THE PONTIFICAL ACADEMY OF SCIENCES

Study Week

Transgenic Plants for Food Security in the Context of Development

15-19 May 2009 • Casina Pio IV

VATICAN CITY 2009

Tomorrow, 7 July, the Heads of State and Government of the G8 Member Countries, together with other world leaders, will be meeting in Japan for their annual Summit. In these days many voices have been raised – including those of the Presidents of the Bishops' Conferences of the Nations mentioned – to ask for the implementation of the commitments made at previous G8 Meetings and for all the necessary measures to be adopted to put an end to the scourges of extreme poverty, hunger, disease and illiteracy which still affect such a large part of humanity. I join in this pressing appeal for solidarity! Thus I address the participants in the Meeting at Hokkaido-Toyako, asking that they make the centre of their deliberations the needs of the weakest and poorest people whose vulnerability today has increased because of financial speculation and instability and their pernicious effect on the price of foodstuffs and energy. I hope that generosity and farsightedness will help them take the decisions capable of relaunching a fair process of integral development to safeguard human dignity.

Benedict XVI, *Angelus*,
Papal Summer Residence,
Castel Gandolfo, Sunday, 6 July 2008

INTRODUCTION

I. Potrykus

Constraints to Biotechnology Introduction for Poverty Alleviation

Poverty in developing countries is usually linked to low agricultural productivity. Inadequate quantity and quality of food impacts human development potential, physically and mentally. Reduced immunity to disease due to poor nutrition increases the burden, and kills. Current technologies (fertiliser, improved seed, irrigation, pesticides) correctly applied can sustainably and safely increase crop yields. Purchase cost and infrastructural issues (lack of roads, credit, market access and market-affecting trade-distortions), however, severely limit small-scale farmers' ability to adopt these life-sustaining and lifesaving technologies.

Plant Biotechnology has a great potential to improve the lives of the poor. Delivery of the technology in the seed largely overcomes the logistical problems of distribution involved with packaged products: farmers can pass seed to one another. Once the initial research is completed the 'cost of goods' (that is, of a biotechnologically-delivered trait carried in a seed) is zero. Total time to market is comparable between biotechnology products and conventionally bred seed. For some traits conventional breeding is not an option: the only way to introduce a trait is by genetic modification. In developing countries, in pro-poor agriculture, intellectual property issues are not usually a constraint.

It is worth noting that agricultural biotechnology uptake has been extremely rapid, for commercially introduced traits, even in developing countries (James, 2007).[1] However, for products from the public sector, despite much research in developing countries (Cohen, 2005),[2] this potential has not materialized. The politicisation of the regulatory process is an extremely significant impediment to the use of biotechnology by public institutions for public goods (Taverne, 2007).[3] Costs, time and complexity of product introduction are severely and negatively affected. Pro-poor projects are significantly impeded in delivering their benefits, especially in a developing country context. (Without such political impediment the technology is very appropriate for adoption by developing country scientists and farmers: it does not require intensive capitalisation). The regulatory process in place is bureaucratic and unwarranted by science: despite rigorous investigation over more than a decade of commercial use of Genetically Modified Organisms (GMOs), no substantiated environmental or health risks have been noted. Opposition to biotechnology in agriculture is usually ideological.

The huge potential of plant biotechnology to produce more, and more nutritive, food for the poor will be lost if GMO-regulation is not changed from being driven by 'extreme precaution' principles to being driven by 'science-based' principles.

Changing societal attitudes, including the regulatory processes involved, is extremely important if we are to save biotechnology, in its broadest applications, for the poor, so that public institutions in developing as well as industrialised countries can harness its power for good.

The programme is organized into eight sessions. The **Introduction to the Study Week** will present the problem of increasing food insecurity in developing countries, the need for continued improvement of crop plants and agricultural productivity to address the problem, the track record and perspective of transgene technology, and the roadblock to efficient use by the established concept of 'extreme precautionary regulation'. **Contributions from Transgenic Plants** will highlight what important contributions in the areas of tolerance to abiotic stress, resistance to biological stress, improved water use efficiency, improved nutritional quality, inactivation of allergens and reduction in toxins, and on nutritionally improved agricultural crops in general, are already in use or in the R&D pipeline. Following an account of the state-of-the-art of the technology and the worldwide, radical opposition to the use of the technology in agriculture, this session will continue with the question of whether or not GMOs diminish or promote biodiversity, and will describe all that is necessary to achieve a sustainable yield, including contributions from the private sector, presenting examples of how the private sector supports humanitarian projects. In the session on the **State of Application of the Technology** concrete examples from India, China, Africa, and Argentina will show which products have overcome the hurdles of the regulatory regimes. This session will end with a lecture on the problems and possible solutions with regards to intellectual property rights attached to the use of the technology, and with a discourse on the ethics of the use and non-use of transgenic plants in the context of development. Finally, it will be shown how altruistic foundations are increasingly filling the gap in support of humanitarian projects, where the public sector fails to fulfil its vital role. The session on the **Potential Impact on Development** will highlight what an important role transgenic plants could play – were they not considered so highly risky by the public, the politicians, and the regulatory authorities. The question of whether or not there is any scientific base for this attitude will be analysed in the **Putative Risk and Risk Management** session. In the introduction to this session a comparison between molecular alterations to the genome by natural genetic variation and genetic engineering will show that there is little reason to be concerned about genetic engineering. Detailed case studies will analyse putative risks to the environment and the consumer to explore whether, in the history of its use, there has been any case for concern. This will be followed by the lessons we should have learned from 25 years of use, biosafety studies and regulatory oversight, and by an overview comparing GMO myths and realities. A brief session on **Biofuels Must Not Compete with Food** will indicate the novel problem arising from the concept of biofuel production from agricultural products, which is seriously affecting food security already, and the novel concepts under study aiming at biofuel production from biological materials which will not compete for food sources, agricultural land and freshwater. **Hurdles Against Effective Use for the Poor** will describe which hurdles under the presently established regulatory regime (established without any scientific justification as has been demonstrated in the previous session) prevent using the technology to the benefit of the poor. This session will also examine: the political climate surrounding GMOs which has spread from Europe to the rest of the world; the legal and trade consequences connected to regulation and political climate; GMO-over-regulation which makes the use of GMOs for the public sector inaccessible for cost and time reasons; the financial support from governments to professional anti-GMO lobby groups; the poor support for agricultural research in general and a ban on GMO work in public institutions which depend upon financial support from donor countries in Europe, such as the Consultative Group for International Agricultural Research. The last session is the most important: entitled **Ways to Overcome these Hurdles**, it will aim at developing strategies to reach the conclusion expected from the entire study week: **Adjusting Regulation to Accumulated Experience and Knowledge** to free the technology from the unhealthy constraints of 'extreme precautionary regulation', in order to enable the public sector in both developing and developed countries to use their R&D potential to take advantage of the potential of transgenic plants as a contribution to food security and development.

As is obvious from the programme, this is not a standard 'science' meeting. It is designed to present the potential of plant genetic engineering and to analyse the hurdles responsible for the fact that, so far, product applications to benefit small-scale farmers have mostly excluded the public sector. If we are to rescue agricultural biotechnology in its broadest form for the underprivileged, we have to change social attitudes including regulatory attitudes to GMOs. This seems an impossible task: extreme precautionary regulation has been established as a legal requirement in most countries around the world. It finds strong support from politics, the media, and the public, and numerous NGOs are making sure it is applied with rigor and would even welcome stricter regulations. However, because of its negative impact and lack of scientific justification, changing the system should be tried seriously at least once. The idea of the study 'week' is to explore what is necessary to make this possible. We need to harness arguments:

- as to why food security for the poor needs efficient access to GM-technology,
- as to why 'extreme precautionary regulation' is unjustified,
- to show the social and economic consequences of over-regulation,
- on how to change regulation from ideology-based to science-based.

We also need to develop ideas for what 'science-based' regulation would mean and to develop strategies to inform the media, the public, the regulatory authorities and governments that it is unjustified, even immoral, to continue with current attitudes and processes.

A necessary follow-up global or regional implementation programme will probably require a further meeting subsequent to this study week since time will not be sufficient to discuss all the problems in detail and design a solid programme for implementation. Completion of the task will probably be assisted by current highlighted global interest in food production and food affordability issues, even for the poor.

[1] James, 2007
[2] Cohen, 2005
[3] Taverne, 2007

Friday, 15 May 2009

	Introduction to the Study Week
9:00	*Welcome to the Study Week* **PAS President Nicola Cabibbo • H.Em. Card. Georges Cottier**
9:15	*Brief Comments* ◆ **Rita Levi-Montalcini** • Italy
9:30	*Introductory Remarks* ◆ **PAS Council Werner Arber** • Switzerland
9:40	*Introduction to the Theme of the Study Week* ◆ **Ingo Potrykus** • Switzerland
10:00	*Food Insecurity, Hunger and Malnutrition – Necessary Policy and Technology Changes* ◆ **Joachim von Braun** • USA Discussion
10:40	Coffee break
11:10	*Need for an 'Evergreen Revolution'* ◆ **M.S. Swaminathan** • India Discussion
11:50	*The Past, Present and Future of Plant Genetic Modification* ◆ **Nina Fedoroff** • USA Discussion
12:30	Lunch at the Casina Pio IV
	Contributions from Transgenic Plants
14:00	*Resistance to Biological Stresses* ◆ **Roger Beachy** • USA Discussion
14:40	*Developing Crops That are Less Thirsty:* *How Biotechnology can Help Agriculture to Cope With Water-Deficit Conditions* ◆ **C.S. Prakash** • USA Discussion
15:20	*Golden Crops* ◆ **Peter Beyer** • Germany Discussion
16:00	Coffee break
16:30	*Inactivation of Allergens and Toxins* ◆ **Piero Morandini** • Italy Discussion
17:10	*Nutritionally Improved Agricultural Crops* ◆ **Martina Newell-McGloughlin** • USA Discussion
17:50	*Toolkits of Genes and Knowledge-Ready for Making Improved Plants* ◆ **Richard B. Flavell** • USA Discussion
18:50	Dinner at the Casina Pio IV

Saturday, 16 May 2009

9:00	*Does the Use of Transgenic Plants Diminish or Promote Biodiversity?* ◆ **Peter Raven** • USA Discussion
9:40	*Concerns of the Church and the Public* ◆ **H.E. Msgr. Marcelo Sánchez Sorondo** • Vatican Discussion
10:20	Coffee break
10:50	*Ethical Arguments Relevant to the Use of GM Crops* ◆ **Albert Weale** • UK Discussion
11:30	*The Private Sector's Role for Public Sector Projects* ◆ **Ingo Potrykus** • Switzerland Discussion
12:10	Lunch at the Casina Pio IV
	State of Application of the Technology
14:00	*Plants Transgenic Research, Technology Development and Diffusion in India* ◆ **S.R. Rao** • India Discussion
14:40	*Do Russia and Eastern Europe need GM Plants?* ◆ **Konstantin Skryabin** • Russia Discussion
15:20	*Latin America – Experience from Use of GMOs in Argentinian Agriculture – Economy and Environment* ◆ **Moisés Burachik** • Argentina Discussion
16:00	Coffee break
16:30	*The Concerns of the Synod of the African Bishops* ◆ **H.E. Msgr. George Nkuo** • Cameroon Discussion
17:10	*Intellectual Property Rights: Problems and Solutions* ◆ **Anatole F. Krattiger** • USA Discussion
17:50	*The Political Climate Around GMOs* ◆ **Rob Paarlberg** • USA Discussion
18:30	Dinner at the Casina Pio IV

Sunday, 17 May 2009

9:00	Holy Mass
10:00	Visit to the exhibition of 'Beato Angelico – L'alba del Rinascimento', Musei Capitolini, Rome
12:00	Lunch at the Casina Pio IV

Monday, 18 May 2009

Potential Impact On Development	
8:30	*Benefits of GM Crops for the Poor: Household Income, Nutrition, and Health* ◆ **Matin Qaim** • Germany Discussion
9:10	*Developing Countries and Transgenic Foods:* *Ex-Ante Economic Impacts of Biotechnology and Trade Policies* ◆ **Kym Anderson** • Australia Discussion
9:50	*Crops Coping with Water Scarcity* ◆ **Chiara Tonelli** • Italy Discussion
10:30	Coffee break
Putative Risk And Risk Management	
10:50	*Genetic Engineering Compared to Natural Genetic Variation* ◆ **Werner Arber** • Switzerland Discussion
11:30	*Environmental Risks from Transgenic Plants* ◆ **Jonathan Gressel** • Israel Discussion
12:10	Lunch at the Casina Pio IV
14:00	*Risks for Consumer Health* ◆ **Bruce Chassy** • USA Discussion
14:40	*GMO Myths and Realities* ◆ **Wayne Parrott** • USA Discussion
15:20	*Poor Support for Agricultural Research in General, and Specifically for the CGIAR System* ◆ **Robert Zeigler** • Philippines Discussion
16:00	Coffee break
16:30	*Tackling Chronic Diseases: The Potential of Preventive Medicine Through Improvements to Diet* ◆ **Cathie Martin** • UK Discussion
Biofuels Must Not Compete With Food	
17:10	*First Generation Biofuels Compete* ◆ **Marshall A. Martin** • USA Discussion
17:50	*Plentiful Second Generation Biofuels, Without Conflict to Food Production, is Within our Grasp* ◆ **Stephen P. Long** • USA Discussion
18:30	Dinner at the Casina Pio IV
20:00	*Formulation of a PAS Statement* ◆ Chair: **H.Em. Card. Georges Cottier** ◆ Computer support: **Nikolaus Ammann** Contributions from all

Tuesday, 19 May 2009

	Hurdles Against Effective Use for the Poor
8:00	*Opposition to Transgenic Technologies* ◆ **Ronald J. Herring** • USA Discussion
8:40	*Trading in Transgenic Crops – Legal-Commercial Regimes and their Food Security Implications* ◆ **Drew Kershen** • USA Discussion
9:20	*Gene-Splicing is Over-Regulated, but Science Shows a Better Way* ◆ **Henry Miller** • USA Discussion
10:00	Coffee break
10:30	*Financial Support of Anti-GMO Lobby Groups* ◆ **Andrew Apel** • USA Discussion
11:10	*Challenges and Responsibilities for Public Sector Scientists* ◆ **Marc Van Montagu** • Belgium Discussion
12:00	Lunch at the Casina Pio IV
	Ways to Overcome These Hurdles *Adjust Regulation to Accumulated Experience and Knowledge*
14:00	*Initial Brainstorming* Chair: **Chris Leaver** • **Ingo Potrykus**
15:30	*PAS Proceedings* **H.E. Msgr. Marcelo Sánchez Sorondo** *Additional Publication in Peer-Reviewed Journal?* **Klaus Ammann**
16:00	Coffee break
16:30	*Agreement on Final Statement*
17:30	*Concluding Remarks* ◆ **Chris Leaver** • UK ◆ **Ingo Potrykus** • Switzerland
18:00	*Closing of the Meeting* ◆ **Nicola Cabibbo** • President ◆ **Marcelo Sánchez Sorondo** • Chancellor ◆ **Werner Arber** • Chairman of the Council
19:00	Dinner at the Casina Pio IV

Developing Countries and Transgenic Foods: Ex-Ante Economic Impacts of Biotechnology and Trade Policies

Kym Anderson

Agricultural biotechnologies, and especially transgenic crops, have the potential to offer higher incomes for farmers and lower-priced and better quality food for consumers in developing countries. That potential is being heavily compromised, however, because the European Union and some other countries have implemented strict regulatory systems to govern their production and consumption of genetically modified (GM) food and feed crops, and to prevent imports of foods and feedstuffs that to not meet these strict standards. This paper analyses empirically the potential economic effects of adopting transgenic crops in Asia and Sub-Saharan Africa (SSA). It does so using a global model of the global economy. The results suggest the economic welfare gains from adoption are potentially very large, especially from golden rice, and that those benefits are diminished only very slightly by the presence of the European Union's restriction on imports of GM foods. That is, if developing countries retain bans on GM crop production in an attempt to maintain access to EU markets for non-GM products, the loss to their food consumers as well as to farmers in those developing countries is huge relative to the slight loss that would be incurred from not retaining EU market access.

Financial Support of Anti-GMO Lobby Groups

Andrew Apel

Financial support for anti-GMO lobby groups is substantial, and severely distorts public discourse over a topic which would otherwise be uncontroversial. Governments, primarily in Europe, support the lobby groups in an effort to appear 'green' to their constituencies. Private enterprise, in Europe and elsewhere, support them in order to protect vested financial interests, or to enhance public perception of their products. Charitable foundations may easily match is spent on them by governments and business. Where available, documented government and foundation payments to these groups, and the financial statements of the groups themselves, disclose the existence of an international "protest industry" which serves its own interests, and the interests of its funders. Sums spent directly by private enterprise on these groups are not easily quantified. These groups will continue to oppose agricultural biotechnology so long as it continues to be politically or financially advantageous to do so.

