@worldbank.org

C O S P O N S O R S

American Association for the Advancement of Science

The Conservation Fund

Consultative Group on International Agricultural Research

Food and Agriculture Organization of the United Nations

Government of Norway

Government of Sweden

International Council of Scientific Unions

Smithsonian Institution

Third World Academy of Sciences

Union of Concerned Scientists

United Nations Development Programme

United Nations Educational, Scientific and Cultural Organisation

United Nations Environment Programme

United Nations Industrial Development Organization

U. S. National Academy of Sciences

The World Conservation Union

The World Bank Group

Biotechnology and Biosafety was a forum associated with
The Fifth Annual World Bank Conference
on Environmentally and Socially Sustainable Development,
held at the World Bank, October 9–10, 1997



**ENVIRONMENTALLY AND SOCIALLY
SUSTAINABLE DEVELOPMENT**



ISBN 0-8213-4242-8