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TOWARDS SUSTAINABLE AGRICULTURE FOR DEVELOPING COUNTRIES:

options from life sciences
and biotechnologies



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set up the European Group on Life Sciences – which presently comprises 13 eminent life scientists – in the year 2000. Included in their mission is giving advice on how to encourage debate and public awareness about major issues in the life sciences.

In 2002, the Group recommended holding a conference addressing the contribution of life sciences, and recent developments in biotechnology, to sustainable agriculture, particularly in developing countries.

In recent years there have been major advances in life science and biotechnology research in areas such as molecular genetics and genetic engineering. This has greatly improved our understanding of living organisms and changed the way we look at sustainable developments in agriculture.

It is our task to examine how these advances might contribute to remedying the severe problems of malnutrition and poverty that exist in the developing world while, at the same time, recognising they do not represent a panacea.

To quote from Louise Fresco of the Food and Agriculture Organisation: “Biotechnology must be redirected to

address the pressing needs of the poor and the new requirements for food quality and quantity and new agricultural products, by complementing existing techniques and holistic agronomic approaches to sustain production and manage risks.”

Consequently, the conference was structured around the challenges and opportunities linked to the exploitation of new knowledge in developing world agriculture.

A further aim of the event was to give scientists a platform for entering into dialogue with society. European society needs to be aware of the international dimension of scientific progress, especially in the life sciences, and to acknowledge the worldwide implications of the choices it does or does not make.

The conference shed light on options for possible future actions and initiatives, in line with the European Strategy for the Life Sciences and Biotechnology adopted by the European Commission in 2002 (COM(2002)27).

During the discussion platform it emerged that the outlook for the future is positive. As Peter Hartman observed: “I like to think we can nourish not just empty stomachs, but hopes and dreams”.



Philippe Busquin

The Discussion Platform

Recent years have seen an awakening of concern for the environment and for the future of the planet. Food security problems seem set to worsen in the next few decades, while current methods of increasing agricultural production are unlikely to be sufficient to meet new demands. Moreover, current high-input systems are potentially damaging to the environment, causing pollution and soil erosion and resulting in negative economic effects for poor farmers who cannot afford the necessary products. We need to find new ways of increasing agricultural production without compromising the future of farmers in the developing world, and leading to sustainable agricultural systems.

The recent revolutionary developments in life sciences, and biotechnologies in particular, provide new opportunities for the development of sustainable agriculture. Transgenic technology, plant tissue culture, genome sequencing, marker-assisted breeding and protoplast fusion all have potential contributions to make. However, they may also prove controversial. Genetically modified organisms (GMOs), in particular, are considered by some groups as being undesirable, with a substantial proportion of Europeans sceptical about their use in food. The protection and exploitation of genetic diversity is also problematic. Then there are the economic issues. Will farmers be able to afford the inputs required? Will increased productivity result in market saturation and a fall in food prices? Can the biotechnology industry be persuaded to work on crops and animals widely used in the developing world, and are there prospects for a critical mass of local expertise in target regions?

The European Commission has set up a Life Sciences Discussion Platform, coordinated by the European Group on Life Sciences (EGLS), to encourage debate among all stakeholders about key issues in the life sciences. At their suggestion, a forum entitled "Towards sustainable agriculture for developing countries: options from life sciences and biotechnologies" was held in Brussels on 30-31 January 2003. The aim was to consider ways in which advances in life sciences and biotechnologies can promote sustainable agriculture in developing countries.

This conference was attended by over 600 delegates from more than 80 countries throughout the world. Participants

included scientists, farmers, politicians, non-governmental organisations (NGOs), representatives of both the biotechnology industry and environmental pressure groups, students, and journalists. Overall, about 70% of the delegates were non-scientists and many came from developing countries. The event was free and open to all, and the European Commission awarded 21 grants to individuals, particularly young people and people from developing countries, to enable them to attend. The forum was webcast live, giving access to many people who were unable to attend in person, and an internet forum was set up to allow interested individuals to contribute before the event.

Taking up the challenges

The Discussion Platform was opened on 30 January 2003 by Philippe Busquin, the European Commissioner for Research. "The idea of this conference is to get input from elsewhere, so that Europe doesn't get too obsessed with its own navel," he explained. "Genes exist: science is not for or against – let's understand first and find out what possibilities there are."

The first three presentations, from Ismail Serageldin, Florence Wambugu and Louise Fresco, set the scene. The forum then focused on seven specific challenges:

- Challenge 1:** What could life sciences do to improve the health and nutrition of the poor without compromising food safety and the environment?
- Challenge 2:** How could life sciences improve the economic viability of food production?
- Challenge 3:** How can life sciences contribute to the production of food under marginal conditions?
- Challenge 4:** How can life sciences contribute to income generation, in particular by creating new markets in developing countries?
- Challenge 5:** How can developing countries become 'actors' in the genome revolution?
- Challenge 6:** How can life sciences contribute to a reduction in the use of pesticides?
- Challenge 7:** How can life sciences provide added value from agrobiodiversity?



Each challenge was illustrated by at least one documented case study, in which a scientific expert from those countries most concerned described his or her field of work. There was an open debate for each challenge during which delegates were invited to share their experiences and views, and to criticise or offer support. A round-up of the main issues which came to light during the conference as a whole follows this introductory section.

Applying the science

The conference provided several concrete examples of ways in which modern biotechnologies are already being applied in developing countries:



- Peter Hartmann spoke about competitive exclusion, whereby non-toxic strains of fungi are produced and released to out-compete toxin-producing strains. He also spoke about the need to produce pest-resistant cowpea. This crop is highly drought-resistant and thus ideal for the sub-Saharan region, but insect pests can slash yields by up to 80%.
- The benefits of using recombinant vaccines for the eradication of rinderpest, a disease that has killed millions of cattle and wild animals in Africa and in the Indian subcontinent, were explained by Tilahun Yilma.
- In aquaculture, Toong Jin Lam provided delegates with a picture of new possibilities for the improvement of fish, a major source of protein in developing countries. Modern biotechnologies, including genetic engineering, has made it possible to produce larger fish – up to 30 times bigger in some cases!
- Soil acidity, a problem in tropical countries, results in the accumulation of heavy metal ions which are toxic to crops. Herrera-Estrella and his team are using biotechnologies to develop plants resistant to these heavy metals.
- Sequencing the genomes of important species can contribute to crop improvement. Paulo Arruda described

Brazil's sugar cane genome-sequencing programme as a basis for improving the characteristics of this crop for ethanol production for fuel.

- China has played a key role in sequencing the rice genome, and Huanming Yang illustrated just how quickly a country can establish hi-tech research facilities dedicated to issues of local importance.
- Jim Peacock discussed the introduction of transgenic pest-resistant cotton in Australia. Such crops could make a substantial contribution in developing countries by reducing pesticide use, thereby decreasing both pollution and input costs.
- Finally, Olivier Hanotte described the use of modern techniques, including genome sequencing and gene mapping, to increase the disease resistance of indigenous livestock breeds.

There was also a session dealing with policy-making. Two European Commissioners, Poul Nielson (Development) and Philippe Busquin (Research) described EU policy, then Timothy Reeves, agronomist and expert in sustainable agricultural production, Affiliate Professor at the University of Adelaide (Australia), gave a more general overview.

The forum ended with an extended open discussion, moderated by journalist Alex Puissant. During this wide-ranging debate, members of the audience were encouraged to express their opinions and concerns. Mr Puissant successfully channelled the various exchanges to create an animated discussion in which some of the public's questions were answered, and several concerns were aired.

This brochure aims to highlight some of the key issues that emerged during the two days of debate and to present some of the diverse opinions expressed by both the experts and stakeholders seeking answers to particular questions. It covers all aspects of the discussion platform, from the presentations made at the conference, through the questions posed by participants, to more informal comments made during the two days, as well as comments submitted to the internet forum.

Sustainable development: setting the scene

“**T**he beginning of civilisation depended on agriculture and so does its future.”⁽¹⁾ Ever since, humans have strived to improve their living conditions. While human population densities were low and there remained new territories to conquer, human activities had relatively little effect on the environment. Today, things are different, and development must be seen not only in the light of its potential benefits, but also in terms of its negative impact on the environment and on prospects for future generations. Sustainability, defined by the Brundtland Commission (the World Commission on Environment and Development) as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”, is now firmly on the agenda.

The shift towards this focus on sustainability can be traced back to the 18th century in Europe. Agricultural innovation increased the efficiency and productivity of food production while the Industrial Revolution provided jobs in cities for those no longer needed on the land. The resulting shift to an urban lifestyle, combined with lower mortality rates, marked the start of a new era in which human activities began to have a more profound effect on the environment. This trend has continued in Europe and has been mirrored elsewhere. The negative consequences of agricultural and industrial development were either ignored or treated as necessary evils for many years, but Malthus⁽²⁾ was one of the first to raise the alarm. He warned that as human populations increase geometrically whereas resources increase arithmetically, human development would inevitably lead to poverty, famine and death.

Changes in farming practices, mechanisation and the application of inorganic fertilisers and chemicals inevitably caused pollution. Rachel Carson drew attention to these problems in her book *Silent Spring*, published in 1962⁽³⁾, which inspired the first environmentalists to set up protest lobbies. The problem repeated itself in developing coun-

tries with the introduction in the 1960s of the ‘green revolution’. Although this successfully increased yields through the use of hybrid crops and chemical inputs, it also created a host of problems concerning economic sustainability, as the chemicals were expensive and the increased productivity resulted in market saturation.

Food for thought

As the new millennium begins, the world faces a major food security challenge. Each year the global population climbs by an estimated 80 million. This means that the world’s farmers will have to increase food production by more than 50% to feed some 2 billion more people by 2020. The challenge confronting the world today is far more intricate than simply producing more food, because global conditions are very different from those present on the eve of the green revolution. To prevent a crisis, the world community must simultaneously address issues of **poverty, food insecurity, environmental degradation, and the erosion of genetic resources.**

Relatively easy gains in food crop yields have been achieved and, in many regions, seem to have reached their ceiling. Much of the most promising land is already under cultivation, erosion is taking a growing toll, water shortages loom in many areas, and the majority of the world’s fisheries are over-exploited. Feeding the world will also depend on our ability to maintain biodiversity, mitigating and adapting to climate change, and addressing the intransigent problems of poverty and poor health which are currently so prevalent in the developing world.

There is no question that sustainability is a major concern in both the developed and developing worlds today.



(1) Future Harvest is a global initiative incorporated in June 1998 as a charitable and educational organisation to advance debate and catalyse action for a world with less poverty, a healthier human family, and a better environment.