Genetic Engineering Compared to Natural Genetic Variation

Werner Arber

Conjectural risks of genetic engineering are principally of two types: (1) risks related to an altered phenotype of an organism with an engineered alteration in its genome, and (2) risks related to the possibility that altered DNA sequences might, at some later time, become transferred to other types of organisms. This latter risk might affect the course of biological evolution. It is of relevance, if an organism with altered DNA sequences is released into the environment, either deliberately or accidentally. In order to evaluate such evolutionary risks, we have to understand the natural process of biological evolution at the level of molecular mechanisms. This has become possible by molecular genetics and genomics. Biological evolution is driven by the availability of genetic variants in large populations of organisms. Variants with beneficial changes will be favoured in natural selection, while detrimental variations are disfavoured and become eventually eliminated. Solid experimental evidence indicates that a number of mechanistically different sources contribute to the overall spontaneous generation of genetic variants. These mechanisms can be classified into three qualitatively different natural strategies for the generation of genetic variations: (1) local sequence changes affecting one or a few adjacent base pairs in the DNA, (2) recombinational rearrangements of DNA segments within the genome, including translocation, inversion, deletion and amplification of a DNA segment, and (3) acquisition of a foreign DNA segment by horizontal DNA transfer. While many such alterations are often detrimental, occasionally favorable effects can be observed that are of evolutionary relevance. In comparison, engineering interventions in the genetic information use the same three strategies to generate alterations of the genomic DNA sequences, i.e. local changes, intra-genomic rearrangements of DNA segments (e.g. the juxtaposition of an open reading frame with an efficient promoter for gene expression), and the transfer of a DNA segment carrying a foreign gene into another organism's genome. In any of these cases, natural selection, including an undisturbed functional harmony of the engineered organism, will eventually decide of the longer-term viability of the organism in question. Therefore, we can postulate that evolutionary risks of genetically engineered crops are of the same order of probability as risks encountered upon the natural biological evolution and also for products of classical breeding. From long-term observations we know that these risks are quite small. As a matter of fact, they are less drastic than the effects of some other human activity intervening with natural biological evolution at the levels of either geographic isolation or natural selection. Possible particular differences between genetic engineering and the process of natural evolution will be discussed.

Resistance to Biological Stresses

Roger N. Beachy

Crops and non-crop plants face a wide range of biological stresses in their environments and cope in a variety of ways: while all plants are immune to most microbes, insects and parasites nearly all fall prey to selected attackers and suffer different types of damage as a consequence. It is estimated that most crops in advanced economies annually suffer minor (1% - 5%) yield losses due to pathogens. In tropical countries, local climactic and other conditions can support year-round reservoirs of disease agents and pests that attack crops on a recurring basis: as a consequence some crops can suffer yield losses of >90%. The monetary value of crop losses due to insects and pathogens is difficult to establish but likely is >$10 billion; the value of losses of the very poor farmers who produce only for the family may not be considered in these estimates. In many situations chemical control agents are used to reduce damage caused by pests and pathogens: farmers may spray their crops with 20 or more applications in a single season in order to save a crop for market. Needless to say, the potential for damage to the health of the farmer and consumer as well as the environment is high under these conditions. As an alternative to use

of agrichemicals, plant breeders and technologists have developed strategies to cope with the disease-causing agents that inflict the greatest damage and are less concerned with those that cause minimal damage. To date scientists have not identified genes that confer resistance to a broad range of pathogens (i.e., to all fungi or pathovars of a single fungal species, or to all viruses or virus types; etc.) Meanwhile plant breeders and crop improvement technologists are employing a range of genomic tools to identify genes that confer resistance to selected diseases and insects. The development of crops with resistance to certain insects using a variety of anti-insect proteins from *Bacillus thuringiensis* (B.t. genes), most notably in maize and cotton, has been widely acclaimed as successful. The monetary value of insect resistance to small holder farmers in China, India and South Africa has been well documented and shows increased returns and decreased use of chemical control agents. It is expected that insect resistant eggplant will be released to farmers in India and/or Bangladesh in 2009 or 2010. Similarly, varieties of virus resistant papaya, squash, plum, tomato, sweet peppers, cucumbers and other vegetables have been developed using 'pathogen derived resistance' strategies. However, these successes do not adequately represent the efforts of researchers in public institutions around the globe. Scientists working alone or in collaborations between advanced and less-advanced laboratories have made remarkable progress in developing genetic and transgenic strategies that control insects and virus diseases in local crops. This research indicates that control of fungi, bacteria and parasitic nematodes can be achieved now or in the near future. Unfortunately, a very small number of resistant crops have been field tested or released to farmers, due in large part to lack of biosafety regulations in countries that lack the capacity to judge their safey, or who consider transgenic crops as a group to be a danger to the environment or consumer. Meanwhile, crop losses continue to mount and unsafe agrichemicals continue to be applied to food crops that go to people and their animals.

Golden Crops

Peter Beyer

Biofortification is a tool to reduce micronutrient malnutrition is a way that is largely deprived of the recurrent costs and distribution logistics encountered upon classical interventions, such as supplementation and industrial fortification. Given the genetic variability is sufficiently large, a desired nutritional trait can be introduced through breeding with the exception of such crop plants that are essentially sterile, such as banana. Breeding is further hindered with plants possessing complex genetic backgrounds and very long life-cycles, such as cassava. Breeding is impossible, when the genetic variability for a given trait is absent. Genetic modification is then the only way forward allowing to engineer biochemical pathways into agronomically important plant tissues or to modify the transport of minerals. To engineer, the genes involved and the enzymology of the resulting gene products must be known, information that stems from research employing mostly model organisms which possess short life cycles. Model systems can also be easily transformed to allow gain/loss – of-function experimentation and possess today a very good molecular infrastructure such as mutant collections and genomic sequence information. Because of the significant degree of metabolic unity existing between organisms (as a conseuqnce of their phylogenetic relatedness), it is possible to transport information as well as physical materials (genes) between model systems and from there on to apply both to crop plants. Thanks to these facts, pathways and physiological processes are being deciphered in an unprecedented velocity. This allows increasingly to engineer pathways into starchy crop tissues which lack the required biochemical diversity to meet the demands. Rice is a typical example, lacking provitamin A in the grain (albeit being present in the leaves) and lacking the genetic variability for this trait. It has therefore been engineered using information elucidated in bacteria and the model plant *Arabidopsis thaliana*. Additional examples exist showing that genetic engineering is an indispensible option to improve the nutritional quality of crop plants. These will be given and discussed.

Food Insecurity, Hunger, and Malnutrition – Necessary Policy and Technology Changes

Joachim von Braun

Global progress in combating hunger has been slow and, alarmingly, the number of undernourished people in developing countries has been increasing in past decades. The global food price crisis in 2007-08 and the deepening financial crisis and recession have further undermined the food security and threatened livelihoods of the poor. The food price crisis also renewed the focus on agriculture, food, and nutrition at national and international agendas, after decades of policy neglect and underinvestment. To improve food and nutrition security around the globe, this focus should be maintained and supported by sound policy and technology changes. In particular, three sets of complementary policy actions are needed: (1) promote sustainable agricultural growth, (2) reduce market volatility, and (3) expand social protection and child nutrition action. Each of these actions needs to be enhanced by innovations. Climate change further increases the risk of food insecurity in the future and calls for accelerated use of science based productivity improvement.

Risks for Consumer Health

Bruce M. Chassy

Governments around the globe have passed regulations that require crops produced using modern biotechnology to be subjected to rigorous, time-consuming, and expensive pre-market safety reviews. These reviews can consume 5-10 years and have a direct cost of 10s of millions of $US; the indirect cost of lost benefits can be staggering. For example, each year that Golden Rice is not introduced about 2 million children will die of Vitamin A deficiency. If Golden Rice reached only half those children and were only 50% effective – these are very conservative estimates – 500,000 children per annum would be spared. This paper will seek to explore if there are risks posed to consumer health from the introduction of Golden Rice, or any other transgenic variety, that merit such extreme caution that we would let a cummulative 10 million children die since the development of Golden Rice about 10 years ago. The paper will outline the current strategy for food safety assessment that is used in countries that have adopted mandatory regulatory review of GMOs. The principles are well described in the literature and in a variety of national regulatory guidelines; *Codex alimentarius* has also developed voluntary guidelines. Food safety assessment relies on a comparative analysis between a transgenic product and its conventional counterpart. The safety of any novel protein or product is established, and through detailed compositional analysis and animal studies, the safety of both intended and unintended changes is evaluated. Taken together, these studies provide the regulator with a weight of evidence that the new product is as safe as, or is safer than, comparable varieties. The question arises, however, if this rigorous analysis is necessary. Crops produced by other means can be shown to contain more numerous and more drammatic genetic changes than are found in the so-called GMOs. The term GMO itself is misleading since all of our crops are extensively genetically modified. It is a matter of record that the great preponderance of scientific opinion suggests that transgenic crops are more precisely made, and the nature of the changes better understood than they are for conventional crops. This leads to the conclusion that they are inherently less risky than crops whose genetics have been altered using more invasive and imprecise tools such as irradiation and mutagenesis. If anything, we should be regulating crops produced by conventional breeding technologies. Instead we treat GM crops as if they were toxic chemicals or new powerful drugs; they are not, they are foods that are as safe – if not safer – as any other food. It is also noteworthy that labels are not required on foods that are genetically modified by any other method, yet we single out the crops produced by the most precise and least risky method for labels which scare consumers into thinking that these products come with uncertainty about their safety. Labels also cost a great deal because they require segregation of GMO from non-GMO varieties and repeated testing to insure that segregation has worked. The billions spent on testing that provides no health benefit could have been used to buy medicine for the needy, inspect food for microbes and mycotoxins that might cause illness or death, or even to buy food for the hungry. It is concluded that transgenic crops present no new or additional risk to consumer health or to the food system, and that the regulatory process applied to them is not only scientifically unjustified, it works to the extreme disadvantage of the hungry and the poor.

The Past, Present and Future of Plant Genetic Modification

Nina Fedoroff

My principal thesis is that contemporary genetic modification of crop plants is embedded in a history of plant domestication that has transformed plants profoundly from their wild origins. Over the past year, the world has experienced a succession of shocks: a global food crisis, spiraling energy costs, accelerating climate change and most recently, a financial meltdown. But even as each crisis sweeps the previous one out of awareness, it is important to recognize that the food crisis is neither sudden nor quickly fixed. It has developed slowly as a result of relentless increases in demand in the context of a finite natural resource base and decreasing global investment in agricultural research and development. No crop better illustrates both the genetic plasticity of plants and the inventiveness of humans better than the maize (corn) plant. Thousands of years before chemistry formally entered agriculture in the late 18th century, early peoples had transformed the hard-seeded teosinte rachis into the soft-kernelled early maize ear through the accumulation of a handful of mutations that profoundly changed the architecture of the plant. Scientific advances in the understanding of plants' chemical requirements throughout the 19th century culminated in the invention of the Haber-Bosch process for synthesis of fertilizer from atmospheric nitrogen in the early 20th century, removing a major limitation on the productivity of agriculture. The rediscovery of Mendel's genetic experiments in the early 20th century led serendipitously to the development of today's highly productive maize hybrids, one of humanity's handful of major cereal grains. The identification of mutant dwarf varieties of wheat and rice that are highly responsive to fertilization belied renewed Malthusian predictions at mid-20th century, giving rise to the Green Revolution. The late 20th century witnessed a second genetic revolution with the invention of recombinant DNA technology, the explosion of genome sequencing, and the development of techniques for the reintroduction of individual genes into microorganisms, plants, and animals. Today, it is possible to modify organisms, including crop plants, in extremely precise ways, adding or subtracting just one or a few genes at a time. While such techniques have been readily accepted both in medicine and food technology, their application to crop plants has remained controversial for more than 30 years. Despite the controversies, several important crop plants modified to resist insects and tolerate herbicides have steadily gained acceptance throughout the world. Today, genetically modified cotton, corn, soybeans and canola are grown in 25 countries by more than 13 million farmers, 90% of whom are resource-poor farmers with small holdings. To date, there is no evidence of adverse effects to either human or animal health. Moreover, environmental benefits include the decreased use of pesticides and increased adoption of no-till farming. While some countries remain adamantly opposed to the use of contemporary genetic modification, there is increasing awareness that these are important tools in the success of global efforts to lift the last billion out of hunger and poverty through agricultural intensification. Moreover, molecular genetic modification will be an indispensable tool in the adaptation of crop plants to changing climatic conditions.

Toolkits of Genes and Knowledge-Ready for Making Improved Plants

Richard B. Flavell

During the past few years most countries of the world have come to realize that agriculture and hence the livelihood of people and the planet are under threats unprecedented in the history of the world. The world's human population continues to increase to intense levels, climate change is putting plant productivity under threat, greenhouse gas increases in the atmosphere need to be decreased, renewable energy from the use of land needs to partially replace use of fossil fuels and world food stocks are at an all time low. In addition, investments in research and development, and especially in plant breeding, are not being made in amounts commensurate with the needs and challenges. All these issues will hurt the poor more than the rich. Yet, during the past 25 years while this situation has been building up we have seen a bigger increase in our knowledge of the science underpinning plant breeding and more opportunities for improvements than over the whole course of human history. For all the thousands of years that man has practised plant breeding to make the crops we now use, man did not know anything about the scientific basis of the process. Now it is different. The science of molecular biology has changed all that. It was only in the 1940s that it was proven that the heredity material was DNA. Now as a result of a few decades of research we have the complete set of genes for many plant species almost completely identified and a good working knowledge of what many of them contribute to the properties of whole plants. We know the chemical DNA sequence of millions of genes, much information on how they are activated and silenced in cells in complex patterns that make organs such as leaves, roofs and flowers different from one another. We can recognize the same genes in different plants because of their similarity and so studies on one plant open up knowledge of the similarities and differences between plants. From these comparisons we can see what has happened during plant evolution and what the plant breeders of the past have achieved. We now have "tool boxes" that are comprised of a very large numbers of genes from a huge range of plant species as well as from a vast number of species from the other kingdoms of organisms. The process of gene discovery and comparisons between species is accelerating every few months as the technologies for sequencing DNA becomes faster and cheaper. Laboratories in almost every country in the world now have stocks of genes and are using these for training students and/or in intense research programs. Databases in the public domain make the

DNA sequences and functional information available to all. This is no longer a science of a few countries or institutions of the rich. In addition to having a virtually unlimited number of genes in the tool box we have learned how to change genes easily and cheaply, either in ways that change the information in its protein or RNA product or how each gene is regulated. This enables genes to be changed in the laboratory at will. New genes can also be synthesized cheaply to any specification from their chemical constituents. We have also learnt how to insert new genes into plant cells and generate new individuals carrying the new gene in every cell for hundreds of plant species, including most of the main crop species. This was first achieved in 1982 using a gene transfer system evolved in nature by a soil bacterium. All these brilliant discoveries have given us the means of understanding and monitoring plant breeding, defining genetic variation, good and bad, and being able to create additional changes in plants by inserting novel, specially designed genes to make them more suitable for agriculture and to be more efficient for mankind. Examples of how just a few carefully selected genes have already aided agriculture for the poor are given in other contributions to this study week. They include the addition of new sorts of health-providing molecules such as provitamin A when new metabolic pathways are introduced, changes in the ability to withstand environmental stresses such as drought and high salt levels, and ability to be cultivated more efficiently because of an ability to withstand herbicides, in contrast to the competing weeds. But in the research laboratories around the world the list of genes already added to plants to make useful changes is enormous. It is this knowledge in the scientific community, linked to the huge number of improvements that plant breeders seek to make to benefit mankind, that drives the arguments for the necessity to allow the deployment of GMOs more efficiently and with reduced regulatory burdens. The future we are addressing is not the addition of a few genes here and there. It is the opportunity to improve plants to enable people and the planet to survive much better than is readily possible without their use. It is important to comprehend these changes that the breeders of today are able to make against the backcloth of what the breeders of yesterday have done. Crops we rely on are frequently not those found in nature, in the wild. Many of our staple crops such as corn and wheat are the products of genetic changes created by man either by deliberate mixing of genes in the making of new hybrids or by selection of rare variants that existed in nature. Thus our present is dependent on past genetic engineering carried out using the mechanisms available to the entrepreneur plant breeders at the time. Adding new genes to change the properties of a plant by genetic engineering is a very targeted approach since defined genes are used. Yet there are processes inside cells that can make introduced genes function more or less efficiently. Plants, for good reasons, have evolved the means of recognizing new genes and silencing them depending on a host of factors. This means that the molecular breeder has to find the plant that has adopted the gene in ways that allow stable and useful activity. This apparent unpredictability in precise gene activity, often cited as sources of unknown harmful risk, is the result of the natural biology of plants and not something peculiar to transgenes designed in the laboratory. In conclusion we should recognize that it is extraordinarily fortunate that we have the knowledge and gene toolkits at this time of great uncertainty and vulnerability for the poor and the planet. The fruits of molecular biology must be used to solve problems. We choose not to use them at our peril. Those who argue against their use do so usually in ignorance of plant breeding, of crop evolution, and of how our standard of life has depended on extraordinary changes in plant genes and plant cross-hybridization. Thankgoodness our ancestors did not use the precautionary principle to their detriment. The scientific community and government funding agencies, as well as companies owed it to future generations and to the future of the planet to establish the extensive gene tool kits and databases of genes and to learn how to use them to improve crops. Now we owe it to future generations to apply the tools and technologies as best we can and as quickly as we can to create a better world. The poor are wanting and waiting. The tools are available. Some leaders have the vision well formulated. Policies and priorities need to catch up.

Environmental Risks from Transgenic Plants

Jonathan Gressel

While transgenic plants may have many environmental benefits (e.g. reduced pesticide, fertilizer and fuel use, reduced soil erosion, omission of allergens from pollen and food), they do raise risks. Such risks must be balanced against the risks to the environment of present agronomic practices to assure that the risks of transgenics are of much lesser magnitude than the current practices. So far, this has been resoundingly the case. One widely discussed potential risk is from transgene flow from the crop to related species; a risk that must be separated to two: the implications are very different for transgene flow to related and interbreeding wild species in their natural habitats, and transgene flow to related, interbreeding weeds in the agricultural ecosystems. At present each case of crop and gene must be analyzed separately, but most pollen does not fly far, so pollination of the wild will be rare, and since most transgenes confer fitness only in cultivated situations, rare hybrids would be naturally eliminated. The greatest risks are in the few cases where crops have related interbreeding weeds (often botanically the same species) that are pernicious competitors in the same ecosystems: weedy rice in rice and shattercane in sorghum are prime examples. The flow of some transgenes to such weeds would be detrimental to agriculture (e.g. herbicide resistance), and others have little or no effect (e.g. resistance to a disease, when the weed is already resistant). In the few cases where there is a gene flow risk, there are genetic engineering "tricks" to contain the transgenes in the crops, and others to mitigate gene flow by precluding establishment and spread of a transgene through the population.

