2001

NATIONAL AGRICULTURAL BIOTECHNOLOGY COUNCIL REPORT

The cover shows a collection of processed and whole foods that may be described as genetically modified. Proteins/enzymes produced by genetically modified organisms may be used in making cheese, bread, soft drinks, beer, and lactose-reduced milk. For example, 80 to 90% of hard cheeses in the United States and Canada are made with highly purified fermentatively produced chymosin rather than highly impure rennin from the stomachs of slaughtered calves. Melons, papayas, potatoes, and tomatoes may have genetically modified sources with advantages such as longer shelf life and resistance to insects or disease. Genetically modified canola, soybean, and corn (with agronomic advantages) may be processed into cooking and salad oils, tofu, and breakfast cereals. A microorganism-produced natural hormone is used by some producers for enhanced milk output. These are only examples; many others exist.

NABC REPORT 13

Genetically Modified Food and the Consumer

Edited by Allan Eaglesham, Steven G. Pueppke, and Ralph W.F. Hardy

Published by the
National Agricultural Biotechnology Council
Ithaca, New York 14853

NABC REPORT 13
Genetically Modified Food and the Consumer

Additional copies of NABC Report 13 are available for $5.
Please make checks or purchase orders payable to:
NABC / BTI

National Agricultural Biotechnology Council
Boyce Thompson Institute Rm. 419
Tower Road
Ithaca, NY 14853
NABC@cornell.edu
www.cals.cornell.edu/extension/nabc

Library of Congress Control Number: 2002100789

♻ Printed on recycled paper

National Agricultural Biotechnology Council

Providing an open forum
for exploring issues in
agricultural biotechnology

The NABC, established in 1988, is a consortium of not-for-profit agricultural research, extension and educational institutions.

Member Institutions

Agriculture Research Service/USDA
Association of Research Directors
Boyce Thompson Institute
Clemson University
Cooperative State Research, Education and Extension Service/USDA
Cornell University
Economic Research Service/USDA
Iowa State University
Kansas State University
Michigan State University
Mississippi State University
North Carolina State University
Ohio State University
Oklahoma State University
Oregon State University
The Pennsylvania State University
Purdue University
South Dakota State University
Texas A&M University System
University of Arizona
University of Arkansas
University of California-Davis
University of Florida
University of Georgia
University of Guelph
University of Hawaii-Manoa
University of Idaho
University of Illinois at Urbana-Champaign
University of Kentucky
University of Minnesota
University of Missouri-Columbia
University of Nebraska-Lincoln
University of Saskatchewan
University of Tennessee
University of Wisconsin-Madison
Washington State University

Affiliate Members

California Community Colleges Economic Development Network
National Cotton Council

Other NABC Reports Available:

NABC Report 6, *Agricultural Biotechnology & The Public Good* (1994)

NABC Report 8, *Agricultural Biotechnology: Novel Products and New Partnerships* (1996)

NABC Report 9, *Resource Management in Challenged Environments* (1997)

NABC Report 10, *Agricultural Biotechnology and Environmental Quality: Gene Escape and Pest Resistance* (1998)

NABC Report 12, *The Biobased Economy of the Twenty-First Century: Agriculture Expanding into Health, Energy, Chemicals, and Materials* (2000)

ACKNOWLEDGMENTS

The thirteenth annual meeting of the National Agricultural Biotechnology Council was organized jointly by representatives of the University of Illinois at Urbana-Champaign (Pradeep Khanna, Steven G. Pueppke, Steven L. Sonka, and Mary Ann L. Smith) and of Iowa State University (Diane Birt, John A. Miranowski, and Colin Scanes). As a result of their foresight and careful planning, the meeting—titled *High Anxiety and Biotechnology: Who's Buying, Who's Not, and Why?*—was a resounding success. Thanks are due also to Walter Fehr and Wendy Wintersteen (both of ISU). Logistics were handled superbly well by staff of the National Soybean Research Laboratory (UIUC): Phyllis Blackford, Marilyn Nash, Carol Neilson, Phil Orwick, Megan Puzey, and Lynn Westgren.

We are grateful to Lynn Westgren also for transcript preparation, and to Susanne Lipari (NABC) for organizational assistance. Raymond Wiiki's skills produced the excellent layout and design of this volume.

The NABC is indebted to Michael J. Burke (Oregon State University) for his exemplary leadership as Chair during 2000–2001.

Ralph W.F. Hardy
NABC President

Allan Eaglesham
NABC Executive Director

January 2002

PREFACE

The National Agricultural Biotechnology Council (NABC) was established in 1988 with the following objectives:

- to represent the leadership of major, not-for-profit agricultural research and teaching institutions,
- to provide an open forum for attendees of all points of view, to speak on, to listen to, and to learn about major issues of agricultural biotechnology,
- to sponsor an annual meeting covering broadly based interests and key issues, and to publish a proceedings report,
- to promote dialogue and search for options for policy makers on agricultural biotechnology issues, and
- to produce and disseminate other documents on agricultural biotechnology and agricultural research.

The NABC strives to identify and consider in open forum the major issues in agricultural biotechnology. Past annual meetings have focused on sustainable agriculture (1989), food safety and nutritional quality (1990), societal aspects (1991), animal biotech (1992), risk (1993), the public good (1994), discovery, access and ownership of genes (1995), novel products and new partnerships (1996), challenged environments (1997), gene escape and pest resistance (1998), impacts of biotech and industrial consolidation on world food security and sustainability (1999), and the biobased economy and agricultural expansion into health, energy, chemicals, and materials (2000). Thus NABC provides all stakeholders—representatives of academia, government, industry, public-interest groups, farming, *etc.*—the opportunity to come together to speak, to listen, and to learn. Its membership includes thirty-six leading not-for-profit agricultural research and educational institutions in the United States and Canada.

Almost all—if not all—Americans and Canadians have consumed foods and beverages (some of which are represented on the front cover) produced from crops and enzymes modified by biotechnological processes. Fermentatively produced chymosins are now used to produce 80 to 90% of cheeses, and about one third of corn and two thirds of soybean crops in the United States have been modified by molecular processes ("genetically modified" or GM). Accordingly, in 2001 NABC's annual meeting focused on the consumer and GM foods. Titled *High Anxiety and Biotechnology: Who's Buying, Who's Not, and Why?*, it was held in Chicago, May 22–24, and was hosted jointly by the University of Illinois at Urbana-Champaign and Iowa State University. The meeting covered the

safety, ethical, marketing, and environmental issues that influence the acceptance of agricultural and food biotechnology by consumers. Some 220 people registered, with the clear consensus that the meeting was a great success. A new debating format was used for the workshop sessions that encouraged the exchange of views; participants came away with a broader understanding of opposition viewpoints and a heightened appreciation of subtle, perceived flaws inherent in their own stated positions.

This report contains an overview of the 2001 meeting, a summary of the workshop debates, and the plenary presentations. Transcripts are included of discussion sessions that followed the presentations, and preliminary results are presented from a survey (on information assessment) in which the participants were invited to participate.

In 1999 and 2000, the popular media frequently published stories that questioned the human and environmental safety of GM crops. By the end of 2001 these stories were infrequent, and were becoming neutral to favorable to agbiotech [1]. As far as environmental aspects of biotechnology are concerned, two sets of research studies published in 2001 should help to allay the fears of many. Crawley *et al*. [2] reported a long-term study of four transgenic crops—oilseed rape, corn, sugar beet, and potato, modified for insect and herbicide resistance—grown in twelve different natural habitats for ten years. All populations of rape, corn, and sugar beet were extinct at all sites within four years of sowing; potato survived at one site for ten years, but none of the survivors was genetically modified. In the second set of studies [3–5] pollen from corn engineered for insect resistance with genes from the bacterium *Bacillus thuringiensis* (Bt) was found to have negligible effects on the larvae of monarch butterflies. (The only transgenic corn pollen that consistently affected the larvae was from Cry1Ab event 176 hybrids that, during the 2001 season, accounted for <2% of corn planted. These hybrids are being withdrawn from sale.)

A Congressional Briefing was held in the Russell Senate Building, Washington, DC, on April 20, 2001. Michael J. Burke, NABC Chair, William F. Brown (University of Florida), and Ralph W.F. Hardy described the results and implications of NABC's twelfth annual meeting, organized by the University of Florida and held in Orlando in May 2000. Copies of *NABC Report 12, The Biobased Economy of the Twenty-First Century: Agriculture Expanding into Health, Energy, Chemicals, and Materials* were distributed. A similar Congressional Briefing is planned—at which this volume will be disseminated—to share the outcomes from *High Anxiety and Biotechnology: Who's Buying, Who's Not, and Why?*.

The 2002 NABC annual meeting will be hosted by the University of Minnesota, St. Paul, MN, titled *Foods For Health: Potential, Perspectives, and Policy*. It will be held May 19–21 at the Radisson Hotel Metrodome (www.coafes.umn.edu/nabc2002). Participants will have the opportunity for discourse and debate on current and future aspects of the marriage of agriculture and medicine, and the potential for agricultural science and technology to directly benefit human health beyond the realms of food, feed, and fiber.

[1] Editorial (2001) Genetically modified maize is not that bad for monarchs. The Economist September 65.
[2] Crawley MJ *et al.* (2001) Transgenic crops in natural habitats. Nature 409 682–683.
[3] Hellmich RL *et al.* (2001) Monarch larvae sensitivity to *Bacillus thuringiensis*-purified proteins and pollen. Proceedings of the National Academy of Sciences 98 11925–11930.
[4] Stanley-Horn DE *et al.* (2001) Assessing the impact of Cry1Ab-expressing corn pollen on monarch butterfly larvae in field studies. Proceedings of the National Academy of Sciences 98 11931–11936.
[5] Sears MK *et al*. (2001) Impact of *Bt* corn pollen on monarch butterfly populations: A risk assessment. Proceedings of the National Academy of Sciences 98 11937–11942.

Allan Eaglesham
NABC Executive Director

Steven G. Pueppke
Associate Dean for Research, University of Illinois at Urbana-Champaign

Ralph W.F. Hardy
NABC President

CONTENTS

PART I

MEETING SUMMARY

High Anxiety and Biotechnology: Who's Buying, Who's Not, and Why?—An Overview

STEVEN G. PUEPPKE
University of Illinois
Urbana, IL

The topic of NABC's annual meeting, held in Chicago on May 22–24, 2001, was "High Anxiety and Biotechnology: Who's Buying, Who's Not, and Why?" The organizers had some anxiety of their own when they realized that the meeting was a likely target for anti-GMO protestors, and these groups did appear on the first day of the conference. But all was peaceful, and the street theater even did us a favor by attracting the media. NABC 2001 participants provided several media interviews, which were broadcast both locally and on an agricultural television network.

The meeting used an optical metaphor to represent the divergent viewpoints of participants in the public GMO debate. Each plenary session examined the subject as focused through a different kind of lens. This centered the GMO debate on the context of its participants and emphasized that not all judge the issue from a single vantage point.

LESSONS TO LEARN FROM

Five plenary speakers set the stage and established perspective for the meeting. Michael Jacobson from the Center for Science in the Public Interest, pointed out the potential benefits of agricultural biotechnology, not just for farmers, but also for consumers and the environment. He reminded the audience that public outcry has brought biotechnology to a crossroads, and he cautioned against extreme views on either side. Those who claim that all applications of agricultural biotechnology are bad fall into one kind of trap, but those who assert that biotechnology will provide all the answers fall into another. Jacobson believes that objective parties, including universities and state and federal agencies, ought to be doing more research on behalf of agricultural producers.

Napoleon Juanillo from the University of Illinois pointed out gaps between the way that scientists tell their story and the expectations of the public.

Researchers avoid eloquence and speak plainly. They are cautious, hesitant to extrapolate, and generally unprepared to deliver sound bites. Increasingly, though, the public is interested in the subjective and in nuance. Is agricultural biotechnology moral? Is it fair, or does it exploit? Does it cause society to lose control? People expect these issues to be addressed, and it is especially difficult for scientists to do so.

We heard about pasteurization as a case study in new technology and the complications that surround technological change. Joseph Hotchkiss from Cornell University surprised many in the audience by reminding us that the technology of heating milk to kill bacteria—a benign process by today's standards—was vigorously resisted in the late nineteenth and early twentieth centuries. As a consequence, infant mortality remained high for decades after the invention of a process to make milk safe. This historical lesson was sobering, especially to those who view biotechnology as an important tool to combat world hunger.

Nancy Millis from the University of Melbourne challenged participants with a thoughtful analysis of risk and its management. Who decides which risks are acceptable and which are not? She reminded us that scientists were allowed to make these decisions in the past, but that society now demands a voice in the process. One of her key take-home messages is that perceptions of hazard must be taken seriously. Australia's experience with GM crops provided several examples of governmental activities to inform both growers and the general public.

C. S. Prakash from Tuskegee University told the story of agricultural biotechnology and its historical roots. The continuum of agricultural improvements over the centuries—beginning with simple selection and now involving biotechnology—represents a success story and a source of pride for many in the audience. But it is difficult for the public to appreciate either the historical context or the future potential for agricultural biotechnology. Instead, people want the unattainable: zero risk. Consumer perception of risk with foods is no different from that with any other kind of change, but this fact is small comfort for those seeking to educate the general public.

Influencing the Consumer Lens

Session II helped us to understand how consumer attitudes can be influenced. Kerry Smith from North Carolina State University provided lessons on the basis of his experience with health risks. One of these, radon gas, can seep into home basements and represents an involuntary risk. If local governments want people to monitor for this gas, impersonal campaigns with notices and posters are ineffective. But as soon as community leaders become involved in educational efforts, citizens begin to respond. The message for biotechnology: Continuous, personalized involvement can make a difference. Efforts to educate on the hazards of smoking provide another perspective: Be honest, build trust, and be

aware of the fact that people become very concerned when the results of the choices they make are irreversible.

Mark Sagoff from the University of Maryland showed us evidence that food processors deliberately and broadly offer food as fantasy, with liberal use of natural in advertising. This was an important message to those who sometimes feel that consumers are conditioned to fantasize only about the products of biotechnology. Sagoff convulsed the audience with colorful Shakespearean imagery of the concept of natural.

Divergent Lenses of Stakeholders

The most all-encompassing session emphasized the rich diversity of participants in the agricultural biotechnology debate. Dave Erickson, a northwest Illinois farmer, gave us a poignant first-person account of agricultural biotechnology from the viewpoint of a midwestern producer of corn and soybean. This perspective is often overlooked by consumers and by those interested in trade and public policy. To farmers, though, biotechnology is primarily a management tool that will be accepted if it makes economic sense.

Anatole Krattiger from *bio*Developments LLC considered the potential for biotechnology to solve problems in the developing world, but with several unique perspectives on globalization. One is the sheer speed with which the technology has been advanced by the private sector and adopted in the developed world. This has caught scientists off guard and mystified some of those interested in improving the human situation. Application of agricultural biotechnology to the developing world has challenged our concepts of intellectual property and the perceived role of public research establishments dedicated to fighting hunger. Krattiger advocates a novel “privic” approach that involves both the private and public sectors.

Tony Van der haegen's after-dinner keynote address offered a view from the European Union, one that underscored the importance of food safety to European consumers who enjoy abundant food supplies and thus the luxury to make food choices. We were reminded that Americans must understand the psychological undercurrents to the debate in Europe. Europeans are more cautious about new technology and the influence of large corporations. And, unlike Americans, they have recently experienced food and health scandals involving mad cow disease and tainted blood supplies that have eroded trust in scientists and regulators. Lack of understanding between the United States and Europe has already disrupted trade. Ongoing thorny debates about regulatory approval and labeling are not likely to be settled in the near future. However, Van der haegen projected that Europe will eventually accept biotechnology-based foods.

Dirk-Arie Toet from Nestlé gave us a personalized and industry view from the European standpoint. Although Americans often view the European situation pessimistically, Toet pointed out that politicians are again speaking publicly

about biotechnology. He summarized plans for a new European framework for discussions, particularly as they apply to tracing and labeling.

Gary Comstock from Iowa State University, who sometimes used audience members as examples in thought games, helped us to organize our ethical thoughts about agricultural biotechnology. The audience learned to distinguish factual assertions from value-laden, normative assertions—and extrinsic objections to the introduction of biotechnology from intrinsic objections that the process itself is in some way harmful.

Susan Harlander from BIOrational Consultants was unable to attend the meeting. Bruce Chassy from the University of Illinois summarized her perspective from the standpoint of the food industry. On the one hand, the United States Food and Drug Administration considers GM crops to be "substantially equivalent" to their traditional counterparts. This means that they can be managed simply as commodities in this country. On the other hand, various sorts of labeling are required in many other countries, and so food companies doing business worldwide must comply with various sorts of regulations. Consequently, food companies have removed GM ingredients in countries with mandatory labeling requirements. These conflicts have led to turmoil in the marketplace. Harlander pleads for harmonization of the regulatory process across international boundaries.

At the final lunch-time session, Stanley Abramson from Arent Fox Kintner Plotkin & Kahn, PLLC, in Washington, DC, shared his recommendations for improving product stewardship and federal regulations.