(2) Thomas Robert Malthus (1766-1834) was a political economist whose work focused on the decline of living conditions in England, which he saw as being linked to increases in the population and the inability of increases in the resource base to match this. His “Essay on the Principle of Population”, published in 1798, is a standard reference work on this subject.

(3) “*Silent Spring*” is the landmark publication in the field of environmental pollution. The most recent edition was published in hardback in 2002 by Houghton Mifflin Co.

The United Nations Conference on the Human Environment, held in Stockholm in 1972, marked the start of concerted global efforts to deal with environmental problems and to promote sustainability. The United Nations Environment Programme was an offshoot of this conference, which also led to the formation of other environmental organisations and improvements in environmental legislation worldwide. The World Conservation Strategy, aiming to advance sustainable development through the conservation of living resources, was developed in 1980.

The final report from the Brundtland Commission, "Our Common Future", published in 1987, brought together economic and environmental dimensions of sustainability. It also recommended that the United Nations sponsor a global conference dealing comprehensively with development and economic practices and their impact on the environment.

Global attack

The resulting conference, generally referred to as the 'Earth Summit', took place in Rio de Janeiro in 1992. It brought together almost 20 000 government delegates and journalists, while an assembly of NGOs – the 'Global Forum' – was held simultaneously. This summit adopted a global plan for sustainable development, 'Agenda 21', dealing with everything from fighting poverty to the protection of human health, together with ways of protecting natural resources and strengthening the role played by particular social groups, such as women. It also generated 'Forest Principles' and 'The Rio Declaration on Environment and Development'. Two conventions – 'The United Nations Framework Convention on Climate Change' and 'The Convention on Biological Diversity' – were also set up. The implementation of Agenda 21 was reviewed five years later at a special session of the General Assembly of the United Nations (Earth Summit + 5).

A second Earth Summit was held in Johannesburg, South Africa, in September 2002. This summit had a more specific brief: to pave the way for action. Progress towards sustainable development since 1992 had proved disappointing. Environmental damage had worsened – with the world's worst polluters refusing to sign the Kyoto Protocol – and the poorest had become even poorer, with the gap between rich and poor ever widening. The Johannesburg Summit set important new targets and established new partnerships. It provided a more profound dialogue than had been seen before and, most importantly, made it clear that there is no miracle solution, with practical, sustained action the best way to deal with the most pressing problems.

Sustainability is now a principle widely accepted in the international community for both developed and developing countries, and forms an important underlying principle in European Commission policy (see COM(2002) 429 final – Communication from the Commission on fighting rural poverty – European Community policy and approach to rural development and sustainable natural resources management in developing countries). But how can the European Union help to establish sustainable agriculture, particularly in the developing world?



The potential of biotechnologies

Although often considered novel, biotechnologies have existed since the dawn of civilisation. The term “biotechnology”, first coined just after World War I, is generally defined as the use of biological processes or living organisms to solve problems or to produce products. Thousands of years ago, when farmers selected the first cereals in the ‘Fertile Crescent’ and began to domesticate and breed animals in the Middle East and China, they were engaged in biotechnologies. Similarly, fermentation – originally developed in Egypt and China – is also a form of biotechnology which now extends beyond the traditional products of wine, cheese and bread.

Biotechnologies have advanced hand-in-hand with life sciences to such an extent that many people now distinguish between ‘traditional’ and ‘modern’ biotechnologies. The rapid progress made in biological research in the 20th century has made it possible to modify living organisms and improve agricultural practices in ways that were unimaginable a mere century ago. This new domain – modern biotechnologies – comprises genetic engineering, molecular biology, tissue and cell culture techniques, and bioinformatics and has opened up entire new vistas of opportunity in the domain of sustainable agriculture. Similarly, many other practical applications, that currently we cannot anticipate, are likely to emerge in the coming decades.

Cell and tissue culture techniques have been making major contributions to the breeding of agricultural crops since the late 1970s. Unlike conventional cuttings, isolated root tips harbour no pathogens and so plants produced from cultured root tips are disease-free. Root-tip culture can also be used to produce large numbers of identical plants, a system of cloning which is now widely used in the commercial production of orchids and ornamental plants. At the moment, cost is the main limitation to its application to agriculture in general.

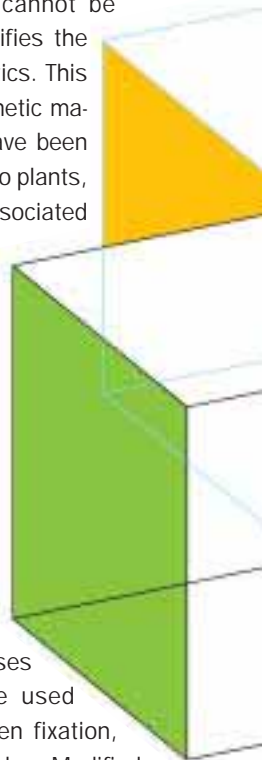
Root and branch

The development of cell-culture techniques has made it possible to produce haploid embryos from pollen, which have only half the normal number of chromosomes. Doubling the chromosome number of such embryos there-

fore results in plants in which both copies are identical for every gene. This eliminates segregation (the production in subsequent generations of plants with different characteristics because of the inheritance of different genes), reducing the time required to produce hybrids, which are produced by crossing two different plants, each of which is genetically uniform.

It is also now possible to generate plant protoplasts which are essentially plant cells lacking the cellulose cell wall. Protoplast fusion has great potential for plant breeding as it enables the crossing of species that cannot be crossed by conventional means, and simplifies the breeding of crop species with complex genetics. This technique can also be used to introduce genetic material or organelles. Leaf cell protoplasts have been used commercially for the production of potato plants, to circumvent the problems of infection associated with the use of seed tubers. Animal cell fusion techniques have also had an impact, making it possible to produce monoclonal antibodies for screening tests, rendering the diagnosis of disease more reliable.

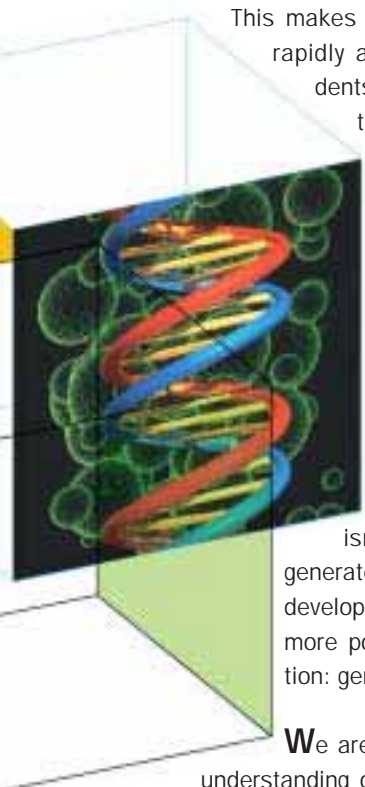
The passage of genetic engineering from science fiction to reality promises new approaches to tackling problems within the developing world. The first transgenic organism was created in 1973, following the transfer of foreign DNA into a bacterium. Transgenic bacteria have many potential uses in agriculture. For example, they can be used directly to improve the efficiency of nitrogen fixation, which is carried out by bacteria in root nodules. Modified bacteria could also be added to animal feed, as probiotics, to increase the efficiency of digestion or to boost the immune system. The genetic modification of bacteria is a key step in the production of recombinant proteins which can be used to replace live attenuated viruses in vaccines for animals, thereby reducing the risk of disease caused by the vaccine itself. Genetic modification has now been extended to plants and animals, opening up endless possibilities for the transfer of desirable genetic traits from one organism to another, speeding up breeding programmes and enabling a plethora of customised changes that were inconceivable in the past.



The way ahead

Techniques for manipulating DNA are now coming into their own. Polymerase chain reaction (PCR) is a method for amplifying tiny amounts of DNA to levels that can be detected. This technique, a mainstay of laboratory research, can now be applied in the form of screening tests. As it can pick up minute traces of fungal, bacterial or viral DNA, the methodology is particularly sensitive for the diagnosis of infectious diseases and of potentially toxic food contamination.

This makes it possible to introduce treatments rapidly and to prevent food poisoning incidents resulting from the ingestion of contaminated food.



Sequencing – once a laborious process even for single genes – can now be applied to entire genomes, providing information about similarities and differences between species and speeding up the identification of important genes. Whole genomes have been sequenced or are being sequenced for a number of agriculturally important organisms such as rice and pig. The data generated by these projects necessitated the development of new analysis techniques and more powerful methods for gene identification: genomics.

We are on the verge of a revolution in our understanding of how living things work, moving on from genomics to proteomics and glycomics. The term genomics was coined to cover the study of the entire gene complement of an organism. This philosophy has now been extended to other elements, with proteomics referring to the entire protein complement and glycomics referring to the entire polysaccharide content of organisms. This knowledge must now make the transition from the laboratory to the outside world. Biotechnologies has been making a contribution to agriculture since the invention of the plough, but what contribution can these new technologies make and, indeed, do we want them to make, towards tackling the food problems of the developing world and improving sustainability of agriculture there?



The application of biotechnologies to developing countries

Food security is the availability of food for the local population and includes production, access, affordability and nutritional quality. Many developing countries currently have food security problems, with malnutrition affecting about 800 million people worldwide and killing 40 000 people every day.

In addition to natural causes of famine such as drought, developing world farmers have to cope with man-made causes of hunger: resource mismanagement, misguided political decisions and wars, and unfavourable trade agreements. One proposed solution to world hunger is food redistribution and changes in the political and economic landscape. However, redistribution can only be a limited and short-term solution; developing countries need to be masters of their own food supply rather than surviving on handouts. Eliminating hunger is one of the most important challenges facing humanity, and can only be achieved through concerted action by national governments and the international community.

How can we apply advances in life sciences and biotechnologies to farming in developing countries, and in particular to the benefit of small farmers? The possibilities seem endless, but the main limitations appear to be workforce access to the knowledge required for the application of new technology, in particular for the use of genetically modified organisms (GMOs); the acceptance of this technology; and the fulfilment of international agreements.



*Albert Sasson and
Pere Puigdomènech*

10

Press reaction: making the headlines

The delegates to the conference included around 40 journalists, and subsequently 49 articles directly linked to the event appeared in the press around the world. More than half these articles were published in the European press, while others appeared in print in Africa, Latin America, the United States, Iran and New Zealand.

Some journalists saw the conference as an attempt by the European Commission (EC) to promote biotechnologies in developing countries. Others lamented the low number of scientists and delegates representing NGOs opposed to the use of GMOs, and focused on the difficult position that Europe now finds itself in – imposing severe regulations on GMOs while simultaneously encouraging up-to-date technology transfer in the developing world.