Epistemic Brokers: Explaining Diffusion and Reinforcement of Contentious Knowledge Claims in Opposition to 'GMOs'

Ronald J. Herring

Global diffusion of transgenic crops in agriculture has been rapid, even by official counting, despite vigorous opposition in global civil society, restrictive intellectual property claims and adverse regulation by many states. Successful political opposition to transgenics has kept much of the world 'GMO-free,' at least legally. Opposition has been effective not at the farm level, where material interests dominate, but in formal international and national arenas. The success of relatively few with ideational interests over the many with material interests poses a puzzle. This paper argues that opposition has succeeded in these arenas largely because of a fundamental early framing success in lumping and splitting transgenic technologies that created a contentious object of governance: the 'GMO.' This authoritative frame enabled mobilization around risk, later interwoven with opposition to concentrated intellectual property: biosafety and bioproperty jointly constituted oppositional strategy. The risk frame supported creation of international soft law inimical to diffusion of transgenics. The global biosafety regime of the Cartagena Protocol enabled nation-level institutional choke points. Choke points allow political actors with appropriate cultural capital and connections to use formal institutions with effects disproportionate to their numbers. Interactive flows of knowledge in these global networks both depend on and reinforce the original narrative's focus on threat, but transform it in important ways.

Trading in Transgenic Crops – Legal-Commercial Regimes and their Food Security Implications

Drew L. Kershen

Agricultural trade between nations is a significant proportion of total international trade. Agricultural trade in transgenic crops faces extra complications due to the existence of domestic and international regimes (e.g. the Cartagena Protocol on Biosafety) that focus specifically on agricultural biotechnology. These specialized regimes create legal and commercial challenges for trade in transgenic crops that have significant implications for the food security of the nations of the world. By food security, one should understand not just the available supply of food, but also the quality of the food, and the environmental impact of agricultural production systems. These specialized regimes for transgenic crops can either encourage or hinder the adoption of agricultural biotechnology as a sustainable intensive agriculture. Sustainable intensive agriculture offers hope for agronomic improvements for agricultural production, socio-economic betterment for farmers, and environmental benefits for societies. Sustainable intensive agriculture offers particular hope for the poorest farmers of the world because agricultural biotechnology is a technology in the seed.

Intellectual Property Rights: Problems and Solutions

Anatole Krattiger

This presentation will argue that it is not intellectual property (IP) per se that raises barriers to innovation globally and technology diffusion to and within developing countries, but that ethical and authoritative IP management is a prerequisite for technology diffusion, especially to benefit the poor in the developing world. Indeed, the real obstacles are in the manner in which IP are used and managed. This is particularly the case of public sector institutions which include universities, national research institutions, and nonprofit organizations. First and foremost, IP is a tool to foster innovation. Whether viewed as a legal concept, a social construct, a business asset, or an instrument to achieve humanitarian objectives, the value of IP cannot be disputed. The notion that inventions can become *property* and can therefore be owned and sold, has encouraged scientists and researchers to invent, and entrepreneurs and companies to invest in innovation, by allowing them to profit from the resulting technologies. But by permitting entrepreneurs to exclude competitors and set higher prices, IP protection may also prevent some individuals, or populations, from being able to access products. There are many ways, however, that IP can be utilized and distributed, and these include donations, different types of partnerships, and various forms of market segmentation and creative licensing practices. As a result, IP should be neither feared, nor blindly embraced; rather, IP should be managed to maximize the benefits of innovation for all of society, especially the poor. Notwithstanding this, IP rights are a compromise and an imperfect solution. They represent the search for balance between making all knowledge freely available within the *public domain* and granting *ownership* of valuable discoveries to the inventors. Historically, we have seen that this balance encourages investment – and reinvestment – in innovation, although this innovation too infrequently is directed toward the needs of the poor. Reaching an appropriate balance requires continuous, sound IP management. Fortunately, as numerous case studies have shown, including the Golden Rice initiative, the public sector can craft effective solutions that can achieve, or at least approach, a suitable balance. This can be accomplished by using the existing IP system, especially as it addresses situations in which companies agree to donate or otherwise share their IP. The emerging global systems of innovation in agriculture and health open up new prospects for innovation everywhere. This notion has profound implications for the management of innovation, technology transfer, market competition, and economic development in every country, regardless of its economic status. Provided with opportunities and resources, scientists and scholars from any locale can create promising inventions with the potential to become valuable technology. And whether inventions are home grown or come from outside, authoritative IP management will play a crucial role in enabling and preserving access to the resulting innovations. The historical trend has been for IP to benefit mostly the affluent. This is due, in part, to the fact that insufficient attention has been paid by the public sector to managing IP. This lack of focused attention must be corrected. Public sector IP management is a rather young discipline, and there have been enormous changes in the public sector's involvement in health research since the 1970s and in agri-biotechnology since the 1990s. The public sector is only now beginning to appreciate how it can use its own IP – and leverage that of others – to help meet its social mission, including its responsibilities to the poor. There is indeed growing interest, within both the public and private sectors, in using IP for public benefit but, also, a lack of knowledge and capacity. Indeed, all parties should take greater advantage of the unprecedented opportunity to benefit from the strategic management of IP aimed at promoting the public welfare – especially those people who have, until now, been unable to partake in technology's benefits – and that this will contribute to building a healthier and more equitable world.

Plentiful Second Generation Biofuels, Without Displacing Food Production, is Within our Grasp

Stephen P. Long

In 2008 the world produced over 60 billion litres of ethanol biofuel. Production is expected to increase 20 – 30% over just the next 4 years. Sugar derived either by crushing cane or hydrolyzing maize starch is fermented by yeast (as in making wine), and then the ethanol distilled (as in the making spirits). Particularly in the case of maize this may set up a direct competition between food, feed, and fuel. Use of maize and other grains or starch crops for fuel has also been criticized on environmental grounds. These crops require large inputs of energy, nitrogen and other environmental resources, in their production. In addition, expansion of annual grain crops onto marginal lands for biofuel production could hasten soil erosion and degradation. Sustainable non-food crops and wastes could provide all of the sugars required for ethanol production, although realization of this possibility would be greatly accelerated via GMOs. Like starch, celluloses are polymers of sugars. Celluloses are arguably the most abundant biological substance on the Earth's surface. Celluloses, together with lignin, constitute the cell walls of plants; collectively this material is called lingo-cellulose. Wood, straw and plant material in general is typically more than two-thirds celluloses by mass. So if celluloses are so abundant, why are starches and not celluloses being used today? Celluloses are of two types: cellulose (a polymer of the 6-carbon sugar glucose) and hemicellulose (a polymer of a range of sugars, mainly sugars made up of five carbon atoms). Starch is also a polymer of glucose, but is far more easily degraded to release its glucose than celluloses. Although ethanol has been made from celluloses for over a century, this has involved an inefficient acid hydrolysis to release the sugars. In nature, micro-organisms in the digestive systems of some termites, wood boring worms and insects, and grazing animals are able to efficiently digest ligno-celluloses to sugars. Discovery of genes coding for the enzymes that allow this breakdown and, in turn, transgenic commercial production of these enzymes, is facilitating increasingly cheaper and more efficient enzyme cocktails for the release of sugars from lingo-cellulose for fermentation to ethanol. This technology has opened up the opportunity for the efficient and economic use of urban, crop and forestry wastes and the vast array of sustainable perennial plants that can be grown on abandoned agricultural, saline and semi-arid land. Analysis of available land suggests that for many countries, demand for liquid fuels could be met entirely from these sources without any impact on food and feed production. It would also benefit the economies of regions where salination, erosion or otherwise poor soils cannot support food crops or any other currently productive use of the land. Further, the low value of this land, coupled with the low inputs required for perennial lingo-cellulosic crops, promises to make the use of food crops on high-quality arable land economically uncompetitive – thus avoiding a food vs fuel conflict. However, GM technologies are critical to accelerating and perhaps ever realizing this transition. Not only are GM technologies currently essential for efficient digestion of ligno-cellulose, but they also provide additional benefits. Currently yeasts are only effective in fermenting six carbon sugars, but GMO yeasts have been developed that can ferment five carbon sugars and so opening the potential to almost double the amount of ethanol produced per gram of lignocellulose. GM is facilitating rapid improvement of the new largely under-developed perennial feedstocks, for example in quickly improving pest resistance. Finally, GM is allowing the engineering of micro-organisms to ferment sugars to oils, rather than ethanol. This latter development avoids the high water and energy use needed in ethanol fermentation and distillation. GM technologies promise to replace our unsustainable and socially unacceptable use of food crops for ethanol production with use of wastes and sustainable perennial systems grown on land which cannot support food crops. Without these technologies and the reduced economic and environmental costs of biofuel production that they provide, pressure to use food and feed crops for fuel is likely to continue.

Tackling Chronic Diseases: The Potential of Preventive Medicine Through Improvements to Diet

Cathie Martin

A major challenge over the next 50 years is to reduce the frequency of the major chronic diseases; cardiovascular disease, cancer and age-related degenerative diseases. Although chronic disease is traditionally considered the affliction of wealthier developed countries, the numbers of people suffering from chronic non-communicable diseases is much higher in low income, developing countries and equals the levels of mortality from nutritional and communicable diseases in these countries. Chronic disease has a particularly serious impact on the poor of all countries, since the inability to work or mortality has catastrophic consequences when they affect the principal breadwinner in a family. In addition medicines to treat chronic diseases are often very expensive and difficult to obtain. Chronic diseases are particularly exacerbated by the metabolic syndrome which is increasing in frequency associated with a general increase in obesity, linked to declining levels of exercise and increasingly poor diets. Numerous epidemiological studies have demonstrated the efficacy of diets high in fruit and vegetables in reducing the incidence of cardiovascular disease, cancer and age-related degenerative diseases. The importance of fruit and vegetables in the diet comes from them contributing a number of important phytonutrients or bioactives which often serve to promote antioxidant defence mechanisms. The relative cost of low quality foods rich in salt and sugar has decreased over the past 30 years, whereas the relative cost of fresh fruit and vegetables has increased, again shifting the burden of chronic disease onto the poor of developed and developing countries, alike. Despite the specific recommendations of the "five-a-day" program of the National Cancer Institute of America (launched 15 years ago and now adopted by many countries) which encourage consumption of at least five servings of fruit or vegetables a day, the most recent estimates are that only 23% of the US population reach these dietary targets and, even more worryingly, that the numbers of people that do reach them have declined in recent years. These figures argue strongly for strategies to increase the levels of health-promoting bioactive compounds, in the fruits and vegetables that people actually consume in significant amounts. Plant biotechnology can make a very significant contribution to exploring this option in a number of ways: developing model foods that test the importance of specific bioactives in promoting particular aspects of health, developing markers that allow molecular breeding for enhanced levels of bioactives in crops and genetic engineering that provides novel, health-promoting foods. Due mainly to the increasing cost of curative medicine, preventive medicine is becoming crucial for improving health in developed societies, and remains often the only resort of those in developing countries. Amongst non pharmacological interventions, nutritional improvements developed through plant breeding and plant genetic engineering represent a feasible means of developing preventive strategies against chronic degenerative diseases for the future.

First Generation Biofuels Compete

Marshall A. Martin

Sharp increases in petroleum prices during the period 2005-08, coupled with the passage of the 2007 U.S. Energy Bill calling for a renewable fuel standard of 36 billion gallons of biofuels by 2022, encouraged massive investments in ethanol plants in the United States. Since the early 2000s, there has been a six-fold increase in U.S. ethanol production capacity. As petroleum prices surpassed $140 per barrel in early 2008 and more ethanol plants came on-line, the demand for corn for ethanol production increased dramatically and corn prices doubled. Suddenly there was a strong positive correlation between petroleum prices, corn prices, and food prices which resulted in an outcry from U.S. livestock producers and food riots in several developing countries. Other factors also contributed to the sharp increase in grain and food prices. Economic growth, especially in Asia, and a weaker U.S. dollar encouraged U.S. grain exports. Speculators and investors shifted funds from various capital markets to the commodity futures markets causing commodity prices to rise. Much of the increase in retail food prices could be attributed to the higher fuel costs for food transportation. Since mid-2008, the world has changed dramatically. Petroleum prices have fallen to around $40 per barrel. The U.S. dollar has strengthened and the world economy has entered the most serious recession since the 1930s with associated increases in unemployment, foreclosures in the housing market, collapse of the stock market, a decline in global trade, and a sharp decline in purchases of durable goods as well as food, especially away-from-home consumption. Agricultural commodity prices have declined by at least 50%. Biotechnology has had modest direct impacts on the biofuels sector to date. Seed corn with yield-protecting traits that help control insects and weeds have been widely adopted by U.S. farmers. Drought-tolerant varieties may soon be available. Genetically engineered enzymes have reduced ethanol production costs and increased conversion efficiency. This paper provides an historic perspective of the biofuels sector in the United States, analyzes the recent biofuel-food price debate, and offers some perspective for the future contribution of grain-based biofuels to meet our liquid energy demands.

Gene-Splicing is Over-Regulated, but Science Shows a Better Way

Henry I. Miller

The application of recombinant DNA technology, or gene splicing (also known as "genetic modification," or GM), to agriculture and food production was once highly touted as having huge public health and commercial potential. The last 20 years have been paradoxically disappointing, however: The gains in scientific knowledge have been stunning but commercial returns from intensive R&D have been relatively meager. Although the cultivation of gene-spliced crops, first introduced in 1995, now exceeds 800 million hectares and there have been more than 60 million individual decisions by farmers in two dozen countries over a 13-year period to plant gene-spliced crops, their cultivation remains but a small fraction of what is possible. Moreover, fully 99 percent of the crops are grown in only six countries – the United States, Argentina, Canada, Brazil, China, and South Africa – and the vast majority of all the worldwide acreage is devoted to only four commodity crops: soybeans, corn, cotton, and canola. Attempts to expand gene-splicing technology to additional crops, genetic traits, and countries have met resistance from the public, activists, and governments. Excessive and unscientific, poorly conceived regulation has been the most significant obstacle. The costs in time and money to negotiate regulatory hurdles make it uneconomical to apply gene-splicing technology to any but the most widely grown crops. Even in the best of circumstances – that is, where no bans or moratoriums are in place and products are able to reach the market – R&D costs are prohibitive. In the United States, for example, the costs of performing a field trial of a gene-spliced plant variety are 10 to 20 times that of the same trial with a virtually identical plant that was crafted with conventional techniques, and regulatory expenditures to commercialize a plant can costs tens of millions dollars more than for a conventionally modified crop. In other words, regulation imposes a huge punitive tax on a demonstrably superior technology. The fundamental public policy failure is regulators' adoption of rules specific for products made with gene-splicing techniques. Regulatory policy has consistently treated this technology as though it were inherently risky and in need of unique, intensive oversight and control – in spite of the facts that a broad scientific consensus holds otherwise – that agbiotech is merely an extension, or refinement, of less precise and less predictable technologies that have long been used for similar purposes (and the products of these older technologies are generally exempt from case-by-case review). All of the grains, fruits, and vegetables grown commercially in North America and Europe, for example (with the exception of wild berries and wild mushrooms), are derived from plants that have been genetically improved by one technique or another. Many of these "classical" techniques for crop improvement, such as wide-cross hybridization and mutation breeding, entail gross and uncharacterized modifications of the genomes of established crop plants and commonly introduce entirely new genes, proteins, secondary metabolites, and other compounds into the food supply. Nevertheless, regulations that apply only to the products of gene splicing have hugely inflated R&D costs and have made it difficult to apply the technology to many classes of agricultural products, especially ones with low profit potential such as non-commodity crops and varieties grown by subsistence farmers, like yams, millet, sorghum and cassava. This is unfortunate, because the introduced traits often increase productivity far beyond what is possible with classical methods of genetic modification. Moreover, many of the traits introduced or enhanced by gene-splicing are beneficial to the environment. These include the ability to grow with lower amounts of agricultural chemicals, water, and fuel, and under conditions that promote no-till farming, which inhibits soil erosion and the runoff of chemicals into waterways. The public policy miasma that exists today is severe, worsening, and seemingly intractable, but it was by no means inevitable. From the advent of the first gene-spliced microorganisms and plants a quarter century ago, the path to rational policy was not at all obscure. The use of molecular techniques for genetic modification is no more than the most recent step on a continuum that includes the application of far less precise and predictable techniques for genetic improvement. It is the combination of phenotype (that is, traits) and usage that determines the risk of agricultural plants, not the process or breeding techniques used to develop them. Conventional risk analysis could easily have been adapted to craft regulation that was risk-based and scientifically defensible; instead, government policy makers defined the scope of biosafety regulations to capture all gene-spliced organisms but practically none developed with classical methods. A basic principle of regulation is that the degree of regulatory scrutiny and intrusiveness should be commensurate with the perceived risk, but for gene-splicing, policy-makers have crafted precisely the opposite: The amount of regulatory scrutiny is *inversely* proportional to risk. We need reform that will right the wrongs that have done such violence not only to research and development but to the interests of the poorest among us. An essential feature of genuine reform must be the replacement of process-, or technique-oriented regulatory triggers with risk-based approaches. The introduction of a risk-based approach to regulation would constitute conformity to the risk-based approach that policy makers traditionally have taken to the oversight of many kinds of products and activities. A relevant example is quarantine regulations, which place restrictions on the importation and use of various materials that might contain or be plant pests, and which focus on the risk-related characteristics of the product rather than the process, or technique, by which the product is created. One such regulatory approach proposed more than a decade ago by my research group is based on the well-established model of quarantine regulations for non-gene-spliced, pathogenic organisms. In 1997, the Stanford University Project on Regulation of Agricultural Introductions published a description of a universally applicable regulatory model for the field testing of any organism, whatever the method employed in its construction. It is a refinement of the "yes or no" approach of extant national quarantine systems; under these older regimens, a plant that a researcher might wish to introduce into the field is either on the proscribed list of plant pests, and therefore requires a permit, or it is exempt. The "Stanford Model" uses a similar, though more stratified, approach to field trials of plants; it is based on the ability of experts to assign organisms to one of several risk categories. In addition to following the model of quarantine regulations, it closely resembles the approach taken in the U.S. government's handbook on laboratory safety, which specifies the procedures and equipment that are appropriate for research with microorganisms, including the most dangerous pathogens known. Panels of scientists had stratified these microorganisms into risk categories, and the higher the risk, the more stringent the procedures and isolation requirements. This model is flexible, in the sense that regulators applying it can opt for relatively greater stringency (that is, more risk categories requiring case by case review, with fewer exempt) or less stringency (more risk categories exempt, with fewer requiring case by case review). Under differing circumstances – the resources available for case by case review, predilections toward or against government involvement in research, and so forth – regulators' application of such an algorithm would likely elicit differences in the stringency of oversight; unlike regulatory mechanisms triggered solely by the use of gene-splicing techniques, the Stanford Model permits such debate to occur within a rational, scientific framework. The stunted growth of gene-splicing technology worldwide stands as one of the great societal tragedies of the past quarter century. We must find more rational and efficient ways to guarantee public health and environmental safety while encouraging new discoveries and their application. Science shows the way, and society's leaders – scientific, political and religious – must lead us there.

