Reflective Discussion on Module V and NABC 15

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Charles Benbrook: Many aspects of the issues that Carolyn Raffensperger, Tom Lumpkin and Paul Jepson addressed also came up earlier in the meeting and I'm sure other people would like to express their views. I'm going to make a few comments on some of the key areas and invite our Module V speakers to contribute to the discussion, then we'll move on when it seems appropriate.

In his comments, Paul focused on some of the ethical responsibilities that the FAO has set forth relative to access to food, food security and agricultural technology. Carolyn focused on the legal framework that has evolved from the incorporation of the precautionary principle, going back to 1972, as a paradigm to shape international consideration and decision-making on technologies that may pose some risks.

I'll start by talking about current standards of the US government relative to the acceptability of agricultural biotechnology. I remember Kay Walker-Simmons's comment that the standard against which an agricultural biotechnology in the United States is judged is conventional technology, conventional systems. I'm not arguing that that is not what the policy is, but many people take issue and disagree with that policy, because if no agricultural biotechnology is going to be perceived to have any risks worth worrying about as long as they aren't as bad the worst of conventional technology, it's really not a very demanding standard. It's certainly not one that's going to command public support for the benefits that appropriate applications of agricultural biotechnology can bring to the production of food and fiber. I would submit that the US government has made a strategic and political mistake in the international arena by adopting that as the standard, and that if agricultural biotechnology risks are going to be deemed as acceptable or unacceptable

relative to contemporary technologies and practices, at a minimum the standard should be the best available technology, which is the standard applied in many other areas of environmental regulation and management of natural resources. When Congress passes a Clean Water Act or a Clean Air Act, the process forces industries, farmers, companies, to adopt the best available technology unless it's completely unfeasible economically. So, I invite comments from our speakers on their degree of comfort in the current US government. Paul, I would say that it's also the EPA standard behind the MON 863 decision. They approved MON 863 corn (a *Bt* hybrid from Monsanto) because they felt that the risks were less than from conventional organophosphate-based insecticides and, moreover, the approval was for, was it a 2- or 3-year period? It was a short-term approval and it was quite clear that there would not be a huge acreage planted in that period of time, during which some more science could be done. So, EPA really embedded in its decision to register MON 863 corn despite the fact that substantial issues remained in its environmental and safety evaluation, because the EPA was convinced that it posed less risk than conventional organophosphate-based soil insecticides. How can the United States move towards a more rigorous health-protective policy?

Paul Jepson: Rigor is evolving over time. Recent regulatory decisions have requirements for a lot more testing, which is admirable. When you look at the regulatory system, and I'm a student of these things, you ask broadly, "Is the system protected largely or is it not?" We have no evidence that the EPA has failed to be protective of environments, livelihoods, health, *etc.*, in the decisions it has made. I'm talking about the details of how you get more rapid inclusion of scientific insight and methodology into the process. I have to say that when you look at the additional stipulations and requirements that have been made, the standard is, overall, rather high. As I mentioned, I have a series of detailed concerns about how that's applied and whether or not there ought to be a revision of that process in the longer term.

Benbrook: Okay. Carolyn. you're going to pass on this?

Carolyn Raffensperger: I am.

Benbrook: Tom, any thoughts?

Thomas Lumpkin[1]*:* Recent improvements in the regulatory system are very encouraging. We still have a long way to go to reach a proper comfort level. You mentioned that you didn't see any reason to be concerned about the EPA, but it was the EPA that approved the testing of StarLink™ corn. Even a first-year

[1]Dr. Lumpkin had to leave early.

agronomy student would have raised a red flag on its release because corn is outcrossing.

Jepson: In any regulatory system it isn't difficult to find examples of flaws. So I don't particularly want to comment on that other than the fact that, broadly speaking, immense efforts are taken to develop procedures that are protective but not so protective that they exclude the technology, and I'm afraid that the balance has to be struck by people sitting in offices in Washington DC, and it's a very difficult job. And the science is evolving, of course, during the period while the technology is being adopted, which is why there is apparent confusion and anomaly on occasion.

