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Panel Moderator: M.S. Swaminathan

CONVERSATION:

GAME CHANGE: INNOVATIONS SHAPING THE FUTURE OF GREEN TECHNOLOGY

Panel moderator:

M.S. Swaminathan
Emeritus Chairman, M.S. Swaminathan Research Foundation

Panel Members:

Marc Van Montagu	Emeritus Professor, Ghent University
Robert Fraley	Executive Vice President & Chief Technology Officer, Monsanto

Introduction by:

Catherine Swoboda
Interim Director of Planning, World Food Prize

We want to go right into the next panel, and with that I'd like to introduce the moderator, and the moderator is someone to people in this room who needs no introduction, so Dr. M.S. Swaminathan.

M.S. Swaminathan
Emeritus Chairman, M.S. Swaminathan Research Foundation

I request the other two panelists to come, Dr. Marc Van Montagu and Robert Fraley. Since we are behind time, I will go straight into the topic. As you will see from the title, "Conversation Game Change: Innovations Shaping the Future of Green Technology," in this particular discussion the concentration will be on biotechnology, and of course biotechnology is a very broad term; but our two panelists will concentrate on the genetic modification, recombinant DNA technology and associated technologies which have opened up some unusual opportunities in terms of crop, animal, microbial improvement.

It's also called "The Future of Green Technology." The "green" word is now widely used, particularly after Rio+20. Everywhere we would like to see the word "clean," in other words, which is environmentally benign, which is environmentally sound and would help to promote what you call "sustainable development," in other words development without having to look back afterwards.

In the case of biotechnology, there are six major issues in terms of green technology, which are heard in many meetings but clearly nongovernmental organizations.

The first is the environmental impact of biotechnology, or ecological factors. The two issues which are of great concern today in our discussion will be both biodiversity, impact on biodiversity, and also in terms of preparation for climate change. What contributions can biotechnology make for us to be able to cope with the new challenges ensuring sustainable food security?

The second is economics, the cost versus returns share of technology, which is one what is in the previous section there was a lot of talk about smallholders and so on. For them the most important thing is the cost risk and returns to the farming. Now there is a lot of question about intellectual property rights, the high cost of technology, the lack of adequate insurance so that farmers are not protected when the rains fail and so on. So the economic aspects of green technology become important.

The third are the equity aspects, both social and gender. Gender in terms of women, either pro-woman or there are problems in terms of technological improvement, included in this is an access to technology, because if you see the Rio+20, it is not only green technology, but green technology for inclusive growth so that nobody is left out, all benefit from technological transformation – that's an important one, so that this technology does not become a divider but a unifier.

The fourth "E," in fact the previous lecturer Kendall Powell frankly mentioned. Innovation and share, he used the words innovate and share. The next important question which concerns any technology in developing countries is the question of employment, is the pro-job let growth or jobless growth, because employment even in this country I find the debates linked very highly on employment issues. If that is so, in most of the developing countries with the high population pressure, employment is very important.

Lastly, energy issues, there are always. Energy in the case of biotechnology. There is a lot of work going on in different institutions on converting C3 plants into C4 plants so they become more effective in terms of utilizing sunlight.

To what extent, so this green biotechnology, to what extent can contribute in terms of ecological sustainability, economic sustainability, social sustainability and overall can it generate more jobs, and also can it be much more energy efficient? And are the current attempts to convert a plant like rice, there's a lot of work at the International Rice Research Institute on converting rice into a C4 plant. These are many of the challenging issues.

We have outstanding members of the panel. I need hardly introduce you to Bob Fraley, the executive vice president and chief technology officer of Monsanto, which has been a pioneer in the whole area of technology development, not only biotechnology but many other areas of technology. And of course Marc Van Montagu is one of the fathers of modern biotechnology, one of the early inventors of the methods of transmission of genes, through vectors, *Agrobacterium Tumefaciens.* He and Jeff Schell did a remarkable job.

So I call upon both of them, first Marc Van Montagu to say what he want to say on the topic is "Shaping the Future of Green Technology," but we are concentrating on biotechnology. And

then of course Bob Fraley will pass and then we'll have a… Because our time is very limited, I find, hardly for 45 minutes having been given for this session. So I will say given their two complete presentations, I will open it up to the floor. Marc.