Challenges and Responsibilities for Public Sector Scientists

Marc Van Montagu

Agrobacterium-mediated gene transfer into plants was, like the majority of innovations, an achievement of public sector scientists. To use this technology for the production of crops displaying an important new trait such as biotic or abiotic stress tolerance is now the privilege of start-ups, SMEs and large corporations. Nevertheless, the price costs due to overregulation mean that it is only the large corporations that can bring these crops to market. We should not forget that the priority of the private sector is economic success, not the Millennium Development Goals. In their dialogue with society therefore, the public sector should stress that they cannot be blamed if the GM-crops commercialised today, do not meet public expectations. Rather, they should explain that the potential of this technology to bring major contributions to alleviate the problems that our planet is facing is very substantial. The public sector scientists have the responsibility to explain this to society and particularly stress that refusing GM-technology will hold back efforts to alleviate poverty and hunger, to save biodiversity and protect the environment.

Inactivation of Allergens and Toxins

Piero Morandini

Plants are replete with thousands of proteins and small molecules, many of which are species-specific, poisonous or dangerous. With time humans have learned to avoid dangerous plants or inactivate many toxic compounds in food plants, but there is still room for improvement. The capacity, offered by genetic engineering, of turning off (inactivate) single genes in crop plants has opened up the possibility of altering the plant content in a far more precise manner than previously available. There are several tools to inactivate genes (classical mutagenesis, antisense RNA, RNA interference, post-transcriptional gene silencing, insertion of transposons and other genetic elements) each one with a mixture of advantages and disadvantages (speed, costs, selectivity, stability, reversibility, regulatory regime). There are different level at which to intervene (genes coding for toxins, allergens, enzymes, transporters or regulators), each one suited for a specific problem, and there are different problems to address. We will describe interventions to ameliorate food crops in terms of their content in allergens and toxins, especially in their edible parts, providing some paradigmatic examples. It will be stressed that reducing the content of natural toxins is often a threshold issue ("the dose makes the poison") and a trade-off process: the least the content of natural toxins, the higher the susceptibility of a plant to pests and therefore the stronger the need to protect plants in field conditions. This has interesting consequences on the domestication process and the development of new pesticides to counter plant pests.

Nutritionally Improved Agricultural Crops

Martina Newell McGloughlin

Agricultural innovation has always involved new, science-based products and processes that have contributed reliable methods for increasing productivity and sustainability. Biotechnology has introduced a new dimension to such innovation, offering efficient and cost-effective means to produce a diverse array of novel, value-added products and tools. The first generation of biotechnology products commercialized were crops focusing largely on input agronomic traits whose value was often opaque to consumers. The coming generations of crop plants can be grouped into four broad areas each presenting what, on the surface, may appear as unique challenges and opportunities. The present and future focus is on continuing improvement of agronomic traits such as yield and abiotic stress resistance in addition to the biotic stress tolerance of the present generation; crop plants as biomass feedstocks for biofuels and "bio-synthetics"; value-added output traits such as improved nutrition and food functionality; and plants as production factories for therapeutics and industrial products. From a consumer perspective the focus on value added traits, especially improved nutrition, is undoubtedly one of the areas of greatest interest. From a basic nutrition perspective there is a clear dichotomy in demonstrated need between different regions and socioeconomic groups, the starkest being inappropriate lifestyle-based consumption in the developed world and under-nourishment in Less Developed Countries (LDCs). Dramatic increases in the occurrence of obesity and related ailments in affluent regions are in sharp contrast to chronic malnutrition in many LDCs. Both problems require a modified food supply, and the tools of biotechnology have a part to play. Developing plants with these improved traits involves overcoming a variety of technical, regulatory and indeed perception hurdles inherent in perceived and real challenges of complex traits modifications. Both traditional plant breeding and biotechnology-based techniques provide complimentary methodologies to produce plants with the desired quality traits. From a technological perspective continuing improvements in molecular and genomic technologies are contributing to the acceleration of product development. I will discuss examples of crops with improved traits in the pipeline, the evolving technologies and the opportunities and challenges that lie ahead.

Transgenic Plants for Food Security: Understanding the Sources of Over-Regulation

Robert Paarlberg

Applications of genetic engineering to agriculture have to date appear to have been over-regulated in most countries. We can reach this conclusion because even in the one country that regulates them with least severity – the United States – there has not yet been, after more than a dozen years, a single commercial release of a single GMO technology found later to have anywhere done harm to human health or the environment (greater than the harm a non-GMO variety of the same plant or food would do). It would seem, then, that where the technology is being regulated more severely than in the United States, which is to say in Europe and much of the developing world, the added stringency of regulation is unnecessary. Excessively stringent regulations come at a price, and in the case of GMOs this price is most steep in developing countries where farmers are poor (and poorly fed) because the productivity of their labor in farming has not yet been improved by modern technology. The source of this over-regulation of GMOs in poor countries is the external influence exercised on those countries by the rich, particularly by rich countries in Europe. The export from Europe to Africa, in particular, of a highly precautionary regulatory approach toward agricultural GMOs is accomplished through several different international channels of influence, including commodity trade ties, development assistance policy, training through intergovernmental organizations, advocacy campaigns by NGOs, and post-colonial cultural influence over local elites. This export of European standards into Africa is too often depicted as a progressive extension of "best practices" from the rich to the poor. It is better understood as an "imperialism of rich tastes" imposed on the poor.

GMO Myths and Realities

Wayne Parrott

The date was 10 April 2007. The headlines in the local newspaper in the particular Latin American country read "Famine," and the regions mentioned precisely coincided with those areas of the country that have practiced traditional agriculture for millennia. A few hours later, the Minister of the Environment was lecturing me how traditional farmers live in harmony with the environment, and how traditional agriculture is perfectly able to protect the environment and meet the health and economic needs of the rural population. This event perfectly illustrates the logical disconnect and the mythology that are frequently encountered when discussing GM crops. In country after country, the primary sources of information on GM crops are the popular press and several NGOs which are constant sources of misinformation, mythologies, and ideological positions. Thus, there are widely held perceptions that GM foods are not tested for safety, and that their cultivation will promote a wide series of problems that range from the carcinogenicity to the destruction of local biodiversity, the need for greater pesticide use leading to the creation of super pests and super weeds, the loss of ownership of traditional varieties, or the extinction of local varieties altogether. The misperceptions about agricultural biotechnology are further strengthened by declarations from prominent international entities, such UNEP-GEF, the World Bank, and UN Secretariats such as the Cartagena Protocol on Biosafety, which give credence to the foundational myth – i.e. modern agricultural technologies are inherently dangerous and unneeded. Various myths will be presented in the context of the available scientific evidence, as will the current consequences for society and the environment that come from abiding by myths and avoiding reality. The wealth of data currently available makes now the time to emphasize reality over myth. It is no longer permissible to turn a blind eye to the destructive properties of low-yield agriculture as practiced by farmers with scarce resources, while at the same time denying them access to modern farming technologies that could improve their livelihoods.

My Experience With Golden Rice

Ingo Potrykus

The following remarks are based on the practical experience with the humanitarian Golden Rice project and are representative for any public sector GMO-initiative to the benefit of the poor. Golden Rice (vitamin A-rice) was developed in the public domain, with public funding and the goal, to contribute to reduction in vitamin A-malnutrition in rice-dependent poor societies sustained and at minimal costs. Proof-of-concept was complete by February 1999. Product development beyond basic research did not find support from the public domain and, therefore, required (and received) support from the private sector. Problems related to intellectual property rights involved with the basic technology were solved within half a year. Product optimisation by the private sector was donated to the humanitarian project. The putative impact of Golden Rice was calculated to up to 40 000 lives saved per year for India alone (1). Development of locally adapted varieties for target countries such as India, The Philippines, Vietnam, Bangladesh, Indonesia is by public national and international rice research institutes, with financial support from national governments and altruistic organisations. Despite of all this support Golden Rice will not reach the farmer before 2012. If Golden Rice were not a GMO but a mutation, variety development and registration would have been completed by 2002. The difference in time between traditional variety development and that of a GMO-based variety of ten years is due to routine, regulatory requirements. This difference translates, on the basis of the calculated impact, to far more than 400'000 lives lost. This is especially difficult to accept, where no risk to the environment or to the consumer can be claimed even hypothetically. The conclusion from this single practical case are: 1) GMO regulation delays use of GMOs for ca ten years. 2) The time and costs required by regulation, to deliver a transgenic product to the market are so immense that no public institution, can afford to invest the necessary personnel nor the funds to release a single GMO-product. 3) Numerous public projects for improved food security, including many from developing country laboratories will end in dead-end roads for the same reason. 4) The damage to lives and welfare are enormous and affect the poor, and not the rich, Western societies who are responsible for this hype. 5) There is, probably, no scientific justification for the world-wide established regulatory system which is responsible for so much damage. The study week will aim at presenting the need for continued improved food production, the possible contributions from transgenic plants, the proven and anticipated positive impact on health, ecology and development, the state of practical application in developing countries. It will discuss the hypothetical risks raised in defence of radical rejection of the technology. Finally the study week will explore ways how to change regulation such that it enables use of the technology to the benefit of the poor, without compromising safety and prepare the ground for a follow-up meeting on the details of implementation.

Developing Crops That are Less Thirsty: How Biotechnology can Help Agriculture to Cope With Water-Deficit Conditions

C.S. Prakash

Bioengineering approaches provide unprecedented opportunities for improving food quality and food production, and are of special relevance to enhancing food security in the developing world. Yet, there is varying levels of opposition to the use of this technology in many countries. While there is some public apprehension with the use of bioengineering in food improvement, the major hurdles facing global adoption of this technology are the stringent and burdensome regulatory requirements for testing and commercialization, opposition from the special interest groups, apprehension by the food industry especially with whole foods, international trade barriers and the European reluctance to move forward with the technology. Much benefit can be harnessed with greater adoption of this technology in a wider variety of crops in the developing world: reduced use of pesticides and fuel, savings in labor costs, cheaper food, greater choice of nutritionally enhanced food products, foods with improved flavor, taste and longer shelf life; hypoallergenic foods like peanut and wheat, and elimination of harmful mycotoxins. Bioengineering of crops such as rice, corn, sorghum, cassava, plantain and grain legumes can clearly contribute to global food security and in feeding the ever increasing population through more sustainable farming with reduced ecological footprint. However, the integration of biotechnology into agricultural research in the developing countries is constrained by many challenges which must be addressed: financial, technical, political, environmental-activist, intellectual-property, biosafety and trade-related issues. To ensure that developing countries can harness the benefit of this technology with minimal problems, concerted efforts must be pursued to create an awareness of its potential benefits and to address the concerns related to its use through dialog among the various stakeholders: policy makers, scientists, trade groups, food industry, consumer organizations, farmers groups, media and NGOs. Communicating the safety of biotech products thus is crucial to ensuring the acceptance of this technology by the society. Such an outreach effort involving complex scientific and regulatory issues requires considerable skill and understanding of the risk communication theory and practice especially in ensuring that the audience recognize the distinction between 'hazard' and 'risk'. The process involves public participation and is a two-way process with strong emphasis on communicating risk assessment concepts and risk management strategies. A better educated public, media and policy makers on the benefits and safety of biotechnology products is crucial to the long-term success of this technology.

Benefits of GM Crops for the Poor: Household Income, Nutrition, and Health

Matin Qaim

The potential impacts of genetically modified (GM) crops on income, poverty, and food security in developing countries continue to be the subject of controversy in the public debate. Here, a review of the evidence available so far is given. Separation is made between first-generation GM technologies, with improved agronomic crop traits, and second-generation technologies, with improved quality traits. As an example of first-generation technologies, the impacts of insect-resistant Bt cotton are analyzed. Bt cotton has been adopted already by millions of small-scale farmers around the world, including in India, China, Argentina, South Africa and other developing countries. On average, adopting farmers in all these countries benefit from insecticide savings, higher effective yields through reduced crop losses, and net revenue gains, in spite of higher seed prices. This also translates into higher household incomes, including for poor and vulnerable farm families. Evidence from India suggests that Bt cotton is employment generating and contributes positively to poverty reduction and overall rural development. As an example of second-generation technologies, the potential nutrition and health impacts of beta-carotene-rich Golden Rice are analyzed from an ex ante perspective. The focus of this analysis is on India, where vitamin A deficiency (VAD) is a serious public health problem, causing a sizeable disease burden, especially in terms of increased child mortality. Simulations show that, with appropriate public backing, Golden Rice could reduce the disease burden of VAD by 60%, preventing up to 40,000 child deaths in India every year. These examples clearly demonstrate that GM crops can contribute to poverty reduction and food security in developing countries. To realize these important economic and humanitarian benefits on a larger scale will require more financial and institutional support for research targeted to the needs of the poor, as well as efficient technology development and delivery.

Plant Transgenic Research, Technology Development and Diffusion in India

S.R. Rao

Government of India has been down to business since 1982 in promoting biotechnology applications in agriculture, health care and industry. A separate Department of Biotechnology in the Ministry of Science and Technology was established in 1986. Agriculture Biotechnology has been the priority area and sustained investments were made to set up centers of excellence, support basic and applied R&D in universities/institutions. Today, more than 200 laboratories and 1000 researchers in public and private sectors are engaged in plant biology; transgenic research and development; molecular marker assisted breeding; genome sequencing and functional genomics. Technology platforms, research resources, facilities and services coupled with training skilled human resources, networks and public-private partnerships are supported in the pathway from discovery to market for desired level of development. Along these developments, the Indian acts, rules and regulations as well as procedures for handling of genetically modified organisms (GMOs) and recombinant DNA products were formulated under the Environment (Protection) Act (EPA) 1986 and Rules 1989 followed by elaboration of series of guidance documents in 1990, 1998 and 1999. Insect resistant cotton with cry1Ac gene was given approval in March 2002 for commercial release after 7 years of regulatory process. A decade of Indian experience with Bt cotton field trials including 3 other Bt gene versions and commercial cultivation of many hybrid versions by more than 30 licensed companies in millions of acres of varied agro-climatic regions taught several lessons in terms of: policy of regulation; biosafety assessment; post-release management; dynamics of seed industry and markets; public perception and response; evolution of anti-GM activists and their agenda; plight of agricultural extension; inter-ministerial coordination; Center- State relations; intellectual property and legal issues. Seven legal battles were fought and the ban by Supreme Court on field trials during 2005-2008 imposed in response to the litigation by anti-GM activists was lifted recently. To streamline the policy of regulation, three expert committees each on agricultural biotechnology, biopharma and GM foods were also constituted by the government. Government of India accepted the recommendations of these committees to restructure the regulatory framework and streamline regulatory process in terms of risk assessment methodology and risk management for sustainable development. Some of these recommendations translated into new guidelines and protocols for risk assessment are immediate challenges to the GM food crops in regulatory pipeline. Further, government has taken decision to establish a scientific, rigorous, efficient, predictable and consistent regulatory regime articulated as autonomous 'National Biotechnology Regulatory Authority' empowered by new 'Biotechnology Regulatory Act' to provide single window clearance mechanism. Department of Biotechnology, Government of India is spearheading this task through consultative process with all stakeholders. Other policy related developments, which would shape the future of GM foods in India, include recently enacted Food Safety and Standard Act (2006), evolving mandatory labeling policy of GM foods and inclusion of GM food trade issues in the foreign trade policy. So far, no permission has been given for the commercial production of GM food crops although nine such crops are in regulatory pipeline. Insect resistant eggplant developed by public and private sectors is in advanced stage. A determined and organized resistance by anti-GM activists perceptibly on behalf of consumers and consumer organizations is a current challenge. It is increasingly being realized that proactive investments for planned marketing research and organized

public relations with strategic communication campaign can only accelerate the path of success than continued funding of plant biotechnology research or frequent meddling with regulatory process.