Final Remarks

NABC 2001 was not just about plenary sessions. As a prelude to the traditional annual conference workshops, we were treated to a rollicking great debate that was moderated by NABC President Ralph Hardy. Featured were two unnamed members of the organizing committee. One was in white lab coat, scrolling really bad slides and pontificating about technology. The other, who was deeply buried under a fright wig, took the role of protestor. The dialogue ran its expected course and ended with hotel security "escorting" the activist from the room.

Tom Hoban's "Hot Topics and Hot Hors D'Oeuvres" provided another change of pace. Tom shared some of his research data on consumer perceptions of biotechnology and then invited meeting participants to comment. The atmosphere was informal and cozy, the subject matter was challenging, and the wine and food worked their magic. This session ended, not when Tom sat down, but when the hotel staff turned off the lights.

"High Anxiety," which attracted more than 200 scientists and leaders in the agricultural and food arenas, was organized by the University of Illinois and Iowa State University. The annual NABC meeting always attracts a diversity of speakers and speaking styles, but rarely have the participants had so much fun, mixing laughter with challenging thoughts on agricultural biotechnology.

PART II

WORKSHOP REPORT

The Great Agricultural Biotechnology Debates: Outcomes from the Workshops

MARY ANN LILA SMITH
University of Illinois,
Urbana, IL

COLIN SCANES
Iowa State University,
Ames, IA

In order to thoroughly examine the conflicting issues and arguments that fuel controversies about agricultural biotechnology in the food system, the workshop sessions were constructed in a modified "debate" format. The overriding intent was to ensure that the workshops were not just cerebral exercises, but would result in strong connections among participants, and thought-provoking, useful take-home outcomes. The debates were engineered in order to:

- engage conference participants as *active players* in a deliberately fast-paced process of discovery, and
- compel conference participants to *critically and thoroughly evaluate rival viewpoints*.

Accordingly, upon entering the workshop-breakout rooms, participants were assigned to a particular framework position, and were called upon to rapidly absorb, adopt, and rigorously defend a stance perhaps contrary to their own deeply ingrained beliefs.

The topic resolution for the debates was: ***Be it resolved: that GM technology is a sound and safe innovation, and should be permitted in the food chain without restrictions.*** Up until this point in the conference, attendees had heard a variety of viewpoints on the issues. Now, they were required to actively advocate and defend a particular position in multi-dimensional arguments that closely paralleled those currently ongoing internationally in the media, and even on the streets in front of the conference venue.

Because so many of the opposing *pro* and *con* arguments about GM food crops are at cross-purposes, debate participants found that irrefutable

arguments and decisive winners were not easy to identify. Although relatively well versed in the issues, frequently they scrambled to counter opinions voiced by the opposing team, and realized that some lines of reasoning, especially those with emotional undertones, were difficult to refute. Therefore, it is not surprising that the general public has a difficult time sorting out the facts surrounding GM issues.

The Great Debate workshop format promoted productive, concentrated interaction, and facilitated appreciation for diverse perspectives. The scenario presented here may be adapted for use in classrooms or other assemblies to foster intensive exchange of viewpoints.

The Set-Up

The debate-format workshops were prefaced by presentation of a mock debate (Appendix I, page 229), which introduced the conferees to the extremes of viewpoints both from the pro-GM and from the anti-GM camps. The moderator introduced the resolution, and the mock debate followed with arguments from a land grant university professor, an advocate of GM technology, that were countered by a European prince/gentleman organic farmer strongly opposed to genetic engineering, followed by arguments from a pro-biotechnology industry representative countered by an anti-biotechnology radical protestor from a consumer advocacy group.

Although deliberately exaggerated in tone and content, the mock debate introduced the rules of engagement for the workshops to come, and provided a preview of the typical point/counterpoint order of argumentation in traditional debates.

Next, the conferees were divided into four workshop-breakout sessions (twenty-five to thirty participants per group). At least two trained debate coaches staffed each breakout session.

Once participants entered a breakout room, they were asked to count, in turn, one through six. All who had called out number one were asked to form a group in one corner of the room, all those who called number two assembled in another part of the room, *etc*. Via this procedure, the attendees were arbitrarily divided into teams, the composition of each likely represented a broad spectrum of viewpoints. This process occurred simultaneously in each of the four breakout session rooms, with four to six teams assembled in each room.

Debate coaches then assigned each team one of the following identities:

- pro-GM university scientists
- anti-GM militant environmental “green” group (anti-multinational companies)
- pro-GM large corporate US/multinational biotechnology company representatives
- anti-GM consumer advocate group in the European Community

- pro-GM farmers in the developing world
- anti-GM organic farmers in the US
- pro-GM US regulatory agency
- anti-GM government regulatory agency (non-US)
- pro-GM politician (you pick the country)
- anti-GM politician (you pick the country)

Individual group members did not have the opportunity to select a preferred position on the GM issue.

Each team selected a captain, who usually served also as recorder. During the remainder of this session, each team identified a 'top-ten' list of arguments in favor (or opposed, depending on their assigned identity) to the stated debate resolution, *Be it resolved: that GM technology is a sound and safe innovation, and should be permitted in the food chain without restrictions.*

Because participants were randomly assigned to possibly unfamiliar positions, the debate organizers had collected a broad selection of written position papers and other statements that were displayed in each breakout session room. A table was laid out with an eclectic selection of actual current literature materials including Website position statements from consumer activist groups, white-paper statements from pro-GM authorities, industry public relations statements, newspaper stories on GM issues, political statements, *etc*. Team members were encouraged to peruse this array of *pro* and *con* arguments surrounding the GM controversy as they assembled arguments to support their positions. Teams were allotted only 15 minutes to compile their top ten lists, and the debate coaches offered assistance and encouragement to any teams that were floundering for ideas. With only a brief period of time to formulate arguments, intensive, cooperative effort was necessary, thus building camaraderie.

Each team captain listed the top-ten arguments (in abbreviated outline form) on large buff sheets posted on the walls. The captains explained the items to the broader audience; discussion ensued and suggestions of potentially stronger arguments were entertained.

For the remaining 10 to 15 minutes of this first session, each pro-GM team exchanged their top-ten list with their counterpart anti-GM team, and *vice versa*. The teams reconvened to develop counterpoint arguments to refute their opponents' arguments. The coaches collected all of the *pro* and *con* and rebuttal arguments, and held them until the afternoon workshop sessions.

THE DEBATES

The second workshop-breakout session was initiated by having the coaches quiz the participants about which positions had seemed most difficult to defend or rebut during the morning session. This brief discussion session helped to prepare the teams for the debate scenario.

Each team designated two spokespersons, and abbreviated debates were staged between the *pro* and *con* teams. Teams were introduced to the following 'Rules of Debate,' which were posted on large buff paper sheets to facilitate order during the debate exercise:

1. First pro-GM constructive speech: affirm the resolution, explain the position, and provide a plan for adopting and embracing GM in the food system. (3 min)
2. Cross-examination by the first anti-GM spokesperson (Q&A): attempt to refute the arguments of the first speaker, and show the audience that you are a truth seeker. (2 min)
3. First anti-GM constructive speech and rebuttal: turn the tide in favor of your position by explaining why the plan of the *pro* side would be disastrous, and/or offer an alternative plan. (3 min)
4. Cross-examination by the first pro-GM spokesperson. (2 min)
5. Second pro-GM constructive speech and rebuttal. (3 min)
6. Cross-examination by the second anti-GM spokesperson. (2 min)
7. Second anti-GM constructive speech and rebuttal. (3 min)
8. Cross-examination by the second pro-GM spokesperson. (2 min)

At least two debates (four teams) were conducted in each session, at the finish of which the audience voted on which side "won," and arguments that were perceived as "turning points" were discussed. Pitfalls that inhibited serious resolution of opposing viewpoints were documented. Cases where the arguments did not seem to address the same points also were noted.

The Outcomes

By general consensus, the debates were thought-provoking and productive, because the debate teams put concerted effort into preparing and delivering strong and persuasive arguments. Team spokespersons, even those assigned to positions contrary to their own opinions, provided well constructed, impassioned short speeches. Rebuttals were made with little hesitation, again even when the participants were playing roles diametrically opposed to personal convictions. Clearly, the participants were well informed about biotech issues.

Since the workshops were strictly timed, the participants were thrust into the task of actively defending their assigned positions and quickly formulating the strongest possible arguments. In most scenarios, within a team of five or six participants, only one or two were elected to provide the formal speeches and rebuttals during the debates. In other cases, all team members were free to ask questions during cross-examination, which amplified the scrutiny of, and the challenge for, the representative speaker in opposition.

As the debates progressed, the intensity of the arguments escalated. When a designated team spokesperson had the chance to refute an argument voiced by

the opposition, (s)he frequently did so with passion. This competitive spirit often engendered the development of stronger counter-arguments. Nuances and hidden perspectives behind each position were brought to light. Participants reported that they came away with new appreciation for the wealth of information and complexity behind opposition viewpoints, which, in some cases, they had previously viewed as one-dimensional.

Participants came away with new appreciation for the wealth of information and complexity behind opposition viewpoints, which, in some cases, they had previously viewed as one-dimensional.

A synopsis of primary arguments and position statements from the *pro* and *con* camps is provided below.

The coaches agreed that the presentations staged in their breakout sessions provided mixes of opinions on GM products in the marketplace that spanned the range from rational to irrational. One coach commented, “Our role diminished the moment the groups understood the task in hand. They jumped right into it, and came up with good arguments for their positions; every individual on each team threw in ideas and perspectives, so we had an excellent mix of people who were not afraid to participate.”

What were the hardest points to refute? Participants found it difficult to defend their stance against ‘the moral high ground’ of a zealous opponent. Interestingly, this particular strategy was used on both sides of the issue. While it was frequently argued that GM technology is “immoral, unethical, and against nature to cross species barriers,” others contended that it is “immoral and unethical” to deny the benefits of GM crop improvements to impoverished farmers or undernourished children in a global context, or to fail to embrace the opportunity for reduced pesticide exposure, or decreased environmental impact.

Another coach commented that some of the participants were “sobered” by the fact that they were most swayed by the *con* arguments. In fact, most of the coaches acknowledged that many of the arguments, *pro* and *con*, were most difficult to refute when based on fears and emotional issues: “It is relatively easy to create a fear and more difficult to allay one, because of the complexity of the subject matter.” One coach noted that he was not sure there were any clear winners in his breakout session, which illustrated that “gray is the color of choice for biotechnology and food.”

Coaches observed that a few debaters "did not always play it straight." There were cases where "fallacious arguments, including begging the question, creating a straw man, *argumentum ad hominem*, and emotional appeals" were substituted for substantive factual materials. In a couple of instances, debate teams spent more time on form (disruptive behavior) than on content. For example, a spokesmen for an 'environmental advocacy group' noted that his opposing spokesman had ridiculed his position and failed to take him seriously—an observation with which the other participants concurred.

In summary, some of the most difficult issues to resolve concerned the approval/regulatory process, labeling, and, as noted previously, moral and ethical issues.

Approval/regulatory process Based on available data, teams were unable to verify to what extent GMOs are required to undergo regulatory approval in the United States. Pro-biotech literature emphasizes that GM is perhaps the most highly scrutinized technology in recent history. The European press argues that the approval process in the United States is shrouded in mystery, and the interconnections among the three major regulatory agencies (the Environmental Protection Agency, Food and Drug Administration, and United States Department of Agriculture) are unclear and without transparency. Further, there was a perception that safety data on which approvals are based may have been compiled by industry and held by private companies.

Labeling Neither side of the issue was able to address to what extent labeling policy is consistent with United States law, practice, or longstanding guidelines. Opponents argued that labeling policy in the United States is out of synchrony with those of the rest of the world, *e.g.*, the EU views labeling as the first step as a matter of policy. The apparent contradiction was noted with regard to "substantial equivalence " of a GM product on one hand and the ability to patent it on the other.

Moral and ethical issues Religious and moral beliefs were among the most strongly held, but proponents and detractors were repeatedly chastised when they "tried to impose their views on everyone else." Opponents should not be forced to consume GM products, whereas advocates should not attempt to force the world to accept the technology without choice. When an opposition team debater claimed, "I'm scared! I want to know my risks!", the fears could not be alleviated with data, statistics, or probabilities.

Pro-GM scientists were faced with the challenge of credibility: "Why should we trust you? Originally you told us that DDT was safe." Anti-GM teams found it difficult to counter accusations of being "against progress" and "against free enterprise." These arguments implied that the precautionary position is shortsighted, especially when challenged with illustrations of past fears over

Religious and moral beliefs were among the most strongly held, but proponents and detractors were repeatedly chastised when they "tried to impose their views on everyone else."

pasteurization, microwave ovens, and vaccination. An agreeable compromise between caution and progress was not easy to reach.

Interestingly, the participants saw clear parallels between their GM debates, and emotion-charged disputes over unrelated issues such as *Creationism vs. Evolution*. It was especially clear that science-based opinions were frequently insufficient against ideological arguments or moral/emotional concerns. One spokesperson, an industry representative from the private sector, had endured the "pesticide wars" in the seventies; he felt that those years were worse in terms of being in an uncomfortable position and representing an industry that was constantly attacked.

Take-Home Message

What was the take-home message of the Great Debate workshop sessions? In order to be effective advocates for what we believe in, in order to readily defend our position, it is essential that we thoroughly appreciate all the nuances and complexities of the contrary view. The participants came away with a broader understanding of opposition viewpoints and a broadened appreciation of subtle, perceived flaws inherent in their own stated positions.

A compilation of *pro* and *con* arguments voiced in the role-playing debates in response to the resolution is presented below. Similar or linked arguments are grouped under subject categories.

Many of these points were made in the heat of open discussion and are not necessarily factual. Their inclusion here should not be interpreted as an endorsement by the NABC.

In order to be effective advocates for what we believe in, in order to readily defend our position, it is essential that we thoroughly appreciate all the nuances and complexities of the contrary view.

Arguments in Favor of the Resolution (pro-GM)	Arguments Opposed to the Resolution (anti-GM)
Environmental Concerns	
• GM products are embraced by farmers because of benefits, *i.e.*, increased efficiency, increased yields, decreased pesticide costs, improved quality of commodities. • Biotechnology can be used to produce food on marginal land, *i.e.*, dry areas, saline and acid soils; this is particularly important for developing countries.	• What aspect of quality has been improved for the consumer? It seems that only farmers and producers are benefiting. • So far, there have been no consumer benefits despite a lot of talk; all benefits are to US producers • Excess food is already produced in the US and EU. Land that is marginal should not be used.
• Growing GM crops means environmentally friendly reduction in pesticide usage on the farm. • Less impact on the environment, *e.g.*, less tillage required, less contamination of groundwater, less erosion of soil. • Reduced off-target drift = better relations with neighbors. • Extensive evaluation of Bt corn does not support initial findings of adverse impact on monarch butterflies. • Less exposure to pesticides, – benefits medical system, – better water quality. • Lessens negative impact on beneficial insects.	• GM crops may induce pesticide resistance in insects, which means we will need all the pesticides anyway. • Monarch butterflies illustrate a definite negative environmental impact.
• GM crops increase genetic diversity/ biodiversity.	• GM crops may decrease biodiversity. • Stronger drive towards monoculture.

Arguments in Favor of the Resolution (pro-GM)	Arguments Opposed to the Resolution (anti-GM)
Environmental Concerns (continued)	
• The GM process is precise—known genes and proteins. • Pollen-flow issue is being addressed to ensure pollen will not be able to reproduce. Organic growers may need to develop their own seed sources and testing procedures. • Data show reductions in use of environmental toxins. • Reduced energy (petrochemical) use.	• GM crops contaminate organic agriculture. • Organic farmers lose certification because of pollen drift. • No data are available showing environmental impacts. • Environmental pollution—superweeds, salmon, toxins.
• Genes used are already present in the environment. • New GM crops are being developed to prevent pollen drift / gene flow.	• Ecological concerns—gene transfer damage to wild species. • Gene drifting.
• Agribusiness is best equipped to scale-up research and development. • No other agricultural processes (e.g. the method of slaughtering animals) are labeled and neither should this process.	• Consumer choice must be preserved (GM ingredients should be labeled, traceable). • There is a danger of induced resistance in pests (threat to organic farming). • GM crops will lead to fundamental restructuring of global agriculture.
• GM crops can produce food on marginal lands (dry regions, saline and acid soils).	• Marginal lands should not be exploited.