Marc Van Montagu
Emeritus Professor, Ghent University

Thank you very much for your kind introduction. Yes, if I can have the first slide. So the title, "Game Change" is very appropriate, and my talk itself, formal talk, what you call discover, innovate and communicate, because those are the three important points.

All my life I was in the public sector at the University of Ghent, so I was at the discover side, but I tried to contribute at the innovation and communication side. We take our planet for granted to have these landscapes. We know the importance of flowering plants, but at the moment with the ever-increasing population growth and all the pressures that it brings on pollution, on environment, and on the products we need for our world, the challenges are enormous and we cannot enough try to see how to apply science to see what we can save, how we can get organized for the immediate future.

Rio+20 this year was very explicit. They restated the Millennium Goals and phrased it very concretely. We have to stop hunger, we have to stop poverty, and we have to stop deforestation. And those are the three goal points that we see how science can contribute there.

So science and technology for sustainable agriculture, because that's what the real problem is. And all this ecology we have to see what is the molecule of base of the development of plants and of the plant communities that we have. And we have to see what are the challenges.

The challenges are at three levels. We talk a lot today of food and feed production, but we also have to realize that in the future with shortage of petroleum, plants will be the raw material for our chemical industry. The science is fully developing. We have a lot of new products coming up, but also for all our plastics we will have to see that initial products come from plants. So we will have, know to have increased biomass production on the same amount of arable land, part of it for food, and sometimes we hope in the future for the same plant that we can develop and what we call now "agricultural waste" and later on city waste and the food that we didn't use, that it can be reused for fermentation industry, for a chemical industry, low energy that makes the product.

And most of all at the level of environment, we know that physical and chemical solutions are too expensive. We have to see how with our innovation in plant molecular genetics, how can we contribute to make plants that we have less polluting agriculture, a more sustainable world than we have now. The picture there is the Gulf of Mexico, the zones of anoxia that are created with the excess of fertilizers coming from the Mississippi River.

So those are the challenges. What did we do until now? Well, it was not so brilliant. So scientists since a long time need a lot of product for industry. We need rubber for the dyes, we need the palm oil. Whole Malaysia has been chopped off, the tropical forest, the population disseminated who was living there, because our industry needed it. But we did it in the classical way, with

trees, with breeding, palm oil trees 35 years when you make crosses, 35 years before flowering. So it's an enormous task for fundamental science to progress there. And we hope we will be able to do it.

That's why I say discovery – yes, agrobacterium was a good start, but we found it just by looking for something else – what was cancer in plants, what was this tumor purification, and there's interesting signs that this is absolutely going on. What is in the plant genome to do the cell proliferation? But immediately we left the fundamental and tried to do the innovations, to do the applications.

So this photograph there is genetic engineering for making hybrid canola, for making maize sterility. Plant scientists all discovered these items in the last 20 years. This maize sterility in food genetic engineering has not been used because meanwhile society reacted against GMOs. And of course for introducing new GMOs were much too expensive and therefore at the moment I will mostly stress communication to society. Because if the society doesn't accept innovations that plant scientists can bring, it will be dramatic.

And again assure you that the fundamental science is going fantastically well. That's a tribute to Beijing Genomics Institute by making, developing DNA sequencing methods and really information handling coming out of that so that now they do about an equivalent of 150 human genomes a day, a sequencing, so that allows them to do the sequencing of all these plants, contribute to the functional genomics to identify the RNAs that are expressed and to really analyze what's going on.

And the fundamental scientists meanwhile discovered the importance of epigenetics. We will have pretty soon better understanding of hybrid vigor, not of singles that are in so-called junk DNA, those who fall out publications of Encode in Nature in early September and in other journals know that 80% of human genome is made of singles for gene regulation that only now we are discovering.

So fundamental science will be able to take enormous challenges there, I have not the slightest doubt. But what we have to do is to apply to innovation, and there it's important that the scientists talk better with the plant breeders, with people who know agriculture, because phenomics, among all the "omics" technologies that are there, is the most crucial. Look to the phenotypic trait, see the decisions that can be taken rapidly and see what molecular biology already can tell us and what we can do. Because indeed plants have an enormous potential. People have communicated that for corn maybe it could go to 65 tons per acre, but it goes for many, many crops.