Need for an Ever-green Revolution

■ M.S. Swaminathan

The term Green Revolution was coined by Dr William Gaud of USA in 1968 to signify the striking advances rendered possible in wheat and rice through genetic alterations in plant architecture and physiological rhythm. The semi-dwarf varieties of wheat and rice which triggered the green revolution were capable of utilizing sunlight, nutrients and irrigation water effectively. Shuttle breeding under diverse environments helped to breed varieties which are insensitive to photoperiod. Also, over 50% of the photosynthates went to grain formation, thereby helping to achieve a harvest index of over 50%. The genes for the semi dwarf character came from Japan in the case of wheat and from China in the case of rice. The green revolution helped to achieve a quantum jump in the productivity and production of wheat and rice in India and many other developing countries. This created a mood of optimism on our ability to raise food production above the rise in human numbers. However, the excessive use of pesticides with long residual toxicity and mineral fertilizers as well as the unsustainable exploitation of soil and ground water led to serious ecological problems, thereby affecting adversely the long term production prospects in many countries. This is why as early as January 1968, before the term green revolution was coined, I had cautioned against the indiscriminate use of pesticides and mineral fertilizers as well as the adoption of monoculture without varietal diversity, Genetic homogeneity enhances genetic vulnerability to pests and diseases. About 2 decades ago, I coined the term "Ever green revolution", to emphasise the need for enhancing productivity in perpetuity without associated ecological harm. The pathways for achieving an ever-green revolution include organic farming and green agriculture. Organic farming precludes the use of mineral fertilizers, chemical pesticides and genetically modified crops and varieties. In contrast, green agriculture involves the adoption of integrated pest management and integrated nutrient supply procedures as well as the cultivation of the most efficient and high yielding variety of crops, whether developed by Mendalian or Molecular breeding. Compounding the already existing problems, the greatest threat to ever-green revolution comes from global warming and climate change. Fortunately, we now have an opportunity through recombinant DNA technology to produce novel genetic combinations for enabling crops to withstand drought, floods and salt water intrusion. The future of agriculture therefore lies in the safe and responsible use of biotechnology, particularly recombinant DNA technology.

Crops coping with water scarcity

■ Chiara Tonelli

Despite significant improvements in crop yield potential and yield quality over the last decades, the forecasted global climatic changes are raising great concern about yield safety. In particular, drought represents a major threat to agriculture and food production. Even in the most productive agricultural regions short periods of water deficiency are responsible for considerable reductions in seed and biomass yields every year. Over 70% of the globally available fresh water is used in agriculture to sustain crop production, with only 30% of this returned to the environment. To cope with the detrimental effects of climate changes on crop yield and to fulfil the growing demand for food production it is imperative to develop new crops with higher performance under water scarcity, able to consume less water and to maintain high efficiency. Plants have evolved two different strategies to resist drought: dehydration avoidance and dehydration tolerance. Dehydration avoidance refers to the plant capacity to maintain high plant water status under the effect of drought. Plant avoid being stressed through mechanisms which enhance the capture of soil moisture (e.g. reaching deep soil moisture with a long root), or reduce water loss by transpiration (e.g. decreasing the aperture of the stomatal pores distributed on the leaf surface). Dehydration tolerance is the ability of the plant to conserve plant function in a dehydrated state. This strategy is relatively rare in nature and either breeding programs or plant biotechnology approaches have given a preference to dehydration avoidance over dehydration tolerance as the major strategy for plants to cope with drought stress (2). Multiple complex pathways are involved in controlling this process, and engineering only a single trait in some cases is not a winning strategy. Because transcription factors (TFs) are proteins that naturally act as master regulators of cellular processes, they are excellent candidates for modifying complex traits such as dehydration avoidance in crop plants, and TF-based technologies are likely to be a prominent part of the next generation of successful biotechnology crops. Some examples of modified transcription factors that improve plant response to drought and salinity stress, a direct consequence of water scarcity, in the model plant Arabidopsis thaliana, will be presented. In one case a transcription factor involved in the control of the opening and closing of stomatal pores, epidermal structures that regulate CO_2 uptake for photosynthesis and the loss of water by transpiration, has been identified and engineered to obtain plants that maintain high water status and high productivity also in water stress conditions. In a second example a transcription factor controlling the composition and thickness of cuticle has been studied. Finally an example of a transcription factor that, when over-expressed, enhances plant salt stress tolerance. The next step is to transfer to crop the technology set up in model plant. The first results of this transfer are very promising.

Ethical Arguments Relevant to the Use of GM Crops

■ Albert Weale

The Nuffield Council on Bioethics (NCOB) has published two reports (1999 and 2004) on the social and ethical issues involved in the use of genetically modified crops. This presentation summarises their core ethical arguments. Three sets of ethical concerns have been raised about GM crops: potential harm to human health; potential damage to the environment; and the 'unnaturalness' of the technology. The NCOB examined these claims in the light of the principle of general human welfare, the maintenance of human rights and the principle of justice. It concluded in relation to the issue of 'unnaturalness' that GM modification did not differ to such an extent from conventional breeding that it is in itself morally objectionable. In making an assessment of possible costs, benefits and risks, it was necessary to proceed on a case by case basis. However, the potential to bring about significant benefits in developing countries (improved nutrition, enhanced pest resistance, increased yields and new products) meant that there was an ethical obligation to explore these potential benefits responsibly, in order to contribute to the reduction of poverty, and improve food security and profitable agriculture in developing countries. NCOB held that these conclusions were consistent with any practical precautionary approach. In particular, in applying a precautionary approach the risks associated with the status quo need to be considered, as well as any risks inherent in the technology. These ethical requirements have implications for the governance of the technology in particular mechanisms for enabling small scale farmers to express their preferences for traits selected by plant breeders and mechanisms for the diffusion of risk-based evaluations.

Support for International Agricultural Research: Current Status and Future Challenges

Robert Zeigler

The success of the first Green Revolution in the form of abundant food supplies and low prices over the past two decades has allowed the world to shift its attention from agriculture to other pressing issues. This has resulted in lower support for international agricultural research and development. Investment in agriculture and related infrastructure by the world's development banks, for example, has dropped dramatically. Research undertaken by the 15 research centers of the Consultative Group on International Agricultural Research (CGIAR) was hit particularly hard. The decline in support for the CGIAR centers was so severe that the total research funding in 2000 dipped below the 1985 amount. However, since 2000, the funding situation has improved somewhat for the CGIAR centers, with almost all the increase coming from grants earmarked for specific research projects. Even for some centers such as the International Rice Research Institute (IRRI), the downward trend continued as late as 2006, with the budget in real dollars reaching the 1978 level of support. Support for research was also increasingly directed toward sub-Saharan Africa, to the detriment of other areas where poverty still abounds. The recent food crisis has renewed a call for a second Green Revolution by revitalizing yield growth to feed the world in the face of a growing population and shrinking land base for agricultural uses. The slowdown in yield growth because of decades of neglect in agricultural research and infrastructure development has been identified as one of the underlying reasons for the recent food crisis. For a second Green Revolution to be successful, the CGIAR centers will have to take on a more complex role by developing approaches that will expand productivity in a sustainable manner with fewer resources. Thus, it is crucial to examine the current structure of support for the CGIAR centers and identify the challenges ahead in terms of sources and end uses of funds for the success of a second Green Revolution. The objective of this paper is to provide a historical perspective on support to the CGIAR centers and examine the current status of funding, in particular, the role of project-specific grants in rebuilding the capacity of these centers. The paper will also discuss the nature of the support (unrestricted vs. project-specific grants) that will be needed for a much-desired second Green Revolution.

BIOGRAPHIES OF PARTICIPANTS

Klaus Ammann. Born December 6, 1940 in Bern, he finished studies in botany with a thesis on the history of vegetation and glaciers in the Alps with summa cum laude in 1972 at the University of Bern. In his years as an assistant in Bern he participated in creating the Swiss Atlas of Plant Distribution, established the first research group in lichenology in Switzerland (dealing with lichen chemosystematics and bio-monitoring air pollution). He lectured in plant biodiversity and vegetation ecology and became director of the Bern botanic garden in 1996 and professor honoris causa in 2000. His sabbatical stays included the University of Bergen, Norway, Duke University in North Carolina, University of West Indies in Jamaica and Missouri Botanical Garden in St. Louis. As an emeritus since 2006 he accepted invitations as a guest professor at the Delft University of Technology and at the Sabanci University in Istanbul. For many years he moderated the 'Berne Debates', an early blog on plant biotechnology, which he turned into the web-based activities of the ASK-FORCE placed on the websites of the European Federation of Biotechnology and the Public Research and Regulation Initiative. He served in numerous committees: Chair European expert committee on plant conservation, Council of Europe, founding member of steering committee Planta Europa, Biosafety Committee of the Government of Switzerland, board of directors of Africa Harvest, chair expert group on biodiversity of European Federation of Biotechnology. He was leader of several Swiss and European research projects on gene flow, plant conservation, lichen chemosystematics and monitoring air pollution. His publications embrace biogeography, vegetation history, vegetation ecology, plant systematics, gene flow of crops and their wild relatives and agricultural biodiversity. His scientific credo: It is his intention to encourage the learning process leading to solutions of today's crucial problems such as protection of biodiversity, risk-benefit assessment of genetically engineered crops and the public debate about biotechnology. All this should serve to enhance the dialogue between the rich and the poor, hunger being the foremost problem on this planet. Ultimately, risk is the balance between hazard and opportunity. If scientists want to be heard with scientific arguments, they must admit that the world cannot be explained exclusively by facts, since the questions about problems and opportunities connected to scientific progress have social and cultural components and are thus extremely complex. Debates on such complex issues need to have a discursive structure taking into account the *symmetry of ignorance* or the *asymmetry of knowledge*.

Kym Anderson is George Gollin Professor of Economics and Foundation Executive Director of the Centre for International Economic Studies (CIES) at the University of Adelaide in Australia. He is also a Research Fellow with Europe's London-based Centre for Economic Policy Research and a Fellow of the Academy of the Social Sciences in Australia, the American Agricltural Economics Association and the Australian Agricultural and Resource Economics Society. During 2004-07 he was on extended leave at the World Bank's Development Research Group in Washington DC as Lead Economist (Trade Policy). His research interests and publications are in the areas of international trade and development, agricultural economics, and environmental and resource economics. He has published more than 25 books and around 250 journal articles and chapters in other books including more than a dozen on the economics of agricultural biotechnology adoption and policies. He has been a consultant to numerous national and international bureaucracies, business organisations and corporations. During a period of leave he spent 1990-92 as deputy to the director of the Research Division of the GATT (now WTO) Secretariat in Geneva, and subsequently became the first economist to serve on a series of dispute settlement panels at the World Trade Organization (concerning the EU's banana import regime, 1996-2008). In 1996-97 he served on a panel advising the Ministers for Foreign Affairs and Trade in their preparation of Australia's first White Paper on Foreign and Trade Policy. His recent edited volumes include *Agricultural Trade Reform and the Doha Development Agenda* (with Will Martin) and *The WTO and Agriculture* (with Tim Josling). The first of those received the American Agricultural Economic Association (AAEA) Quality of Communications Award for 2006 and the Australian Agricultural and Resource Economics Society's inaugural Quality of Research Discovery Prize in 2007. Earlier books on agricultural trade policy are *Disarray in World Food Markets: A Quantitative Assessment* (with R. Tyers, 1992), *Changing Comparative Advantages in China: Effects on Food, Feed and Fibre Markets* (1990 in English and French, 1992 in Chinese) and *The Political Economy of Agricultural Protection: East Asia in International Perspective* (with Y. Hayami and others, 1986 in English, 1996 in Chinese). The last of those books received the Tohata Memorial Award in 1987, provided by Japan's National Institute for Research Advancement. Currently he is directing a large research project for the World Bank involving 140 consultants and more than 70 countries, aimed at quantifying the changing extent of policy distortions to agricultural incentives around the world, the political economy reasons for them, and their effects on farmer incomes, on national economic welfare and on income inequality and poverty. A total of seven edited volumes are currently in various stages of production (4 due out by end-2008, the other 3 in 2009). Details are at www.worldbank.org/agdistortions

Dr. Andrew Apel holds degrees in philosophy and law, and as a journalist has focused exclusively on agricultural biotechnology since 1996. He is the former editor of AgBiotech Reporter, and former contributing editor for Seed & Crops Digest. Currently, he is editor in chief of GM*O*belus, http://www.gmobelus.com, an online news publication covering agricultural biotechnology. He owns a farm in Iowa, which has been in his family for four generations.

Werner Arber. Swiss microbiologist and academic. *Education*: Aargau Gymnasium, Eidgenössische Technische Hochschule, Zürich and Univ. of Geneva. *Career*: Asst at Laboratory of Biophysics, Univ. of Geneva 1953-58 1960-62, Dozent, then Extraordinary Professor of Molecular Genetics 1962-70; Research Assoc., Dept of Microbiology, Univ. of Southern California, USA 1958-59; Visiting Investigator, Dept of Molecular Biology Univ. of California, Berkeley 1970-71; Professor of Microbiology, Univ. of Basel 1971-96, Rector 1986-88; Pres. Int. Council of Scientific Unions (International Council of Scientific Unions) 1996-99. *Honours and awards*: Nobel Prize for Physiology or Medicine (jtly)1978.

Roger Beachy, Ph.D., is president of the Donald Danforth Plant Science Center in St. Louis, Missouri. Beachy completed the Ph.D. at Michigan State University, and post-doctoral research at the University of Arizona and Cornell University. As founding president of the Danforth Center he is responsible for setting the scientific mission of the Center, namely *"To improve the human condition through plant science"*; in 2009, approximately one-third of sponsored research at the Center is devoted to projects that will benefit farmers in developing economies. Beachy is recognized for his work in molecular virology and gene expression, including development of transgenic plants that are resistant to virus infection; his work led to the first field trial of a transgenic food crop (1987). Current research includes: studies of mechanisms of transgenic virus resistance in model and crop plants; functional activities of transcription factors; and developing a chemical gene switching system for crops. His work has led to more than 275 peer reviewed articles and book contributions. Beachy has engaged in active collaborations with scientists in developing economies for more than 20 years to develop local crops with resistance to virus diseases. He has supported streamlining of the regulatory oversight and commercialization of crops developed through genetic transformation. Beachy previously held academic positions at Washington University in St. Louis; and The Scripps Research Institute, La Jolla, California, where he held The Scripps Family Chair in Cell Biology and was co-founder of the International Laboratory for Tropical Agricultural Biotechnology. He is a member of the U.S. National Academy of Sciences, Foreign Associate of the Indian National Science Academy (New Delhi), a Fellow of the American Academy of Microbiology, AAAS, among others. Awards include the Wolf Prize in Agriculture, the D. Robert Hoagland Award from the American Society of Plant Biologists and Ruth Allen Award from the American Phytopathological Society, Common Wealth Award, and others. Beachy serves as Chair of the AAAS Section on Agriculture, Food and Renewable Resources, and is President of the International Association of Plant Biotechnology.

Peter Beyer is a Professor at the Department of Cell Biology at the Centre for Applied Biosciences of the University of Freiburg, Germany, where he heads a research group working on the biochemistry, molecular biology and regulation of the plant prenyllipid metabolism with emphasis on the biosynthesis of carotenoids. Besides doing basic science the group focuses strongly on applied pathway engineering to improve the nutritional value of crop plants. Peter – together with Ingo Potrykus – is inventor of Golden Rice. Peter and Ingo both share the mission and vision to promote the use of the Golden Rice technology and to share it freely with resource-poor farmers in the developing world. Starting 2005 Peter became the Principal Investigator in the ProVitaMinRice Consortium, a program funded by the Bill & Melinda Gates Foundation and one of the selected Grand Challenges in Global Health projects. Peter received the "ProEuropa" European Award for Culture in Science and been voted – both together with Ingo Potrykus – "the most notable personalities in the areas of agricultural, environmental and industrial biotechnology" by readers of Nature Biotechnology.

Joachim von Braun, IFPRI's Director General, guides and oversees the Institute's efforts to provide research-based sustainable solutions for ending hunger and malnutrition. With about 270 staff members – two thirds of which are based in Washington DC and the others in developing countries – IFPRI is the world's premier research center on food and agriculture policy research. Before becoming IFPRI's Director General in 2002, he served as Director of the Center for Development Research and Professor for Economic and Technological Change at the University of Bonn, Germany. His Doctoral Degree in Agricultural Economics is from the University of Gottingen, Germany. Dr. von Braun has done economics research at global and local levels incl. in Egypt, Sub Sahara Africa, China, and Russia. He has published extensively, chiefly on the topics of economic policy, agriculture change, science and technology and on policy issues relating to trade, hunger, health, and nutrition. This includes publications relevant for this conference, such as J. von Braun "*The world food situation: New driving forces and required actions*". Food Policy Report. Washington, DC: IFPRI 2008; Qaim, M.; A.F. Krattinger; and J. von Braun (eds.). "*Agricultural biotechnology in development countries: Towards optimizing the benefits for the poor*." Boston, Dordrecht, and London: Kluwer Academic Publishers, 2000; and J. von Braun, E. Diaz-Bonilla,*"Globalization of Food and Agriculture and the Poor"*, Oxford University Press. Oxford, New Delhi, 2008. He was President of the International Association of Agricultural Economists in 2000-2003, is member of Academies in Germany and China, Fellow of AAAS, and serves numerous scientific societies, international organizations, and advisory councils/boards around the world. For more information see: http://www.ifpri.org/srstaff/vonbraunj.asp

Moisés Burachik obtained his Ph.D. Chemistry (University of Buenos Aires) and did post-doctoral research at The Rockefeller University and at The New York Blood Center. At present he is the Head of the Biotechnology Office within the Secretary of Agriculture, Livestock, Forestry and Food. Dr. Burachik leads the work on three aspects of the regulatory system for GMOs in Argentina: environmental risk assessment, guidelines (writing, updating and compliance) and design and formulation of policies and participates in the safety assessment of GMO-derived food. He has been involved with GMO regulatory activities in Argentina since their onset in 1991. He participated in the National Advisory Committee on Agricultural Biotechnology, first as a member, then as staff and now as head of the Biotechnology Office, where the Advisory Committee operates. As head of the Biotechnology Office, he led the development for the Strategic Plan 2005-2015 for the Development of Agricultural Biotechnology in Argentina, with the participation of a wide range of institutions and experts. He has participated in a variety of GMO-related meetings, has lectured and written several training courses and workshops in Latin America, has participated in several expert consultation meetings and organized or co-organized workshops. He was awarded the 2004 FAO-RedBio Gold Medal, in recognition of his activities at training, diffusion and harmonization of GMO biosafety in Latin America and The Caribbean. At present, he is also the Coordinator for Argentina of the ongoing FAO Project (Technical Cooperation Programme TCP/RLA/3109) on the Development of the Technical Reference Tools for the Management of Biosafety in the Countries of the Extended Mercosur (Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay). He acted as country delegate (scientific support) at the Argentina, Canada and US vs EU controversy Panel at the WTO. He attends the OECD meetings of the Working Group on Harmonization of Regulatory Oversight in Biotecnology as the Head of the Argentina's Delegation. He also led the Argentine delegation at the Conference of the Parties of the Cartagena Protocol (CBD). Prior to his appointment as Head of the Biotechnology Office, Dr. Burachik lectured at the Department of Exact and Natural Sciences, University of Buenos Aires, as chair of the Biotechnology course. Before this, he had organized the Biotechnology Unit at the National Institute of Industrial Technology. At these institutions he did research on some biotechnological applications involving microbial systems.