Arguments in Favor of the Resolution (pro-GM)	Arguments Opposed to the Resolution (anti-GM)
US Regulations/Trust in Government	
• The process is as safe or safer than conventional crop improvement. • GM foods are scrutinized more rigorously than conventional foods. • GM technology has earned third-party endorsements (AMA, NAS, FDA, USDA, etc.).	• Has there been enough testing? Where is the scientific literature? Where is the third-party testing? • A neutral third party should do the testing.
• If a product is substantially equivalent, labeling has no point. To give total information on a label would be both confusing and counterproductive.	• Labeling should be mandatory. What is being hidden by companies who are reluctant to label? • The concept of substantial equivalence is inappropriate since GMOs by definition are not equivalent.
• Farmers are adversely affected by any requirement to segregate a crop—such would be an ill-advised regulation. • Legal liability is of great concern. • Safeguards are already in place to protect the environment and the consumer through the legal system. • GM is proven by 13+ years of testing. • US consumers do not want further regulations and restrictions. • There has been equivalent or greater testing than for non-GM food.	• Government has misinformed us in the past: mad cow and hoof and mouth diseases in Europe. Pre-market review has been voluntary only, not mandatory. • Segregate GM from other crops. • Poor public health history. • If the current approval system is supposedly effective, what happened with StarLink™? • Testing of all commodities should be required (and defined by law).
• There have been no public-health issues to date. • Extensive testing and regulation is done, even more than for most non-GM food products. • Vertical integration is an on-going economic process regardless of the science. • USDA requirements are adhered to.	• Trace-back-to-origin systems should be set in place. • Post-market surveillance should be required.

Arguments in Favor of the Resolution (pro-GM)	Arguments Opposed to the Resolution (anti-GM)
Health and Safety	
• Human health will be improved due to lower incidence and levels of toxins (including aflatoxins), carcinogens, and allergens	• Bt proteins are toxic to insects; how do we know that there will be no long-term effects on humans? • How do we know that there will be no changes that will elevate production of toxins?
• Dr. Pusztai's interpretations of data were found to be faulty by a review panel. • GM is far more precise than conventional breeding and selection. • Pharmaceuticals produced by GM methods are well accepted—why not food? • Higher quality, "cleaner," more uniform products; nutritional benefits. • Known allergens are not used. • Antibiotic markers are no longer used in GMO development. • GM with breeding will increase nutritional quality of food. • The Brazil-nut/soybean episode shows that industry takes the responsible self-regulating course when required.	• Arpad Pusztai's potato-feeding experiment shows how dangerous GM is. • Mark Lappe's soybean analysis paper shows GMOs have lower isoflavone content. • We have co-evolved with our food supply and GMOs introduce unnatural new proteins. • Antibiotic resistance markers may transform our cells or those of gut bacteria. • StarLink™ proves we cannot regulate these things. • We have no way of telling what will be an allergen. • The Brazil-nut protein in soybeans proves how dangerous the technology can be. • We cannot anticipate new health hazards that could arise from these unknown crops. • Safety is uncertain, especially long term.
• GM benefits the American consumer. Without it we could not get out-of-season produce. Free-trade channels are desirable. • Producers/farmers have an improved quality of life/efficiency.	• Threatens the way of life of small-farm communities. • Poor public health history (mad cow, hoof and mouth diseases in Europe).

Arguments in Favor of the Resolution (pro-GM)	Arguments Opposed to the Resolution (anti-GM)
Research Issues	
• Biotech offers more control of the product and its consequences. • There is an exact characterization of inserted genes. • Safety has been tested and proven. • Pleiotropic effects are tested in the laboratory and in field trials over 5–7 years.	• This is a new technology and we are dealing with living organisms. There may be unforeseen consequences. Science has not always been right, e.g. mad cow disease. • Not enough research has been conducted. • There have been no long-term studies.
• Delaying science will result in reduced capacity to meet future challenges.	• Pesticide resistance may build up over time. • No fixed protocols have been established. • There have been no studies in humans.
• GM is the quickest way to add value. • Academia was doing this research long before the large corporations had a profit stake. Corporate funding is necessary to finance university research.	• Corporate research information has not been available to the public. • Corporate profit trumps public health. • Biotech companies exert undue influence in setting public research agenda. • Data favoring biotech products have been produced by industry, not by unbiased scientists. • Data are not published in peer-reviewed journals; data are limited or lack substance; peer-review is biased; scientists are untrustworthy (especially in industry).

Arguments in Favor of the Resolution (pro-GM)	Arguments Opposed to the Resolution (anti-GM)
Moral and Ethical Issues	
• In the long term, more food can be produced from a relatively constant area of arable land to feed an increasing population. • The potential exists for a major contribution to alleviating world hunger. We cannot take the risk of not developing this technology. The impact has been small so far; products to decrease world hunger are still being developed. • Food choice is plentiful in the US and Europe, but not in many other parts of world, and biotech can help. • Most critics of GM are well fed, as are their children; they may feel differently if hungry, as are many in developing nations.	• GM is not needed to "feed the world." Why not control population? There is no clear-cut evidence of increased yields with GM crops. • Currently there is a global excess of food—the issue is one of distribution—golden rice is not an answer to world health / hunger.
• Hybrids and past and current farming practices have for years been based on manipulating Mother Nature.	• GM is against God and nature; a perversion of Mother Nature. • GM is immoral.
• Given the benefits of biotechnology it would be criminal not to progress and bring its advantages to our world.	• A moratorium should be established. • The precautionary principle should be followed; do not approve until certain.
• Religious and moral convictions should not be imposed.	• Religious and moral issues must be addressed.

Arguments in Favor of the Resolution (pro-GM)	Arguments Opposed to the Resolution (anti-GM)
General Considerations	
• Intellectual property rights and protection provides more incentive to enable products to be brought to market.	• Corporate power is driving the technology. • Terminator + Developing World damage from multinationals. • Domination / control by multinationals. • Profit-driven research funding. • Industry is buying credibility. • Focus is share holders, profits. • Industry donates only unprofitable technologies. • Public pressure is forcing transparency. • Industry is selectively transparent—GM-producing companies do not want us to know they make pesticides. • Biotech a conspiracy—ecompassing large companies and government agencies
• GM will benefit small-farm communities.	• Ordinary farmers do not see advantage; benefits accrue only to corporations. • Potential liability for farmers. • Threatens small-farm communities. • Hurts small family farms; local production is important—eat locally, shop daily.
• GM contributes to medical, industrial and environmental advances.	• Unforeseeable risk: plant it, cannot sell it. • Intellectual property issues—patenting life is wrong. • Decreased cultural / local identity. • GMOs are not needed. • Farmers will become serfs to large corporations.

PART III

SESSION I: LESSONS TO LEARN FROM

Agricultural Biotechnology: Savior or Scourge?

MICHAEL F. JACOBSON
Center for Science in the Public Interest
Washington, DC

I am grateful for the opportunity to participate in this important meeting. It comes at a time of great controversy over biotechnology, and I hope that the audience and speakers can identify some areas of agreement.

For those of you who are not familiar with the Center for Science in the Public Interest, it is a nonprofit consumer-advocacy organization that, since 1971, has focused on food safety and nutrition. Our activities have touched most Americans lives, because in 1990 we led the efforts to win passage of laws mandating the Nutrition Facts food label and a federal definition of "organically grown" foods. We are supported largely by the 850,000 subscribers to our *Nutrition Action Healthletter*, along with foundation grants. We do not accept funding from government or industry.

Though CSPI sometimes has been accused of being anti-everything in the world of food, from fettucine Alfredo to olestra to McDonald's french fries, we have a decidedly middle position on genetically engineered foods. We believe that, if used properly, engineered crops could greatly benefit farmers, consumers, and the environment. They hold the promise of increased yields, reduced use of pesticides, lower costs, and better nutrition. Indeed, some of those benefits already have been partly realized. But, if misused, biotech foods could cause great harm.

Biotechnology is reaching a crossroads, where public opposition may become so great that no farmer, food manufacturer, or retailer will want to market a food with biotech ingredients. The biotech industry, by and large, has insisted that genetically engineered foods are sufficiently regulated and perfectly safe. That posture simply is not flying in the age of StarLink™ corn, mad cow disease, and the Internet.

Critics are generating many questions about biotechnology, ranging from accusations of potential health and ecological catastrophes to monopolization of the seed industry by a few companies. Currently, genetically engineered crops benefit primarily the seed and chemical companies and farmers, not consumers. When benefits are enjoyed by one party, but possible risks are borne by another, it is a formula for suspicion. In such an environment, it behooves those who hope to realize the potential benefits of biotechnology to address valid concerns, debunk red herrings, and build long-term public confidence. One key step would be to establish strict rules to protect the environment and ensure safety and choice to consumers.

Before I address the concerns, let me emphasize that farmers, the environment, and environmentalists should draw some measure of satisfaction from existing benefits of genetically engineered crops and the absence of known health and environmental problems.

- The widespread use of Bt cotton has dramatically reduced the use of organophosphate pesticides. According to the National Center for Food and Agriculture Policy, Bt cotton in 1999 resulted in 2.7 million pounds less use of chemical insecticides and 15 million fewer applications of insecticides. Cotton production increased by 260 million pounds per year, and net revenues increased by an estimated $99 million. That is a tremendous boon to farmers and presumably to non-target species, including insects and the birds and other organisms that feed on them.

Bt cotton in 1999 resulted in 2.7 million pounds less use of chemical insecticides and 15 million fewer applications of insecticides.

- Herbicide-tolerant soybeans reduced weed-control costs by $216 million in 1999, and reduced herbicide applications by 19 million. Although biotech soybeans have led to a great increase in the use of glyphosate herbicides, those herbicides appear to be much safer than some that they replace. No-till farming, which herbicide-tolerant crops encourage, should reduce soil erosion.
- Bt corn saved an estimated 66 million bushels of corn from European corn borer in 1999. Also, Bt corn should have lower levels both of insect damage and of some mycotoxins.
- Genetically engineered papayas provide Hawaiian farmers an effective new means of coping with the papaya ringspot virus, which has been decimating crops.

Other crops could be providing similar benefits:

- Bt sweet corn and potatoes could dramatically reduce insecticide use.
- Apples resistant to fire-blight bacteria could benefit farmers in the Northeast.
- Herbicide-tolerant sugar beets could reduce soil erosion.

However, farmers and processors are unwilling to plant or accept those crops for fear of consumer backlash.

Herbicide-tolerant soybeans reduced weed-control costs by $216 million in 1999, and reduced herbicide applications by 19 million.

Safety Concerns

From the point of view of the *consumer*, the key question about biotech foods is, "Are they safe?" Many consumers are leery because they do not know what biotech foods are, and the term "genetically modified" sounds scary.

To date, of course, biotech foods have not caused any known health problems whatsoever. Though still in its infancy, biotechnology's record of safety is reassuring. To be honest, though, it probably would be impossible to identify many long-term problems, such as immunotoxicity, carcinogenicity, or neurotoxicity, with current testing procedures.

One of the obvious concerns is whether engineered foods might cause allergic reactions. Known allergens are easy to identify. However, if a protein to which people have had only limited exposure were introduced into foods, one could not state definitively that it would not cause any allergic reactions.

Another concern is that levels of naturally occurring toxins in plants might be increased. Again, known toxins are easy to assay. But it is not inconceivable that a genetically engineered food would display a novel toxicity, such as by activating a "silent" gene or unexpectedly altering a metabolic pathway. Finally, some scientists have speculated that there is a very small risk that transgenic foods could cause a catastrophe: anything from being carcinogenic to introducing prions causing something like Creutzfeldt-Jakob disease. While speculative, those concerns indicate the need for a rigorous, but not suffocating, regulatory scheme, including appropriate testing standards.

Ecological Concerns

While *consumers* may focus on *safety,* transgenic crops raise diverse environmental questions. Whether it is the effect of Bt corn on monarch butterflies and other non-target organisms, the spread of genetically engineered characteristics to wild relatives, or the development of pesticide resistance in insects or weeds, GM crops deserve the closest scrutiny. After all, the self-propagating nature of living organisms—be they fish or wheat—means that once a problem occurs, it might be uncontrollable. The United States Department of Agriculture (USDA) and the Environmental Protection Agency (EPA) are responsible for anticipating and preventing environmental problems caused by GM crops. But serious questions have been raised about the rigor of those agencies' scrutiny and judgment. For example, last year a committee of the National Academy of Sciences (NAS) identified numerous ways in which the system should be strengthened. And last March an EPA Science Advisory Panel concluded that data requirements for the effects of Bt corn on non-target insects were not complete, leading the EPA to ask companies for new studies.

The USDA recently established an Advisory Committee on Agricultural Biotechnology to provide independent advice on environmental concerns, and commissioned the NAS to conduct an ongoing review of its (USDA's) regulatory process. Those committees should help guide the USDA cautiously into the future and increase public confidence in agricultural biotechnology.

Regulation – Safety

Most Americans, I believe, are open to biotechnology, but want assurances that the foods are safe and that crops and other organisms will not adversely affect the environment. We need to upgrade the regulatory system to respond to these concerns.

The Food and Drug Administration (FDA) has long considered genetically engineered plants to be "substantially equivalent" to conventional varieties, relying upon a voluntary consultation process to address any safety concerns.

The Food and Drug Administration (FDA) has long considered genetically engineered plants to be "substantially equivalent" to conventional varieties, relying upon a voluntary consultation process to address any safety concerns. Although that process has not resulted in any health concerns, it invites criticism.

In contrast, the FDA has a mandatory, albeit secret, process for approving transgenic animals—such as genetically engineered fish

Although that process has not resulted in any health concerns, it invites criticism. After all, the process largely transpires behind closed doors and does not result in formal approval. In contrast, the FDA has a mandatory, albeit secret, process for approving transgenic animals—such as genetically engineered fish—and the EPA has a mandatory, relatively open, process for evaluating transgenic pest-protected plants, such as Bt corn. The USDA, too, has a relatively open process for considering whether new crops may adversely affect agriculture.

The FDA recently proposed a mandatory review process to replace its current voluntary system for evaluating GM crops. Importantly, the new process would ensure that all new food crops are scrutinized. Also, the new process would be open to public scrutiny, with most company documents being placed on the public record. However, because the FDA has not provided formal safety-testing guidelines, and because companies propose safety tests to the FDA, the process gives the appearance of being driven by industry's decisions. Moreover, the new review process still would not result in formal approval. Instead, the FDA would say, "We have no further questions." While that approach might not result in any safety questions, it would still invite the accurate criticism that transgenic crops are not formally approved in the United States, and that, unnecessarily, diminishes public confidence.

Because the FDA has been unwilling to argue that it has the authority to formally approve all biotech foods, Congress should pass a law to mandate that it does so. New legislation would distinguish transgenic organisms from existing categories, such as "generally recognized as safe" substances, incidental additives, or food additives. Last year, Congressman Dennis Kucinich and Senator Richard Durbin introduced different bills to establish a formal approval process. Those bills provide good starting points for debate. Passage of such legislation could reduce public controversy.

New legislation should require each proposed new GM crop or animal to be supported by a petition to the FDA. Importantly, such petitions would be public documents, enabling any concerned party to scrutinize the data and provide input to the agency. The end point would be the publication of a formal approval in the *Federal Register*. That notice would explain the agency's thinking and respond to any concerns submitted by outsiders to the agency.

Although food and seed companies support "mandatory consultations," currently they object to a formal approval process. They contend that the FDA could take years to make decisions. That problem might be soluble simply by requiring that a decision be made within a specified period of time. If necessary, user fees or ordinary appropriations could provide the FDA with adequate staffing to make timely decisions. Industry also fears that legislation on biotech approvals might be saddled with all sorts of amendments. Frankly, I fear the same thing: that industry would use the bill as a vehicle for achieving other goals. I would hope, though, that voluntary agreements and astute management of the bills would restrict the content to a mandatory approval process.

Representative Kucinich's bill incorporates several other sensible measures. It would ban common or severe allergens from biotech foods, phase out antibiotic-resistance marker genes, and have the NAS's Institute of Medicine evaluate FDA's system for evaluating biotech foods. One question that should be studied carefully, as the NAS recommended last year, is whether sub-chronic or chronic toxicity animal-feeding tests should be conducted on transgenic foods. New legislation also should fund research at the National Institutes of Health or the FDA to develop better means of predicting allergenicity.

The StarLink™ episode revealed two additional problems. First, farmers and seed producers apparently lack the ability to ensure that corn—or other crops—grown for feed will not appear in food. Hence, as Kraft Foods and others have recommended, the FDA and EPA should not approve biotech crops for animal feed if they are not also approved for human food. Second, the FDA and USDA lack the authority to recall products, engineered or not. Senators Tom Harkin and Byron Dorgan have introduced legislation to give those agencies recall authority, but that bill has not moved through Congress.

Those all are simple, sensible steps that the biotech and food-manufacturing industries should be able to accept and, indeed, to support.

The FDA and EPA should not approve biotech crops for animal feed if they are not also approved for human food.

REGULATION – LABELING

The second component of an improved regulatory scheme concerns the labeling of genetically engineered foods. Concerns about labeling range from those about allergies to ethics to the environment.

In response to environmental groups, the European Union, Australia and several other countries are requiring labeling of foods containing genetically engineered ingredients. The FDA says that it is not obligated to require foods containing biotech ingredients to state "Contains Genetically Engineered

Ingredients," or "GM," somewhere on the label. Instead, the FDA recently defined a *voluntary* labeling scheme that it believes will be useful to consumers. It has described situations in which terms like "does not contain genetically engineered ingredients" may be used on labels. Consumers concerned about GM foods would then have a choice. I hope that the FDA will anticipate future developments by providing guidance to ensure that labels claiming that a transgenic product offers benefits—such as "reduces the use of pesticides" or "increases nutritional value"—are honest. Overall, the FDA's labeling guidance represents a small improvement, but does not satisfy those who want mandatory labeling. And even the FDA admits that very few foods, other than those grown organically, will sprout labels.