To give you just a symbol for bananas. Most cultivation of bananas have ten kilograms per banana tree. In the plantations you go - Dole and the different companies go to 24. But in Costa Rica in CATIE and together with what Swennen did at the Catholic University of Leuven in Belgium, they have tetraploid bananas where they have 230 kilograms per tree. So yields potential is there, how to handle it, how to exploit it.

Final solution for agriculture, of course, is political will, is good governance, but R&D can do a lot. If we see in Brazil what EMBRAPA could do, a state company that does fundamental research, applied research, and really the applications in agriculture. It could be a model for quite some developing countries if this good governance could proceed that these companies do

this work, so they could recently, through genetic engineering, make beans disease resistant that are important for a million poor farmers.

In India there is an enormous discussion around brinjal. We know that the pesticide that is used for the insect for brinjal is really very dangerous. We have the solution with the BT. Why don't we use it? And, oh, if you talk to people who work on biotic stress, it's enormous what fundamental science has learned through the genomics technology on the evolution of the genome and to see how microorganisms cope with challenging environment.

Well, it will be the same for the plants. We know that the genes that give disease resistance are only temporarily functioning, that pathogens can take over, and then this battle goes on. But now we can no longer wait. Know that we have analyzed that we wait how this interplay goes, we have really to use the capacity we have to identify ten, twenty interesting genes and to make the necessary synthetic genes. We know that plant disease can be controlled by molecular geneticists, and we have to see that we can apply it. And at that moment we will really progress.

We know that the number of crops that we use are very limited and there are fascinating orphan crops around, like lathyrus that's in a picture of Ethiopia where under drought conditions it's a leguminous plant grass pea, that this crop, if we could remove the toxic compound of this that is only attacking cells for the nerve cells of the lower lymphs when maybe persons are about 45, 50 years. But most of it, if you can remove it and turn it into a crop and understand why these crops are called the miracle crops already 4,000 years ago. We find the seeds in the tombs of the Pharaohs. In Bangladesh after three months of flood, the crop that comes up again is again lathyrus. So this should be studied, and we should have possibilities. So innovation will be to start also on the orphan crops.

But we have to see how to organize our society. The fundamental sector, the public sector, goes well, but society asks – where are the innovations? And the innovations are blocked because there is not always the political will, the financial support to do these innovations, so therefore we have to communicate. And if we talk to society, we see that in Europe all over in the last several leading papers the same say it's dangerous. But there is not the slightest proof that it was dangerous, and there have been many false publications that came out and have been endorsed by political groups. And that's what we have to do.

Then if this attitude seems to fade out with … it is again, it gets a push and people immediately accept it. But then meanwhile they said it's bad for environment, but again not the slightest argument has been seen that it is dangerous for environment. People think it's unnatural, but there we are with the drama that we have not well enough communicated what these genetics. The idea is still for the idea of 20, on the years 20 and the years 30 the pure lines, the pure genomes, but the drama of genetics evolved already for it – yes?

So molecular biologists shows us how flexible a genome is. Yes, we have a lot of products of advantage but it doesn't reach the market, and people see only a monopoly of six multinationals, and that's what in Europe really disturbs. And Rome interpretation that is gave, and not seeing that these multinationals have already saved a lot in the food production and could push agriculture at new levels. But, no, the price tag that the green movement and the people who attack science have put on us, that is tremendous.

At the moment the price of introduction of a new GM crop reaches tens and sometimes hundred million dollars, at that moment the multinationals cannot bring in the new ones, and the small medium enterprises that really have to make the products in the developing countries where the needs are biggest for having the novel crops, they cannot do it. And for that reason we have to develop communication. And for that reason it's dramatic, the misinformation that circulates, and that's what we have to fight.

So we have to see that in the world we have to create systems for communication. We know all the false IDs emotionally that exist, and for many cases emotions are important for people's reaction towards the challenges in society, but some can be dramatic and especially if we don't accept science and the technologies.

So I am convinced that we will be able to do that, but we have to do it all together and see that it is the most important bottleneck at the moment. And I am convinced that we will in the 21st century have the plants and in a better environment if we talk together with people that are now keen on only agroecology and people who think that ecology is really the reason to block GMOs. If we do that environment and talk with them, then we can win and we can save and the challenges we need.