Nevertheless, every one of these articles, regardless of their conclusions about the value of the conference or Europe's position regarding the agenda, can only stimulate the debate and, as was pointed out by a number of the delegates – debate is essential. The EC is continuing to fund conferences in the developing world to encourage all stakeholders to participate in the debate so as to enable society to find answers to the pressing problems confronting developing countries, and to encourage the development of a science-based sustainable agriculture.

Progress that respects traditions

Modern biotechnologies have been developed in industrialised countries by scientists familiar with the farming methods and needs of such countries. The agricultural systems and conditions found in many developing countries are very different and it remains unclear as to how best to adapt modern biotechnologies to local conditions.

Many participants saw the application of modern biotechnologies as inevitable because, to quote Patrick Cunningham, "traditional methods and technologies cannot solve this problem [food security]".

One approach is to force local systems to adapt to developed country methods. "Slash and burn was the traditional technique, and was indeed a sustainable technique when population density was low," Kirsten Brandt reminded us, but "with this cultural heritage, the know-how required to manage on one small plot has not been developed. Improved management and agricultural techniques would make an enormous contribution."

"Peer pressure makes desirable practices become acceptable and used," according to Jim Peacock who also described Monsanto's efforts to ensure that farmers comply with their recommended practices. However, there was some opposition to this idea. According to Agenyo Dzagbedo, "the dismantling of current agrarian systems under the knife of a few multinationals would be a catastrophe in the countries of the South". Nonetheless, education clearly has a role to play. "I have seen people growing cotton on soils that are not suitable for growing cotton, using methods that are not fit to grow cotton," lamented Kameswara Rao. "So educating farmers in cultivation practices and the benefits of the new varieties that you are developing is very, very important."

Many felt that local practices and traditions should be taken into account when adapting biotechnologies for use in developing countries. "Africa and developing countries are full of 'white elephant' projects," explained Florence Wambugu. "Why? Because the technologies were not conducive to the cultural practices." Olivia Mbazang agreed, "The European model of agriculture is not really applicable to Africa. For example, seed can be part of the family heritage, so small farmers may not appreciate a system that

involves buying seed every year, even if it does improve yield. The farmers want something to pass on to their daughters." Nonetheless, for Florence Wambugu the seed is the most appropriate means of applying biotechnologies. "Farmers know how to handle the seed. They are professors in the seed business," she said. "Even if they cannot read and write, if you give them a seed that is resistant they will use it." However, she was in favour of a more flexible approach to seed sales. "Our farmers believe in giving each other cuttings," she pointed out. "You need technology that keeps that cultural practice of sharing. You cannot change people's culture overnight." And maybe you should not try to.

The tendency of biotechnologies to overlook the most important crops grown in Africa was raised. As Anne McLaren pointed out: "The green revolution was a success in Asia but, as it mainly addressed rice, it had little impact in Africa. Africa needs its own revolution to improve the production of African (small grain) crops." "Food is like culture," continued Florence Wambugu. "People prefer their own food." Peter Hartmann also emphasised the importance of traditional African crops, describing cassava as "the lifeblood of sub-Saharan Africa." However, Jennifer Thomson felt that too little attention was given to the work being carried out. "It's almost as if people don't realise how much work is being done on African-specific problems," she said. "There's a lot that is actually happening."



Jim Peacock

The key to success undoubtedly concerns the most suitable crops and the most pressing issues. "When we are addressing the problems of the developing world, we should not forget that we should apply technology to what the farmer wants, not what we want," affirmed Olivier Hanotte. Benedikt Haerlin criticised molecular biology saying it was "a narrow-minded approach. The scientists do not know how the plant grows in the field. Biotech does not address the right questions." Ismail Serageldin accepted there was some way to go: "If you look at adaptation to

cold, drought, salinity – all that's still in the realm of promises." In addition, as indicated by Jean-Baptiste Sene, "results in trials at experimental stations are quite different from those achieved by peasant farmers". However, observations dictated by realism can only lead to two types of response: to abstain, or to double the efforts.

Producers vs. consumers

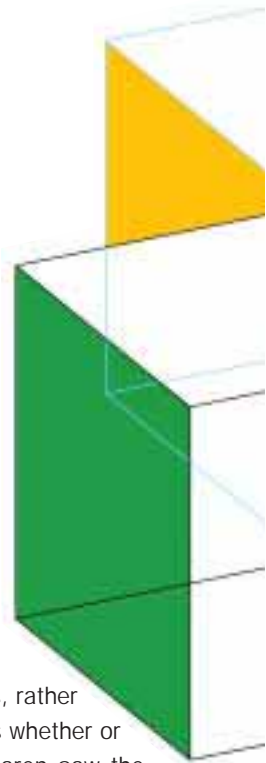
During the conference it became clear that market-based issues are likely to have a major influence in determining the fate of biotechnologies in developing countries. Superficially, developing countries, with their food security problems, might be expected to favour biotechnologies as a means of increasing production. However, if food is to be sold, either within developing countries or to developed countries, then it must be acceptable to consumers.

For Ismail Serageldin, "the debate, regretfully, has focused totally on rich consumers and their concerns rather than on what the science can actually do". This EC-sponsored discussion platform was, in part, designed to redress the balance, focusing on the potentials of biotech-

nologies for those to whom it really matters, rather than on a single contentious issue, such as whether or not GMOs provide the solution. Anne McLaren saw the urban-rural divide as a major factor here. "Townies often have little idea of the 'how' and even the 'where' of agricultural production, and have a Disney image of farming," she stated. Therefore, the producer and the consumer are isolated from one another, and find it hard to see each other's point of view. "Here in Europe, the producer and the consumer are two separate people," explained Florence Wambugu. "In developing countries, in Africa, it is the same person."

"On average, people in developing countries spend 60% of their income on buying food," continued Florence

Olivier Hanotte



Wambugu. "In Europe you spend 25%, in America, 12%." As Timothy Reeves pointed out: "If you're spending 70 or 80% of your income on food, you're going to have a different perspective on the importance of producing more and cheaper food than if you only spend 10 or 15% of your income on food." This is relevant to the implementation of biotechnologies for two reasons. First, production costs may increase – for example, if farmers have to buy transgenic seed every year, any resulting increase in prices may worsen the food security problem. Secondly, if biotechnologies do manage to increase yields, overproduction may result in a drop in prices – ideal for consumers, but a disaster for producers. Magloire Nkouannessi recalled that in the early 1980s, developing countries were encouraged to increase food production and exports. The result was overproduction and damaging competition between poor countries. "Will biotechnology not relaunch the overproduction of certain agricultural products, leading to a fall in market prices, resulting in the famous formula: produce and get poorer?" he asked. "Hunger exists because staple crops like manioc, plantain and niebe, which people prefer, are simply not developed," he added. "Countries are asked to produce what is exportable to Europe." Mamadou Cissokho agreed, "there are crops that we just eat, but don't sell – manioc, for example – where biotechnology has brought us nothing".

However, in the long term, the biodiversity of developing countries may provide them with a source of new food products and genes that could prove highly lucrative. In Olivier Hanotte's opinion: "Indigenous livestock represents a gold mine for the developing world."

Potential markets for foods produced with the aid of biotechnologies is another key issue, particularly within the current international context. Joseph Nkonga expressed concern about this. "There is a potential risk that, if planted, GM maize will affect the export of baby

corn and honey in particular, and organic foods in general, to the European Union," he said. Karla Bohuslava Bouckova summed up the situation: "It's an excellent idea if your farmers are able to produce something, but then you've got somehow to create a demand to be able to sell it." According to Jane Morris: "Developing countries should be looking beyond sustainable agriculture to develop an agriculture system and science base that can assist them to participate actively in the global economy." But Benedikt Haerlin, opposing GM food, felt "regulations in Europe [concerning the importation of GM foods from developing countries] are a very good thing, and will prevent research and export as local regulation in the developing world is less likely to be effective."

As most farmers, even in the developing world, produce at least some food destined for sale, its acceptability to the consumer is essential. This is probably the reason for the skewing of public debate towards consumer issues. The debate at the discussion platform certainly confirmed the importance of export markets for developing countries. The key question now is whether consumers, in both developing and developed countries, will accept modern biotechnologies and under which conditions. Roberto Tuberosa has his doubts. "I am totally in favour of consumer rights," he said, "the problem starts when the consumer is not rightly informed."



Florence Wambugu and Ismail Serageldin

Avoiding the pitfalls of neocolonialism

There is a large gulf between developing and developed countries in terms of the know-how, facilities and expertise required to capitalise on the potential of modern biotechnologies. This leads to an imbalance in power, made all the more uncomfortable by history. Colonisation has left a legacy of unequal partnerships which may have negative effects on the implementation of biotechnologies in the developing world.

Part of the problem lies in differences in priorities and culture between rich and poor countries. "What is talked about in the West has very little relevance to what is going on in the field, particularly in North Africa," said Fons Werrij. "Locals use the words 'quality' and 'food safety', for example, but they are just sounds, with little understanding or compliance with what they mean. The only aim at local operational field level in North Africa is to produce enough." An African participant also bemoaned a situation in which problems are frequently discussed and "solved" in the North by people who have no idea of what's going on in the field, and who have not spoken to farmers or Africans. Louise Fresco also pointed out that 85% of all transgenic crops planted were developed "to reduce input and labour costs in large-scale production systems, not to feed the developing world. There are no serious investments in any of the five most important crops in the semi-arid tropics – sorghum, pearl millet, pigeon pea, chickpea and groundnut."

Some participants expressed suspicion as to the motives behind the introduction of modern biotechnologies in developing countries. "The West is just using cheap labour, local sun, the absence of regulations and the lack of environmental protection constraints in Egypt," complained Fons Werrij. "All products of investment go straight to the West." Poul Nielsen, European Commissioner for Development, claimed that developed countries might be avoiding involvement in GMO food in poor countries as a means of manipulating markets. According to Eusebius Mukhwana: "The irony is that food and other farm products currently flow from areas of hunger and need in Africa to the North, where money and other resources are concentrated. The use of biotechnologies is most unlikely to change this unsustainable situation, where people who are dying from hunger are exporting coffee, tea or cotton."

Agbenyo Dzogbedo also expressed concern that "the introduction of GMOs would initially lead to the dependence of small farmers on the multinationals and then to the concentration of farms, to the detriment of small farmers". Florence Wambugu countered "we cannot all blame the companies for what we have not done".

This perception of exploitation extends to the realms of scientific research. "You have taken our diamonds. You have taken our gold. Now you are taking our genes!" accused Jeffrey Ambali Luhanga. "When you take our best scientists out for training, they don't come back," added Eusebius Mukhwana. "They always get poached, mostly by the North where the jobs are better and the salaries are higher." Huanming Yang expressed the egalitarian views of the Chinese government: "The human and other important genomes belong to all the people in the world, so the job should be done by all and then the achievement should be shared by all."