Some critics hope that GM labeling will be the kiss of death for engineered foods and agricultural biotechnology. But it may be that the public is simply not going to have confidence in biotechnology if companies are not more open about their use of transgenic ingredients.

Some critics hope that GM labeling will be the kiss of death for engineered foods and agricultural biotechnology. But it may be that the public is simply not going to have confidence in biotechnology if companies are not more open about their use of transgenic ingredients. Indeed, the FDA's own focus-group research revealed intense feelings around the marketing of genetically engineered foods without special labeling.

To better understand the public's interest in biotech labeling and how consumers might react to it, CSPI recently commissioned a national telephone survey of about 1,000 American adults.

First, two questions found that 62% to 70% of people say they would like engineered foods to be labeled. Those percentages, of course, are similar to many previous surveys indicating fairly broad support for biotech labeling.

We wanted to get beyond that first question and understand attitudes about labeling in greater detail.

The survey found that as the amount of the engineered ingredients in a food decreased, so does the desire for labeling. If labeling were required, 61% of those surveyed said that a whole food, such as a tomato, should be labeled. If a major ingredient, such as the wheat in Wheaties, was engineered, 53% said that that should be labeled. The percentage favoring labeling dropped to 42% for a minor ingredient, such as corn starch in a frozen dinner and to 38% for a food

containing soy oil that does not contain any other engineered material. Thus, if labeling were required, well under half of people wanted labeling when only small amounts of, or no, genetically modified material was present.

One thing about surveys that ask whether people want more information is that people indicate a desire for just about any piece of information about food production. Thus, based on two questions in our survey, 76% wanted labels to disclose the spraying of pesticides, and 66% wanted information on genetic engineering. But 43% wanted label statements on foods grown with practices that cause soil erosion, and 40% wanted the use of hybrid corn to be disclosed. It could be that most Americans know little about food production and are suspicious of any process or term they do not understand. One may interpret our survey as indicating that 40%, not 0%, should be considered the baseline when asking people if they want something on labels about growing practices.

Another question gave people four choices and asked them which one they would add to food labels, if they could add just one. Almost twice as many people, 31%, wanted labeling for pesticide residues as genetic engineering, 17%. Considerably fewer people, 8%, wanted imported wheat to be labeled, and 7% wanted processing contaminants to be declared.

Several questions indicate that support for labeling is not as deep as appears at first glance. We asked people how much extra they would pay for their family's food to have labels declare that foods were genetically engineered. About 50% of the people whose top labeling priority was genetic engineering, or who said that engineered foods should be labeled, would pay either nothing or only $10 per year for that labeling. One in four respondents said they would pay $50 per year or more for labeling. A small group of consumers, 12%, would pay $250 a year or more to get labeling; those are the hard-core proponents of labeling. Thus, although most consumers may desire labeling of GM foods, relatively few appear willing to pay additional costs for that information. Of course, some people might want labeling, but feel that someone else — namely the food and seed industries — should bear the costs.

To better inform the public and decision makers, an agency like USDA's Economic Research Service should estimate the costs of different forms of GM labeling.

We next explored how people interpret label statements. About one-third of respondents believed that foods labeled “contains genetically engineered ingredients” are less safe or not as good as foods without labels. There was little difference if the term “biotechnology” was used instead of “genetically engineered.” Conversely, about one-third of respondents believed that foods labeled “does *not* contain genetically engineered ingredients” are better than foods without such a label. Thus, if, as appears to be the case, there is no difference in safety or quality between conventional and GM crops, many consumers apparently would be deceived by labels that state “genetically engineered” or “not genetically engineered.”

Those perceptions about safety, quality, or other matters carried over into buying behavior. Only about 40% of respondents said they would buy foods made with genetically engineered ingredients. It did not matter whether the foods were transgenic fruits and vegetables or processed foods that contained only minor ingredients that came from engineered crops. Clearly, considering the public's current views, no food manufacturer would market foods containing engineered ingredients if they had to put a statement on the label.

We also asked people if they would buy foods bearing other labels. Interestingly, while only 43% of the respondents said they would buy foods labeled "genetically engineered," about the same percentage said they would buy foods labeled as having been sprayed with pesticides, treated with plant hormones, or made from hybrid corn. Apparently, people have apprehensions about any unusual and suspicious-sounding statements on labels.

One thing our survey did not examine is the reaction to different kinds of labels. We left to the imagination of the respondents the prominence of the GM label on food packages. It would be worth exploring how differently people might perceive the term "contains genetically engineered ingredients" on the front of the package, the term "genetically engineered" embedded within the ingredient statement, and a small "GM" symbol somewhere on the front of the package. Our only finding in this area was that when GM labels stated "reduces pesticide use," the percentage of people who thought those foods were safer jumped from 7% to 21%. Still, about 30% of people continued to believe that the GM food was not as safe as other foods that might have been sprayed with pesticides.

If foods are to be labeled, Congress should give the FDA a clear mandate, because the FDA will not require such labeling on its own. In any case, though, whether label statements are mandatory or voluntary, such statements should not lead people to think that a food made *with* genetically engineered ingredients is inferior, or that a food made *without* genetically engineered ingredients is superior.

Labeling is a "catch-22" problem for industry. As long as engineered foods are not labeled, people will contend that the public's right to know is being short-changed and will criticize government and companies for hiding that information. If engineered foods were labeled, many people would not buy them, and so companies, not wanting to lose sales, will not market engineered foods with a label. Considering how negatively the public views the term "genetically engineered," I think that industry needs to be candid with consumers about the benefits and pitfalls of the technology. The food industry could lessen suspicions if it mounted a full-scale advertising campaign depicting hundreds of packaged and restaurant foods that contain ingredients from engineered crops. Those ads could explain the apparent safety and the environmental benefits, while acknowledging that safety can never be assured with absolute certainty.

Regulation – Environment

Probably the most likely problems concerning biotech products pertain not to consumer health but to ecological disruption. One major concern is that while the EPA stipulates that certain crops, such as Bt corn, be accompanied by refuges of conventional crops, no agency polices and enforces such critically important requirements. That must be corrected. Also, the NAS report on pest-protected plants made numerous specific recommendations, ranging from regulating viral coat proteins under the Federal Insecticide Fungicide and Rodenticide Act (FIFRA) to improving inter-agency coordination. All of those recommendations should be implemented.

The USDA is charged with ensuring that new crops do not become pests. But experience suggests that environmental reviews by the Animal and Plant Health Inspection Service (APHIS) have underestimated the potential for significant problems resulting from Bt corn's impacts on lepidopterans, from the weediness potential of herbicide-tolerant canola and virus-protected squash, and from the need for pest-resistance-management planning for Bt crops.

Despite the millions of acres planted with GM crops, APHIS has never prepared a full environmental impact statement (EIS) for any of the GM crops that it has approved. Full EISs would have led to better analysis and mitigation for any remaining questions.

To summarize: now is the time, while agricultural biotechnology is still young, for Congress and regulatory agencies to create the framework that would maximize the safe use of these products, bolster public confidence in them, and allow all of humankind to benefit from their enormous potential.

Other Concerns about Agricultural Biotechnology

Aside from effects on the public's health and the ecosystem, agricultural biotechnology raises many other concerns. While it is impossible to explore each of these matters in detail, I will touch on various measures that would boost public confidence and help ensure that biotechnology is used wisely and productively.

Underlying many of the attacks on biotechnology is the question of whether a handful of giant companies will soon control the world's major crops and the technology itself. The briar patch of patent rights that affects Golden Rice exemplifies the extent to which private industry (and, in some cases, universities) has gained control over the technology. Also, it is clear that commercial interests focus on the largest and most profitable crops in the developed world—and then only on applications that are profitable—rather than those the primary purpose of which is to protect the environment.

To bring the greatest benefits to the most people, it is essential that the industrial nations sponsor more basic and applied research to ensure that new methods and products are in the public domain. Government-sponsored research also should address the needs of small farmers, consumers, and the

To bring the greatest benefits to the most people, it is essential that the industrial nations sponsor more basic and applied research to ensure that new methods and products are in the public domain.

environment, as well as the so-called minor crops, which may not be so minor to the people who grow and eat them, whether in the industrial or developing world. To ease the regulatory-cost burden for small businesses, universities, and researchers, government could waive certain fees. For example, the USDA's current IR-4 program, which helps register certain low-profit uses of pesticides, could be expanded to support "orphan" biotech applications. Furthermore, we need to expand aid programs to train scientists in developing countries, fund research stations, and help those nations build a regulatory structure to anticipate and prevent possible problems. In some of those countries, the need for careful regulation is particularly acute, because ancestral cultivars grow side by side with commercial varieties, making it difficult to prevent gene pollution of the traditional genotypes.

Organic farmers in the United States have justifiable fears that pollen from biotech farms will pollute their crops, possibly rendering them non-organic under the law. If an organic farmer saved his or her seed from year to year, it is easy to see how even 1% contamination per year by neighboring biotech crops would soon significantly decrease the purity of the seed. While the definition of "organic" does not specify allowable contamination levels, anything over a few percent would certainly begin to jeopardize the premium that organic food commands. Organic farmers also fear that insects will develop resistance to Bt toxin. While that concern was always present due to the use of that natural insecticide by organic farmers themselves, the widespread planting of Bt corn and cotton increases tremendously the possibility that pests will become resistant. I do not pretend to have the solutions to these tough problems, but they deserve careful attention. Buffer zones, compensation by seed companies, and other measures should be developed to protect the integrity of organic foods, without raising their prices even further.

BEYOND BIOTECHNOLOGY

Let me conclude by noting that many critics of biotechnology are opposed to any and all of its applications, apparently regardless of its benefits. Advocates should not fall into a similar trap of thinking that biotechnology is the answer, regardless of the question. Genetic engineering is not the only tool in the agricultural toolbox. Conventional breeding and non-transgenic applications

Many critics of biotechnology are opposed to any and all of its applications, apparently regardless of its benefits. Advocates should not fall into a similar trap of thinking that biotechnology is the answer, regardless of the question. Genetic engineering is not the only tool in the agricultural toolbox.

of biotechnology offer tremendous opportunity. We should also note that production agriculture, biotech or not, suffers from real problems. Many farmers are losing money and declaring bankruptcy. Many more would, were it not for huge government bailouts. Both advocates and critics of genetic engineering should recognize that the wisest course of action would be simultaneously to follow several paths to satisfy our food needs, making use of genetic engineering, conventional methods, and organic or sustainable approaches. Many farmers are discovering that sustainable agriculture, including organic farming—based on smaller farms, diverse crops, and natural means of pest control—may be just as profitable, or even more so. Their input costs may be lower, while their crops may command premium prices in the marketplace.

There are no big chemical or seed companies or government subsidies to support this approach to agriculture. Hence, my final recommendation would be for agricultural schools, the USDA, and state departments of agriculture to conduct more research and provide greater technical and financial assistance to farmers who want to get off the agribusiness treadmill.

Q: You mentioned the organic farmers and risks of contaminations. They have indicated only 100% organic, or zero percent contamination, is acceptable. Is it reasonable to think that anyone in today's agricultural environment in the United States can produce soybeans that are zero percent transgenic?

A: It may be possible in some areas of the country to produce 100% non-transgenic soy, but organic food does not have to be 100% organic. The Food and Drug Administration and the United States Department of Agriculture have called for an identity preservation system, with affidavits and so on, indicating that the intent of the farmer and the food system is to keep these products as pure as possible, but the government is not insisting that they be 100% organic with regard to pesticides or transgenics or other contamination. Food will not be declared non-organic if one kernel of Bt corn is in the crop.

Q: To what degree would you say previous interactions of consumers . . . [inaudible]

A: I think the bigger factors in consumer perceptions are the very effective criticisms by the opponents, who have created symbols that are very easy to understand: a dead monarch butterfly, for instance, or the term *frankenfood*, which are powerful means of communication. The advocates of biotechnology have not developed equally effective symbols—"fewer farmers poisoned by pesticides" for example. Proponents have not waged an effective campaign to educate the public. It amazes me that so few are talking about the benefits from reducing insecticide use, or herbicide use. The critics cannot bear to acknowledge that there are some benefits from biotech foods, even though these people are critical of pesticide use—they've been campaigning against them since Rachel Carson was around. So, the critics aren't talking about it, and, on the other hand, the companies can't talk about it because some of them make pesticides. For these companies, it is not a plus for pesticide sales to go through the floor. And the trade associations, which represent industry's lowest common denominator, cannot talk about these benefits. Somebody must contribute to the debate facts that demonstrate benefits to the public at large, maybe not as consumers, but out of concern for the environment. This is needed in Europe also. The advocates of biotechnology, the companies, the professors, consumer groups, *etc*., need to go to Europe and talk about how Europeans' insistence on non-biotech crops means that the American ecosystem will be more polluted, that more farmers will be harmed, and that more non-target insects and other species will be killed.

Q: With reference to your remarks on sustainability, were you implying that there is no role for genetic engineering in sustainable agriculture?

A: No. Genetic engineering can contribute to sustainability. Twenty years from now, organic farmers may be clamoring for genetically engineered crops that are beneficial and safe, and fit into their systems; they are not inconsistent.

Q: A key problem in Europe is that organic agriculture is striving for 100% zero tolerance of genetic engineering. Don't you think that organic agriculture has to come to terms with the fact that genetic engineering is part of agriculture, therefore they have to find a way to accommodate a threshold as they are doing for pesticides and herbicides?

A: They don't have to. If you are against genetic engineering, you'll want zero tolerance. It's a political decision. In the United States, a decision has been made that the test for organically grown foods will not be chemical; instead, it will be a paper trail. The government has not indicated a percentage, neither 0.1% nor 5%. The assumption is that it is a small fraction, and court cases may be needed at some point to decide what the percentage will be. The government has said *minimal* contamination—a little is okay.

Q: Something we have learned in the food industry is that you can sell an advantage that is directly linked to the product, but it is difficult to sell advantages that are far upstream in the process. You mentioned that the biotech industry has failed to draw attention to decreased pesticide use. In my opinion, even if they produce pesticides *and* GM crops that are resistant to these pesticides, if the biotech industry is unable or unwilling to articulate these advantages it will be extremely difficult to change the minds of the consumer.

A: Yes, it is pathetic that the industry itself can't do it. It could be that's life and we will not have genetically engineered foods for a period of years. The biotech industry needs to wake up. Companies like Monsanto that don't market most chemicals—obviously they market Roundup—that are adversely affected, need to speak out, and maybe the academic community and regulators need to talk to them and try to knock some sense into their heads. But ultimately, the technology may be lost for some years, or its use will be restricted to feed grains or fiber crops, like cotton, that don't enter the food chain.

Q: Does the CSPI provide informational hand-outs or brochures on educating the public on issues such as labeling?

A: We are just beginning to do this. We have had a couple of articles in our newsletter, the *Nutrition Action Healthletter*, which reaches 800,000 people, and we have had a couple of op-ed articles in the *Wall Street Journal* and other newspapers. We are beginning to reach out to the public via the usual Website, but it has to be much bigger than CSPI alone. We are hoping to serve as a nucleus around which groups that have a reasonable attitude may coalesce and call for sensible regulation of genetically engineered crops, portraying them neither as evil nor as a panacea. The big money lies with the food industry and the seed and chemical companies, and any mass-media efforts must come from them. If they are unwilling to mount a significant effort, they may see their market shrivel. The academic community could speak out more clearly, particularly in regard to calls for a better regulatory system. The public has had sufficient reassurances from professors who consult for the biotech companies and are less than totally believable—but they would have greater credibility if they called for tighter regulatory controls. Especially people at the University of Illinois because Senator Durban is very influential and very sensible.

Frames for Public Discourse on Biotechnology

NAPOLEON K. JUANILLO, JR.
University of Illinois
Urbana, IL

In the past five years, science-based food-safety issues have been a staple of daily news in the United States as well as in other parts of the world. Developing news on mad cow and foot-and-mouth diseases from Europe, furor over golden rice in Southeast Asia, and the continuing coverage of the risks and benefits of agricultural biotechnology have vigorously put science and the scientist in the public arena. As the lenses of the public are trained increasingly on science and the scientist, it becomes inevitable, then, for the scientist to also have the public very much in mind.

In the evolving interaction involving the public, the mass media, and scientists, it is reasonable to expect some convergence in the discourse on biotechnology. However, what we have witnessed so far seems to show increasing divergence. Although public-opinion studies in the United States do not exhibit the anti-biotechnology phenomenon that we hear about, the movement against biotechnology has certainly gained momentum in other parts of the world. This is particularly true in Europe and parts of Asia, where public opinion about biotechnology has been unfavorable and public suspicions of GMOs and institutional regulatory agencies and industry have remained unabated.

Indeed, we would not be here today if it were not for the intriguing question as to why agricultural biotechnology has become a lightning rod for conflicting public discourses. Although I am not a scientist and can comment only from within the limits of my training and scholarly reflections, I would like to proffer some insights that relate to the communication dimension of this phenomenon. In reexamining the divergent opinions expressed in public discourses over biotechnology, I thought it best to go back to the basic question: Who are the actors and from what contextual frames do they see agricultural biotechnology as they further their agendas in the public sphere?