Robert Fraley
Executive Vice President & Chief Technology Officer, Monsanto

Let me begin. I'm just going to stay here and make a few comments and make sure we leave plenty of time for your questions. First of all, I'd like to thank the organizers and the opportunity to be here. It's a real privilege to be here with a group that understands the importance of agriculture and technology and who continues to be a part of the mission to deliver the vision that Norman Borlaug had to use science and technology to address the food needs and sustainability needs of the planet.

It's also a tremendous privilege to share the stage with two of the leading figures and friends and colleagues who have driven the science and the opportunity to use these tools. I'm going to just make a couple of points, and then we'll address your questions.

I think coming into this meeting every year, I think for me it always reinforces just what an important time this is for agriculture. You know, if you look at the topics of this meeting, whether it's food security, water, the environment, biofuels, they're all central to the topic of agriculture. But clearly in my mind what puts preeminent is the need to ensure that food security is manifest across the world.

And I see that both through the lens of the importance of science and technology, the business opportunity, but the need. I think when you step back and you think of where we are today, seven people on the planet over the next 30 or 40 years that number will increase to nine or ten and create the incremental food demand. You all appreciate that as global wealth increases, as diets improve, that there will be incremental demand.

Some of the analysis that for me is the most stunning is that we'll see a billion new consumers reach the middle class globally and create another incremental demand, that if you look at it

over the next 30 to 40 years I think most experts agree, we need to double food production to meet the demand to feed the growing world. And that's really where I think the science, the technology, the business interests of all of us come together to achieve that demand.

And it's unprecedented, as you know, in the history of this planet. And so I think that's clear – unprecedented demand. That kind of leads me to the next point, which is the opportunity that the advances in science and technology, unprecedented demand without the unparalleled opportunity to innovation, would be a futile cycle. But what's exciting is the explosive amount of new technology that's possible. And I'm just going to limit my comments to a couple of points.

I think the first thing you would expect me to say is that it's all about biotechnology. I will tell you that the advances in science and technology across plant breeding, across equipment, across information technology and biotechnology are going to be part of that systems approach that allows us to meet and exceed that need for doubling.

As a company, I've had the opportunity to work with hundreds of universities, lots of small and big companies, lots of not-for-profit and environmental groups to meet that need. Collectively I think we've laid out a path where it's clearly possible to achieve doublings or triplings in crop yields as we are fully able to deploy and use technologies to meet that need.

For me one of the most remarkable advances I've seen has actually been how the basic tools of biotechnology have fundamentally changed plant breeding. You know, ten, fifteen years ago when we first got into the seed business, the best and most sophisticated corn breeders in our companies were making decisions maybe based on 10 or 12 characteristics, you know, the size of the plant, the yield, the disease properties. Today, having had the ability to sequence every single gene in a corn or a soybean or a cotton or a tomato plant, plant breeders today are now making their decisions on advancement based on thousands of genes.

When I first joined Monsanto, it took us nearly six months to sequence a single gene. Today with the technology we can sequence a genome in a day. And that means that today plant breeders around the world in almost all crops and species have the ability to literally breed gene by gene. So the biotechnology has enabled breeding to become molecular.

At the same time we are seeing the advance of biotech traits. I know there's frustration, I know there's challenges in their advancement, but think about it this way. Since 1996, biotechnology is now being used to deliver GMO seeds in 30 countries around the world, we're planting about 20% of the surface area that's farmable, using biotechnology crops. And despite some of the challenges, it's been the most rapidly adopted technology in the history of agriculture.

And today what we're seeing is continued advances in this area. The most popular corn hybrids in the U.S. contain eight genes. In our research laboratories we're working on developing the ten or fifteen genes that will be needed to accelerate yields over the next several decades. We're testing not only the traits for improving resistance to bugs and weeds but testing now traits that can protect crops against disease and against drought. So this science continues to advance.

In fact, I would argue that because breeding has become more molecular and seeds incorporate traits into that germplasm, breeding and biotechnology have coalesced, like both sides of your hands. But that's just the beginning, because the advances in genomics and the advances in

information technology and computerization have come together, and that creates the next paradigm shift for advancing technology.