Benbrook: We have a complicated situation in that most of the genetically engineered crops that are planted widely today, certainly in their original forms, were submitted to EPA for approval in the early 1990s. The initial commercial approvals were granted as early as 1990 or 1991. Since the approval of *Bt* cotton, Roundup Ready® cotton and soybean, the various *Bt* corn events and then the Roundup Ready-*Bt* stacked corn, no other substantial event has been approved. The US government faces a difficult balancing act in that it is trying to improve the rigor and scientific quality of its ongoing assessment of these initial technologies while, at the same time, trying to get it right as new technologies are reviewed. There is tremendous tension, because the US government has stated consistently over the last decade that, in general, it perceives genetically engineered foods and crops to be substantially equivalent, to pose no unique risk and to be good, modern technology. Yet the US government is having to interact within the international arena where issues of risk and the quality of science supporting safety judgments are very much in play. A few months ago the Codex issued new guidelines for allergenicity testing of GM foods and it will come as no surprise to most people in this group that the early GMOs approved by EPA and the FDA were approved on the basis of science substantially less complete and rigorous than what Codex is now calling for. Somehow, we've got to bring the science supporting existing technologies up to scale.

Joseph Jen talked about the $3 million a year that the USDA is spending on biotechnology risk-assessment research. Probably most people in this room have a sense that that is a rather modest sum, given the total public and private investment behind agriculture biotechnologies. Jim Cook said there's somewhere between 900 and a 1,000 transgenic events in various stages of development in the United States, some in the greenhouse, some in small field trials, which puts the $3 million dollars a year investment into perspective. I do a lot of work in the pesticide arena. When a chemical company is either introducing a major new pesticide or defending an old one and bringing the database supporting its registration up to contemporary scientific standards,

just the core toxicology data set—the long-term reproductive, cancer, chronic feeding studies—cost about $3 million dollars for one pesticide. Most companies are glad if they can get through the health and safety testing for a major pesticide that's being newly registered or going through re-registration, for $30 million dollars. And for important products where there are contested regulatory issues, the two best contemporary examples being use of chlorpyrophos, an organophosphate insecticide that Dow Agrosciences engaged EPA very aggressively to try to preserve as many uses as possible, and atrazine, a corn herbicide that's found widely in drinking water in the mid-west that may or may not pose some level of cancer risk to people as a result of drinking-water exposure. Dow in the case of chlorpyrophos and Syngenta, used to be Novartis, have spent, I am sure, at least $50 million in creating the science base to defend the continued registration of those products. So, we need to realize that there is an enormous gap between the extent and rigor of publicly supported science being done to assess the risks of GM foods relative to the ongoing assessment of risks from pesticides. Moreover, I think my colleagues would agree that, given that we don't even know what to test for, we don't have endpoints, we don't have models, so there needs to be an even greater upfront investment by USDA to develop the sensitive long-term ecologically based screening protocols that are going to deliver the data that Paul felt was lacking to evaluate the MON 863 technology. It will be important for the USDA to ramp up that investment fairly rapidly from $3 million. Because of the perception that the USDA is really a promoter of the technology it might be appropriate for some of the hard-core risk-assessment research on GMOs to be funded through the NSF or NIH or other agencies whose mission is to develop the science base for state-of-the-art regulation. Any comments on the level of investment?

Kay Walker-Simmons (USDA-ARS, Washington, DC): Just for clarification, the USDA budget for biotech risk-assessment research includes approximately $3 million for NRI competitive grants and includes approximately $5 million for the in-house ARS research budget. So the total is $8 million—still just a start, but it's actually $8 million. And I would also point out it doesn't reflect an increasing interest from scientists for a number of reasons. Increasingly, scientists are becoming much more aware that the customer is always right and are trying—lesson learned—to develop strategies to reduce the amounts of transgene products in foods.

Benbrook: Thank you.

Raffensperger: I wonder if we need to take some of that funding and give it to different agencies. We have a certain set up for food and drugs, and for agriculture. I'm wondering if we couldn't give some money to the Centers for Disease Control. They have experience in monitoring outbreaks and coming up

with new public-health measures for tracking problems. We could give money to some other players to design systems that would help us to prevent big problems from becoming bigger.

Benbrook: Yes. As a tactical and political strategy, the US government would be very wise to diversify the number of players that are contributing to the science base on GMOs. Whether that will happen or not remains to be seen.