Bruce M. Chassy is a citizen of the USA. He grew up in San Diego, California and holds a baccalaureate in Chemistry from San Diego State University. He was awarded his Ph.D. in Biochemistry at Cornell University in Ithaca, NY. Dr. Chassy served as a research chemist at the National Institutes for Health (NIH) from 1968-1989 where he researched the biochemistry and molecular genetics of lactic acid bacteria that are dental pathogens and others that are used in food and dairy fermentations. His research experiences with the development of genetically modified microorganisms that could be used in foods led him to an interest in food safety and the safety evaluation of "biotech foods." He received the Distingushed Service Award of the US Public Health Service in 1985. In 1989 he moved to the University of Illinois as Professor and Head of the Department of Food Science. The Dept. of Food Science was merged with Foods and Nutrition to form the Department of Food Science and Human Nutrition in 1995. After serving as first Head of FSHN from 1995-2000, Dr. Chassy became the Executive Associate Director of the Biotechnology Center and was named Assistant Dean for Research in the College of Agricultural, Consumer and Environmental Sciences. He currently serves as Assistant Dean for Science Communication and Outreach and as a Professor of Food Science and Professor of Nutritional Sciences. He teaches a graduate course in food safety assessment and another that explores key issues at the interface between the science of food and nutrition and the consumer. In recent years Dr. Chassy has continued to be active in the development of strategies for food safety evaluation and their application to the setting public policy. Dr. Chassy has served as an expert advisor or consultant with numerous organizations that have a role in agricultural biotechnology policy and regulation (ie. WHO, FAO, OECD, ILSI, IFT, US FDA and the US EPA). Outreach education has been a career priority for Dr. Chassy; he has served as an ASM Visting Professor, an NIH Visiting Professor, a UNDP Consultant in India, and as a Fulbright Lecturer in Spain. He has been an Associate Editor of several scientific journals and Chaired the IFT Expert Panel on Food Safety and Nutrtion as well as the IFT Biotechnology Division. He recently authored or co-authored papers on "The History and Future of GMOs in Food and Agriculture" and "Crop Biotechnology and the Future of Food: A Scientific Assessment." He is also a co-author of the recent ILSI publications: "Nutritional and Safety Assessments of Foods and Feeds Nutritionally Improved through Biotechnology (2004)" and "Nutritional and Safety Assessments of Foods and Feeds Nutritionally Improved through Biotechnology: Case Studies (2008)."

Nina V. Fedoroff received her Ph.D. in Molecular Biology from the Rockefeller University in 1972. After doing post-doctoral work, Fedoroff joined the faculties of the Carnegie Institution of Washington (now the Carnegie Institution for Science) and the Johns Hopkins University. Fedoroff moved to the Pennsylvania State University in 1995, where she served as the Director of the Biotechnology Institute and the founding Director of the Huck Institutes of the Life Sciences, a consortium of colleges devoted to the promotion of multidisciplinary research and teaching in the life sciences. She is the Willaman Professor of Life Sciences and an Evan Pugh Professor at Penn State, as well as a member of the External Faculty of the Santa Fe Institute. Fedoroff has published two books and more than 130 papers in scientific journals. She has served on the boards of the International Science Foundation, the Genetics Society of America, the American Association for the Advancement of Science, and the Sigma Aldrich Corporation. She has also served on the Council of the National Academy of Sciences and the National Science Board. She is a member the National Academy of Sciences, the American Academy of Arts and Sciences, and the American Academy of Microbiology. Fedoroff received the University of Chicago's Howard Taylor Ricketts Award in 1990, the New York Academy of Sciences' Outstanding Contemporary Woman Scientist award in 1992, the Sigma Xi's McGovern Science and Society Medal in 1997, Syracuse University's Arents Pioneer Medal in 2003, and a National Medal of Science in 2006. Fedoroff is currently on leave of absence from Penn State serving as the Science and Technology Adviser to the Secretary of State and to the Administrator of USAID.

Dr. Richard Flavell joined Ceres in 1998. From 1987 to 1998 he was the Director of the John Innes Centre in Norwich, England, a premier plant and microbial research institute. He has published over 190 scientific articles, lectured widely and contributed significantly to the development of modern biotechnology in agriculture. His research group in the United Kingdom was among the very first worldwide to successfully clone plant DNA, isolate and sequence plant genes, and produce transgenic plants. Dr. Flavell is an expert in cereal plant genomics, having produced the first molecular maps of plant chromosomes to reveal the constituent sequences. He has been a leader in European plant biotechnology initiating and guiding a pan-European organization to manage large EU plant biotechnology research programs more effectively. In 1999, Dr. Flavell was named a Commander of the British Empire for his contributions to plant and microbial sciences. Dr. Flavell received his Ph.D. from the University of East Anglia and is a Fellow of EMBO and of The Royal Society of London. He is currently an Adjunct Professor in the Department of Molecular, Cellular and Developmental Biology at the University of California at Los Angeles.

Dr. Jonathan Gressel joined the Plant Sciences Weizmann Institute of Science, Rehovot, Israel in 1963 and is now professor emeritus. He has considerable experience dealing with the use of transgenic crops and transgenic biocontrol agents for the control of parasitic weeds that devastate crops in Africa and around the Mediterranean, with joint projects with scientists in Egypt and Kenya. Conversely, he has extensively studied the evolution of herbicide resistance in weeds from evolutionary, genetic and biochemical perspectives, and has consulted widely from India to Argentine on dealing with these issues. He and his colleagues have also developed tools to assess the risks from transgene flow as well as developed strategies to mitigate such transgene flow. He has lectured widely on transgenic biosafety, as part of the UNIDO academic biosafety course given at various universities around the world. He has been made an honorary fellow of both the Weed Science Society of America and the International Weed Science Society. He is an editor or on the the editorial board of four journals in plant sciences and is a co-author or author of over 275 scientific papers and book chapters and six books dealing with these issues. His latest edited books are entitled Crop Ferality and Volunteerism (2005), Novel Biotechnologies for Biocontrol Agent Enhancement and Management (2007), Integrating New Technologies for *Striga* Control: Ending the Witch-hunt (2007) and his single authored books are Molecular Biology of Weed Control (2002) and Genetic Glass Ceilings - Transgenics for Crop Biodiversity (2007).

Ronald Herring has taught at Cornell University since 1991, where he's served as Director of the Mario Einaudi Center for International Studies and John S. Knight Professor of International Relations, Chair of the Department of Government, and founding Director/Convener of Governance and Nature. Before Cornell, Herring was Professor of Political Science at Northwestern University and held brief visiting positions at the Universities of Chicago, Texas, Washington, and Wisconsin. Herring has been Editor of *Comparative Political Studies*, and remains on its editorial board, as on the boards of *Contemporary South Asia, Critical Asian Studies* and the *Journal of Development Studies.* Recent work has explored connections between economic development and ethnicity – e.g. *Carrots, Sticks and Ethnic Conflict: Rethinking Development Assistance* **(**University of Michigan Press, edited with Milton Esman), on class theory – e.g. *Whatever Happened to Class?* [Routledge/Lexington/Daanish 2008] edited with Rina Agarwala, and on genetically engineered organisms [as editor of a special issue of *Journal of Development Studies* Vol 43 (1), 2007 and in book form with Routledge (Oxon-London) as *Transgenics and the Poor*]. He is now with Ken Roberts team leader of Cornell's Institute for the Social Sciences theme project on Contentious Knowledge: Science, Social Science and Social Movements: http://www.socialsciences.cornell.edu/theme_projects.html.

Professor Drew L. Kershen has been teaching at the University of Oklahoma since 1971. He is admitted to the Oklahoma Bar and the Bar of the United States Court for the Western District of Oklahoma. He is a member of the American Agricultural Law Association, the American Bar Association and a life-member of the Council on Agricultural Science and Technology (CAST). He was a Director of the Rocky Mountain Mineral Law Foundation and the Co-Reporter to the NCCUSL/ALI Drafting Committee on Article 7 that redrafted UCC Article 7 Documents of Title (i.e. warehouse receipts and bills of lading). Revised Article 7 became part of the Uniform Commercial Code in October 2003. He has been a visiting professor at the law schools of the Univ. of Arkansas – Fayetteville, Univ. of Arkansas – Little Rock, Drake Univ., Univ. of Illinois, Univ. of Kansas, Oklahoma City Univ., Texas Tech Univ., and the Univ. of Texas. He was a Fulbright Teaching Fellow to the Universidad José Cecilio del Valle in Tegucigalpa, Honduras in the summer 1999. Professor Kershen concentrates his teaching, research and writing in the areas of agricultural law (with a particular emphasis on agricultural commercial law, agricultural environmental law, and agricultural biotechnology) and water law. His work is part of the Natural Resources curriculum at the College of Law. He has published more than 30 articles, 2 books, and 3 book chapters on agricultural law topics. He is a frequent lecturer on topics related to agricultural law and water law. In the past ten years, Professor Kershen has focused his teaching, writing, and speaking on agricultural biotechnology law and policy issues. He has written extensively on legal liability, intellectual property, and regulatory issues in agricultural biotechnology. He has been a speaker on agricultural biotechnology in Canada, Costa Rica, Guatemala, Honduras, Italy, India, Israel, Malaysia, Spain, and the United States. He is also a member of the Public Research Regulation Initiative, a public service organization, through which he has participated in international negotiations concerning agricultural biotechnology.

Anatole Krattiger is Research Professor at Arizona State University (ASU), teaches at the Sandra Day O'Connor College of Law at ASU and at Cornell University, and serves as Chair of *bio*Developments-International Institute. He focuses on intellectual property and innovation management in the life sciences, building and managing public-private partnerships, deals with "humanitarian" licensing and "global access" issues, and consults widely for public and private sectors, including philanthropic foundations and developing country governments. A Swiss citizen, he began his career as a farmer, worked at CIMMYT in Mexico, at Cornell University in Ithaca, and at the International Academy of the Environment in Geneva. He worked on the creation of ISAAA which he led for seven years and served as Executive to the Humanitarian Board for Golden Rice. He is a member of: the Advisory Council of the Franklin Pierce Law Center; of the Board of the Black Sea Biotechnology Association; of the Editorial Boards of the *Int. J. of Biotechnology* and of the *Int. J. of Technology Transfer and Commercialization*; was Distinguished Advisor to the Council for Biotechnology Information until the Council merged with BIO; and is Editor-in-Chief of *Innovation Strategy Today*. Most recently, he spearheaded the editing and production of *Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices* which comprises over 150 chapters, an Executive Guide, CD-ROM and online version. He holds a PhD and MPhil in Genetics and Biochemistry from the University of Cambridge, UK, a BSc in Agronomy, and Diplomas in Farming, in Farm Management and in Agriculture.

Christopher John Leaver. British scientist and academic. Emeritus Professor of Plant Sciences, University of Oxford. *Education*: Imperial Coll. of Science, London, Univ. of Oxford. *Career*: Fulbright Scholar, Purdue Univ., Ind., USA 1966-68; Scientific Officer, Agriculture Research Council Unit of Plant Physiology, Imperial Coll. London 1968-69; Lecturer, Univ. of Edinburgh 1969-80, Reader 1980-86, Science and Eng Research Council Sr Research Fellow, 1985-89, Professor of Plant Molecular Biology 1986-89; Sibthorpian Professor of Plant Sciences, Univ. of Oxford 1990-2007, now Professor Emer., Head of Dept of Plant Sciences 1991-2007; Nuffield Commonwealth Bursary, Sr Visiting Fellowship (SERC), Commonwealth Scientific and Industrial Research Organization Div. of Plant Industry, Canberra 1975; European Molecular Biology Org. Long-term Fellowship, Biozentrum, Basle 1980; Trustee and member Governing Council, John Innes Centre, Norwich 1984-; Trustee, Nat. History Museum, London 1997-2006; member Council, Agriculture and Food Research Council 1990-93; member Ministry of Agriculture, Fisheries and Food Priorities Bd 1990-93; member Royal Soc. Council 1992-94; member European Molecular Biology Org. (Council member 1992-97, Chair. 1996-97), Advisory Council on Science and Tech. 1992-93, Council Biochemical Soc. (Chair. NA & MB Group) (Vice-Chair. Exec. Cttee 2002-04, Chair. 2005-07); Dir Isis Innovation Ltd, Univ. of Oxford 1996-2002; Visiting Professor Univ. of Western Australia 2002-; Delegate Oxford Univ. Press 2002-07; member Individual Merit Promotion Panel, Biotechnology and Biological Sciences Research Council (BBSRC) 1996-2005 (member BBSRC Council 2000-03); Chair. External Scientific Advisory Bd, Inst. of Molecular and Cell Biology, Univ. of Oporto; member Scientific Advisory Bd, Inst. of Molecular and Cellular Biology, Singapore, Int. Advisory Panel, A*Star Graduate Acad., Singapore, ITQB Advisory Cttee, Univ. of Lisbon; member Academia Europaea; corresponding member, American Soc. of Plant Biologists 2003; Emer. Fellow, St John's Coll. Oxford. *Honours and awards*: Huxley Gold Medal, Imperial Coll. 1970; Tate & Lyle Award, Phytochemical Soc. of Europe 1984, Humboldt Prize 1997. *Publications*: ed. several books; numerous papers in int. scientific journals.

Steve Long is the Robert Emerson Professor in Plant Biology and Crop Sciences at the University of Illinois. He obtained his B.Sc. in Agricultural Botany from the University of Reading and Ph.D. in Environmental Physiology from the University of Leeds. He moved from Leeds to a faculty position at the University of Essex where he rose through the ranks to Full Professor. He has also held positions at the Smithsonian Institution, Brookhaven National Laboratory, and the University of Vienna. He moved to Illinois in 1999. Photosynthesis is directly or indirectly the source of all of our food, and much of our fuel. Long's research has examined, and continues to examine, how the efficiency of photosynthesis can be improved through both conventional breeding and transgenic technologies. His research extends from the laboratory to field production, and includes adaptation to climate change. He is listed by ISI as one of the 250 most cited authors in Animal & Plant Biology and one of the 20 most cited on Global Climate Change. He is author to over 200 peer reviewed journal publications on photosynthesis, global change impacts on plants, and bioenergy. He is Founding and Chief Editor of Global Change Biology, which has risen to be one of the most highly cited journals in environmental science. He has co-organized and taught eleven courses on research techniques in photosynthesis and bioproductivity improvement in developing countries and assisted in research programme development under the auspices of UNEP/UNDP. He gave a US Congressional Briefing on the impacts of atmospheric change on crops and on opportunities for mitigation in 2005 and last year provided a briefing to President Bush at the White House on opportunities for mitigation through renewable fuels from crop systems. Long is Deputy Director of the UC Berkeley/University of Illinois Energy Bioscience Institute – which was awarded $500M over 10 years by BP in February 2007. The mission of the Institute is to develop environmentally and economically sustainable biofuel systems beyond corn ethanol and soy diesel, that do not conflict with food production. He was made a Fellow of the American Academy for the Advancement of Sciences (AAAS) in February 2008.

Cathie Martin has been a group leader at the John Innes Centre, Norwich UK since 1983. The John Innes Centre is the leading Research Institute in Plant Sciences in Europe. She is a Professor at the University of East Anglia and also holds a chair as Niels Bohr Visiting Professor in the Faculty of Life Science, University of Copenhagen, Denmark. Her research has focused on cellular specialisation in plants and she was the first to identify genes regulating cell shaping in plants. She has been a plenary speaker and session organiser at several international biotechnology meetings, and has been asked to present the work she co-ordinates on the European Union-sponsored FLORA project at many international biotechnology meetings. She recently co-founded a spin-out company (Norfolk Plant Sciences) with Professor Jonathan Jones FRS, which aims to bring the benefits of plant biotechnology to Europe and the US. She has been involved in setting up the Centre for Preventative Medicine in Norwich UK which is supported by a unique combination of internationally leading researchers who are developing the scientific understanding of how diet can help to maintain health, lead to healthy ageing and reduce the risk of chronic disease. Her interests span the entire spectrum of plant biology, and biological questions from the fundamental right to the applied ends of plant science. She is currently Editor-in-Chief of Plant Cell, the highest ranking international journal for primary research on plants sponsored by the American Society of Plant Biologists.