Today, whether you're a farmer employing precision agriculture - you know, there's more computational power in today's tractor than there was in the first spaceships, and that's giving farmers literally the capability to farm meter by meter and use that information technology to be more precise in positioning of seeds and chemicals.

And again just like we've seen biotechnology itself go around the world, we're seeing that same advancement in communication technology influence farming around the world. One of the best examples we have in India is every Indian farmer has a cell phone, the ability now to prescribe agronomic recommendations to warn in the advance of insect flights and others to growers has become a global part of the incorporation of those tools.

So the need is there, the advancement in science will enable that. And the last piece is – this will have to be done collectively. It will have to be done through public and private partnerships. It will be done through the concerted efforts of multiple companies and parties that bring the advancements in science together. It will take a systems approach on a global basis.

And if we do that and do that well, I'm absolutely convinced that we can increase the production of agriculture and we can do sustainable intensification in a way that meets the demand and the need and the societal values that we all share.

So with that, I thank you again for the opportunity to be here. I look forward to your questions. Thank you.

M.S. Swaminathan

Both our panelists have brought out clearly the opportunity that exists today for what is called in Rio, "the shaping the future we want". On the other hand, I think it could be wrong on our part to deny the fact that there is a great deal of apprehension all over the world, both developed and developing countries, on the risks and benefits associated with modern biotechnology. There's a growing perception change, not only with reference to biotechnology but nanotechnology. A laboratory was set fire in Mexico. There is also the nuclear power. What the nuclear power protagonists will say is that clean power – there is no greenhouse gas emission. But nevertheless after Fukushima, there's a lot of apprehension.

There's a growing difference in the perception. That's why I think the Royal Society of London many years ago set up a committee called Copus – Committee for the Public Understanding of Science. They also extended the committee on the political understanding of science. Now a recent editorial in *Science* says that we need more work on the signs of science communication, in other words how to communicate to different groups of people what they call the signs of science communication.

Q&A Session

Swaminathan Now we have about eight minutes, a couple of questions from the floor because it's a very important topic, shaping the future with modern technology. Please announce your name and then…

Q I don't know if you are too familiar with the methodologies that you employed to make this transformation from the cell to make these changes in the crops and these things in the seeds. Which kind of methodologies do you use to transfect or transfer these cells?

Fraley What I heard, the question was what types of technologies are used for…

Q Methodologies, lab methodologies.

Fraley Yeah, so I think just broadly, you know, we use both the tools of biotechnology for advanced breeding as well as for creating transgenic crops for GMOs. As I said in my introductory comments, in the last five years, plant breeding has really become molecular based on the known sequence genomes of all the crops and the ability to use markers and tools to understand precisely the combinations of new genes that come together as we cross and breed crops.

And then from a biotechnology perspective, we use a lot of the tools that scientists around the world are using with agrobacterium and other methodologies to introduce new genes into crops to both increase the biodiversity of the plants but also to give them new attributes that aren't possible through breeding.

Q What is your posture when you are doing a new seed with these modifications? Are you trying to patent these seeds?

Fraley I didn't quite understand the question.

Van Montagu Take a patent, if you do it, patent on the seeds.

Fraley In many of our technologies where we've created new innovations, we have taken patents out on the genes and the seeds, just like people who work in the information technology, the software area. As a company we invest significantly and use that as a way of enabling us to create a return for our investment, for our owners and create value.

Q The panelists both have mentioned that there's a growing sort of competition and polarity between agroecological farming practices and advocates and biotech. And my sense is, it doesn't necessarily have to be so. But I do see that there's a tremendous gap between the kinds of resources and attention that's provided to encourage and promote and develop biotech solutions, and what is left is bootstrapping operations to develop the kinds of agroecological sciences that could actually be a complement and partner. I look at the limited value being put to soil health and fertility research, I see the very limited work being done on things like system rice intensive and its applications to other cereals. And it would seem to me that if there were a way to find a way of bridging the

gap and actually having the biotech community be promoting the rapid development of agroecological solutions, we would actually be able to compound the advance and improvements and efficiency and intensification of production that is really possible if we were to use both technologies. But in today's environment, agroecological is very poorly understood and poorly advanced, and the biotech one is skewed in the opposite direction. And I'd be very interested in your comments on your willingness to provide much more aggressive support for agroecological solutions that could be combined at the farmer's choice with your solutions.