I want to switch gears and pursue a thought from Fred Kirschenmann. He talked about the need to solve for pattern, and, in his workshops summary, Bill Lacy mentioned how many people are uncomfortable about GM foods because the current developers and promoters of the technology are using it to address the symptoms of sick farming systems as opposed to fixing the underlying problem in those farming systems. If you are going to solve for pattern you need to understand what the important patterns are that are influencing the health, the productivity, the sustainability, of farming systems. I know Paul Jepson, at several points in his career, has had "aha" discoveries about the relationships of nonpartner organisms in the field that have a profound impact on what crop the farmer is able to harvest and what the farmer has to do to bring that crop through the process. He has gained insights into what some of those patterns are that had not previously been clear to people. I've been thinking about this for about 6 months: one of the most important patterns that we have not thought about or done any systematic research on—and it's a pattern that is profoundly relevant to the practice of biotechnology—how changes in agricultural technology affect the comparative rate of evolution across organisms within an agricultural system. I am becoming increasingly convinced, based on my reading of the scientific literature, that many of the problems in agriculture—animal diseases, antibiotic-resistant bacteria, infectious diseases, poor soil quality, resistance to pesticides—arise because farmers have done things with their farming system that increase the advantage of bacteria, pests, viruses, in terms of their ability to evolve, relative to the other organisms in that system, which have to maintain some kind of a balance if that system is to be healthy. Of course, the tools of biotechnology are designed to accelerate evolution by breaking down the species barrier, by promoting the expression of traits that are not normally expressed in a given plant, and I wonder if we need to ask questions about the pattern of rates of evolution and how technology impacts that. If we could solve that puzzle and not increase rates at which pathogenic bacteria evolve a greater capacity to harm farm animals or people, we might really be doing some long-run good. I invite your comments.

Jepson: Regarding the evolutionary processes, we don't have the tools to explore or to validate assertions like that. David Tillman has proposed that the evolution of weeds has been radically affected by modern agriculture, but most

of the pests we are faced with, in their evolutionary history, have adapted to exploit how we present the crops to them. Let's not think that pests are new. There are twenty-seven references to *Locusta migratoria* in the Bible, for example. We heard about GM maize and pesticide reductions in Africa to treat stem-borer. In my experience in East and West Africa, maize is attacked by a plethora of pests including grasshoppers, locusts, meloid beetles, stem borers—a whole variety of taxa, some of which are affected by *Bt*, some of which are not. To suggest that that technology alone will result in comprehensive pesticide reductions, or, as some of growers have suggested, that that's an overall solution to pest resistance, is absurd. Pest pressure arises because of the way we produce commodities, but we accept that trade-off and try not to compete. How we've affected the evolution of those organisms is open to question, and I doubt whether there's been a dramatic impact on the evolution in general of the life histories, voracity, *etc*., of most pests, diseases or weeds in the particular sense that you were referring to. We are managing the environment. We're part of it and agriculture has to be seen as a part of the landscape, so inevitably we're affecting the evolution of organisms in the longer term, but we're not in a position to argue that it is, by definition, a bad thing.

Raffensperger: Could you design an experiment to find out?

Jepson: Monitoring over eons. Our experiments are carried out on a time scale and spatial scale that allow proper statistics and proper voicing of hypotheses. Some of the things we're talking about are beyond the capacity of experimental science to answer. As a country, we have not bought into the idea of ecological long-term monitoring, but it would be a really great thing to start to do. Why haven't we done that? Well, Oregon is a 100,000 square miles—excuse the imperial units—with about 3 million people. And people say, "Why don't we have the level of ecological monitoring that exists in United Kingdom? Well there are nearly sixty million people there, and every county has a recorder for virtually every insect family. That goes back 150 years, and is a lot of monitoring. We're never going to have that long-term basis for evaluating what's going on with biodiversity, but somehow we need to start to amalgamate what monitoring is in progress to get some idea about the impacts of anthropogenic practices. But, we don't really have a basis for argument either way at this point.

Q&A

Audience Member: I have to disagree with the comment that regulatory agencies must have a balance between approving technologies and safety testing and safety regulations. As a citizen, I need to know that regulatory agencies are weighing my safety and my environment's safety over approving technologies. As a citizen, I don't want a balance, I want my safety first.