Marshall A. Martin is the Associate Director of Agricultural Research Programs and Professor of Agricultural Economics at Purdue University. He earned his B.S. in Agricultural Economics from Iowa State University (1966), and his M.S. and Ph.D. degrees in Agricultural Economics from Purdue University (1972 and 1976, respectively). His professional interests include agricultural policy, international trade, and technology assessment (especially biotechnology and pesticide use). His recent research has emphasized the socioeconomic implications of biological, insecticide, and transgenic approaches to management of insects in maize. He has received many research, teaching, and Extension awards including best MS Thesis Award from the American Agricultural Economics Association both as a graduate student and as a major professor, Quality of Communication Award from the American Agricultural Economics Association, Frederick L. Hovde Award from Purdue

University for Excellence of Educational Service to the Rural People of Indiana, Certificate of Distinction from the Purdue Agricultural Alumni Association, and Certificate of Merit from the United States Department of Agriculture. He has supervised the research of over 35 graduate students. He has authored 36 peer-reviewed journal articles, published 35 Abstracts from selected papers presented at professional meetings, co-authored four books and four book chapters, and published over 100 research bulletins and extension publications. He has taught undergraduate and graduate courses in agricultural price analysis and agricultural policy to more than 3,000 students. He currently co-teaches the capstone course in agribusiness research in the distance-learning MS/MBA program offered jointly by Purdue University and Indiana University. He has been a speaker for more than 1000 Extension programs. In his current role as an Associate Director of Agricultural Research Programs he provides oversight for Federally funded research projects for approximately 300 faculty in 16 disciplinary departments in three Colleges-Agriculture, Veterinary Medicine, and Consumer and Family Sciences. He was appointed by Secretary of Agriculture Dan Glickman to the Advisory Committee on Agricultural Biotechnology for the United States Department of Agriculture. He co-chaired a national conference for the National Agricultural Biotechnology Council on biotechnology and risk communication. For several years, he was a member of the Committee on Biotechnology of the Division of Agriculture of the National Association of State Universities and Land Grant Colleges and a member of the Operating Committee of the National Agricultural Biotechnology Council. For eight years, he served as chairman of three North Central Region food and agricultural policy research committees. He has chaired the North Central Agricultural Experiment Station Directors Association and the North Central Multistate Research Committee. He also serves on the Board of Directors of the Agricultural Alumni Seed Improvement Association, Indiana Pork Board, and the Indiana Soybean Alliance. He is a member of many academic honoraries including Phi Kappa Phi, Gamma Sigma Delta, Epsilon Sigma Phi, and Ceres. He is a past President of the Purdue University Chapter of Sigma Xi. He is a member of several professional organizations including the American Agricultural Economics Association, the International Association of Agricultural Economists, the American Economics Association, and the American Association for the Advancement of Science. He chairs the Purdue University Department of Band Advisory Committee. He has had extensive international professional experience in Argentina, Russia, Bolivia, Brazil, Mexico, the Netherlands, Egypt, Hungary, Spain, India, and Portugal. During his Purdue University career he has worked in these countries with government, university, and private sector organizations as an agricultural policy and development specialist with special focus in recent years on the adoption of agricultural biotechnology. He lived in South America for six years as a teacher, school administrator, and researcher. He has served as a consultant for the World Bank, Ford Foundation, and the U.S. Agency for International Development. He is fluent in Spanish and Portuguese.

Em. Prof. Marc Baron Van Montagu, president of the European Federation of Biotechnology (EFB), is a pioneer in plant molecular biology. With his colleague, Jeff Schell, he discovered the mechanism of DNA transfer from *Agrobacterium tumefaciens* to plants, and constructed the first chimerical plant genes. Van Montagu used this new technology to study gene regulation and to discover the molecular basis of several plant physiological processes. He has made major contributions to the identification of genes involved in plant growth, development and flowering. He ranks among the 10 most cited scientists in the fields of Plant & Animal Science (ISI classification). His laboratory raised two spin-offs, Plant Genetic Systems (PGS), and CropDesign. At PGS, he drove front-line innovations for biotech agriculture, such as plants resistant to insects or tolerant to more environmentally friendly herbicides. In 2000 he created the Institute of Plant Biotechnology for Developing Countries (IPBO) at Ghent University. Its mission is training, technology transfer and plant biotechnology research oriented towards the needs of less-developed countries. He is also President of the Public Research Responsibility Initiative (PRRI). He has received numerous awards, among others the Japan Prize. In 1990, due to his scientific accomplishments, he received the title of Baron, he is member of several academies of science, agriculture and engineering and holds numerous Doctor *Honoris Causa* degrees. Marc Van Montagu holds a Ph.D in Organic Chemistry/Biochemistry and earned a B.A. in Chemistry from Ghent University.

Piero Morandini, after receiving a summa cum laude degree in Chemistry at the University of Turin in 1986, turned to the field of biology. He worked for three years in Munich at the Max Planck institute for Biochemistry and the Zoological institute of the Ludwig-Maximilian University, specializing in the field of molecular biology and development of the soil amoeba Dictyostelium. He moved on to Cambridge (UK), working on the same subject at the Medical Research Council in the Laboratory of Molecular Biology for three years. From 1994 he is at the University of Milan, in the Department of Biology, working on fundamental problems of plant biology and biotechnology. Since 1999 he has been a Researcher in plant physiology, focussing in later years on the control of metabolism in plants. Dr. Morandini is author of more than 20 articles in refereed journals and two book chapters in the field of molecular biology and plant biotechnology. He works as a referee for several journals and national granting agencies. Piero Morandini currently teaches Plant physiology, Plant industrial biotechnology and Public perception and communication to biotechnology students at the University of Milan. He is a member of the Scientific Committee for Agricultural Biotechnology of the Lombardy Region. He tries to improve the public understanding of agricultural biotechnology by contributing articles to several newspapers, including *Avvenire* and *Tempi* and participating to public debates on TV and radio, as well as schools and cultural events.

Martina Newell-McGloughlin directs the UC Systemwide Biotechnology Research and Education Program (UC BREP), which covers all ten campuses and the three national Laboratories, Lawrence Livermore, Lawrence Berkeley and Los Alamos. The founding director was Nobel Laureate Paul Berg. She is co-director of an NIH Training Program in Biomolecular Technology, one of four in California, the others being at UC Berkeley, UCLA and UC San Diego, and co-director of the NSF IGERT program in Collaborative Research and Education in Agricultural Technologies and Engineering, a UC/Ireland collaboration. Prior to her UC BREP directorship she was director of the UC Systemwide Life Sciences Informatics Program and the local UC Davis Biotechnology Program. She helped contribute to the formation of Science Foundation Ireland and is now a member of its Board of Directors. In her position she is required to be cognisant of the state-of-the-art in everything from stem cells to nanotechnology research across academia and industry. She has broad experience in developing novel biotechnology research, training and education programs and experience in managing large multidisciplinary grants programs. She has published numerous papers, articles, book chapters and three books on biotechnology including her latest book "The Evolution of Biotechnology: From Natufians to Nanotechnology" published in January 2007. She has also edited four books and has a fifth in progress. Her personal research experience has been in the areas of disease resistance in plants, scale-up systems for industrial and pharmaceutical production in microbes and microbiological mining. She has a special interest in Developing World Research and is part of the USAID Applied Biotechnology Research Program. She speaks frequently before scientific and other associations, testifies before legislative bodies, and works with the media. She travels worldwide for various organizations evaluating programs and as an expert on biotech research and education issues. The UC Davis Academic Federation selected her to receive its 2001 James H. Meyer Distinguished Achievement Award. In 2003, the Council for Biotechnology named her one of the DNA Anniversary Year, Faces of Innovation among such luminaries as Norman Borlaug, Ingo Potrykus, Mary Dell Chilton and Roger Beachy, the pioneers and innovators behind the progress of plant biotechnology over the past 20 years. In 2005 she and Lester Crawford, former FDA Commissioner, among others, were awarded the 'Irish America Life Science Awards' as one of the top contributors to Irish American Life Science.

Robert Paarlberg is the Betty F. Johnson Professor of Political Science at Wellesley College and currently a Visiting Professor of Government at Harvard University. He received his undergraduate degree at Carleton College and his PhD at Harvard. He is the author, most recently, of "Starved for Science: How Biotechnology is Being Kept out of Africa" (Harvard University Press, 2008). He is a member of the Board of Agriculture and Natural Resources at the National Research Council and has been a consultant to the International Food Policy Research Institute, the World Bank, the U.S. Agency for International Development, the Chicago Council on Global Affairs, FAO, and the Bill and Melinda Gates Foundation.

Wayne Parrott is a native of Guatemala, and has a degree in agronomy from the University of Kentucky, and MS and PhD degrees in Plant Breeding and Plant Genetics from the University of Wisconsin. He is currently a professor of Crop Science at the University of Georgia, where he has been for the past 21 years. He conducts research on the development and deployment of transgenic crop plants, and has published over 70 journal articles in refereed publications, along with 12 book chapters and three patents. He has served on the Editorial Boards of *Plant Cell Reports*, *Plant Cell Tissue and Organ Culture*, and *Crop Science*. He has been elected chair of the biotechnology section of the Crop Science Society of America and of the plant section of the Society for In Vitro Biology, and is a fellow of the Crop Science Society of America. He is actively engaged in training graduate students and postdoctoral fellows, and teaches graduate-level courses in genetics and undergraduate courses in agroecology and sustainable agriculture. The latter course is taught on-site in Costa Rica. He has traveled extensively throughout Latin America, and worked closely with legislators and regulators in the various countries with their legal and regulatory issues relating to biotechnology. He is the scientific advisor to the Biotechnology Committee of the International Life Sciences Institute, which serves to bring the best science available to help formulate regulatory policies.

Ingo Potrykus was awarded degrees at the University of Cologne and the University of Basel. He spent his scientific career at the Institute of Plant Physiology at Stuttgart, Max-Planck-Institute of Genetics at Heidelberg, the Friedrich Miescher-Institute at Basel, and Institute of Plant Sciences at the ETH Zürich. He was teaching Plant Biology and Biotechnology in the Faculties of Biology, Pharmacy, Agronomy, Forestry, and Environmental Sciences. His science was aimed at the development and application of genetic engineering technology with plants, to contribute to food security of poor societies in developing countries. His best known project is that of 'Golden Rice', engineered to provide provitamin A as sustainable intervention against vitamin A deficiency, a nutritional problem that takes a daily toll of 6'000 lives and leads to widespread blindness of children (*www.goldenrice.org*). Proof-of-concept was realized in 1999, at the time of his retirement from his post as full professor in plant sciences. Since that time he is devoting his efforts to guide the project through the hurdles of intellectual property rights, product development, and GMO regulation, to make his invention freely available to those who suffer from vitamin A-malnutrition. He has numerous international recognitions, membership of national and international academies, honorary doctorates from Uppsala and Freiburg, and has ca 330 peer reviewed publications and ca 30 patents in plant biotechnology.

Dr. Channapatna S. Prakash, Professor at Tuskegee University (USA), has been actively involved in enhancing the societal awareness of food biotechnology issues around the world. His Internet website www.agbioworld.org has become an important portal disseminating information and promoting discussion on this subject among stakeholders such as scientists, policy makers, activists and journalists. Dr. Prakash has actively worked to promote biotechnology research and policy in developing countries of Asia and Africa through training of students and scholars, research collaboration and lectures. See his website. He has earlier served on the USDA's Agricultural Biotechnology Advisory Committee and the Advisory Committee for the Department of Biotechnology for the government of India. His outreach activities include writing commentaries, delivering public lectures, providing media interviews, and moderating daily Internet discussion group and newsletter '*AgBioView*' which is read by more than 5000 experts in 65 countries. The *AgBioView* is widely recognized as a premier news outlet on agbiotech issues because of its broad focus on technical, societal and ethical issues. Dr. Prakash, through his efforts has been successful in impacting decision makers, the media and consumers in creating awareness of agbiotech issues especially on technology development and biosafety issues. He been instrumental in catalyzing the scientific community in many countries to be more proactive in the biotechnology debate. Dr. Prakash's contribution to agricultural biotechnology outreach was recognized by the magazine *Progressive Farmer* who awarded him the 'Man of the Year' award 'in service to Alabama Agriculture'. He was recently named as one of a dozen 'pioneers, visionaries and innovators behind the progress and promise of plant biotechnology' by the Council for Biotechnology Information. He was chosen by his peers as among the "100 Top Living Contributors to Biotechnology" (October 2005) while the prestigious 'Nature' magazine readers' short listed him for "Who's who in biotech some of biotech's most remarkable and influential personalities from the past 10 years" (March 2006). Dr. Prakash has a bachelor's degree in agriculture and a masters in genetics from India, and obtained his Ph.D. in forestry/genetics from the Australian National University, Canberra. His research interests include studies on transgenic plants, gene expression, tissue culture and plant genomics. Dr. Prakash's group at TU has led the development of transgenic sweetpotato plants, identification of DNA markers in peanut and the development of a genetic map of cultivated peanut. He serves on the scientific advisory board of American Council on Science and Health (NY), BioScience Policy Institute (New Zealand), Norman Bolaug Institute of Plant Sciences (UK), Institute for Trade, Standards and Sustainable Development, Lifeboat Foundation, Policy Network (UK) and Life Science Foundation India.

Matin Qaim, a citizen of Germany, holds an MSc in Agricultural Sciences from the University of Kiel and a PhD in Agricultural Economics from the University of Bonn. From 2001 to 2003, he was a Post-Doc Visiting Fellow at the University of California at Berkeley (USA), before he became a Senior Researcher at the Center for Development Research in Bonn. Between 2004 and 2007, he was a Professor of Agricultural and Development Economics at the University of Hohenheim in Stuttgart. In 2007 he became Professor of International Food Economics and Rural Development at the Georg-August-University of Goettingen. Qaim has extensive research experience related to the economics of agricultural technologies in developing countries. In particular, he has implemented and coordinated numerous studies on the adoption and impacts of biotechnology in the small farm sector in countries of Asia, Africa, and Latin America. Apart from impacts on farm productivity, income, and poverty in rural areas, he has also analyzed wider effects on nutrition and public health. Qaim has published widely in international scientific journals and books. His research has also been awarded several academic prizes.

Dr. S.R.Rao, Adviser, Department of Biotechnology (DBT), Minister of Science & Technology, Government of India is Graduate in Agriculture with Ph.D in Mycology and Plant Pathology from Indian Agricultural Research Institute, New Delhi. He was post Doctoral Fellow in Tottori University, Japan and visiting Scientist at Waite Agricultural Experimental station, Adelaide Australia and has specialized in Molecular pathology. He served in various positions in Department of Biotechnology, Ministry of Science and Technology, Government of India since 1989 and was actively involved in establishment of oil palm cultivation in India, several sophisticated biotech infrastructure facilities, forging bilateral collaboration with Asian and /European countries, introduction of Golden rice for research in India, formulation of National Biotech policies, strategic planning and investment matters. He served as Adviser for Science and Technology for a period of three years (2004-2007) to Minister for Science and Technology, Govt. of India. During this tenure he initiated important programmes on public health access in villages through public-private partnerships, S&T interventions in judiciary reforms, technology assessment of bioenergy and biofuel resources and various issues of S&T and public policy interface. He served/serving as member of several Technical Committees of the Government of India; Academic /research councils of Universities/institutions; member-Golden rice Humanitarian Board; Elected Member-Asia Steering Advisory Committee on Capacity Building of Cartagena protocol Secretariat, CBD, Montreal; Member, Liaison Group On Capacity Building of Protocol. Currently, he is also coordinator in DBT for the establishment of National Biotechnology Regulatory Authority and new Biotechnology Regulatory Bill. He specializes in core and cross-sectoral policy issues of Biotechnology development; regulation; biosfety assessments; safety; public-private partnership, international relations; biotech R&D Innovation and Development; responding to public concerns and consensus building. He is founder and editorial board member of Asian Biotechnology Development Review (ABDR) published for knowledge sharing among developing countries and has published 30 research papers in national/international Journals and made several presentations in various national and international conferences.

Peter Hamilton Raven. American botanist, administrator and academic. Director, Missouri Botanical Garden. *Education*: Univ. of California, Berkeley, Univ. of California, Los Angeles. *Career*: Nat. Science Foundation Postdoctoral Fellow, British Museum, London 1960-61; Taxonomist, Rancho Santa Ana Botanical Garden, Claremont, Calif. 1961-62; Asst Professor, then Assoc. Professor of Biological Sciences, Stanford Univ. 1962-71; Dir Mo. Botanical Garden 1971-, Engelmann Professor of Botany, Washington Univ., St Louis, Mo. 1976-; Adjunct Professor of Biology, Univ. of Missouri, St Louis 1973-; John D. and Catherine T. MacArthur Foundation Fellow, Univ. of Missouri 1985-90; Chair. Nat. Museum Services Bd 1984-88; member Nat. Geographic Soc. Commission on Research and Exploration 1982, Governing Bd Nat. Research Council 1983-86, 1987-88, Bd World Wildlife Fund (USA) 1983-88, NAS Commission on Human Rights 1984-87, Smithsonian Council 1985-90; Home Sec. NAS 1987-95; Pres. Org. for Tropical Studies 1985-88; appointed Pres.'s Cttee on the Nat. Medal of Science 2004; member Bd of Trustees Nat. Geographic Soc.; Foreign member Royal Danish Acad. of Sciences and Letters, Royal Swedish Acad. of Sciences; Fellow, American Acad. of Arts and Sciences, Calif. Acad. of Sciences, American Association for the Advancement of Science (former Pres.), Linnean Soc. of London. *Honours and awards*: Hon. member American Soc. of Landscape Architects ; several hon. degrees ;Distinguished Service Award, American Inst. of Biological Sciences 1981, Int. Environmental Leadership Medal of United Nations Environment Programme 1982, Int. Prize in Biology, Japanese Govt, Pres.'s Conservation Achievement Award 1993, inducted into St Louis Walk of Fame 1995, Field Museum of Natural History Centennial Merit Award 1994, Nat. Medal of Science 2000, Tyler Prize for Environmental Achievement, Int. Cosmos Prize 2003, Engler Medal, Volvo Prize, named by TIME magazine a Hero for the Planet.