One of the positive legacies of colonisation is the network of strong trading links and partnerships between European countries and countries in the developing world. Several delegates expressed fears that the current European position on GMOs, together with aggressive US GMO policies, may damage historical links between Europe and developing countries. "Europe has the luxury of isolating itself in a sort of cocoon," said Roberto Tuberosa. "From a research standpoint, this will have severe consequences for the type of interactions we may have with Africa." Florence Wambugu was particularly vocal on this point: "We have lost a lot of collaboration links. Don't say we may not do in Africa what you are not doing in Europe." She feared a 50% decrease in exports to Europe and an increase in American influence in Africa. "There is global business going on in GMOs and we in Africa do not want to be left out," she asserted.

So, if modern biotechnologies are to be part of the solution to food security problems, then developed countries need to find a way to help those which are developing, without dominating or patronising them. Real communica-





tion is required to set priorities. However, the economic stakes are high. The gauntlet was laid down by Florence Wambugu in a recent interview with *BioMedNet News*: "Here is an opportunity for European life sciences companies to get involved, but the link with Europe is being lost. Africans are looking for other trading partners."

Profit or altruism?



Another issue raised by participants was the potential influence of the source of funding on the direction taken by biotechnology research. Unlike previous advances in life sciences, biotechnology research is largely funded by private companies which need to make a profit. The priorities of national governments may be very different and, unless public funding is made available, some of the most important issues for developing countries may never be tackled.

Hamid Ahmad expressed concern about the differences in the priorities of private companies and developing world populations. "The agriculture issues having priority due to poverty and hunger in the developing world are not the priority of GMO research by the corporate sector," he claimed. "Lust for money is, at present, overrunning all laws and morals." Louise Fresco was concerned about the possible negative environmental and economic effects of privately funded biotechnologies. "The perceived profit potential of GMOs has changed the direction of investment away from systems-based approaches to pest management and towards a greater reliance on monocultures," she observed.

Several delegates thought that the answer was more public funding for biotechnologies research. Andrew Dorward felt

that there were "questions about the relationships between funding and research by public agencies (with a development agenda) and by transnational corporations (with a commercial agenda)". "One of the things that concerns me about sustainable agriculture is the falling away of public investment and this is happening in both the South and the North," said Timothy Reeves.

However, private sector involvement can be successful if well directed. Tilahun Yilma stressed the importance of involving the people concerned. "True eradication [of rinderpest] happens when people who suffer from the disease themselves are responsible for their own fate and there is no commercial interest in sustaining this highly lucrative eradication programme," he asserted. "Our approach is to equip developing countries so they can deal with the disease themselves." Professor Yilma described the successful involvement of the local private sector in the development of screening tests. "Our real interest is not so much commercialisation to make money but to make the technology available to everyone in developing countries," he said. In any case, farmers do not necessarily object to paying for new technology if it increases their productivity. Themsite Buthelezi, a South African farmer, put this view succinctly in an interview with *La Libre Belgique*: "We currently have to buy new seeds every year, but at least we can make a profit with the genetically modified seeds, which isn't the case with the others."

Eradicating poverty

Timothy Reeves



Many of the developing world's problems stem from poverty. If agriculture is to be sustainable, then it must provide a decent living for farmers and affordable food for the rest of the population. Poverty is also a potential barrier to the adoption of modern biotechnologies in developing countries. The high cost of the facilities and equipment may impede local biotechnological research and, if the farmers cannot afford to pay for the products of that research, they will not be used in developing countries.

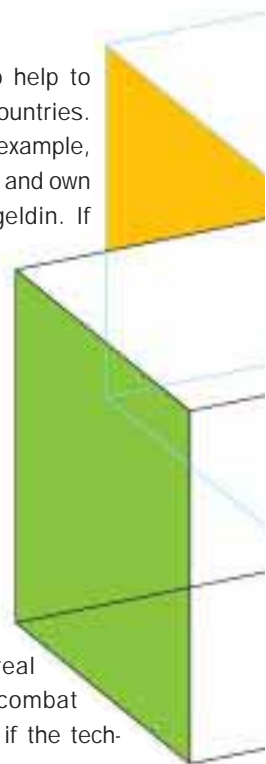
This discussion platform was designed to look at ways in which biotechnologies can be applied to the food security problems of developing countries. For Commissioner Busquin, the key question is: "How can we make the benefits of technology, genomics in particular, accessible to everyone, including starving peasants in developing countries?" However, financial gain is one of the potential benefits of this technology and so the effects of biotechnology on living standards are extremely important. "Subsistence farmers in the developing world live a miserable life and part of development is to help them improve their livelihoods," said Ismail Serageldin. "How can life sciences contribute to generating revenue is the challenge here isn't it?" asked Thierry Kesteloot. "So surely the question is how much you sell your fish for once you've caught it. What is the real impact going to be on the income of the farmers at the end of the day?"

There is great hope that biotechnologies will offer a wide range of alternatives, particularly where agriculture strives in environments subject to particular stresses, such as aridity or high concentrations of heavy metals in the soil. However, the key question for farmers is whether biotechnologies can also increase their standard of living. "Even if peasant farmers increase their productivity, if they can't sell their crop at a price that will enable them to feed themselves, develop and reinvest, then new technologies will serve little or no purpose," explained Jean-Baptiste Sene. "It's extremely important for food prices to come down for the urban poor," asserted Ismail Serageldin. "That raises the dilemma of how do you raise the income of farmers who produce food – it is a question of increasing productivity faster than prices come down."

Other aspects of the food supply chain also require consideration. "Improvement of yield alone cannot improve the lives of the poor in rural Africa as storage, transportation, marketing, distribution and ability to purchase the food remain nagging problems," according to Eusebius Mukhwana. "Much of the best land and resources are committed to producing cash crops for export, leaving production of staple foods to poor and marginal areas." Poul Nielsen, Commissioner for Development, also expressed concern on this point. "Part of the problem is the absence of normal market flows from country to country," he said. "It is dangerous to be poor."

The benefits of biotechnologies may also help to improve social conditions in developing countries. "Women farmers, especially in Africa, for example, produce 80% of the food, earn 10% of wages and own less than 1% of land," said Ismail Serageldin. If biotechnologies can increase the profitability of farming it should increase the financial power of women farmers, one of the special groups identified in Agenda 21. "Improving farming would improve the conditions of women in Africa," agreed Olivia Mbazang. But Marek Poznanski advised caution. "We have to maintain the social structure," he said. "Although currently unsatisfactory with poverty on farms, it would be no advance to improve agricultural productivity by creating 50% unemployment, where the unemployed starve." For Yves Savidan, there is no real choice. "Objective number one is to combat poverty," he said. "This won't be possible if the techniques are not available in poor countries."

Unfortunately, although biotechnologies might help to solve poverty, poverty is also a barrier to the introduction of biotechnologies in the developing world. In the opinion of John Gibson, "the establishment and particularly the long-term sustaining of such facilities will remain beyond the reach of many of the world's poorest countries for many years to come".



Proud to be partners

The nature of the partnership between developed and developing countries in the application of biotechnologies is important. Most of the technologies, knowledge and facilities required for biotechnology research are currently in the hands of developed countries.

"There is a molecular divide between the rich and the poor," as Louise Fresco put it. As with food itself, we have the option of either helping developing countries to help themselves or of providing them with a ready-made 'solution'. As Maria-Helena Goldmann asked: "Should we help these countries to develop new technologies themselves to be applied to their own plant varieties and their own particular needs in their own countries, or should we develop the technology and just provide it ready to use?" Is it better or even feasible to treat developing countries as partners rather than the recipients of assistance?

There was broad agreement that partnership was the best way forward. "Scientific collaboration between the North and South has been encouraged by the European Union since its foundation," pointed out David Taylor. "Biotechnology is one of the most important areas for European and Chinese agricultural scientists to work together," emphasised Yi Zhang. The European Union is also co-operating with the developing world by encouraging their agricultural exports. "The European budget for supporting EC export is being slashed", said Patrick Cunningham, "and 97% of agricultural imports from poor countries are free of tariffs or quotas." According to Olivia Mbazang, the European Union's efforts to encourage debate are also a useful means of helping developing countries. "REDA (Rural Empowerment and Development Association, Cameroon) strongly believes that participation in important conferences such as yours, that involve one of its main activities, will improve its skills and allow it to acquire more knowledge to impart to its rural community."

Despite broad agreement that there should be partnership, the issues of who the partners should be and who should take the final decisions were not resolved. "Who do we talk to in the South?" asked Marek Poznanski. "Who is representing the views of the poor peasant?" Florence Wambugu was also concerned about the nature of potential private-sector partners. "It is so important that in Africa we support our local private sector so that we are not dominated by international multinationals," she affirmed. Timothy Reeves stated: "My colleagues in the South have been telling me that they don't want to have something foisted upon them, either from private industry on the one hand, or from another government on the other hand. They want to make their own decisions." For Florence Wambugu, it's not simply a question of involving the right partners. "They have to take genes from the local varieties, work with the local scientists, back-cross genes into the local varieties," she insisted. "That makes the developing countries become partners, become stakeholders, and not just victims."

Intellectual property rights, which make biotechnological products expensive to use, may also prevent the use of biotechnologies in developing countries. Louise Fresco cited "the case of 'golden rice', in which around 70 different patented steps were called on for payment at the time of release" as a "clear example of barriers to access". However, it was agreed that the product could be used without charges for farmers with incomes under \$10 000 per annum.

"Give a person a fish and you give him a meal for a day. Teach him how to fish and he has food for life." This popular Chinese proverb was frequently quoted at the discussion platform.



Louise Fresco

Production, not pollution

Previous efforts to improve productivity in the developing world have had only limited success. The green revolution, for example, increased rice yields considerably in Asia, but the high levels of chemical inputs used caused pollution and had a negative impact on local wildlife. Understandably, today's peasant farmers are concerned that biotechnologies may increase their yields in the short term only to damage their livelihood in the long term because of negative environmental effects.

The use of crops able to produce bacterial insecticidal (or Bt) proteins caused particular concern. "Turning the plant into the pesticide is not the solution," asserted Benedikt Haerlin. "The culture of insecticidal maize constitutes a threat to all insects," said Agbenyo Dzogbedo. One participant was worried that the form of the protein used might be toxic to animals other than insects. However, the Bt proteins have been applied directly to crops for years and, as Jim Peacock pointed out, "genes cannot be overdosed. The technology stops the farmers reading the label then adding a little bit more." This, plus the fact that the pesticide is actually in the plant, should reduce pollution incidents. Florence Wambugu asserted: "There is absolute demonstrated evidence that Bt technology used in integrated pest management has reduced the use of pesticides to a very large extent."