Jepson: I understand what you're saying, of course. Whenever a safety concern is raised, it becomes our highest concern. But the EPA has the difficult job, on our behalf, of striking a balance. Whatever agency does this, and in whomever you place your trust, those decisions have to be made one way or another, and certain limits and acceptabilities have to be determined by whatever process. We decide through the ballot box, through this enormous democracy, which ultimately affects the regulatory process. Now, I can understand your being unhappy with it, and other people are unhappy with it for the opposite reason. They consider it too costly, that there are too many tests, *etc.*, but, somehow or another, a compromise is reached. The most difficult aspect of risk assessment is accepting that it's an equation. You make a certain number of measurements and in your best judgment based on those measurements, you determine whether something meets some defined level of acceptability. It's one of the most difficult things we do, and it applies to whatever form of agriculture and whatever are our methods of food production—high-tech science-driven or low-tech culture-driven—you end up having to strike a balance between some perceived risk and some perceived benefit, hopefully both measured in the best ways possible. We tend to have poor measurements of benefits. We see sub-high-school economics in arguing for some of the benefits of GMOs, but there also have been some very good studies, and I find it difficult to judge all the benefits. Also, it's very difficult to judge all the risks. Therefore, striking a balance between risks and benefits is difficult with all new technologies. At some level or another in society, we have to place our trust in an organization that does strike that balance.

Raffensperger: There's another perspective on that. We have devolved into that kind of risk assessment and that kind of cost-benefit analysis without asking some other questions. And I think it's a cultural value. It's our fault that we've gone into this ballgame. I think it's our view of science. In a 1996 budget speech, Al Gore said that all Americans understand that we need more research and development to promote global economic competitiveness. Almost anything else is subservient to that. I think we have an invitation to ask if that's really what we want it to do, if that's the only thing we want science and technology to be for. Jane Lubchenko, president of AAAS, has proposed another set of ideas for what science might do; this is where we bring in ethical norms. The Office of Management and Budget has proposed that we devalue the lives of the elderly in looking at the cost and benefit of environmental regulation. The EPA has come out with a different take on that. But it says that our elderly are not our elders—they are not important. This is a cultural value and it plays out in how those costs and benefits are estimated at agencies like EPA. So, this conversation is not simply about whether EPA is doing a good or bad job. It's about values and how they are taken into account and how we hold that conversation as a democracy.

Jepson: I don't believe that those values are excluded from the current process. I see them in abundance in the debate. I see them taken into account in virtually every forum I've participated in, including the final deliberations on whether or not to register certain products.

Raffensperger: I would never say they are excluded completely. But, even in your comments, about the need to balance cost-benefit—that language expresses a certain set of deeply imbedded values in our culture. Not at EPA or the immediate conversation of risk assessment, but in our larger culture, which influences that discussion.

Audience Member: Paul, regarding your comment that you see poor information on benefits—I'd have to say the opposite. I have seen, in this conference at least, poor information given on the risks, at least not satisfactory to me. That leads into my comment on the precautionary principle. Thank you for your questions on tracking the harms because they are the same questions that I've been trying to ask and have been repeatedly reassured by many here that scientific methods that are brought about by technology are sound, rational and objective. In the last 2 days, when I've asked questions on the precautionary principle I've received similar bland and obscure answers, that scientists agree on the safety, that the benefits far outweigh the risks, that fear of risk is irrational and that if something goes wrong, well we'll just repeal it and we'll take it back because in a few years there will be no traces of it in the environment. To me, if science wants to reach a crossroads with society then scientists are going to have to do a much better job in answering these questions. I'm not a scientist, but I've seen the wonders of natural life and one of those wonders is its ability to defy western science's attempts to simplify and control its innate tendency towards continual change as well as nature's interconnection where one thread tugs on another.

Benbrook: Do you have a question?

Audience Member: Not a question. I see this is as a central theme to this conference. It's important to say this, because a lot of people have the same concerns. I refuse to believe that we can throw this technology into any ecosystem and then simply take it out when it goes wrong. I would feel better if science acknowledged the risks to society to my face, rather than deny and reassure me that science has it under control, or give me a vague response that I may not understand science. As a person who's on the fence, I'm trying to understand all sides of this issue. I would trust that scientists are working on it. As a part of society I want to know the truth. I don't want to be patted on the head and be reassured. I want straight answers on this question. It just makes sense to me that the precautionary principle is the best way to approach

biotechnology, because going ahead without implementing it will not win the hearts of the society that I'm a part of. Thank you.