Fraley Good. Let me just make a quick comment here, because if I said anything that gave you the impression that I thought these were antagonistic, I would say it's exactly the opposite. Let me be really clear here, because I think there's a general consensus coming together. If you go through the three points I made, there's absolute consensus we need to double food supply. And I can remember sitting down with Norm and talking about, you know, there's two ways to do it – you can either double the amount of land, or you need to use the sustainable intensification of agriculture and farm those lands that can be farmed the most stably and increase production.

And so I think the alignment is recognized, that the solution's set for the future, people, there will be more demand, people will lead, and the best way to meet that demand is to take our lands and farm them more sustainably and to be able to intensify their production. So I think there's an alignment there.

And I would agree absolutely, and I tried to make the point, this is a systems approach. It won't be just breeding, it won't be just biotechnology, it won't be just computers, but it's going to be agronomy, the information technology, and the integration of all that together. And certainly understanding increasingly the productivity and the potential literally field by field and meter by meter is going to require that type of intensity in knowledge across both the genetics and the agronomy. I just, I couldn't agree with you more.

Q The question I had – We look at the problem of marketing cost and making the GMOs and other forms of farming inputs affordable to farmers, and we realize, as the first speaker said, that many GMOs have been too high cost to be implemented at the smallholder farmer level. At the same time the ignorance that's been spread around attacking GMOs creates a political environment that can also affect those cost variables.

One, how do you interact with the political bodies, which are too heavily influenced by a number of different voices, which in turn have been one of the factors driving up the cost?

And, two, when we look at the issue of cell phones, which you mentioned, could you amplify your answer on the effective use of cell phone networks to be utilized in agricultural marketing to be able to overcome the problem of asset specificity and transfer and transaction cost, all of which would help the

smallholder farmer be enabled to not only utilize GMOs but also expand their markets to make sure they get a cost benefit analysis in their favor for doing so?

Fraley Just as a general comment, I mentioned in my introduction that, despite all the challenges that we're aware of, the remarkable story, I think, has been the prolific adoption of the technology. Thirty countries around the world are now planting GMO seeds, and there are more farmers in India and China using this technology than anywhere else in the world.

A tremendous opportunity to extend biotechnology seeds to small farmers and other crops, and there are many, many pilot projects. Probably the one that I'm most excited about is our WEMA project where really it's the collaboration between our company, between CIMMYT, between the African Agricultural Technology Foundation and the Gates Foundation to bring the latest technology in drought to small farmers in Africa.

The beauty, I think, of biotechnology is – every farmer in the world knows what to do with the seed. And if you're using technology to enhance that seed through advanced breeding or advanced biotechnology, that can be utilized. So the ability to use this technology broadly is extensive.

I think the key challenge to your point is the involvement of regulatory agencies around the world as they're setting up their principles adds to the cost of development, but there's no doubt in my mind that the ability of this technology to reach growers globally is inherent in the technology. Thank you.

Swaminathan I'm sorry. We have come to the end of this. It's a very important question and I'm sure will be ongoing all the time.

I only want to say a word about the very… question raised about agroecology and biotechnology – are they compatible, are they different? But, you know, biotechnology is only a tool, and therefore in agroecology if you have the objective of cleaning up the waters, bioremediation will be needed. If you've got an objective of trying to improve the health of the people by overcoming hidden hunger like micronutrient deficiencies, biofortification is an option.

I will therefore say it depends on what we want to do, but the most effective tool, which is the most economical, effective tool and reliable tool. And even in the International Forum for Organic Agriculture movement, molecular market-based selections and breeding, which is now becoming the most common method of plant breeding, as Dr. Fraley mentioned, that is accepted for organic certification.

Therefore, I hope instead of conflict we'll have harmony and use all techniques, old and new, in the most effective way to achieve the single goal for which we are all committed, and namely, how to avoid the hunger, the widespread hunger, preventing.

Thank you all very much. Thank you to the two panelists. Please give them a big hand, the two panelists.