Clearly the actors involved are scientists, the mass media, and involved publics. It also is obvious that each of these actors brings to the discourse a way of knowing and presenting truth and knowledge, a peculiar rhetorical and epistemological style, and a set of values and meanings that cannot be removed from history and immediate experiences. Whether or not they are, in our view, protagonists or antagonists in the biotech debate would also depend on the frame that we ourselves use in examining the unfolding events of agricultural biotechnology.

The Scientific Frame and the Transformation of Scientific Discourse

In order to understand the manner of scientific discourse or talk, a look back in history might help. As we all know, the Scientific Revolution was characterized by a denunciation of scholasticism and the use of rhetoric in investigating nature. In order to dissociate itself from the moralizing and personalizing types of discourse, science had to seek other ways of presenting information. The imperative to have a distinctive discourse for science was particularly underscored in Thomas Sprat's History of the Royal Society, which admonished its members to separate the knowledge of Nature from the colors of rhetoric, the devices of fancy, or the delightful deceit of fables. Robert Hooke, in his draft preamble to the original statutes of the Royal Society of London, specifically argued that scientists should have nothing to do with "Rhetoric." During a scientific congress in Italy in 1839, Grand Duke Leopold II even remarked that one of the forbidden topics would be "eloquence." These admonitions reflected the need to have a scientific discourse that was characterized by logic and analysis, the direct evidence of the phenomena, the results of observations, stripped of all charms of fancy. In this context, scientists were conduits through which nature spoke directly, across the great divide between the independent, outer world of phenomena and the subjective, inner world of the observer (Gross, 1990; Fahnestock, 1998).

These distinctive marks of scientific discourse continue to be evident in contemporary science. Then, as now, the imperative has always been for a close, clinical, naked, natural way of speaking, almost mathematical plainness. It reflects both the values and social structure of science, which is entrenched in the tradition of peer review and careful evaluation and scrutiny (Martin and Veel, 1998; Priest, 1999). It implies a degree of separation between science and society, with the former as the fountainhead of all new empirical knowledge. The autonomy of science was seldom contested. Knowledge, per se, is devoid of ethical content or moral value. It is the society, at large, that deems as good or bad (or both) the uses of knowledge and understanding, and even pure information, depending on the social, historical, and cultural contexts, and on the prevailing human and social values of the times (Brown, 1998).

Thus, when modern scientists communicate, we note cautious attempts to

establish the validity of the observations they report, emphasis on methodology, and importance given to tables, figures, photographs, and all other representations that can solidify the claim for the physical evidence generated. It is a type of discourse that can be characterized as "forensic" or "empiricist" in that it is largely based from observable characteristics of the natural world, aided by actuarial, toxicological, epidemiological, or probabilistic risk analyses and risk assessment. Using this rhetorical style, scientists simply restate the results of scientific research and suggest that risk can be calculated with precision. To deviate from this process is to negate the epistemological underpinnings and moorings of the scientific enterprise. When scientists communicate with their peers through papers, reports, or conferences, they reaffirm this built-in ethos of empiricism and try to hold back from any celebratory discussion of the significance or relevance of the work. The audience is left to infer and spell out the relevance of the study for a particular context (Sera and Shea, 1991; Priest, 1999).

But what happens when scientists shift to another type of discourse? The problem, I believe, begins when the scientific discourse slides from the forensic or empiricist style to what I would call the "celebratory" style. Communicating scientific reports and findings in ways that would make sense to the larger, non-scientific (lay) audience requires that the scientific information be adjusted to meet the lay audience's already held values and assumptions. This celebratory scientific discourse veers towards explicating the value and significance of scientific discoveries for lay audiences. It focuses on the breakthroughs, advances, contributions, applications, and benefits of scientific discoveries. It tries to contextualize science. The increasing importance of "context" shifts the discourse of science from the more traditional, established scientific search for truth to the more pragmatic discourse of "science that works." Indeed, there is a change from a discourse of methods and processes to a discourse that gives a final answer (Fahnestock, 1999).

In the case of agricultural biotechnology, celebratory scientific discourses may extrapolate, for example, the social benefits of biotechnology in terms of

---

It can be argued that, in the era of three-second sound bytes and diminishing attention span of media audiences, such creative catch-phrases that herald scientific accomplishments and potential social benefits may just be the proper counterpoint to other equally mind-grabbing sound bytes such as "frankenfood" and "terminator genes."

---

solving world hunger and even poverty in developing countries. The term "golden rice" for the genetically modified rice grain that contains beta-carotene is an example of a celebratory connotation for science. One scientific organization is even more effusive by referring to the so-called "golden rice" as the "grain of hope." It can be argued that, in the era of three-second sound bytes and diminishing attention span of media audiences, such creative catch-phrases that herald scientific accomplishments and potential social benefits may just be the proper counterpoint to other equally mind-grabbing sound bytes such as "frankenfood" and "terminator genes." Perhaps, scientists should fight fire with fire. While this strategy may be convenient, what the public gets at the end of the day, however, is simply a clash of sound bytes and more confusion.

Ironically, in an effort to make scientific discoveries relevant and appealing to the lay audience, celebratory scientific discourse all but foregoes some of the exacting standards of empiricism that have gained respect for science and entrenched its institutional role in society. Thus, it has been noted that celebratory scientific discourses tend to pay less attention to caveats, contradictory evidence, and qualifications that are highlighted in forensic or empiricist discourses. By downplaying scientific uncertainty, it alludes to greater certainty of scientific results for public consumption (Brown, 1998).

However, as it inevitably moves closer towards the arena of debate over what constitutes the common good and what is socially beneficial, it opens itself up also to a wide range of questions engendered by a different set of frames of public discourse for which science may not have the answer.

The Lay Audience's Frame: Moral and Societal Meanings and the Demands for Certainty

In my opinion, the lay audience's contention over biotechnology is neither about the science *per se* nor the content of forensic-empiricist discourses on biotechnology. For how then can we explain continuing public expectations for definitive answers or their needs for certainty, from science, even if these are rather unrealistic demands? These expectations could only suggest that, in the eyes of the public, science is still a repository of answers to many of the problems that beset the human condition. I would like to offer an analogy, despite its obvious limitation. This relationship between scientists and the public is almost akin to the principle of the separation between church and state. The church is respected as a purveyor of profound reflections on matters of morality, ethics, and conscience. The public expects that. But it is altogether a different discourse if the church dictates to the state as to what is moral and ethical. It weakens the state.

Hence, in the public discourse of biotechnology, conflict arises when science begins to be perceived as precluding public judgments and playing a decisive role in setting directions, policies, and regulations on food production and

food-safety standards. There is evidence that negative public reaction to agricultural biotechnology is driven to some extent by uneasiness over regulatory and risk-management policies that are solely based on technical risk analyses and risk assessment. This process is seen as disenfranchising other discourses that embody particular values and meanings *vis-à-vis* biotechnology. In the eyes of the public, it weakens the democratic nature of the public sphere that is supposed to engage a wide spectrum of participants and discourses. The conflict may very well be about the process of envisioning the common good and the best way to attain it (Gilbert and Mulkay, 1984; Webber, 1990; Gregory and Miller, 1998).

Scientific assertions evidently have a rightful niche in the public sphere. Celebratory scientific discourses on the wonders and socio-economic benefits of biotechnology have, in fact, been used as a rhetorical tool in several marketing or public information campaigns. In a functioning public sphere, however, these scientific claims must be evaluated side by side with other assertions, each carrying a frame of meanings, priorities, and values. This may be the reason why we do not see a blanket rejection of biotechnology. There is, in fact, disparity in public choices and levels of support for biotechnology. Public-opinion surveys indicate more support for the use of biotechnology for medical or pharmaceutical purposes than for the use of biotechnology in the production of food.

What, then, are these frames of meanings and values that inform non-scientific or lay discourses of biotechnology? These frames pertain to (a) ethics and morality, (b) control, (c) fairness, (d) familiarity, and (e) trust in institutions that regulate biotechnology. These frames are essentially reflective of Professor Peter Sandman's categorization of the more than twenty factors that influence public perceptions and opinions about risk-related issues. Using some of these categories, let me outline the typical arguments that characterize lay discourses of biotechnology (Juanillo, 2001).

Ethics and Morality Lay discourses tend to liberally equate “ethics” with “moral concerns.” Hence, if the application of a technology and related instances is unethical, it is also consequently considered morally wrong.

Public support for a technology is largely contingent on its perceived moral acceptability. Studies indicate that moral acceptability is a strong predictor of support for biotechnology and that moral concerns outweigh questions of risk and utility. The emphasis on ethics has even swayed institutional structures. In France, forums on ethics in biotechnology have been institutionalized with the creation of National Consultative Ethics Committee (de Cheveigné *et al*., 1999).

In general, lay discourses about the ethics and morality of biotechnology are informed by naturalistic or ecocentric worldviews, which see humans as only a part of nature. They manifest deeply held existential ideas about humankind and our relationship with nature. Fundamental to the ethical-moral question of

biotechnology is the guiding principle among many that nature is pure, and "all that is natural is valuable and good in itself." Thus, an action is right "when it tends to preserve the integrity, stability, and beauty of the biotic community (and) … wrong when it tends otherwise (MacLean, 1995). Hence, biotechnology is intrinsically wrong because it is seen as tampering with nature and as contrary to the very essence of humanity and its position in nature.

This particular discourse on biotechnology becomes even more complex when framed in a religious perspective. "Playing God" has been a familiar accusation against biotechnology and a basis for not a few impassioned public objections.

Interestingly, however, nationwide surveys conducted in Austria, the United Kingdom, Australia, Germany, Japan, and the Netherlands generally show less ethical opposition to genetic engineering for medical, pharmaceutical, or therapeutic applications than to applications in food production and agriculture. Genetic testing and medicines are deemed useful, morally acceptable, and to be encouraged, but genetic manipulation of food crops and animals is considered morally unacceptable.

Control Perceived loss of control over the effects of biotechnology on human health and the environment has been a recurring theme. For example, biotechnology opponents cite the threat to the independence of small farmers and the consumers' right to know and choose. People ask how broad public interests can be served in light of the growing concentration of ownership of food resources in a handful of multinational companies, particularly their control over key aspects of food growth, production, and marketing. There are concerns over the move toward agricultural research being predominantly influenced and funded by the very companies that stand to benefit most from genetically modified crop technology.

There is widespread perception that the genetic engineering industry seeks to industrialize agriculture even further and to intensify farmers' dependence upon industrial inputs abetted by a system of intellectual property rights, which legally inhibits the rights of farmers to reproduce, share, and replant seeds (Altieri, 1999).

Opponents also express fears about similar effects of agricultural biotechnology in developing countries, opening up the debate once more on the dependency that technology creates on the research and manufacturing capacities of developed economies. They believe that agricultural biotechnology will exacerbate the marginalization of small and resource-poor farmers since the technology is under corporate control, protected by patents, expensive, and inappropriate to the needs and circumstances of indigenous people. There is a perceived threat of total "corporatization" of farming, of unfairly burdening the farmers of developing countries who would become dependent on corporate genetically engineered seeds, despite being unable to afford them (Altieri, 1999).

Fairness Public debates over genetically modified foods have also centered on the technology's role in exacerbating social inequities. Concerned groups both in developed and in developing societies, for example, see current intellectual property rights as devices for perpetuating, rather than alleviating, entrenched discrepancies between rich and poor countries (Jasanoff, 1999).

Non-government organizations also have decried the limited flow of information and resulting lack of transparency as a result of the patent system in developed countries. Existing patent systems allow biotechnology industries to protect the product as well as the process, and therefore to limit the flow of technical information. Procedures and policies have yet to be established in order to promote access to these technologies. As a consequence, the public perceives that the whole biotechnology business is shrouded in secrecy, conjuring up images of technology as an instrument of social control.

Stringent regulations in developed countries on the release of genetically modified organisms or their products also are seen as making developing countries particularly vulnerable to uncontained on-site applications of biotechnology as these countries do not yet have the necessary regulatory policies. Current guidelines governing the release of genetically modified organisms do not include provisions governing the testing and application of organisms in other countries, particularly in the developing world. This situation provides opportunity for the biotechnology industry to test new products or locate their production facilities in developing countries that are ill-prepared to respond due to the lack of national safety policies, effective regulatory mechanisms, technical know-how, and institutional accountability.

The perception that developing countries are being “exploited” by companies who profit from the use of indigenous biological resources has triggered anti-biopiracy awareness campaigns by non-government organizations worldwide. There are serious concerns that these companies are being granted patents for products and technologies that make use of these indigenous genetic materials, plants, and other biological resources (Altieri, 1999).

Voluntariness An exposure to risk that is perceived as involuntary is regarded as more threatening than when an individual has a choice over personal exposure (Frewer *et al*., 1997). Consumer food choices are informed by the general feeling of well-being and satisfaction associated with products that have been chosen voluntarily, guided in part by an array of cultural, ethnic, and religious motivations.

The negative attitude of consumers towards biotechnology products appears to emanate from the perception that food and dietary risks are personal choices and ought not to be imposed on them by corporations. Much of the opposition revolves around upholding the consumer's autonomy and right to be informed through mandatory labeling and disclosure of any salient nutritional differences or new production methods in foods. In the United States, public-opinion surveys continue to demonstrate that consumers want labeling. A Gallup poll

conducted in September, 1999, showed that even though a bare majority of Americans believe that biotech foods are safe, most are willing to pay more to have labels that distinguish between gene-altered food and conventional produce. Sixty-eight percent of the respondents said they would pay more for labeled foods whereas 29% would not.

Moreover, as a reaction to this perceived threat, Europe and a growing number of developing countries have proposed a Biosafety Protocol that would require exporters of "living modified organisms" to notify the importing nation in advance, giving that nation a chance to reject the shipment. Agricultural commodities would be included because they contain seeds that can be presumably planted or can escape into the environment.

Familiarity and Tradition Agriculture has been closely associated with land-based farming where small communities have cultivated crops and domesticated animals for consumption and commerce. In the United States, powerful images of agriculture and the virtues of harmonious agrarian life persist even as the modern farm has lost much of its folk character. The village and the countryside are still perceived as the stronghold of primal American values: a sense of human values, neighborliness, respect for family, moral stewardship of the land, and a bastion of democracy and religion.

Opposition to the application of biotechnology in food production and agriculture emanates partly from the belief that it destabilizes the firmly rooted cultural archetypes and the deep symbolism associated with agrarian culture. Many environmental and sustainable agriculture groups view transgenic food as a symbol of the assault on traditional sources of food. Decreasing familiarity with their food and its origin and composition engenders such anxiety. The benefits of using biotechnology on food and crops seem far-fetched and superfluous, bear no immediate impact on individual well-being, and lack personal relevance.

Trust and Credibility Central to the public discourse on the risks and benefits of biotechnology is the issue of trust and perceived credibility of societal institutions such as regulatory agencies, life-science companies, and private research organizations. Communication between the public and proponents of biotechnology breaks down, perhaps irreparably, when the public perceives that the proponents are not telling the truth about the risks of biotechnology or are not sufficiently prepared to handle the potential risks of the technology. Public expectations about the competence of societal institutions involved in biotechnology are often based on the institutional track record or on the basis of how these institutions have handled food-related crises in the past.

The level of public trust in institutions and sources of information and how the public perceives risk work in tandem. This ongoing public suspicion of self-interest mars the relationship between the public and the governmental regulatory agencies and private food companies in debates over the risks and benefits of biotechnology. As public trust in institutions declines, the public

perceives the hazards of biotechnology to be greater, and public trust in advocacy groups increases.

The Eurobarometer surveys conducted by the European Commission in 1996 on public perceptions of biotechnology show that public authorities, administrative institutions, and industry are least trusted to tell the truth about biotechnology, and are perceived to be least reliable to regulate biotechnology. Non-government entities such as consumer organizations and environmental groups are most widely trusted, followed by school- and university-based experts. Trust, however, is issue-specific. Those in the medical profession, for example, are most widely trusted for introducing genes into animals to produce organs for human transplants. There also is more trust in the providers of biotechnologies for medicinal or therapeutic use than in those involved in biotechnologies for food production (Durant *et al.*, 1998).

A study I conducted in Southeast Asia (the Philippines, Singapore, and Thailand) on public perceptions of food safety manifests similar trends. Results of the survey show that life-science and food companies and government regulatory agencies rank lowest as trusted sources of information on food-related risks including biotechnology. University scientists rank first in all three countries, followed closely by non-government organizations such as consumer-advocacy and environmental groups and the mass media. Life-science and food companies and government regulatory agencies are perceived as being most biased in releasing information and most likely to withhold information on food-related risks. Moreover, the public perceives university scientists to be much more concerned about public health and safety with regard to biotechnology issues than are government agencies or life-science and food companies.