Benbrook: Everyone who has followed this issue and is a part of it wants to see science progress. I think that one of the things that we are going to have to admit in the United States is that the number of independent scientists who have a well grounded, in-depth personal knowledge about the risks and the impacts of transgenic crops, and experience from their own work, is surprisingly small. The number of people involved in that work and who are gaining independent expertise is going to increase, I hope, fairly rapidly. It won't settle the debate, but it'll place it in a more grounded context. Before the scientific community in this country can speak credibly with one voice on this, there needs to be a lot more independent science done and a lot more process to achieve a meeting of the minds. At an American Phytopathological Society or Entomological Society of America meeting, a majority of the scientists there might take the view of Jim Cook that we really understand this stuff, that there are no real concerns about risks. But, if you go to an Ecological Society of America meeting a much more substantial portion of the scientists will have some interest and questions about what the technologies might do. We're a long way from unanimity in the scientific community.

Raffensperger: And not just those disciplines. How many of those independent scientists actually understand how a combine works? We've been fascinated by the discussion about how seed banks have gotten contaminated because people didn't understand that you can't clean out a combine.

Anne Schwartz (Blue Herron Farm, Rockport, WA): About 165 people registered for this conference. There are fewer than sixty-five people in the room and that to me is a real shortcoming. Understandably, people have busy lives, but the discussion today captures the tensions that scientists and concerned citizens raise. One of the problems with getting these two groups to communicate is that scientists do tend to work, I won't say in a vacuum but in isolation from the impacts of their work on the rest of us. And as a person who's worked for many years on funding and research priorities at Washington State University, I see the direction that WSU is going in with their new biotech center and how much money actually goes into systems research such as Fred Kirschenmann talked about and such as those of us in the organic farming community would like to see advanced. We need to have more of the decision makers playing the role of the bridge between the scientists who are doing research that excites them and concerned citizens who ask, "What will be the impacts of this research?" It does feel like our efforts to bring these conversations into the public domain have been successful. I appreciate the media representatives who are here. I appreciate the fact that this is going to wind up in print, and it

certainly is my goal to see scientists and concerned citizens find a way to talk, and I think we've started that conversation.

Benbrook: Anne would you just stay right there for one second? Jim Cook raised an important question the other day. He asked what could be more organic than a gene? I've been thinking about that and I'd like to offer my answer to his question. You have deep roots in the organic community and perhaps you'd like to share your thoughts on what could be more organic than a gene. From the perspective of the organic community, the answer to that is an understanding of how farming systems impact the interactions between organisms that bring out or compromises the genetic potential of that farming system to produce a profitable, healthy, sustainable crop. That is what is more organic than a gene: the organic understanding of how that system functions. Anne, as a farmer, do you have a different one?

Schwartz: One of the ways I respond to how genetic engineering winds up in the public domain is to ask who controls it and who owns it. Issues around seed are complicated and difficult to get into the public discussion. They don't distill into sound bites very easily. As we look at the cultural history of seed, I find a higher degree of comfort as I listen to the talks about doing this research in the public domain and providing seed free to a community in need. That starts to make me feel a little more accepting of the technology. My barrier hits when I see the technology furthering the concentration of our food supply. If I leave discussion of the biological implications over here and just look at the political implications that's where my lines get drawn.

Robert Wager (Malaspina University College, Nanaimo, BC): I'm a scientist and I'm trying to learn how to better educate the public about this issue and other issues of science. I've read a fair bit on the precautionary principle and it seems to me that it can be used to stop or ban virtually anything that has risk associated with it. Therefore, if we adopt the precautionary principle what would happen to the organic food industry that has well documented risks of pathogenic microorganisms, use of pyrethroids, which are likely carcinogens, use of copper sulfate, and others. And, before I get an answer, I'd also like to express my happiness in understanding that the regulations are improving and that there is an ongoing effort to increase the stringency of the regulations based on good scientific principles. That's a very good thing and continued improvements in regulations that are based on good questions can only benefit everybody.

Benbrook: Carolyn, do you want to respond to that?

Raffensperger: The early thinking on the precautionary principle, at least in the United States, ran the risk of doing exactly what you said. You bring it in late in the game and say, "Oh no, stop it." That's just kind of dumb. That's why setting goals helps, then you know what you are trying to accomplish and if you look at the larger system, comparing your alternatives for meeting your goals, then you can use the precautionary principle well. If it is used only as a risk-management tool—if you've done your risk assessment and then say, "Oops, this warrants this precautionary action, ban it—that's the problem that I see in bringing the precautionary principle in at the end game. It has to be brought in earlier and used to help society to meet its goals.

Wager: What would stop it from being used exactly the way I just put forward? It seems to me that full application will result in bans where there is any risk.