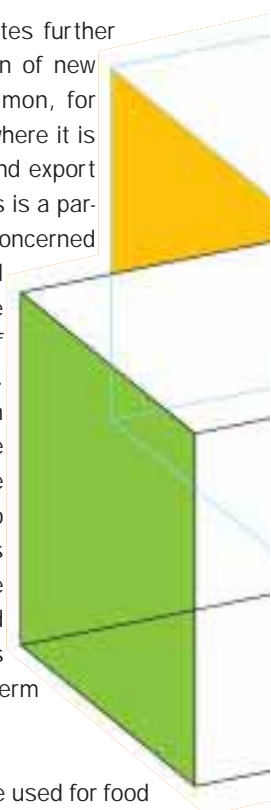
Herbicide-resistant plants, associated with the use of herbicides, also account for a significant proportion of the transgenic crops currently being grown. Julian Smith explained the problem: "The weeds grow, but are killed before they can seed," he said. "Birds nest, but the nests are destroyed. No seed is produced as wild animal food and so there is less biodiversity. This can even be used as an approach to pest control (reducing pest numbers) rather than as a way to increase the yield of the crop."

The possible effects of biotechnological developments on the substantial biodiversity in developing countries raised concerns. "The enormous wealth of the countries of the South in biodiversity would be threatened by the introduction of GMOs into agricultural systems," complained Agbenyo Dzogbedo. "Gene flow has been occurring for a long time from commercial varieties to the land races but that doesn't mean that the land races disappear,"

asserted Luis Herrera-Estrella. "When people talk about land races that have been kept for thousands of years, they have been phenotypically kept for thousands of years but genetically they have been changing – in fact, they are probably not the same as they were 20 years ago." Florence Wambugu expressed different priorities. "Having biodiversity is not going to help you if you cannot use science and technology to harness it," she said. "Poverty is the worst polluter. Poverty is the worst destroyer of biological diversity, not GMOs!"

The mobility of certain food animals creates further problems when controlling the introduction of new species and transgenic animals. The salmon, for example, has been introduced into Chile, where it is now an important source of both protein and export revenue. "The introduction of exotic species is a paradox in terms of conservation and we are concerned that the salmon may be affecting local species," said Gonzalo Gajardo. Siglinde Fischer described the observed effects of salmon introductions in North America. "Each year, tens of thousands of salmon escape from net pens," she said. "There are already Atlantic salmon in the rivers on the Pacific side and vice versa, and they also seem to mate with the natural species there." Toong Jin Lam admitted that there was a potential problem but said "it's good that we start thinking about such problems and it's good that we start conserving fish germ plasm from local species, just in case".

Modifications to the content of plants to be used for food also raised concern. For example, Luis Herrera-Estrella described his work in creating transgenic crop plants able to sequester heavy metals and therefore to grow on soils containing these metals. "You're surely not going to think about having high-manganese plants as either food or feed unless you have shown that high-manganese plants are safe!" retorted Julian Kinderlerer. "It's not purely the plant that we have to think about but the secondary impact of what you have done on that which will feed on what you have produced," he continued. "There are plants that have very high aluminium and manganese content. The tea plant, for instance, is full of aluminium," replied Luis



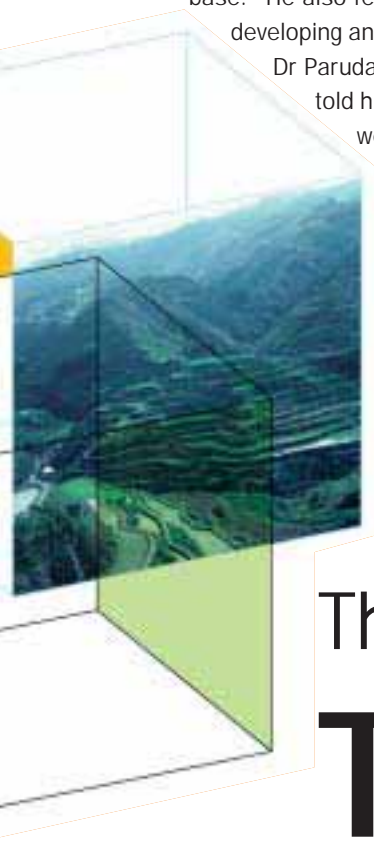
Herrera-Estrella. "We have been drinking tea for centuries and nobody has died!"

Timothy Reeves took a more negative view of the current situation and a more positive view of the potential of biotechnologies. "We just cannot go on damaging our natural resource base the way we have been doing," he affirmed. "It's not a case of preservation or conservation. In many cases we have to look at improving the resource base." He also felt that priorities were different for developing and developed countries and quoted Dr Paruda, a scientist he met in India, who told him "first, we feed our people, then we think about sustainability".

Mamadou Cissokho observed that caution was the best policy. "The precautionary principle must be respected,"⁽⁴⁾ he insisted.

"Twenty-five or 30 years ago, when animal feeds were being promoted in Europe, we were told that this was going to increase the quantity of milk 20 or 30 times, and it did. But no one had foreseen that farmers would disappear because of BSE." Ana Brasileiro disagreed. "Farmers in the south of Brazil are simply importing seed illegally from Argentina," she claimed. "Too much of the old 'precautionary principle' can sometimes lead you astray, and now you've got the worst possible consequences – totally wild transgenic plants being used in Brazil with no control whatsoever."

Rigorous monitoring is required to ensure that negative effects on the environment do not counter the benefits of biotechnologies. However, the debate pinpointed a current weakness – we worry far more about the effects of new technologies than about those of more traditional techniques. Perhaps we should be monitoring the potential environmental effects of all agricultural practices and techniques more thoroughly?



The geography behind research

Today, most biotechnological research is carried out in developed countries, and focuses on developed world priorities. Many participants stressed the importance of developing biotechnological research in developing countries to ensure that the work carried out is relevant to local needs.

"As long as the centres of bioscience expertise and capacity remain in the developed world, the vast majority of applications will understandably be focused on developed world issues," asserted John Gibson. "In Europe, yield is not really an issue; in Africa it is," said Julian Smith. "Placing the technology in context is therefore very important." "We need to avoid the kind of scientific apartheid that might otherwise emerge," affirmed Ismail Serageldin.

The development of biotechnologies in developing countries would also have other benefits. "Research carried out locally, in Africa, is sociologically valuable as it demonstrates that research and high-tech activities are possible in these areas," said Anne McLaren. "It also encourages these career choices and enhances national self-image." According to Jane Morris, "it is essential that technology platforms be built up in developing countries so that they can fully participate in the life sciences opportunities, and be positive contributors rather than reluctant users of technology".

However, there are problems with this approach. "The ability of these networks to take advantage of rapid and dramatic developments in biotechnologies is becoming increasingly constrained by the lack of appropriate

(4) The term "precautionary principle" means that in cases where scientific uncertainty exists but a preliminary scientific evaluation gives reasonable grounds for concern about potential adverse effects on the environment or health, even if the risk is not proved, action to avert it should be considered. (Article 174 (ex Article 130r) of the EC Treaty - see <http://europa.eu.int/eur-lex/en/treaties/dat/amsterdam.html>)

facilities in the South," warned David Taylor. "The cost will be high both for establishment and maintenance." According to Ismail Serageldin, other aspects within the developing countries themselves are also critically important. "Redressing the urban bias in policy and investment is an important part, without which the best science, the best packages, and the best approaches will not actually be feasible," he explained.

Another problem is that of scale and expense. Following Huangming Yang's presentation describing China's contribution to genome sequencing, Jorge Huete-Perez, from Nicaragua, expressed the view that such technology was not really accessible to small countries with fewer

resources. "Small countries would have to be allowed to participate in consortia, perhaps, to use these advances," he suggested.

Commissioner Philippe Busquin said: "We can involve the scientists themselves in our projects, and we can pay for them in their countries if that's what the science requires." Provision has been made in the Sixth Framework Programme for just such an approach (to find out more, visit Research DG website at http://europa.eu.int/comm/research/fp6/index_en.html).

More on genetically modified organisms

Modern biotechnologies comprise many elements, including tissue culture, protoplast fusion, marker-assisted breeding, genomics and bioinformatics. However, the debate in Europe has tended to focus on one single aspect: GMOs. As Commissioner Poul Nielson observed: "The public debate has often been narrowly restricted to GMOs which has hampered full recognition of the broad potentials of biotechnologies."

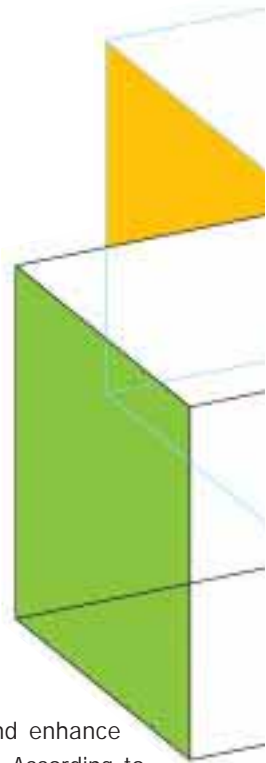
Participants felt that the importance of GMOs had been overestimated. "Perhaps the greatest potential of biotechnologies does not come from GMOs but from genetic markers, genomics and proteomics which can comple-

Huanming Yang



ment conventional breeding strategies and enhance their efficiency," suggested Louise Fresco. According to Timothy Reeves, "the greatest breakthroughs today that have had beneficial impacts in the developing world would actually be from tissue culture and cloning".

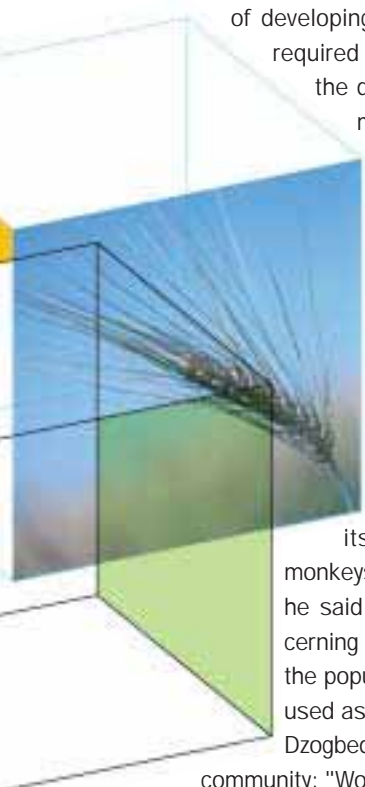
The GMO debate is far from resolved and is clearly the most contentious area of biotechnologies for the European public at the moment. The impact that GMOs will have on the food problem of the developing world is likely to depend on public attitudes and their acceptance. Regulations concerning GMOs are currently not coherent, and the next few years will be crucial in determining whether GMOs are to play a substantial part in the next



phase of the green revolution, with Europe or without it.