The Mass Media Discourse: Focusing on the Frames that Sell

Turning now to the mediator of scientific and lay discourses on biotechnology, I believe that there is no doubt about the critical role of the mass media. Studies have pointed out the possible role of the mass media as influencing the rise and fall of social issues in the public agenda. Whether rejected, accepted, or modified, the comments by definers of scientific issues in news accounts have become points of departure for personal conversations. The lay public's understanding of science and technology issues and its evaluation of technological risks stem more from a reliance on a broader, more popular vocabulary of risks and benefits provided by the mass media than on the traditional risk analysis and assessments given by experts. Risks do not just emerge as issues for the public according to their intrinsic importance, but rather in interaction with social processes such as the manner by which the mass media frame, construct, or define risks. Media effects are manifested especially in issues that lie outside the individual's personal experience, and for which the mass media are the only frames of reference.

Do reports in the popular media reflect scientific discourses or lay discourses? Tentative findings from my content analysis of the *New York Times* for the period 1998 through 2000 show that nearly 30% of the content is devoted to scientific discourses, in both celebratory and forensic styles. Evidently, much of the coverage focused on social dimensions of agricultural biotechnology, particularly on issues pertaining to control and fairness, trust and credibility, and voluntariness. Lesser coverage was devoted to issues of tradition and familiarity and ethics and morals.

REFERENCES

Altieri M (1999) The myths of agricultural biotechnology: Some ethical questions. Ethics and Biotechnology: An Agro Ecological Perspective. http://www.cnr.berkeley.edu.

Brown R (1998) Toward a Democratic Science. New Haven: Yale University Press.

de Cheveigné S *et al.* (1998) Biotechnology in France, in Biotechnology in the Public Sphere: a European Sourcebook (Durant J *et al*. eds) 51–62. London: The Science Museum.

Durant J *et al*. (eds) (1998) Biotechnology in the Public Sphere: a European Sourcebook. London: The Science Museum. ISBN: 1-900747-09X

Fahnestock J (1998) Accommodating Science. London: Sage Publications.

Fahnestock J (1999) Rhetorical Figures in Science. Oxford: Oxford University Press.

Frewer L *et al*. (1997). Public concerns in the United Kingdom about general and specific applications of genetic engineering: Risks, benefits, and ethics. Science, Technology, and Human Values 22 98–124.

Gilbert GN Mulkay M (1984) Opening Pandora's Box: A Sociological Analysis of Scientists' Discourse. Cambridge: Cambridge University Press.

Gregory J Miller S (1998) Science in Public. Cambridge, MA: Perseus Publishing.

Gross A (1990) The Rhetoric of Science. Cambridge, MA: Harvard University Press.

Jasanoff S (1999) Learning from crisis: How (not) to read the GM food controversy. Paper presented at the International Conference on Biotechnology in the Global Economy September 2–3, 1999. Cambridge, MA: Center for International Development, Harvard University.

Juanillo N (2001) The risks and benefits of agricultural biotechnology. American Behavioral Scientist 44 1246–1266.

MacLean D (1995) Environmental ethics and human values, in Handbook for Environmental Risk Decision Making (Values, Perceptions, and Ethics) (Cothern CR ed) 177–193. Boca Raton: Lewis Publishers.

Martin J Veel R (1998) Reading Science. London: Routledge.

Priest S 1999 Popular beliefs, media, and biotechnology, in Communicating Uncertainty: Media Coverage of New and Controversial Science (Friedman SM *et al*. eds) 95–112 Mahwah, NJ: Lawrence Erlbaum Associates,
Sera M Shea W (1991) Persuading Science, Canton, MA: Science History Publications
Webber D (1990) Biotechnology: Assessing Social Impacts and Policy Implications. New York: Greenwood Press.

Q: Should scientists change their mode of address and move to a more celebratory style when dealing with the public?

A: Some communications research is being conducted by the Environmental Protection Agency (EPA) on the merits and demerits of using narrative discourses over more empirical, or more forensic, discourses. But the real challenge will be implementing the EPA findings in outreach programs or seeing them in action through information campaigns, and that has yet to be evaluated.

Q: Recently when I gave an introductory talk on genetically modified foods, one of the audience members asked me the question: “If you were to be offered only genetically modified foods for one year, would you accept it or not?” In terms of your framework—celebratory versus forensic—as an academician, what answer should I have given to that question?

A: As an academician, I don't have answers to very practical questions such as this. I think I work best as an observer. The real challenge is in evaluating communications strategies applied in outreach and extension programs. As of now, I have not seen any solid evaluations or findings of which strategies work best. Suffice it to say that certainly we know that when scientists try to celebrate, to take pride in, their own work, and to allot meaning to their discoveries, something else happens. It is a totally different framework—one of values and meanings—in which it is fair game for everyone to accuse you of something else. I think the public expects the scientist simply to talk about findings as empirically as possible, which is the reason that there is solid recognition for the role of scientists in society. It is something else when the scientist steps into the arena of value and meanings.

Q: Several surveys have shown that people trust in those with academic and scientific knowledge, but they get most of their frontline information from the media. I think it would be to the benefit of the consumer to hear from scientists, because they do respect the empirical point of view. On the other hand, we really do have to think about putting things into terms that the consumer can understand and hear what the consumer is really asking, fundamentally: is the food safe? That's what the consumer wants to know.

A: Albert Gunther, at the University of Wisconsin, has stated the following in response to the strategy question of what should be said to the consumer: when interviewed, the scientist usually begins in an empiricist mode, but then switches to a celebratory mode, which is when the mass media interprets and reinterprets and puts new meaning into what the scientist has said. It is a complex communication dynamic, and I don't think you can fault the scientist for not answering the question—certainly the mediators of the information from the scientist to the consumer play an important role. We still have to come up with an examination of how the mass media tinker with information from scientists. Who knows, rather than being actually celebratory, added meaning may be injected by the mediator to cloud the fundamental issue: is the food safe?

Q: The issue of celebratory science and communication is interesting. We are seeing increasingly more of this, particularly in the genomics area in which the identification of genes for specific diseases is leading to expectations for cures. As funders of the scientific enterprise, we are increasingly being called upon to be accountable. Do you see this as an increasing problem likely to erode the public's confidence in scientists? And do we as members of the scientific community need to exercise control to decide what is a biologically significant correlation—is it 20%, is it 80%? Do we need to set some thresholds for press releases?

A: I think this is a trend. Once you start celebrating science, it is difficult to change course. We must recognize that at some point the discourse will be empiricist and it will eventually slide to celebratory. I think the challenge for the scientist is, how best can you come up with communication strategies—remember when you engage in celebratory discourse you subject yourself to social criticism, which is an arena of public meanings, values and priorities that you put into your communication. Whereas, with an empiricist approach, you control the discourse. Therefore, I think that your concern about scientists exercising more control of the information that they release, whether celebratory or empirical, has to be seriously considered particularly by science communicators and educators. Inasmuch as there are checks and balances in empiricist discourse—through peer reviews and conferences—the same should happen in celebratory discourses. And we have to be careful about whether or not we are educating the public appropriately. If you choose to call golden rice the “grain of hope” you open yourself up to criticism—you enter a discourse that is not totally yours. It calls for a different way of thinking. However, henceforth it will be impossible to concentrate on empiricist discourses; some scientists will fight fire with fire. When Michael Jacobson asked what is the best way to herald some of the benefits of agricultural biotechnology, he was asking what is the best way of celebrating it.

Lambasting Louis: Lessons from Pasteurization

JOSEPH H. HOTCHKISS
Cornell University
Ithaca, NY

Despite extensive lay, regulatory, political, and scientific discussions and reviews of recombinant DNA technology (*i.e.* biotechnology) and its application to food and agriculture, worldwide opposition remains. Human and environmental safety and socio-economic concerns have been discussed and debated in rational and scientific detail, yet opposition remains fervent. Is this opposition due, somehow, to the unique nature of biotechnology, or should it be expected with any new technology, especially when applied to food, agriculture, and the environment? Or is there a general distrust of new technologies that are not widely understood and for which there is little direct individual experience or for which the benefits seem obscure? If it is, at least in part, due to a general distrust of technology, how might we better plan for such debates? It may be useful to look back at past controversies.

Providing food has always been one of the major applications of basic science. It should not be surprising that one of the foremost applications of advances in biology has been food, along with medicine. One hundred and thirty-five years ago, Louis Pasteur and others were also making striking discoveries in basic biology leading to the field of microbiology. Major discoveries over the past three decades have, likewise, led to biotechnology. The application of Pasteur's discoveries to food and agriculture was controversial, just as the application of biotechnology is today.

LOUIS PASTEUR

Pasteur did not discover microorganisms. He made the immensely important observation that they were not a consequence of disease, decay, and putrefaction—as was the common scientific opinion at the time—but were, in fact, the causes of these problems, and that eliminating them could eliminate the

problem. This knowledge led to revolutionary changes in medicine and food preservation, not the least of which was the understanding that relatively mild heating kills microorganisms and substantially improves the safety and quality of foods without destroying desirable nutritional and sensory characteristics. The process of heating perishable foods to make them safer and last longer while retaining nutritional and eating quality was, as we all know, named after Pasteur. As a good Frenchman, he applied his discovery to the preservation of that most important beverage: wine. According to McCulloch (1936), in order to "prove" the effectiveness of his process, Pasteur shipped a cargo of pasteurized wine around the world in 1868 on the French frigate, La Sybile, "without spoilage of a single bottle." Pasteur later applied his mild heating method to beer preservation, but there is no evidence that he applied it to milk.

It can be reasonably argued that pasteurization ranks, along with mass immunization and water purification, as among the most significant developments in public heath during the early twentieth century. Nevertheless, in spite of overwhelming evidence that pasteurization was beneficial, there was fervent opposition in the late nineteenth and early twentieth centuries. This opposition delayed widespread implementation for 30 years or more, and undoubtedly resulted in the unnecessary loss of thousands of lives (Pirtle, 1926). Opposition was so strong that some companies pasteurized milk in secret (McCulloch, 1936).

The early scientific work on pasteurization and microbial thermal death and the many time-temperature recommendations for several pathogenic organisms associated with milk have been reviewed (Westhoff, 1978; Holsinger *et al*., 1997). For many years there was no consensus on the time-temperature combination to inactivate the major milk-born threat, *Mycobacterium tuberculosis.* Values ranged from 50 to 100∞C for 1 min to 6 h. North (1921) pointed out that thirty-one different heating recommendations were made between 1890 and 1920. Pasteurization times and temperatures were not based on rigorous thermal death studies, but generally on the "complete" destruction of *M. tuberculosis* as measured by infectivity.

The current time-temperature requirements for pasteurization were set in the 1950s, based on "complete destruction" of *Coxilla burnetti* (Q fever) in milk containing 100,000 infectious guinea-pig doses. This organism cannot be enumerated directly, therefore, studies were based on number of infectious doses in laboratory animals (Enright *et al*., 1957). This approach to thermal death might not withstand current scientific scrutiny were it not for pasteurized milk's safety over the past four decades. Scientific uncertainty about the most appropriate time-temperature combination for milk remains even today, and current research may determine that there is need for further adjustment (Grant *et al*., 2001). Pasteurization and biotechnology, like other applications of science, share a degree of scientific uncertainty.

PASTEURIZATION DEFINED

Modern pasteurization is the application of sufficient heat to a product for a period of time in order to destroy pathogenic microorganisms, yet leave the product acceptable from sensory and nutritional standpoints (Lewis and Heppell, 2000). This latter point distinguishes pasteurization from other heat-based processes that destroy microorganisms at the expense of product acceptability. We now know that microorganisms generally die in a logarithmic fashion when exposed to heat (Figure 1). One log cycle reduction in survivors gives a 90% reduction in numbers. The time required to complete this 90% reduction, the "D" value, is dependent on the specific organism and the temperature to which it is heated, as well as on the medium in which it is heated. This means that total microbial destruction is not possible, only that some number of log-cycle reductions (D values) can be achieved and that authorities must decide how many log reductions are required to adequately protect public heath. Typically, food products are subjected to sufficient heating for a period of time to give reductions of five to twelve D values. Thus, pasteurization is not a guarantee of absolute safety, but a matter of risk reduction. Some degree of risk must be accepted. Statistically, pasteurization leaves behind some number of pathogenic organisms. Again, this is similar to biotechnology, which also carries inherent hazards for which we must be willing to accept some degree of risk.

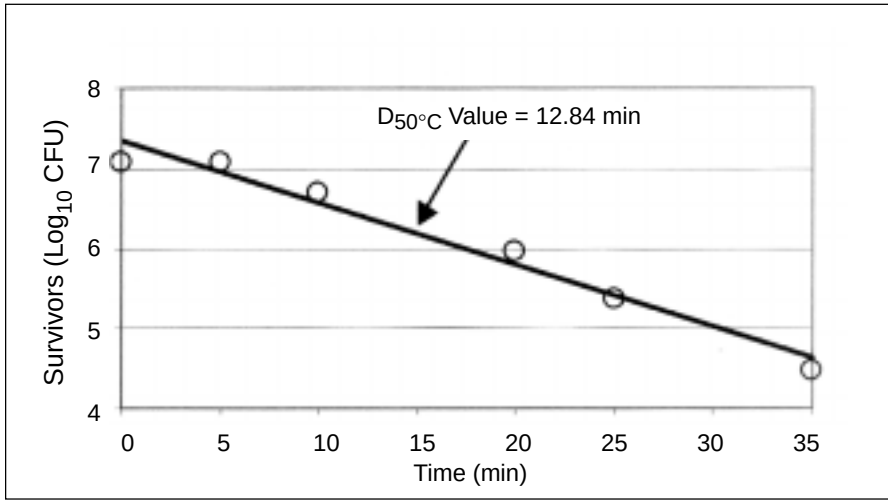

Figure 1. Thermal death-rate curve for *Pseudomonas fluorescens* in milk at 50°C. One D value equals the time to give a 1-log (ten-fold) reduction in survivors, in this case 12.8 min.

Microorganisms differ greatly in their sensitivity to heat, and, thus, the combination of time and temperature that is sufficient to kill one species may have little effect on others. Pasteurization, like biotechnology, is not a single entity, but has been developed into a complex group of related technologies. The appropriate heat treatment depends on the desired outcome and product.

Milk in the Nineteenth Century

Today, we think of milk as one of the safest foods available, and guard its integrity and wholesomeness with near-religious fervor. But this has not always been so. In the nineteenth century, in the words of Stenn (1980): milk "was as deadly as Socrates' hemlock." It was one of the very few animal foods that was almost universally consumed without heating or refrigeration, and was less of a health risk when consumed within a few hours of collection. But, as cities grew larger in the industrial revolution of the mid-1800s with mass immigration to the United States, the time and distance between collection and consumption increased. In the early 1800s, dairy cows were commonly found within residential areas of American and European cities. As the cities grew, dairy farming became more rural and milk transportation took longer, hence the term "milk run" became synonymous with frequent stops as made by trains of the latter half of the nineteenth century. Rosenau (1912) pointed out that urbanization increased the time between collection and consumption from a few hours to more than forty-eight without refrigeration. Given the nature of milk as a microbial growth medium, one can only imagine the microbial condition of raw milk kept at ambient temperature for two days.

Then, as today, milk was seen as important in infant nutrition and, as such, it held a special place in the hierarchy of foods. It was surrounded with superstitions such as the belief that thunder was responsible for curdling, as the following demonstrates (Belcher, 1903):

> *The prevailing belief that a thunderstorm is the cause of milk souring is one instance of misunderstanding. The fact that it is easy to purchase milk which will not sour during a thunderstorm should suggest to the consumer that there must be some other reason. And the reason is the presence of lactic acid forming bacteria in milk. It is not disputed that milk sours during a thunderstorm, but the cause is not the thunderstorm itself, but certain conditions accompanying it, which are favorable to the action of lactic acid bacteria. (emphasis added)*

In the latter half of the nineteenth century, scientists who followed Pasteur began to investigate the microbiology of milk and its possible relationship to human disease, especially to the scourge of the day: tuberculosis. In the United States, the yearly death rate from this disease in the early twentieth century was 160,000 and, of a population of 90 million, about 6 million could expect to die from it. Typhoid fever claimed 25,000 per year (Rosenau, 1912). These and

other often-fatal infectious diseases including gastroenteritis, scarlet fever, cow pox, milk sickness, diphtheria, septic sore throat, Malta fever, foot and mouth disease, anthrax, contagious abortion, and rabies were, at least partially, linked to raw milk.

In 1886, Soxhlet described a heating apparatus for pasteurizing milk at home, and, in 1889, the Prussian-born physician Abraham Jacobi (the first professor of pediatrics in the United States) brought Soxhlet's ideas to this country with the goal of improving the health of infants. Later, he and Henry Koplix (a pediatrician in New York City) became convinced that pasteurization would save children's lives. Later work by M.J. Rosenau of Harvard Medical School and C.E. North, among others, began to define the thermal death of bacteria in milk.

In the nineteenth century, high infant mortality was considered a fact of life. Rates, both in the United States and Europe were, by today's standards, unfathomable. The United States census of 1900 found infant mortality rates as high as 40% (North, 1921). In Baltimore alone, 3,000 infant (<5 years of age) deaths per year were reported (Knox, 1906). One third of all deaths were of infants. In 1905, infant deaths totaled >105,000, of which 39,000 resulted from diarrhea (Hygienic Laboratory, 1909). In 1920, infant mortality rates were seventy-two to 203 per 1,000 infants in twelve major cities in the United States (North, 1921). The current rate is <0.8%.