Raffensperger: Well, it's actually been used in interesting ways in Europe to force technology innovation. Instead of stopping everything, it's actually forced new and cleaner technologies. So your fear, in its almost 35-year history in Europe, has just not proven to be true. Where you do see the possibility of what you say is in international trade. Europe may say, "We don't want your biotech foods without labels. I suspect that they will apply conditions, like labeling, rather than actually banning it, but we'll see. I think you'll see it being used as a risk-management tool unlike in the larger framework that I laid out. So, at least the European experience is that it has not banned things or stopped technology. They didn't go back to horses and buggies in Germany, but they used it to do some very innovative things.

Jepson: One beneficial impact of adopting the precautionary approach has been greater and more rapid access by growers to newer and less-hazardous agrichemicals. I'm a European so I've seen this thing work. In practice, the regulatory methods and tests that are used—the packages that registrants submit—are not profoundly different, and at some level this debate about the precautionary principle *vs*. the science-based risk-assessment principle is a semantic argument. The reality of what is actually asked for, what is done, how the adjudication is made, is not terribly different. Let's not get caught up in somebody else's debate. We need to focus on the quality of the insight we have and the general acceptance that risk-assessment procedures are flawed. They're not perfect. Some systems are more flawed than others and we need to try to improve them. That's the key behind where we need to go. A more precautionary approach may benefit the system here, but the gradual, incremental, conditional approvals that the United States is giving—if you actually analyze that according to the precautionary principle—come out looking rather precautionary. I wonder sometimes at the semantics *vs*. reality.

Raffensperger: I agree that we need risk assessment to compare alternatives. There's no other way to do this. And we need science to give us the best information. This is not an anti-science thing. The precautionary principle has proven to be difficult in international trade, no question. International trade was difficult for Germany in terms of costs.

Wager: I believe it can be used to argue absolutely any point on any side of the issue.

Steven Garrett (WSU Cooperative Extension, Tacoma, WA): As an extension agent I try to interpret these technologies for others. I try to express the polarity, both sides of the argument, and let people make up their own minds. We've talked about the double standard of testing between pesticides and genetically engineered crops and it seems to me another double standard is running as a thread through this conference. Most of us agree that one of the strong benefits of genetic engineering is reduction of pesticide use. But we hear people say—especially from companies that produce both—that pesticides are safe. This strikes me as a problematic stance: promoting genetic engineering with something that is safe while reducing something that is safe. Could you comment on the ethics of promoting *Bt* this way, because it has a bearing on regulations and how we set up regulations and on how people assess risk.

Jepson: You're absolutely spot on in saying that this presents a dilemma to a company that, on one hand, is marketing an agrochemical and on the other hand is marketing a product that can reduce the use of that chemical. They are put into the position of arguing for reduced hazard while claiming that their regular chemicals are safe anyway. Of course, many conventional pesticides are not safe. They are rather hazardous if misapplied or even in conventional use. In modern farm practices they are used far less than in the past and in different ways, and are even being replaced with beneficial technologies like biological control. The term "safety" is misapplied by virtually everybody that uses it. We are using some extremely hazardous, toxic materials and we're trying to find ways of avoiding or minimizing their use, and one possible way of doing that is with biotech products. It is remarkable that the statistics from biotech trials for this country are showing for the first time productive agriculture in the absence of heavy pesticide use in the era of modern science. When you see the dramatic differences in natural enemy abundances between the biotech crop and the conventionally treated crop, it's a shock. In Oregon the growers of NewLeaf™ potatoes became biodiversity converts overnight because of the amazing abundance of organisms that recolonized that system when it was released from so much spraying pressure. Again, the term "safety" is often misapplied. Some very toxic materials can be used in a way where the risks are reduced but not removed. The hazard is always there and that's what we've grown to "accept" in the way we work.

Benbrook: There is good evidence, particularly in cotton not so much in corn, of substantial pesticide reductions. However, in the case of herbicide-tolerant crops, which account for two thirds of the acreage, the whole purpose was to allow farmers to rely more predominantly on herbicides. Herbicide-tolerant varieties are treated in the medium- to high-dose range—they have not reduced the volume of herbicides applied. So when you make statements about impacts on pesticide use, it's important to be specific to both the GM technology and the area. Reductions in insecticide use in Arizona and Mexico in cotton are much more substantial than in the southeast because of differences in ecology. It gets really complicated in a hurry.