This discussion platform aimed to address biotechnologies in its broadest sense, but GMOs inevitably figured among the participants' greatest concerns.

Perspectives concerning the potential use of GMOs differ according to context. "In the West, the debate is about GMOs – food safety and sufficiency can be taken for granted," said Patrick Cunningham. "This is not true of developing countries: new technologies are required for food safety and sufficiency in the developing world. The GMO debate must not be allowed to overshadow this point," he added.



"GMOs should not be released. Will they be a disaster waiting to happen, like the 'unpredictable' BSE?" asked Benedikt Haerlin. Steve McGiffen expressed equally negative views. "When I read about the determination to take this science out of the laboratory and into the field at this stage of its development I am reminded of monkeys playing with boxes of matches," he said. "Given [these] uncertainties concerning the relative effects on health, will the populations of the South once again be used as guinea pigs?" questioned Agbenyo Dzogbedo. Jan Storms asked the scientific community: "Would you not be able, with your knowledge, single-handedly, to eradicate the world food problem not by genetically engineering thousands of different species, but just by engineering the human species – producing very small humans who require very little food. That would not be any crazier than what you are doing now, although just as smart maybe!"

In contrast, Yvonne Umurerwa expressed qualified support. "GMOs reducing the use of pesticides to feed a larger number of people in developing countries is a necessary evil," she said. "There are big values that outweigh small ones and scientists should first agree to save lives." Themsite Buthelezi, a South African farmer, was more pos-

itive. "Since I started planting the BT cotton, my life has changed," he enthused. "I've seen the benefits, a lot of them." In Jim Peacock's opinion, "it would be a sin, a crime, to waste this technology".

This issue divides not just countries, but populations within countries. "There is controversy only in urban areas, and particularly in intellectual circles. It is not really a concern of the whole population, at least not the rural population which is concerned with producing more food," explained Luis Herrera-Estrella. "One potential solution is that we provide products that give a direct benefit to the rich consumers in big cities because if they don't see the benefits they don't give a damn about the farmers," he concluded.

There was also some debate about the efficacy of GMOs. "No one knows for certain as yet whether gene technology can make a positive contribution to sustainable development," pointed out Joseph Nkonga. "Genetically modified seeds still have the same requirements: water, the nutrients in the soil, good climatic and environmental conditions in particular, and the space necessary for their growth and productivity," explained Saidi Asenge. "When applied to the realities of developing countries, the production of agricultural GMOs cannot give the same yields as in Europe due to different contexts." Jennifer Thompson gave one concrete example of success. "White maize is the preferred kind of maize for Africans to cook for food," she recounted. "White maize is slightly grey in Africa [due to fungal contamination]. Now, Bt maize is called 'whiter than white'."

However, the main GMO-related issue raised at the discussion platform was regulation and control. "The accumulating evidence about GMOs is reassuring," asserted Patrick Cunningham. "The control of food supply by multinationals is an economic not a scientific issue." "There's a lot to be done in terms of regulatory and investment work before we try to spread these products to other countries," said Gilles-Eric Seralini. "There is a problem of control in many developing countries," explained Donald Bruce, "not necessarily due to inefficiency, but more to lack of resources."

Existing regulations, in countries that have them, are often extreme or have unexpected consequences. "The

controversy on genetically modified plants has got so out of hand that the Mexican Congress recently passed a new law. Since January last year, we [scientists working on genetic modification] have become criminals," complained Luis Herrera-Estrella. Under Mexican legislation, GMO release carries a sentence of up to nine years in prison. Derek Burke pointed out an irony in Mexican regulations. "It struck me as so ironic that you have two cultivars, both of which release excess citrate, one of which is 'natural' and one of which is genetically modified," he said. "They both have the same phenotype and they're similar in their effects in the field – one is impossible and one is normal and that's because of the fears that people have about genetic modification."

Equally illogical situations can also arise in countries with less strict rules. "Because of the problems of regulation, the genetically engineered tomato, which was actually cleared in the UK, is no longer acceptable to consumers,"



Luis Herrera-Estrella

explained Derek Burke. "But the plant breeders now know exactly what gene to modify by conventional techniques and are monitoring a conventional breeding programme using gene probes to follow the development. I think that this is a wasteful way of doing it, but they are going to do by conventional breeding what has already been done by GM." Furthermore, as David Bruce stated: "It may be impossible to know whether seed on the market is GMO or not."

Another potential barrier to the use of GMOs is the widespread view in Europe that such organisms are a special case. "It has been argued that GM is particularly unsafe, that there is something unusually unsafe about GM," said David McConnell. "I would like to argue in very simple terms that any new crop developed by any method in plant breeding has the same potential to be 'unsafe' as anything that is created by GM." Another participant agreed that concern seems to be focused on transgenic technology, whereas foods produced by other means may be just as potentially dangerous. "Why do we only check and monitor transgenics?" he asked. "Why don't we guarantee the quality of all products in the same sort of way?"

Information and disinformation

Modern biotechnologies, and the use of GMOs in particular, has provoked very strong reactions amongst Europe's population. The possible benefits and risks of this technology for developed economies remain unclear, and myths and exaggerations are rife. So, just how are developing countries supposed to react when faced with the diametrically opposed attitudes of the US and Europe and the conflicting information coming from seed companies, the press and other sources?

Philippe Busquin said of the conference that it was "not a debate about manipulating living things, but about understanding". For the Research Commissioner, "all scientific progress raises concerns", and the best way of diffusing scientific expertise to countries outside Europe is to "explain to the public and this may provide a pressure to drive politicians".

"How can we improve public perception on the use of new technologies," enquired Maria-Helena Goldman. "It is not

enough to develop the technology – it will be necessary to convince people it is safe, otherwise the technology will have no use." This is a particular problem in the developing world, and Richard Baguma expressed doubts about whether the developing world media "itself inadequately equipped with information" could "effectively serve the relatively ill-informed farming communities", particularly given the deep divisions evident in the scientific and political communities.

Information is essential if biotechnology, like any other innovative field, is to fulfil its potential in the developing world. As Florence Wambugu pointed out, "small farmers are the most difficult to convince. They know their priorities. They do not accept anything until they see the evidence that something is better than what they have." The chief problem seems to be the reliability of the information provided. "Although the structures exist in my country to diffuse information to farmers, the information has to be fed in at the top," said Olivia Mbazang, "and what is the true real information?" She expressed concern that disinformation is being spread in Africa from developed countries as she has found that many farmers in Cameroon believe GMOs to be dangerous, despite having no evidence.

Olivia Mbazang is not alone in her fears. Andrew Ward described the collapse of a project to develop GM potatoes in Bolivia. "False information about toxicity (that, if eaten, the potatoes would cause infertility or deformed children) was promulgated by opponents of GMOs, such that farmers wouldn't use them," he claimed. "Stories have been going around that if GM potatoes were available on the market then pregnant women would miscarry," confirmed Javier Franco. Such views have even been expressed at government levels, with the President of Zambia last year banning the importation of GM food, qualifying it as "poison" – an act which, according to Joseph Nkonga, resulted in food relief agencies having to find

alternative food sources for about 2.9 million people and consequently cut rations. Fons Werrij felt that the problem was more general. "Biotechnology is a dirty word for cultural and religious regions in parts of North Africa," he affirmed.

How can we make the voice of science and reason be heard above the clamour of rumour and fear, with regard to introducing new foods which may have been modified?" asked Jorge Huete-Perez. According to Florence Wambugu "money is needed to diffuse a lot of the misinformation and arguments". She refuted the argument that GM food is potentially toxic: "There is no way Americans would be eating food that is toxic and poisonous!"

A source of politically neutral, factually correct information is essential if developing countries are to take sensible decisions concerning the possible use of biotechnologies. As Gilles-Eric Seralini put it, "it would be irrational to think that technologies as powerful as transgenesis present no advantage or, inversely, no risk". Clear information on the possible risks and benefits of these technologies is essential but who will provide it? Anti-GMO pressure groups and multinational companies have been accused of distorting information to their own ends. There seemed to be general agreement among the participants that more input from scientists and politicians is required. "Is this the way for politicians to lead the masses?" challenged Florence Wambugu in an interview with BioMedNet News, "NGOs are running the show!"

The European Food Safety Authority was set up in 2002 in an attempt to improve the exchange of information on all matters having a direct or indirect impact on food safety. It will provide independent scientific advice on all stages of food production, gather information on a global scale, and communicate directly with the general public in its areas of responsibility.



Worlds apart?

Faced with significant differences of opinion between participants from the developed and developing countries, the question arose as to whether or not consensus was possible over the application of modern biotechnologies.

"The thing is that here we are having a discussion from very different perspectives," argued Emilia Müller, Member of the European Parliament. "We have developing countries which have some pretty basic problems of hunger to solve, and then we have Europe – people arguing from a comfortable European position with surpluses." But Hong Enping pointed out: "The discussion often seems to address two sides: Europe with enough food and ideals versus Africa that only wants more food and doesn't want to consider other issues. This is too simplistic, especially for the many countries at intermediate stages of development." A Bolivian participant agreed. "Every developing country has different problems and is in a different situation," she said. "We can't all be managed as if we all have the same problems, the same features." Faced with these differences of opinion and of context, is it really possible to develop a coherent strategy concerning the application of biotechnologies in developing countries? According to Derek Burke, "The stem cells conference convinced the Commission that a one-size-fits-all approach to these issues will not work. It has consequently extended the application of subsidiarity."

Communication and discussion are clearly essential. "The EGLS commends those who challenge technologies, and believe that this is an essential part of the proving process," stressed Patrick Cunningham. "Dialogue is absolutely important and cannot be replaced by anything else," affirmed Florence Wambugu. However, as Joseph Nkonga put it, "facing famine and drought, the debate which has just heated up is not going to be an easy one".



Toong Jin Lam

The debate extends to all sections of the community and there are differences of opinion within different groups of stakeholders. "Scientists have divergences, and debate among themselves," said Patrick Cunningham. "Biotechnology, largely because it is often reduced to GMOs, provokes profound public mistrust across continents," observed Louise Fresco. "Governments, consumers, farmers and, to a lesser extent, scientists disagree fundamentally on its benefits and risks." In the face of such differences, research is essential. "People who stop the studies are not going to help us find the answers," said Ismail Serageldin.