In the nineteenth century, high infant mortality was considered a fact of life. Rates, both in the United States and Europe were, by today's standards, unfathomable.

Undoubtedly, this high death rate had multiple causes, but careful epidemiological studies were not undertaken. Studies in the United States and Europe, however, suggested that diet was a particularly important source of fatal infections. Savage (1912) reviewed the compelling evidence that milk caused significant numbers of infectious-disease cases. The high rates of death due to diarrhea, and increases in deaths in warm months, also provided clues. Studies in England compared death rates of "suckled" infants to those fed "cow's milk only" (Tables 1–3). Breast-fed infants died at a rate of 6.2% compared to 36% for those fed only cow's milk. This difference was even greater when only the first 3 months of life were considered. While we now know that breast milk has many advantages, such as passing on immuno-stimulants, they are not great enough to explain these differences. The evidence that milk was a transmitter of diseases such as tuberculosis, typhoid fever, scarlet fever, and "septic sore throat" was, even by the epidemiological standards of the day, incontrovertible.

TABLE 1. RELATIONSHIP BETWEEN MILK SOURCE AND INFANT MORTALITY FROM DIARRHEA IN BRIGHTON, ENGLAND, 1903–1905 [CENSUS OF 10,308 HOUSEHOLDS (SAVAGE, 1912)].

Milk source	Age at death (months)			
	0–3	3–6	6–9	9–12
	(% infant mortality)			
Breast only	1.9	1.3	—	—
Bovine only	92	69	25	22
Unknown	2	4	2	2

TABLE 2. FRACTION OF 1-YEAR-OLD INFANTS DYING FROM DIARRHEA[a] WHEN FED DIFFERENT MILK SOURCESIN BRIGHTON, ENGLAND, 1903–1905 (SAVAGE, 1912).

Milk source	Percent
Breast only	6.5
Bovine only	36
Condensed	30
Unknown	8

[a]121 of 1,259 infants died in the first year of life.

TABLE 3. INFANT (<1 YEAR) MORTALITY IN THE SUMMER MONTHS FED DIFFERENT MILK SOURCESIN BRIGHTON, ENGLAND, 1903–1905 (SAVAGE 1912).

Milk source	Percent
Store milk	19
Condensed	20
“Good bottled”	9
Central distributed milk	3
“Best bottled”	0
Breast only	0

Knowing what we now know about diseases, there is little doubt that milk was a very dangerous food in the late nineteenth and early twentieth centuries. As late as 1942, G.S. Wilson reviewed the broad range of infectious diseases transmitted through milk, and pointed out that they caused thousands of deaths in Great Britain annually, and concluded that milk was "probably the most dangerous article in our dietary" (Wilson, 1942). In an article titled "White Poison," Atkins (1992) reviewed milk quality in London at the beginning of the twentieth century, and concluded that *E. coli* counts were more than 1 million per milliliter. Current standards in the United States require fewer than ten coliform (fecal) bacteria per milliliter. Stenn (1980) estimated that residents of Berlin, Germany consumed 300 pounds of "cow dung" daily in their milk due to the poorly hygienic conditions in which dairy cows were kept. Scarlet fever was widespread, and transmitted via the milk supply (Wilson, 1986). It is not surprising that a cartoonist of the day portrayed milk as a harbinger of death (Figure 2).

Figure 2. "I drink to the general death of the whole table."
(This cartoon won a prize from the American Medical Association, ca. 1910.)

Some of the most compelling evidence for the dangers of raw milk came from New York City and the work of Nathan Straus, a wealthy principal owner of Macy's department store. Reportedly, he lost a child and was convinced it was due to milk. Although he had no scientific training, he became interested in the thermal treatment of milk after meeting Jacobi, and installed a pasteurization unit in 1897 on Randall's Island at the city's asylum for children. The mortality rate in 1897 at the asylum was an astounding 44%. After the introduction of pasteurized milk in 1898, the rate dropped to 20% and further dropped to 16.5% by 1904 (Straus, 1917). The introduction of pasteurization was the only major change during this period.

The success at Randall's Island convinced Straus that he could save more children's lives through milk pasteurization, so, between 1899 and 1910, he set up depots across the city to dispense free or low-cost pasteurized milk to families with infants. While it is impossible to know the precise impact of milk pasteurization, the infant mortality rate fell from 12 to 3.8 per 1,000 between 1893 and 1916. The then-commissioner of health in New York City stated that there could be "little doubt" that the major factor in this reduction was "the compulsory pasteurization of milk" (Straus, 1917).

Some in the young field of public health believed that raw milk was a carrier of disease and that pasteurization offered a solution. In discussing the causes of "food poisoning" Jordan (1917) pointed out that "of all foods, milk is the most likely to convey disease," and "the amount of illness traceable to milk far exceeds that ascribable to any other food." Knox (1906) found that 30% of the 10,000 deaths per year in Baltimore in the early years of the twentieth century were of infants under 5 years, and concluded that 1,000 of these infant deaths were due to milk consumption.

The headlines of the day were likewise critical of the milk supply. Nearly every week the *New York Times* carried articles on the hazards of milk (Figure 3). Headlines such as "Public Health and Infected Milk" appeared as early as 1873.

As we now know, pasteurization is effective at controlling pathogenic bacteria to the point that milk is now one of the safest of all foods. According to the Centers for Disease Control and Prevention in Atlanta (CDC, 2000), between 1993 and 1997 only 207 of 86,058 (0.2%) were confirmed food-disease cases—and no deaths—were traced to milk. It is likely that some, if not most, of these cases were related to the still legal practice of selling raw milk, which, in recent years, has been implicated in outbreaks of human disease (Steele, 2000).

Resistance to Pasteurization

For decades, strong and adamant opposition succeeded in stalling moves to make pasteurization mandatory in many parts of Europe and in North America. The opposition came from almost all quarters, including the medical community, the dairy industry, dairy technologists, and the milk-consuming public.

- Public Health And Infected Milk, September 10, 1873.
- Milk—Pure and Impure, July 21, 1874.
- Milk as a Spreader of Disease, Editorial, October 25, 1878.
- Milk—Cow with Rabies: Milk Sold on Staten Island, June 14, 1887.
- Milk, A Source of Disease, April 20, 1890.
- Cattle—Tuberculosis Contracted from Diseased Milk, March 3, 1894.
- Milk—Disease Transmitted: Pasteurization Urged" May 24, 1896.
- Milk—Deaths Due to Milk, August 19. 1903.
- Coblenz—E.L. James Says Death Rate of Children Under 5 Has Increased in Last 6 Years and that Milk is Lacking, January 8, 1919.
- Diphtheria—2 Deaths, Traceable to Milk, Occur in Greenwich, March 4, 1920.

Figure 3. Selected headlines from the *New York Times* concerning milk and disease 1873–1920.

Wing (1897) advised that the use of pasteurization was an "open" question and that "official" herd inspection was a better safeguard than pasteurization or sterilization. He advised that the main culprit in milk-borne disease was the dairyman "who is careless in regard to the cleansing of his utensils." Bailey (1909) described pasteurization in terms of contemporary agricultural practices in the Cyclopedia of American Agriculture, but suggested that it be used only when outbreaks of contagious disease were attributable to milk.

Opposition was based on four general arguments (Wilson, 1942):

- It was reasoned that milk pasteurization was deceptive and not needed if milk was properly handled. Pasteurization would mask low-quality milk, conceal evidence of dirt and filth, remove any incentive to produce clean milk and cull diseased animals, and legalize ineffective dairy practices. The efficiency and effectiveness of pasteurization was questioned based on observations that in some cases it appeared to work well and in others not at all. These differences, no doubt, resulted from differences in recommended time-temperatures. Although the precise times and temperatures were not known with certainty, there was sufficient understanding of the technology to broadly implement pasteurization (Kilbourne, 1916). Equipment to heat-process milk was widely available by 1901, when Monrad (1901) described in detail the technology to pasteurize, cool, and ship milk.
- The agricultural industry in particular worried that pasteurization would disrupt the economic status quo. There was fear that mandatory pasteurization would place the cost of milk beyond the means of too many Americans, and would put small producers out of business. Only the large companies would be able to afford the process. Milk was already too expensive for many, and was consumed in greater amounts by the wealthy

(who suffered the ill effects of the raw product). The sentiment was asserted that people have a "right" to drink raw milk if they wish.

- One of the most common arguments against pasteurization was that it adversely affected milk composition and its organoleptic properties. It was said to "ruin" the flavor and "take the life out of milk." It must be remembered that milk then, as today, held a special place as a food.
- Ironically, the most vehement opposition may have been from the medical community who argued that pasteurization would diminish the health benefits associated with milk, particularly in infants. The concern was that pasteurization would destroy the nutrients. Understanding of human nutrition was just beginning in the early part of the twentieth century. One focus was on milk's "anti-scurvy" properties of milk.

The exact nature of scurvy and its relationship to vitamin C was largely unknown, but physicians had made the observation that raw milk could have anti-scurvy activity that was lost upon heating. Hess (1920) suggested that whereas milk heated in the home was not adversely affected, commercial pasteurization would destroy the anti-scurvy activity. We now know that raw milk contains a small amount of vitamin C (<2% of the current RDA per serving) and that excessive heating can reduce this low level. It is possible that even this small amount would be sufficient to ward off scurvy in an infant whose total intake of vitamin C was borderline.

Another health-related objection was connected to tuberculosis. It was clear that this was an infectious disease, but its precise cause and vehicles were not understood. Cattle also suffered from tuberculosis, but there were differences between the organisms infecting humans and cattle. Some suggested that bovine tuberculosis was not transmittable to humans and, therefore, milk could not be a vehicle. Some suggested that exposure to bovine tuberculosis had a protective effect on humans.

Other objections were less scientific. It was suggested that pasteurization interfered with nature, that infants failed to thrive on pasteurized milk, and that pasteurization would give a false sense of security because bacteria grew rapidly when added to pasteurized milk. These objections came not only from the fringe, but often from mainstream science. Comments on pasteurization by McCollum (1918) in a nutrition text are illustrative:

> *Milk which has been pasteurized at 165°(F) is more liable to induce scurvy than either boiled milk, or milk which has been pasteurized at lower temperatures, as 140–145° for thirty minutes. The most satisfactory explanation for these results seems to be found in the bacteriological condition of the milks treated in the various ways described. . . . These results strongly support the view that there is a bacteriological factor involved in the causation of scurvy, and emphasizes the importance of securing clean milk, and of having it so handled as to insure its delivery in a good bacteriological condition.*

Hess (1920) agreed:

> *It has become increasingly evident that in the course of pasteurization milk loses an important measure of antiscorbutic vitamine* [sic].

Proponents of pasteurization countered these objections by arguing, as did Savage (1912) in England and Rosenau (1912) in the United States, that milk was the cause of significant human disease and that pasteurization would make it safer. Savage (1912) argued that four strong lines of evidence linked milk to disease:

> *The incidence is upon those who drink a particular supply of milk* (disease outbreaks are traceable to specific milk supplies).
>
> *Outbreaks are explosive in nature* (large numbers of outbreaks occur simultaneously).
>
> *Incidence falls upon the milk-consuming part of the community* (segments that tend to consume more milk have higher disease incidence, and milk consumption and disease correlate with economic status).
>
> *Milk drinkers in particular houses are attacked* (milk consumers have a higher incidence than non-consumers living in the same household).

In 1909, the United States Hygienic Laboratory published a collection of papers on the relationship between milk and the public health, by epidemiologists, bacteriologists, dairy chemists, sanitarians, and dairy-processing specialists (Hygienic Laboratory, 1909): the cost in lives from milk-borne disease was immense and the answer readily available. Yet, broad implementation was decades away.

In 1909, the United States Hygienic Laboratory published a collection of papers on the relationship between milk and the public health, by epidemiologists, bacteriologists, dairy chemists, sanitarians, and dairy-processing specialists (Hygienic Laboratory, 1909): the cost in lives from milk-borne disease was immense and the answer readily available. Yet, broad implementation was decades away.

Opposition to pasteurization exists today, disseminated on the Internet. Dr. Regan Golob, writing for the Dynamite Company, tells people that pasteurization "kills" milk. The "Milk Quiz" at the "Not Milk" Web-site indicates that the main reason for pasteurization is to "fool you." Proclaimed nutritionist Aajonus Vonderplanitz and a raw-milk farmer tells Internet surfers that "the bacteria-phobia has no empirical basis" and that there have been no clinical studies to prove or disprove the "theory" that pathogens in milk can cause disease in humans.

Parallels Between Then and Now

There are several parallels with the debate over biotechnology, and the solutions discussed in the early 1900s seem quite applicable today. In 1912, Rosenau debated what should be done about the opposition to pasteurization or, as he put it in his book, "The Milk Question." He called for patience, public and professional education, and cooperation between commercial, government, and scientific communities, and that all should let the "facts speak for themselves." Interestingly, he promoted the comparison of milk with other health issues such as water treatment, which apparently generated no opposition. This suggestion is similar to the contemporary view that technologies should be viewed in light of the magnitude of risk associated with implementation (or not). Decades later, Hill addressed strategies to deal with the still-strong opposition to pasteurization (Hill and San, 1947). He argued for the importance of public education on pasteurization and that scientists should strongly repudiate misinformation. He also counseled that facts overcome falsehoods, that credible authorities should speak out on the issues and present factual information based on unbiased research, and he admonished scientists to acknowledge imperfections and shortcomings.

These approaches do not seem much different from those proposed today, but there are notable instances where they appear to have been ignored. It is also instructive to note that the opposition to new technologies is not a new phenomenon associated solely with recombinant DNA technology. Recent examples range from food additives, coloring, and pesticides, to irradiation and packaging. It seems that opposition to technology in agriculture and especially consumer foods will occur no matter what the technology.

What lessons and strategies can scientists and technologists gain from this history? The most obvious is that controversy and opposition are likely to develop in response to the implementation (not discovery) of any new technology used in food and agriculture. Anticipation and planning should accompany technological development, and not be a reactive response. When controversy is not anticipated and planned for, technologists and scientists are forced into the position of reacting to the debate as framed by others, rather than being framers of the debate.

It is also instructive to note that the opposition to new technologies is not a new phenomenon associated solely with recombinant DNA technology. Recent examples range from food additives, coloring, and pesticides, to irradiation and packaging. It seems that opposition to technology in agriculture and especially consumer foods will occur no matter what the technology.

The controversy surrounding pasteurization also points to the importance of the media. For more than 40 years, the press has been generally in favor of pasteurization. It is important to educate the media early in the development stage and not to delay until implementation. Perhaps because of his experience in the retail business, Straus seemed to understand the importance of the press.

While it is essential that scientists educate themselves and their colleagues about new technologies, they cannot dismiss the importance of the broader audience. Professional societies with interests in food, agricultural, environmental, and health issues have produced a number of excellent overviews of, and discussion-pieces on, biotechnology, and have issued rational position papers (*e.g.* IFT, 2000). And several professional groups have been producing educational documents, technical summaries, and detailed reports for nearly a decade. The American Dietetics Association and the American Medical Association, among others, have also developed reports and positions on agriculture-related biotechnology. These publications are especially useful for educating groups with direct interest in the technology and with sufficient background to grasp the underlying science.

Unfortunately, these efforts are at times "preaching to the choir" in that they target groups willing to listen and to learn and to evaluate new technologies on their merit, and may miss lay audiences. This latter constituency may have little interest in the technical details—whereas most educational materials consist almost entirely of technical explanations—and be more interested in the broader implications. Among the most important questions for consumers are: Who benefits? Who is at risk? What will it cost? Who oversees the technology? What are the health and environmental risks? Powell (2000) pointed out the importance of understanding the audience's concerns in communication of risk to lay groups.

There is little evidence that those who developed and promoted pasteurization understood these lessons any more in 1901 than modern promoters of biotechnology do today. If influential groups (*e.g.* the press, see Figure 4) who are likely to oppose technology were considered early in the development process, rather only after controversy has erupted, implementation might involve a less arduous route. Strategies for early engagement of influential lay interests might foster easier transition from basic discovery to practical implementation.

REFERENCES

Atkins PJ (1992) White poison? The social consequences of milk consumption, 1850–1930. Social History of Medicine [Great Britain] 5 207–227.

Bailey LH (1909) Cyclopedia of American Agriculture; a Popular Survey of Agricultural Conditions, Practices and Ideals in the United States and Canada. New York: The Macmillan Company.

Belcher SD (1903) Clean Milk. New York: The Hardy Publishing Company.

CDC (2000) Surveillance for Foodborne-Disease Outbreaks—United States, 1993–1997. Surveillance Summaries. Atlanta: Centers for Disease Control and Prevention.

Enright JB et al. (1957) Thermal Inactivation of *Coxiella burnetii* and Its Relation to Milk Pasteurization. Public Health Monograph No. 47. Washington, DC: Public Health Service.

Grant IR et al. (2001) *Mycobacterium avium* ssp. *paratuberculosis:* its incidence, heat resistance and detection in milk and dairy products. International Journal of Dairy Technology 54 2–13.