Konstantin G. Skryabin (29 April 1948, Moscow, Russia) Centre 'Bioengineering', The Russian Academy of Sciences. *Education* Moscow State University, Biological Faculty, Department of Molecular Biology (1965-1970). *Training* (1970-1973) Moscow State University, Russia, postgraduate studies, Biological Faculty, Department of Molecular Biology. Ph.D. in 1974; (1976-1977) Honorary research fellow in Biology, Harvard University, USA, (Prof. W.Gilbert, Head of the Department). *Positions* (1974-1984) Senior scientist in the Institute of Molecular Biology, USSR Academy of Sciences; (1984-1991) Head of the Department, the Institute of Molecular Biology, USSR Academy of Sciences; (1986-present) Professor, Faculty of Biology, Moscow State University; (1991-present) Director and founder, Centre 'Bioengineering', The Russian Academy of Sciences; (2007-present) Vice-Director, Russian Research Centre 'Kurchatov Institute'; (2007-present) Head, Chair of Biotechnology, Faculty of Biology, Moscow State University. *Society Membership* The Russian Academy of Sciences, Full member (academician); The Russian Academy of Agricultural Sciences, Full member (academician); The European Molecular Biology Organization, Associate member. *Research activities* Establishing genome sequencing techniques in Russia, pioneering research projects on sequencing of eukaryotic ribosomal RNA genes, genomes of plant viruses and bacteriophages; Development of systems for production of growth hormones, other biologically active proteins in bacterial and eukaryotic cells, structural studies of pharmaceutically important proteins; Construction of transgenic plants resistant to herbicides, pathogens and abiotic stresses; Genetic analysis and mathematical modeling of plant flower development; Development of new techniques for expression of target proteins in plants based on the use of self-replicating plant viral vectors. Production of vaccine proteins in plants; Design and engineering of artificial proteins, protein complexes and viral-like particles with predetermined properties for nanobiotechnological applications; Sequence and analysis of genomes of extremophilic microorganisms, isolation of new enzymes for biotechnological applications; Plant genome studies and biodiversity assessment using molecular methods; Analysis of genetic diversity of human populations, identification of polymorphic loci associated with various diseases in different ethnic groups; Biosafety and ethical issues of genetic engineering. *Public activities* (1989-1997) COBIOTECH (Committee on Biotechnology of International Council of Scientific Unions), Secretary General/ Treasurer COBIOTECH; (1993-present) Chairman, Scientific Council on Biotechnology, Russian Academy of Sciences; (2001-present) Member, The Council at the President of the Russian Federation on Science, Technologies and Education; (1997-present) Vice Chairman of Inter-Agency Committee on Genetic Engineering; (2006-present) Vice Chairman of Russian Bioethics Committee under the Commission of Russian Federation for UNESCO. *Editorial Posts in different years* Prof. Skryabin has been associated with the Editorial Boards of several peer reviewed journals in Russia and abroad, including *FASEB Journal* (USA), *The Plant Journal* (UK), *Trends in Biotechnology*, *BioEssays*, *Biotechnology* (Russia), *Problems of Biological, Medical and Pharmaceutical Chemistry* (Russia), *Reports of Russian Academy Agricultural Sciences* (Russia), *Plant Protection News* (Russia), *Ecological genetics* (Russia), *Cell technology in biology and medicine* (Russia). *Publications* 420 scientific papers, including over 59 patents and inventions. *Awards* (1983) State Prize of the USSR in Science and Technology; (2006) Officer of Order of the Academic Palm (France); (2008) Rank IV of the Order For Service to the Fatherland (Russia).

Monkombu Sambasivan Swaminathan is an Indian agriculture scientist, born August 7, 1925, in Kumbakonam, Tamilnadu, the second of four sons of a surgeon. His ancestral home is the island village of Monkompu, Alleppey District, Kerala. He is known as 'Father of the Green Revolution in India', for his leadership and success in introducing and further developing high-yielding varieties of wheat in India. He is founder and Chairman of the MS Swaminathan Research Foundation, leading the 'Evergreen Revolution'. He is a visionary whose dream is to rid the world of hunger and poverty. Dr. Swaminathan is widely respected for his effective advocacy of sustainable development, especially using environmentally sustainable agriculture, sustainable food security and the preservation of biodiversity. His motto is '*if conservation of natural resources goes wrong, nothing else will have a chance to go right*'. He said, in 2005, that: '*I am firmly convinced that hunger and deprivation can be eliminated sooner than most people consider feasible, provided there is a synergy among technology, public policy and social action*'. He often answers serious questions and requests with the reply: '*Why Not?*'. He is married to Mina Swaminathan whom he met in 1951 while they were both studying at Cambridge. They have three daughters: Chennai-based TB researcher Soumya Swaminathan, Kolkata-based economist Madhura Swaminathan and Nitya Rao, who works on gender issues. Dr. Swaminathan lives in Chennai, Tamilnadu with his wife. He has five grandchildren.

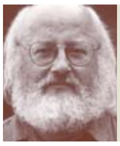
Chiara Tonelli is Professor of Genetics at University of Milan, Italy, and leader of the Plant Molecular Genetic Group of the Department of Biomolecular Sciences and Biotechnology of the same University. She is an EMBO member, the European Molecular Biology Organisation. Her scientific interests span from fundamental aspects of plant biology to biotechnological applications. The major focus of her studies is to deciphere the logic of transcriptional control and gene regulation in plant during development and in the interaction with the environment. She contributed to the identification and molecular characterization of regulatory gene families responsible for the coordinate control of flavonoids and anthocyanin metabolic pathways. She discovered an interaction among duplicated genes, termed REED (Reduced Expression of Endogenous Duplications), an epigenetic mechanism of silencing mediated by DNA methylation of their promoter regions. More recently she discovered the first transcription factor specifically regulating stomata movements in the plant; this finding opens new possibilities to improve crop survival and productivity in water scarcity conditions. She has served on numerous national and international scientific committees and science advisory boards. Currently she is member of the Advisory Group for Food, Agriculture and Fisheries, and Biotechnology of the European Commission and of the Expert group for Food and Health Research, board member of the European Plant Science Organisation (EPSO) and member of the Research and Technological Transfer Committee of the University of Milan. She is reviewer for scientific journals (Molecular Cell, Molecular and Cellular Biology, EMBO Journal, Plant Cell, Plant Journal, Plant Molecular Biology) and for international granting Agency (USDA, EMBO, TWAS, Human Frontier). Since 2005 she is Secretary General of the "Future of Science Conference", a cycle of International conferences gathering together eminent experts from various disciplines addressing to the different spheres of the society with the aim to bring Science in Society, choosing every year a theme crucial to society, to underline the contribution and implications of scientific progress to everyday life.

Albert Weale is Professor of Government and co-editor of the *British Journal of Political Science* at the University of Essex. Since January 2008 he has also chaired the Nuffield Council on Bioethics. His research and publications have been concentrated on issues of political theory and public policy, especially the theory of justice and the theory of democracy, health policy and comparative environmental policy. His principal publications include *Equality and Social Policy* (Routledge and Kegan Paul, 1978), *Political Theory and Social Policy* (Macmillan, 1983), *The New Politics of Pollution* (Manchester University Press, 1992), *Democracy* (Macmillan, 1999, second revised edition 2007) and, with others, *The Theory of Choice* (Blackwell, 1992) and *Environmental Governance in Europe* (Oxford University Press (2000) as well as a number of edited works and papers. He graduated in Theology from Clare College Cambridge in 1971 and was awarded a PhD in Social and Political Sciences at the University of Cambridge in 1977. Between 1974 and 1976 he was Sir James Knott Fellow at the University of Newcastle. He was Lecturer in Politics (1976-85) and Assistant Director of the Institute for Research in the Social Sciences (1982-85) at the University of York and then became Professor of Politics at the University of East Anglia (1985-92). Between 1986 and 1990 he was a member of the Advisory Board of the King's Fund Health Policy Institute and chaired the King's Fund Grants Committee between 1997 and 2001. He has also served on a number of committees for the UK's Economic and Social Research Council. Between 1995 and 1996 he chaired the Working Party on The Ethics of Xenotransplantation, established by the Nuffield Council on Bioethics. In 1993 he became a Council nominated Fellow of the Royal Society of Arts and in 1998 he was elected a Fellow of the British Academy.

Robert Zeigler is an internationally respected plant pathologist with more than 25 years' experience in agricultural research in the developing world. He became director general of the International Rice Research Institute (IRRI) in 2005. IRRI is based in the Philippines, with offices in 14 countries and activities in over 25 countries. It focuses on sustaining, understanding, and using the genetic diversity of rice to improve rice productivity and the livelihood of rice farmers and consumers. It works to improve sustainable production practices and understand the social and political context in which improved rice production systems operate. As director general, he is the chief executive officer of the institute and directly manages and administers its affairs in accordance with the policies and decisions of a board of trustees. He also serves as a spokesperson on a wide range of issues that affect rice growers and consumers everywhere. Dr. Zeigler had previously worked at IRRI from 1992 to 1998 as a plant pathologist, when he led the Rainfed Lowland Rice Research Program and the Irrigated Rice Research Program. After graduating in 1972, he joined the Peace Corps and spent two years as a science teacher in the Democratic Republic of Congo in Africa and later joined the International Center for Tropical Agriculture (CIAT) in Colombia as a visiting research associate working on cassava. In 1982, he went to Burundi to work for three years as a technical adviser for the African nation's maize program at the Institut des Sciences Agronomiques du Burundi. He then returned to CIAT, eventually becoming the head of the rice program. He became professor and head of the Department of Plant Pathology and director of the Plant Biotechnology Center at Kansas State University in the U.S. Before returning to IRRI, he was the founding director of the Generation Challenge Program, based in Mexico, of the Consultative Group on International Agricultural Research. In this capacity, he implemented a program that took a conceptual framework for understanding and applying genetic diversity to crop improvement and translated it into a functioning and vibrant program with management and governance structures and, most importantly, a comprehensive research program. He has degrees from Cornell University, Oregon State University, and the University of Illinois. He is the chairman of the board of directors of the Association of International Agricultural Research Centers until 2010. He has served as an expert resource person (quoted or broadcast) on major television networks (BBC, CNN, Bloomberg, NHK Japan, Al Jazeera, Deutsch TV, Spanish National TV, Finnish National TV, Danish National TV), on various international radio programs, and in major international print media (*The Economist*, *New York Times*, *Financial Times*, *Newsweek*, *Time*). He was awarded the Global Innovator Award by *Time* in 2007. He is a member of various American and international scientific committees and societies and is a fellow of the American Association for the Advancement of Science (AAAS). He was awarded a medal of recognition "for the cause of agricultural development in Vietnam" in 2007. He has authored and co-authored well over one hundred refereed international journal articles, reports, and scientific papers, and has delivered numerous invited lectures worldwide. Among his important publications are scientific journal articles that appeared in *Plant Disease* (2001) – Agricultural biotechnology: Reducing poverty in developing countries; in *Genetics* (1999) – Population structure and dynamics of *Magnaporthe grisea* in the Indian Himalayas; and in *Annual Review of Phytopathology* (1998) – Recombination in *Magnaporthe grisea*. He is the principal author of two major books: Rice Research and Development Policy: A First Encounter (1996) and Physiology of Stress Tolerance in Rice (1996).

For the biographies of the other Academicians of the PAS, cf. Pontificia Academia Scientiarvm, *Yearbook* (Vatican City 2008), p. 15 ff.

LIST OF PARTICIPANTS



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CEPR and World Bank
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Editor in chief of GM*O*belus
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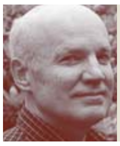
H.E. Msgr. George Nkuo
Bishop of Kumbo
(Cameroon)



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Prof. Wayne A. Parrott
The University of Georgia
(USA)

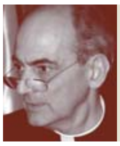
Prof. Ingo Potrykus, Chairman
Humanitarian Golden Rice Board & Network
(Switzerland)

Prof. Channapatna S. Prakash
Tuskegee University
(USA)

Prof. Dr. Matin Qaim
Georg-August-University of Göttingen
(Fed. Rep. of Germany)

Dr. S. Raghavendra Rao
Department of Biotechnology
Ministry of Science and Technology
(India)

Prof. Peter H. Raven, President
Missouri Botanical Garden
(USA)



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University of Milan
(Italy)

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Pontificia Universidad Católica de Chile,
Facultad de Ciencias Biológicas
(Chile)

Prof. Albert Weale
Nuffield Council on Bioethics
and University of Essex
(UK)

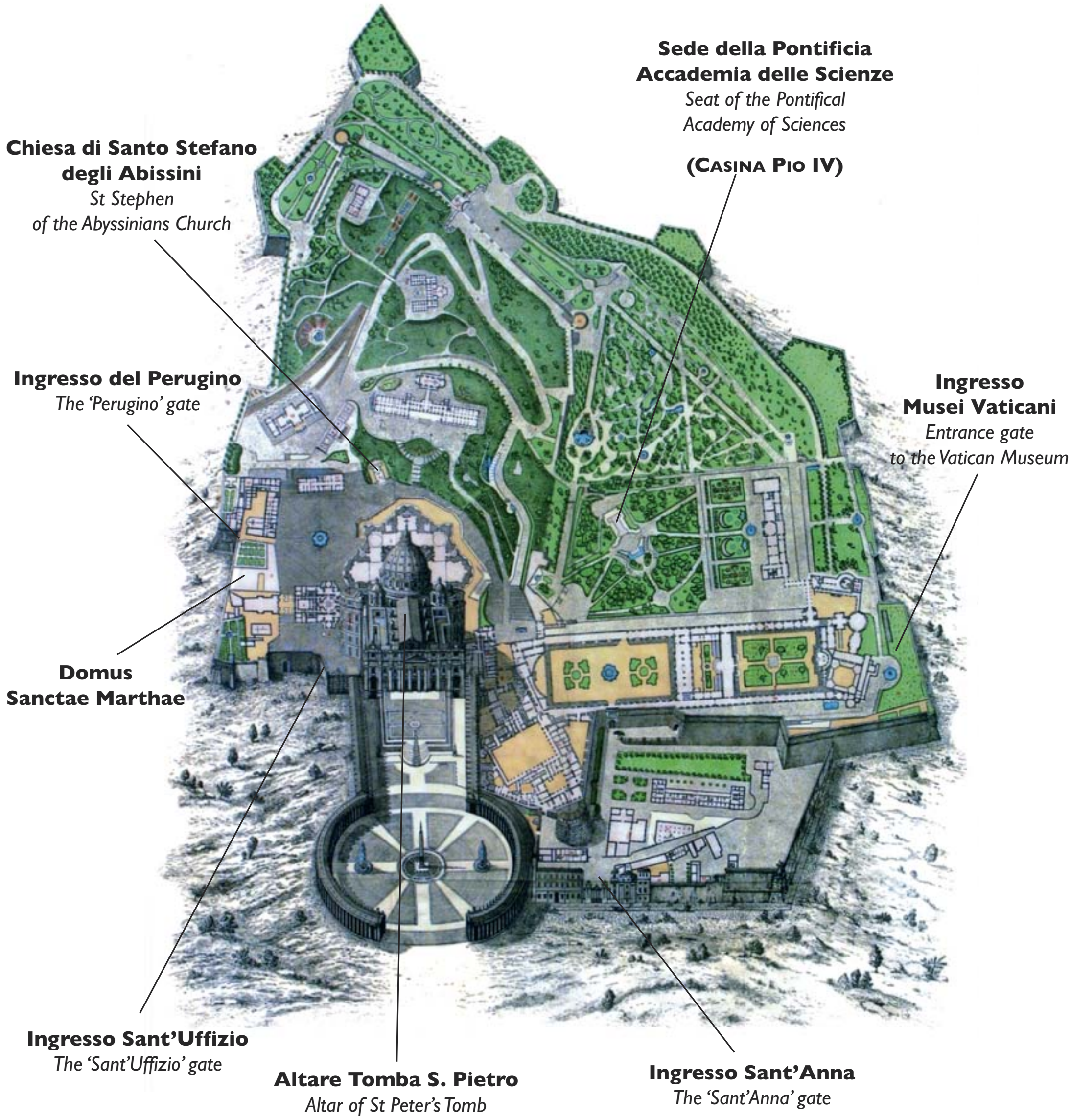
Prof. Robert Zeigler, Director General
International Rice Research Institute
(Philippines)

Memorandum

1) Every day a bus will leave the Domus Sanctae Marthae at 8:45 for the Academy fifteen minutes before the beginning of the session. A bus will depart from the Academy at the end of each session (about 21:30) to take participants back to the Domus Sanctae Marthae. From 15 to 19 May, lunch and dinner for the participants will be served at the Academy except on Sunday, 17 May, when only lunch will be served after the visit to the Musei Capitolini.

2) Every day, except Sunday, Holy Mass will be held at 7:00 at the Domus Sanctae Marthae for those who would like to attend.

Note
Please give your **form for the refunding of expenses** to the secretariat at least one day before your departure so that you can be refunded immediately.



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Transgenic Still Life,
digital painting,
Lorenzo Rumori