One of the key difficulties is weighing scientific 'fact' against more nebulous quantities such as emotions and beliefs. "Sometimes emotions are not backed up by facts," said Toong Jin Lam. "You must not make a distinction between science and emotion unless you are simply saying that all feelings, all values, are just purely irrational," asserted Donald Bruce. As a former regulator in the nuclear industry, he had found that trust and belief outweigh scientific data. "If you don't trust me it's irrelevant what science says," he affirmed. "There is a greater need on the part of science to actually have a dialogue and listen to people's values." Ismail Serageldin believes "there is a scientific judgement. Beyond that, what society does with that judgement is, of course, another set of issues."

Debate and differences also extend to the level of policy-making. "There is a huge gap between what the public thinks and what the government follows," complained Minakshi Bhardwaj. "Unfortunately, I think that one of the lessons has been that we haven't looked enough at the breadth of modern biotechnologies and life sciences when we've thought about the policies and when we've thought about our actions in terms of research," related Timothy Reeves. Pere Puigdomènech felt that European policy-makers had concentrated their efforts on minor issues. "In Europe, we're spending a lot of time and money on labelling questions, on co-existence questions – on the less important issues, to a certain extent," he argued. "Our problems are philosophical, whereas there are real problems elsewhere."

The clear message from the conference is that debate is essential at all levels if we are to develop appropriate policies for the beneficial use of biotechnologies. It is vital to include all stakeholders in that debate, which must refer to actual problems rather than philosophical issues.



Peter Hartmann

Alternative solutions



B iotechnologies may be able to provide smart responses to a variety of local threats and handicaps at the root of food security problems in the developing world. However, there is considerable opposition to its use, particularly among people living in developed countries. The current situation is not sustainable and, whether biotechnologies play a major or a minor role, change will have to come.

"We have pushed the traditional systems to the limit," said Peter Hartmann. Saidi Asenge felt that the use of biotechnologies was inevitable if we are to feed a population set to double by 2050. "But, above all, we will have to exhaust all the traditional means that science has made available to us," he stressed. "Biotechnology and life sciences are not a panacea for all ills," pointed out Timothy Reeves. "They are tools, contributors, and have to be integrated with other technologies."

Some of the delegates challenged the notion that biotechnologies could help to solve the developing world's food problems simply by increasing productivity. "We must avoid the approach that says 'we have the solution here, now what is the problem we can apply it to', but should deal instead with the problem of how to help the Third World poor," said

Benedikt Haerlin. "If we look at what is really needed, biotech currently has nothing to offer." According to Eusebius Mukhwana, "much of the hunger and the poverty that we have in our world is caused by an unfair and an exploitative system of international trade and resource control, so that improving yield alone will not really improve the lives of poor people in Africa". "While biotechnology could play a role in improving this situation, there is a need to change the structures that keep many poor and hungry in this part of the world," assented Eusebius Mukhwana. For Karla Bohuslava Bouckova, "sometimes there might be more simple and more safe solutions".

Tom Barrett felt that, as far as rinderpest vaccination was concerned, the issue was not how the vaccine was produced. "We don't really need a new vaccine. The vaccine we have will do the job," he asserted. "What we need is a means of sustaining the laboratories in Africa after the donor funds leave." Olivier Hanotte felt that it was better to conserve indigenous livestock breeds by using them in the field rather than by conserving their genes. "I think this is the most stable way to ensure conservation," he said.

Diversification is another possible solution. "Farmers are naturally trying to reduce risks by diversification," recounted Timothy Reeves, "but the reality is that people are pushed into systems that are not the optimum because of the necessities of producing food." "There

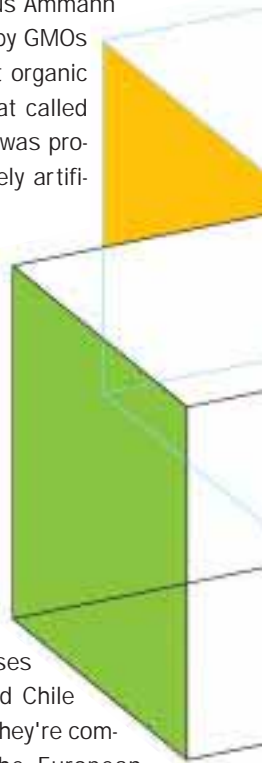
may be many other species that may be useful," said Marc van Montagu. "By concentrating on the few species of plant and animal currently exploited by agriculture we may be ignoring other resources. However, thousands of years of development with a familiar species is a great advantage." The unequal distribution of food has often been blamed for food security problems. Certain organisations have proposed the redistribution of food as a possible solution, but Timothy Reeves dismissed this view. "Actually, just redistributing food better around the world may help the food problem but would probably exacerbate the poverty and livelihood issues of making a living from agriculture," he argued.

Many of the opponents of biotechnologies, particularly of GMOs, regard organic farming as the logical alternative. However, organic farming alone is unlikely to be able to produce enough food for the expanding population. "The productivity of organic farming is very close to that of conventional farming," said Kirsten Brandt. "African farmers are the quintessential organic farmers because they simply cannot afford fertilisers and other inputs," pointed out Jennifer Thompson. "One of the problems is that we're simply not growing enough organic material on our farms to plough back some of the goodness into the soil so that we can build it up for the next growing season." "Organic farming has failed African farmers," claimed one Kenyan delegate. "This is what they have practised for centuries." Dominique Cabuy refuted this negative view. "I just can't accept that, put so boldly. What Africans eat today is organically farmed, largely," he insisted. "I think the real problem in Africa is famine, apart from poverty of course. Whether it's organic or transgenic, you've got to have the money to buy your tubers of whatever it is you eat. The fundamental problem is poverty."

"How can the poor afford to buy organic, which is maybe five to ten times more expensive?" asked Farida Shah. "Organic cannot feed the poor." Benedikt Haerlin responded: "One of the reasons organic is comparatively more expensive in Europe," he argued, "is that it is more labour-intensive, while another is simply that it is on a smaller scale and so most of the additional costs do not stem from the production but from distribution." However, given the widely recognised distribution problems in much of the developing world, such costs are likely to be high there too, maintaining organic food prices at high levels.

Organic farming and the application of biotechnologies to agriculture are seen by many as incompatible. "Not only the European standards for organic farming, but also the United States standards for organic farming and even the codex alimentarius standards for organic farming all categorically exclude the use of GMOs. So, a decision has to be made about which side you want to go on," said Benedikt Haerlin. The chief problem is that transgenes may pass from GM crops to other crops in the area by cross-pollination. "The difficulty is to have a system that doesn't allow the GMO form of agriculture to contaminate the others," observed Lorenzo Consoli. Klaus Ammann found the insistence on non-contamination by GMOs bizarre. "How on earth can you explain that organic farmers all over the world are using a wheat called *Triticum durum* for producing spaghetti that was produced by radiation mutation and is absolutely artificial?" he demanded.

The general view seemed to be that we must find a way to combine different types of agriculture. According to Timothy Reeves, "what we should be looking at is not one thing or the other, because none of this is the magic bullet. What we should be looking at is what combinations of interventions we can make to actually lift the yield." "There are many forms of farming, including organic farming, which have a market, and there's intensive farming, which we want to bring back to reason, and there's farming that uses GMOs," said Albert Sasson. "Argentina and Chile have all of them. There's no contradiction – they're complementary." Emilia Müller stated, "In the European Parliament, we think that we must promote both conventional and biotechnologically assisted agriculture," she explained. "I don't think that organic agriculture alone can feed the world. You need biotechnology and you will do increasingly in the future." Timothy Reeves felt that arguments about what type of agriculture we should adopt were pointless. "A new variety – doesn't matter whether it's a GM variety or a conventional variety – but an improved variety with better drought tolerance, better tolerance of low soil fertility, etc., might be able to bridge 30% of the gap. The other 70% of that gap has to come from improved management practices," he claimed. "To




have a debate about whether it should be one or the other makes little sense to me."

Perhaps Gilles-Eric Seralini summed up this view when he said: "I don't think we'll ever solve the problem of poverty or hunger by having a good variety with one or several genes modified. We have to work on an ecosystem. We need an integrated approach. We have to manage water. We have to look at the education of farmers. There are lots of responses and biotechnology is only a small part of the jigsaw."



Paulo Arruda

Which way now?



What can we expect from biotechnology and how can we move towards sustainable agriculture? Or, as Jorge Huete-Perez asked: "How can we benefit from technological advances in the promotion of our sustainable agricultural development with the consent and co-operation of all parties on both sides of the biotechnology debate?"

"Physics was the science of the 20th century. Life sciences will be that of the 21st century," Philippe Busquin predicted. "Thirty years ago, no one could have foreseen how micro-electronics would change our lives and how it would be taken for granted," recalled Patrick Cunningham. "Biotech will be the same: predicting exactly how is not possible." Commissioner Busquin added, "whatever we identify here as being what science can provide will not be definitive – that is too much to hope for".

Other participants felt that research into life sciences and biotechnology should be guided rather than allowed to develop freely. "Scientists, like computer programmers, only see a too

small part of the whole. We need systems analysts to orient efforts appropriately," suggested Benedikt Haerlin. "We are not in a situation where offer creates a demand," affirmed Michel Ferry. "Research must be defined by development." Greater attention to the needs of developing countries is required but focusing the efforts of researchers from one part of the world on the most important questions for people from another part of the world is not easy. This was illustrated by a question from Jeffrey Ambali Luhanga. "Looking at the list of project proposals for China, the genome projects – there's the pig, the soybean – is there any way that list can accommodate some of the priority crops from Africa?" he asked. Local research may be the way to bridge this gap.

The participants expressed diverse views about the way forward, depending on their own priorities. For some participants, education and impact studies were of key importance. "We need to invest in education," insisted Paulo Arruda. "We don't want good farmers; we want very good farmers!" While, for Toong Jin Lam, who works with mobile species – fish – "studying the situation before the implantation of exotic species, for example salmon in Chile, is necessary as it is the only way to know what the impact is".

Definition of the way forward in terms of germ plasm conservation was also considered a major issue. "Keeping complete DNA samples from species becoming extinct may be as good as keeping the species alive," suggested Anne McLaren. "All the genes can be found subsequently." However, Olivier Hanotte was less enthusiastic. "Breeds are not static – their continuation is a dynamic process," he explained. "We've lost both breeds and some of the genes of these breeds. Storing samples from one point in time is limiting. We have a responsibility to ensure that this loss of breeds is minimal, given that we can't predict the needs of the future. We are putting a lot of effort into characterisation."

Coherent regulations are required if biotechnology is to be implemented successfully. "The results are there, but the regulations stop them doing anything useful," complained one Malaysian delegate. "There is no expertise for evaluation and control, so progress is blocked." Reliable data

concerning biosafety are required for the formulation of appropriate legislation. Since 1985, the EC has supported research in this area through successive Framework Programmes – a combined Community contribution of around €70 million has funded 81 projects involving 400 teams across the Member States.