Garrett: I don't think we can have that conversation unless we say upfront that it's of societal benefit to reduce pesticide applications.

Jepson: Right, and that's implicit even in the case industry is making.

John Browne (Judd Creek Nursery, Burton, WA): I'm the local-grade unwashed, and probably badly educated. While I was standing listening to the conversation, it occurred to me this the predilection of western reductionist science—whether it's extracting good whiskey out of beer or heroin out of opium or the pyrethrin out of a daisy—it's an ongoing thing. I'd actually prefer to deal with the devil that I know on at least a microbiological level than the devil that I've only met recently in the form of hallogenated hydrocarbons or our present subject. I guess my question is—

Raffesperger: I would just point out that the devil is a fallen angel.

Browne: Sure. This may be an ethics and economics, rather than an agricultural, question, but the GM debate seems to impel a two-world economic model. It puts the First World economies and technologies in one group and the Second and Third World community in another economy, like two side-by-side global economies. The generic and specific examples I have of that is the present economic model, of the Third World selling in the First World and then, on the other hand, to produce, say, DDT in the First World and only sell it in the Third World. Is there an ethical component to that or is this just human behavior and we'll have to put up with it?

Jepson: Thank you, John. There's a deeply ethical component to what you've raised, and its something we haven't mastered. If we offered the developing world access to American markets we'd do a great deal to raise the value of agricultural production in the developing world and achieve a great deal of progress thereby. It's a chronically difficult problem, globally dealing with trade with the developing world. I go to sustainable agriculture meetings all around

the world. One thing I've learned lately is of a parallel project going on in East Africa on maize pest suppression that uses modern science and technology in a way that is very sympathetic to a partnership with, in this case again, Kenyan growers of maize. If you look, in the pages of the *Journal of Royal Society*, *Proceedings of the Royal Society* or *Nature*, there is something described as "push-pull" technology—using indigenous Kenyan plants to repel the pests from entering fields and using the trash from those plants, to use an Americanism, to suppress striga, which is a major goal. And extracts from those plants are used to attract beneficial insects that feed on corn borers. This has been so incredibly effective that it's produced a new grower-science partnership that is one of the good news stories to come out of East Africa. African growers today were portrayed as "technology isolated." Well, I can tell you their not innovation-isolated. This is a way of growing corn in Africa that is extremely productive and effective, and I'd hate to think that the technology we heard about from Drs. Hoisington and Ngichabe would either be seen as a substitute or a replacement for such an extraordinary, capable and valuable way of developing and growing a commodity. I'd say a similar thing for breeding exercises in Mali where for thousands of years growers have been producing millet and sorghum, and maize more recently, and they practice a system of crop improvement there that has the admiration of crop geneticists the world over. Again, I'd hate to see that diminished by having centralized breeding that offers services back to that community when I don't believe that's what they really need. Ethics are behind this. Ethics play far too small a role in education in the United States. If we considered the ethical implications of what we do, sometimes we would curtail our activities.

Benbrook: Regarding the point that Paul made about research in Africa on striga and stem borer in the United States and USDA context, we heard this morning about a ramping up to over $100 million support for genomics—genomics being the cutting-edge basic science that needs to be done for the development and employment of the tools of biotechology. I assume none of us is laboring under the notion that applied systems approaches to agriculture—to solve a lot of the same problems—are getting anywhere near that kind of investment. In fact, the funding, academic positions and amount of work being done on that area is certainly down 50% from 10 years ago and at some institutions it's even more. Whether it's a conscious choice or not, we are putting a lot of new resources into building the scientific infrastructure for genetic engineering types of approaches. At least that's how it appears to a lot of people. And we are certainly disinvesting in the other types of science, which are public policy choices underpinned by values and ethics.

Gabrielle Roesch (Western Washington University, Bellingham, WA): Science and society at a crossroad could also mean science and ethics at a crossroad. Some

have said that scientists should not be addressing ethical questions, but should be left to society and policy makers. But, oftentimes, we see science authorized by its rationality and objectivity, and it is often proposed by scientists and industry people that if only we (society) understood the science of biotechnology then we would embrace its implementation. How can we engage in conversations about ethics when science is often viewed as superior to the ethical, social, cultural and political questions that arise when we discuss and consider biotechnology.