Intellectual property rights continue to concern participants in the biotechnology debate. "I believe that this is a major barrier, real and perceived, to getting much better investment and use of life sciences," said Timothy Reeves. "We need to look at new things, like the 'open source' approach that has been taken for software," he added.

Overall, attitudes to the future were positive. "There are risks with all technologies. However, we have to be responsible citizens, and not ostriches," said Jennifer Thompson. "I want to know what we are going to agree to do today that will make a difference for the children, because the rest of us, we are history, we are dinosaurs!" exclaimed Peter Hartmann. "I like to think we can nourish not just empty stomachs, but hopes and dreams," he added.



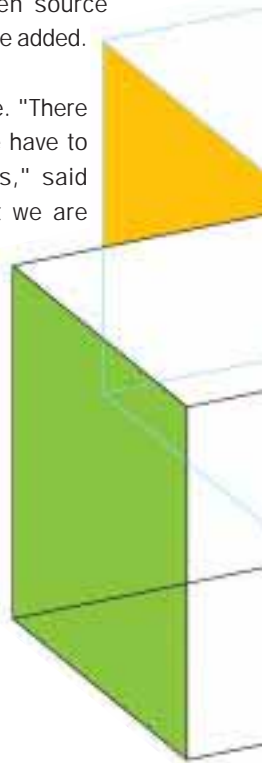
Mamadou Cissokho

The right to decide

In a world of international trade, with the intricate web of connections between different organisations and countries, it is no longer clear who is responsible for making decisions concerning technology and agricultural practices. Should the farmer be allowed to do what he wants? Should individual countries make their

own laws independently or do we need multinational agreements?

At the end of the day it has to be the farmer who decides what to do," asserted Mamadou Cissokho. "Small farmers need to be included in decision-making, but how can



this be achieved?" questioned Olivia Mbazang. "The depth of understanding regarding small farmers in Africa is poor, and disseminating information can be problematic. Indeed, many are illiterate."

Scientists and seed companies clearly have a major role in developing biotechnologies and their decisions at the research stage determine what is available at the end of the process. However, it is unclear whether they should have the right to decide. Benedikt Haerlin was sceptical about the potential involvement of seed companies in the decision-making process.

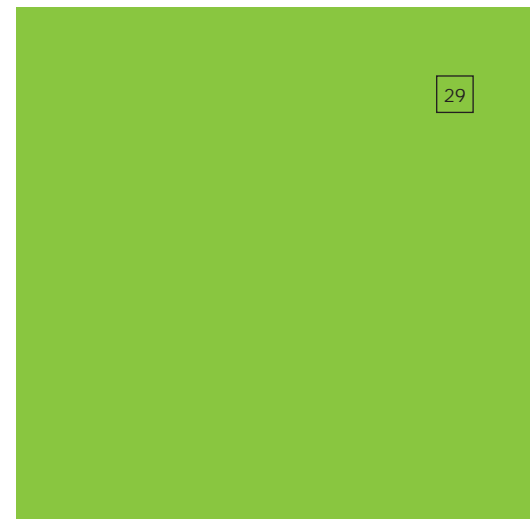
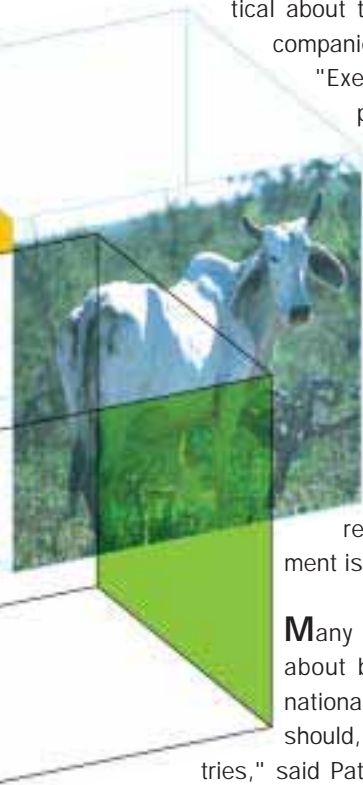
"Executives of big multinational suppliers would be worse – representative of no one, their decisions are invisible," he warned. Some felt that the decisions taken during the research process should be guided by input from other stakeholders. "Research scientists in isolation can only produce potential solutions," claimed Marc van Montagu. "They need to interact with the other stakeholders to arrive at applicable solutions to real-life problems, including management issues."

Many delegates agreed that decisions about biotechnologies should rest with national governments. "The right to decide should, and does, remain with the countries," said Patrick Cunningham. "Of course, the developing countries should decide for themselves," agreed Emilia Müller. According to Philippe Busquin: "The NGOs have the right to express their fears, notably concerning the risk of contamination of other species by GMOs, but it is for each country to take its own decisions."

However, in the words of Commissioner Poul Nielson, "being so-called politically responsible is not necessarily the same as having the power to decide". International trade agreements and market forces may constrain the actions of national governments. "They [developing countries] are not going to be allowed to use GMOs because we won't allow their food to come into our market," argued

David McConnell. "That is very, very serious indeed. Europe has got to think again." On another level, governments in the developing world have their own problems, which may also make it difficult to reach clear, sensible decisions. A participant from Togo expressed doubts about the ability of his own government to make appropriate decisions about biotechnologies and GMOs.

According to Timothy Reeves, "the whole question of policy is one of the most critical issues if we're talking about sustainable agriculture per se and the contribution that life sciences can make to it". Ilias Charlafti asked, "are we really talking about some kind of emerging agricultural socialism required to make sustainable agriculture a reality?" "I would say that it's a sort of self-interested socialism that is required," responded Timothy Reeves.



Emilia Müller

At the end of the two days, the wide-ranging debate between the participants revealed a wealth of opinions, views, concerns, questions and possible solutions. The main messages emanating from the conference, in relation to developing countries in particular, can be summarised as follows:

- **The policies and strategies proposed and developed by Europe, as regards life sciences and biotechnologies, will have a major impact on the developing countries.** Therefore, the interests of developing countries must be taken fully into account by the European Union when considering the future direction for these domains.
- **Life sciences and biotechnologies will not be a panacea to solve all the problems in the developing countries,** but they will be important tools in finding solutions to some of the many pressing issues there.
- Developed and developing countries have common fields of interest in life sciences and biotechnologies. Therefore, **new informed, democratic, ethical and transparent partnerships** should be encouraged amongst them in order to take full advantage of both the promising technologies available primarily in the North and an extraordinary potential for biodiversity found mainly in the South.

- **Demand-driven and tailored solutions for poor small-scale farmers require coordinated commercial investments and public funding** at national, regional and international levels. For this to work efficiently, technological packages should be provided which are both adapted to local conditions and affordable to the poor.
- **Environmental and health concerns are paramount** when considering life sciences and biotechnologies and, as such, they must be fully integrated into those strategic choices contributing to sustainable development, in accordance with international commitments and conventions, and the precautionary principle.

In other words, **life sciences and biotechnologies are seen as valuable tools** for the reduction of poverty and promotion of sustainable development in developing countries. However, they should only be employed in accordance with **the complete respect of national sovereignty and international commitments**, and with a view to facilitating partnerships not just in research and development, but also through responsibility-sharing in education, extension, popularisation, monitoring and evaluation. The decision-makers would have to attribute greater importance to the precautionary principle in regulating all technologies, both known and unknown.

Members of the European Group on Life Sciences:



Prof. Victor de Lorenzo



Prof. Anne McLaren



Prof. Derek Burke



Prof. Leonardo Santi



Prof. Hans Wigzell



Prof. Ernst-Ludwig Winnacker

Ensuring food security is a prerequisite for a stable society. As populations double in developing countries over the coming generation, and as living standards improve, the demands made on agricultural systems will be unprecedented. Since usable land areas per person are actually decreasing, continual improvement of biological efficiency will be one of the important solutions to meet the challenges that are ahead of us. The discovery, spread and use of improved, sustainable, affordable and environmentally friendly technologies are therefore an essential part of building the future.

Europe has a duty to contribute to these developments by sharing its wealth of experience, resources and knowledge. The conference highlighted many examples of how new knowledge in the life sciences can contribute to resolving old problems – knowledge often generated by scientists in and from developing countries. Crop and livestock productivity can be enhanced, pesticide use can be reduced, disease losses can be lessened, and traditional farming systems can be made more productive.

While most of these developments are welcomed for the benefits they bring to farmers and consumers, some are not without controversy, in particular, GMOs. To ensure that benefits from the life sciences spread to those populations in greatest need, all stakeholders should help clarify controversial areas and meet legitimate concerns.

Therefore, the EGLS:

- respects the positions of those who challenge scientific developments. Their scepticism is an important part of

the proving process, insofar as it may bring to the surface the right scientific questions;

- sympathises with the right of individual countries and regions in development to make their own judgement on whether to accept or encourage particular technologies;
- acknowledges there is persuasive cumulative evidence that present GM food is not more injurious to human health than traditional food, and that the potential danger of uncontrolled releases of GMOs is less extensive than postulated by some. The Group recommends that a thorough, independent and authoritative review of this evidence in the specific context of developing countries be commissioned and published, with due reference to the international regulatory framework in place;
- recognises that a number of cases have been described whereby research on genetic modifications of crops has led to real benefits, even though some applications remain restricted (either by refusal of funding, or by administrative constraints). The Group recommends that, in its research and development policy, the EU should not impose unjustified constraints on the generation of new and potentially useful knowledge; and
- believing that knowledge is and should be a shared and freely available commodity, and that it is the most important ingredient in progressive, sustainable and productive agriculture, it calls for strengthened commitment by the EU to support scientific partnerships with developing countries at national, regional and global levels. Such a partnership should foster a flexible approach to intellectual property and should emphasise scientific training as the main pillar of future equitable developments.

For more information on the EGLS:

http://europa.eu.int/comm/research/life-sciences/egls/index_en.html



Prof. Jan H. van Bommel



Prof. Ladislav Kováč



Prof. Nadia A. Rosenthal



Prof. Philippe Kourilsky



Prof. Christiane Nüsslein-Volhard



Prof. Marc Van Montagu



Prof. Patrick Cunningham

For further information visit the conference website on the Europa server:
<http://europa.eu.int/comm/research/sadc>

The discussion platform 'Towards sustainable agriculture for developing countries: options from life sciences and biotechnologies' was the starting point for a dialogue in which anyone concerned by the importance of the changes being brought about by progress in the life sciences is welcome to take part. Ideas, proposals for action and other initiatives should be sent to: rtd-food@cec.eu.int

For further information, contact Mrs Balzi (elisabetta.balzi@cec.eu.int) or Mrs Parel (marianne.parel@cec.eu.int).