Raffensperger: Can I give a sideways answer to that? I came up with a new proposal for a legal standard for sexual harassment law. It's called the respectful-person standard and you can read about it in the Harvard Law Review. If we judged more of our work by whether it's respectful—*e.g.*, you know the trade issue of DDT and what we export and what we import—if it was not only rational but also a respectful decision that we would go a long way to being able to understand ethics especially in the face of uncertainty. The respectful-person standard probably sounds as loosy-goosy to some as the precautionary principle, but it's no more loosy-goosy than saying the word rational when what you mean is you disagree with me.

Jepson: The ethical debate in this country lacks both quality and depth. Scientists in particular, have sought the pedestal and have built the ivory tower, and have done a terrible job of explaining what the benefits of its technology might be and of considering the reasonable concerns of members of the public. You are describing a rather tragic situation that's not being helped by the increasingly polarized nature of the debate. And you're seeing the phenomenon of what happens when a shockingly new idea is introduced to society, and it's not going as well as one might have hoped.

Carol Gonsalvez (Hilo, HI): I'd like to speak for a group of people who have no word here today. How much voice will you allow the poor in the world to have? I've seen them, especially in Thailand, because we work with them, trying to help them improve, to have transgenic papaya because there's no other way to have healthy papaya crops. Every day our collaborator says that people come to her station in Thailand and ask, "Can I have the seeds?" They are asking for virus-tolerant seeds because that's the best they can get. They eat papaya there in northeast Thailand as a stable food and here we are—we think we know everything—but, really, who should decide? We need to think of all the stakeholders. We are stakeholders and the poor are stakeholders. How many of them are here today speaking for themselves? Because, they don't have money, they can't come to this meeting. As we close, I want us to think about the world, the needs, and could you sitting there tell me how much voice are you willing to give them in this discussion?

Jepson: Gaining access to the indigenous peoples of the world, the poor and the excluded, and having their voice play a role in the way we shape our science is extremely difficult. I suppose as individuals we have to make choices in how we do that. I have spent a lot of my career working in places in the world where agriculture is not part of a cash economy, it's part of a subsistence economy, and hopefully I have made contributions to management of pests in those countries. But, it's a pathetically small contribution compared to the enormity of the challenge. All I can say is that through our participation in overseas programs where we actually meet with growers in parts of the world where the agricultural economy is impoverished, the understanding gained hopefully influences the research we do. I hope it's had an influence on me. I do a fair amount of work with the FAO, which has developed in the past 10 to 20 years the farmer field school principle, which has had hundreds of thousands of participants. It's a principle that seeks to learn from growers first about the problems they have and the way they manage their systems and then to find ways of assisting them to reach conclusions about how they can take things further. That's been really successful. If you do a Google search on community IPM you can see how important and successful that's been. It reverses the model of Green Revolution, the top-down way of imposing science on cultures around the world and I think it has a lot to offer. But that's all I can say. We make pathetically small individual contributions. It's a deeply concerning issue and there's no easy way around it. I'm sorry I can't give you a better answer.

Raffensperger: You've asked it so beautifully—democratic participation is essential. I wish it were up to me to figure out how to get more voices here. It's not. I wonder if that's not a role for more of the social sciences in figuring that out. I don't know a lot of the world very well. I know a little corner of North Dakota where our farm is, and I know how farmers feel there—disenfranchised from the conversation, powerless in the face of government telling them what to do, whether it's my neighbor who wants to shoot his coyotes or whatever else, and the inability to pay for their kids' school fees or even buy their kids glasses because they can't afford the basics of life. That's just the little corner I know, and they feel that they have no voice. It's a striking problem. We're sitting in this extraordinary hotel—I had papaya yesterday with my tofu egg-rolls—and it's a key problem.

Bonnie Rice (Washington Sustainable Food and Farming Network, Bellingham, WA): I took a part in planning this conference and assisted bringing in different viewpoints. Because of the expense involved, many people cannot be here. I hope the discussion does not stop here. There is much concern, which has been obvious throughout the meeting, and a lot more discussion is needed. It's very appropriate for people in public institutions, especially the land-grant universities, with their mission of serving agriculture and rural communities,

to find more ways to engage the public in dialog on this issue. There hasn't been nearly enough dialog. I heard Dr. Cook say that the scientific community decided they've got to move ahead of this. They see enough benefit. That is not something that I wanted to hear or that I accept. People in this country and around the world are not going to stand for it. We need to look at questions like what right does the United States have to force this technology literally down people's throats?