Hess AF (1920) Scurvy, Past and Present. Philadelphia: J.P. Lippincott Company.

Hill H San FR (1947) Pasteurisation. London: H.K. Lewis & Co. Ltd.

Holsinger VH et al. (1997) Milk pasteurisation and safety: a brief history and update, Scientific and Technical Review of the Office International des Epizooties 16 441–451

Hygienic Laboratory (1909) Milk and its Relation to the Public Health. Bulletin, No. 56. Washington, DC: Government Printing Office.

IFT (2000) Introduction / Human food safety evaluation of rDNA biotechnology-derived foods / Labeling of rDNA biotechnology-derived foods / Benefits and concerns associated with recombinant DNA biotechnology-derived foods, in IFT Expert Report on Biotechnology and Foods (assembled reprints from Food Technology vol 54 August / September / September / October 2000). Washington, DC: Institute of Food Technologists.

Jordan EO (1917) Food Poisoning. Chicago: University of Chicago Press.
Kilbourne CH (1916) The Pasteurization of Milk from the Practical Viewpoint. New York: John Wiley & Sons.
Knox JHM (1906) The relation of the milk supply to infant mortality. The Johns Hopkins Nurses Alumnae Magazine 68–81. (Reprinted in the American Journal of Public Health 89 (1999) 408–409.)
Lewis M Hepple N (2000) The Continuous Thermal Processing of Foods. Pasteurization and UHT Sterilization. Caitherburg, MD: Aspen Publishers.
McCollum EV (1918) The Newer Knowledge of Nutrition; the Use of Food for the Preservation of Vitality and Health. New York: The Macmillan Company.
McCulloch EC (1936) Disinfection and Sterilization. Philadelphia: Lea & Febiger.
Monrad JH (1901) Pasteurization and Milk Preservation: with a Chapter on The City Milk Supply. Winnetka, IL: J.H. Monrad.
North CE (1921) Milk and its relation to public health, in A Half Century of Public Health (Ravenel MP ed) 237–289. New York: American Public Health Association.
Pirtle TR (1926) History of the Dairy Industry. Chicago: Mojonnier Bros. Company.
Powell DA (2000) Food safety and the consumer—perils of poor risk communication. Canadian Journal of Animal Science 80 393–404.
Rosenau MJ (1912) The Milk Question. New York: Houghton Mifflin Company.
Savage WG (1912) Milk and the Public Health. London: Macmillan & Co., Ltd.
Steele JH (2000) Commentary. History, trends, and extent of pasteurization. Journal of the American Veterinary Medical Association 217 173–176.
Stenn F (1980) Nurture turned to poison. Perspectives in Biology and Medicine Autumn 69–80.
Straus LG (1917) Disease in Milk: The Remedy—Pasteurization; The Life Work of Nathan Straus. New York: E.P. Dutton & Co.
Westhoff DC (1978) Heating milk for microbial destruction: A historical outline and update. Journal of Food Protection 41 122–130.
Wilson GS (1942) The Pasteurization of Milk. London: Edward Arnold & Co.
Wilson LG (1986) The historical riddle of milk-borne scarlet fever. Bulletin of the History of Medicine 60 321–342
Wing HH (1897) Milk and its Products; a Treatise Upon the Nature and Qualities of Dairy Milk, and the Manufacture of Butter and Cheese. New York: The Macmillan Company.

SOME FACTS ABOUT MILK

Germ changes and contamination of milk
Information important to women…

House wives and mothers should be versed in milk lore—modified milk sterilization and pasteurization…

…the prolific source of danger which is harbored in this fluid…

…severe epidemics of typhoid fever…owing their existence to the common source of tainted milk…

…it is no imperative that milk must be contaminated…

They (British and Americans), continue to drink milk…without protection from infection. It is true but strange that every savage nation on the globe that uses milk... has some form of protection.

Milk as used in large cities is a very different article from that used by primitive man. It is seldom perfectly fresh, pretty sure adulterated, and almost always dirty.

Until we are assured of absolute purity, we should resort to protection. Science has unmistakenly established the importance of this.

Figure 4. New York Times headline and excerpted article, September 22, 1895.

Q: Was pasteurization accepted differently in different countries, and are there lessons to be learnt from that?

A: It was controversial both in Europe and in the United States, but possibly less so in Europe, even as recently as post World War II. Since pasteurization makes milk last longer, it received a boost after the war. However, it remained controversial, certainly in the United Kingdom, whence comes much of my information.

Q: Considering that the concept of pasteurization was so hard to sell, against the reality of the high rates of infant mortality, what are your thoughts regarding biotechnology, the benefits of which are less obvious to the public?

A: Clearly, it is a harder sell. However, mind-set is important. People had always expected their children to die. Even educated individuals said that this was the way of the world. Many thought that infants died because they had "poor constitution." I don't know exactly what that was, but it was regarded in terms of it being better that they died. It is ironic that a lay person, Nathan Straus, raised this issue, rather than the medical community. With respect to biotechnology, people who are bringing it to practical use must tell the lay public why they are doing it, what it will do, who will benefit, and they must admit that profits are involved. It should have been stated much more forcefully that children were dying and that there was good evidence that it could be stopped by pasteurization.

With respect to biotechnology, people who are bringing it to practical use must tell the lay public why they are doing it, what it will do, who will benefit, and they must admit that profits are involved. It should have been stated much more forcefully that children were dying and that there was good evidence that it could be stopped by pasteurization.

Q: Have you considered writing this story for, say, the *New York Times* magazine or the *Atlantic Monthly* to obtain broad communication of this message to encourage people to draw their own conclusions as to where we are today?

A: That is an interesting question. Particularly on a lay level, I think there is an important lesson that technology in general should be judged by what it can and cannot do, and what its risks and benefits are.

Q: Were the business interests in pasteurization similar to or different from the business interests that underpin biotechnology?

A: Nathan Straus died poor, broken because the authorities made him shut down all of his pasteurization plants. He was Jewish, and had hoped to take the technology to what is now Israel. He made no money for this, and, in fact, lost most of his fortune in trying to promote it. Opposition to pasteurization came, in part, from the entrenched dairy industry—farmers and processors—which is different from the situation today. On the other hand, some companies did promote pasteurization, primarily Borden Foods, in Syracuse, New York.

Louis Pasteur began to understand pasteurization in 1865, however, violent opposition exists even today, as evidenced by what can be found on the Internet.

Q: Cheese is made with unpasteurized milk in Switzerland. I eat it when I can get it, because it is so good. I eat it knowing that there is some risk. One of your slides mentioned the "right" to consume unpasteurized milk. Do you agree with that, and are their parallels with people declaring that it is their right to choose GM foods or to avoid them?

A: Cheese is a poor analogy in that, if it is aged more than 60 days, the risk is substantially reduced. There is on-going argument on this issue between Europe and the United States. In the United States, all cheeses under 60 days of age have to be made from pasteurized milk. On the question of the right to drink "raw" milk, I think it is a societal question. Drinking such milk, and possibly eating such cheese, is to play food-poisoning roulette. As a society, where do we draw the line on what we protect ourselves from? In general, where the risk is high and technology exists to reduce that risk, we as a society should apply that technology. Where the risk is low, I believe that the technology again should be applied—but that is subjective and will be interpreted differently by different people. We have decided that the risk from unpasteurized milk is high. Roughly two-thirds of the states have made it illegal to sell it. Each case should be looked at in terms of risk versus benefit, and as a society that is why we elect supposedly very smart people to make such decisions for us. That brings some smiles.

Q: In your coverage of opposition to pasteurization you mentioned small-scale producers. Do you see a time when a similar issue will apply to biotechnology?

A: Yes I do, not for technological reasons, but for marketing reasons. We at Cornell put the gene-gun into a Winnebago and drove it around the state and let high-school students genetically modify plants. In other words, it is not a centralized technology, although it is centralized as a business. When I'm in Europe, I tell people that they should protest the fact that biotech is broadening the gap between the rich and the poor, and that biotech is not being applied where it is needed most: in the developing world.

An Agricultural Response to the Feeding Frenzy

NANCY F. MILLIS
University of Melbourne
Melbourne, Australia

The ancestors of our agricultural plants and animals were subjected to stresses that selected among populations for fitness to survive in particular environments. But, for our purposes, survival was not enough—we wanted other properties as well, such as more starch, oil or protein in the seed, shorter stalk, more protein in the leaves. We selected parents with these properties, bred from them, and ruthlessly culled any inferior offspring. So, slowly, randomly, the genome of the population was nudged towards wanted goals. Obviously, this so-called selective line breeding was restricted to organisms where crosses produced fertile offspring. This severely restricted the pool of genes from which useful properties could be drawn.

In the middle of the last century, opportunities for improvements came from unnatural techniques like protoplast fusion, where cells of related, but incompatible, species were fused as protoplants and then regenerated into whole plants. Other sources of variation were developed using somoclonal variation, embryo rescue, and mutagenesis. By altering the genome, these techniques have added considerably to the range of agriculturally useful plants and animals. These new cultivars and animals have been readily accepted by farmers, and consumers now demand the improvements so achieved—who wants stringy beans, small, tough, high-tannin apples, bitter lettuce, or poisonous potatoes?

The first transgenic plant was developed In 1982, but it was a further 13 years before transgenic crops were grown on any significant area. Currently, that area is estimated at over 50 million ha in the west, with further significant, but unknown, areas in China. In Canada 55% of the canola is GM, the United States has extensive areas of GM cotton, corn, soya and canola. Argentina's soya crop is 95% GM, and a third of Australia's cotton crop is GM. The European

Union, however, has shown considerable reluctance to accept GM crops, particularly in certain countries, *e.g.* Denmark, Austria and Switzerland; Belgium, the United Kingdom and France are prepared to consider them, provided appropriate supervision is in place.

Why is Opposition to GM Crops So Heated?

It is clear that the reasons for the fuss must be addressed by farmers who adopt the technology with the intention ultimately of selling their produce. Consumers' perceptions are vital. The scientists may make and use the constructs, identify potential hazards and, with the regulators, assess risks and suggest appropriate management strategies, but they are often not well disposed to empathize with the perceived risks held by various sectors of the general public. This brings me to concerns I have observed in the debate about GM crops destined for the food supply. But, first I want to talk about risk and various ideas related to it.

Consumers' perceptions are vital. The scientists may make and use the constructs, identify potential hazards and, with the regulators, assess risks and suggest appropriate management strategies, but they are often not well disposed to empathize with the perceived risks held by various sectors of the general public.

Risk Analysis, Acceptable Risk, Perceived Risk, Managing Risk

For me, risk analysis is the combination of some identified hazard or harm and the probability that that harm will come to pass. This is linked to considerations of the seriousness of the identified harm. Risk management follows from the information just listed, as it leads to devising ways to eliminate, minimize, or control serious harm. I believe we should not use the concept of acceptable risk, as it immediately raises unanswerable questions:

- Acceptable to whom?
- Who decides what that level of risk will be?

The concept is value-laden and, accordingly, the level of risk chosen tends towards zero, as the only acceptable risk. This fails to recognize that effort spent in risk reduction may be misapplied if, to be acceptable, risk must be zero or

close to it. Effort in risk reduction is best spent after comparing the seriousness of the identified risks associated with an activity, and then putting effort into reducing the most serious—in other words, *managing the risk* in a cost-effective fashion.

When risk assessment of gene technology began in the 1970s, it was very much the autonomous domain of science and technology. Science methodology was applied to identifying hazards and quantifying risk. Social implications received scant attention, and the scientific and social sectors of the community engaged in name-calling; this fueled mistrust of science among the general public and a dismissive "irresponsible" label was applied by scientists.

From 1980 onwards, attitudes changed, and it is more widely appreciated that science and technology are also socially constructed and must interact with the public, companies, and farmers. Scientists must recognize that there are issues unrelated to science that are very significant to some sectors of the community that ultimately will buy (or not buy) GM products depending on whether they feel comfortable and consulted about the process of surveillance and regulation. The way in which surveillance and regulation was established made those with concerns for social issues feel powerless. Scientists and regulators must recognize that the resulting stand-off is counter-productive, and take time to meet with the stakeholders and explain in plain terms the process of surveillance and risk assessment, how it works, and how a reasonable accommodation can be reached between differing positions.

Concerns About GM Agricultural Crops

It may be helpful to recognize the types of concerns held by the community. They can be placed in two broad classes. One consists of concerns stemming from personal beliefs, moral values, religious convictions, lifestyle preference, and method of food production, or from socio-economic concerns about multinational companies that own the patents on many of the genes and processes, and make the chemicals associated with the use of some of them, for example GM plants with herbicide resistance. Others simply do not trust scientists. It is important to note that these concerns are not connected with any risk of the GM crop to the worker, the farmer or the environment, nor with claims of efficacy. The other class of concerns relates to hazards identified as possible outcomes from growing the GM organism.

It is not acceptable for GM advocates to dismiss the first class of concerns as inconsequential, any more than it is appropriate for GM opponents to deny others access to a technology that they perceive as beneficial. It is a dangerous path to develop regulations based on the religious beliefs or lifestyle preferences of particular sectors of the community. It is, however, possible to offer choice. In the case of GM foods and food ingredients, labeling will give those who do not wish to eat such foods the option to avoid them. Moral, religious or ethnic

issues cannot be readily addressed by legislation, but those who oppose GM technology on these grounds must be prepared to accept the differing views of others. Similarly, with small-scale cottage agriculture/organic farming, those advocating these methods must recognize the escalating demands for food from the world's increasing population, and by populations currently undernourished. This requires us to be responsible in adopting every tool at our disposal to increase productivity, reduce predators in crops, competition from weeds, disease infestation and post-harvest losses. We know that the planet has no new land suitable for agriculture, but gene technology may enable marginal land to become productive by designing plants to tolerate high salinity, or with the ability to complete their life cycle in areas with a very short growing season. One could ask whether it is ethical to deny such possibilities.

Addressing Identified Hazards

Scientists must be seen to address honestly any hazards that might be associated with transgenic plants. A list of some of these follows:

- Crop plants might become weeds.
- Herbicide-resistance genes might pass to related weeds.
- Growing herbicide-resistant crops might result in greater use of herbicides.
- Plants carrying genes for a pesticide could result in insects becoming resistant more rapidly because of continuous selective pressure.
- Genes for pesticides could pass to weeds and encourage their growth, since they would not then be eaten by pests.
- Transgenic plants may cross with free-living relatives and thus contaminate the gene pool.
- The novel gene could cause the plant to produce a toxin, carcinogen, teratogen, or allergen.
- Transgenic plants could be inferior nutritionally, less digestible, or have inferior processing properties.
- A crop-plant resistant to one herbicide may acquire resistance genes for other herbicides from other crops. Such multiply resistant plants would become difficult to control in farming rotations.

Whether these hazards will materialize must be considered case by case. The growth habit and genetics of crop plants are, in most cases, well known, the gene being introduced and its product are fully characterized, and the properties of the donor organism also are known. If the host and donor organism have a long history of safe use, it is highly unlikely that the transgenic will exhibit injurious or unwanted properties. Nevertheless, pre-commercial trials offer every opportunity for such possibilities to be detected; such trials are usually conducted at multiple sites over 5 to 7 years. Problems of gene

introgression can arise from outcrossing either to other crop plants or to weedy relatives. Canola is such a crop, whereas peas, clover, wheat, barley, *etc*., are essentially self-fertile, and present a less serious problem. Plants like cotton that are polyploid, are restricted by ploidy and type of genome from crossing with native *Gossypium* relatives. To manage gene escape in canola trials in Australia, for example, we require 15-m buffer rows of non-transgenic canola to be planted, and a 50-m zone to be rogued free of *Brassica* species and related weeds. During flowering, a 400-m zone is maintained free of *Brassica* species. Post trial, volunteer transgenic and weedy relatives are removed from the trial site, buffer rows, and the 50-m zone for three seasons. The area may be planted to pasture or cereals.

This management plan does not guarantee zero risk of pollen escape, but the likelihood is greatly reduced, and the hazard (a weed or canola plant becoming herbicide resistant) can be managed using a herbicide with a different mode of action.

To reduce the possibility that insects may become resistant to Bt, refuge areas of non-Bt cotton or sacrificial crops like maize are incorporated to allow a ready source of fully sensitive moths to mate with those that have acquired one copy of a recessive resistance gene. This strategy slows the emergence of resistant insects, which must be homozygous recessive diploids. This strategy, combined with constant observation of the insect population and appropriate timing of the application of other pesticides will enable the usefulness of Bt crops to be prolonged.

Good Agricultural Practice

Whereas the pre-commercial stages in the development of transgenic crop plants are under government surveillance in most countries, the real test comes when large areas are planted commercially and government surveillance is less direct, or absent. In an endeavor to meet this situation in Australia, the agriculture department combined efforts with the genetic surveillance, science, and farming sectors to produce guidelines for good practice in the use of GM organisms on the farm. A set of issues was drawn up to be addressed by those breeding, using, growing, or selling GM organisms, as well as consumer and environmental groups. It was recognized that diversity of crops/animals, agricultural region, climate, topography, soil, etc. made uniform rules impossible. Rather, the plan is to have a workshop of interested parties in the region at the time of the first field trial to ensure that the right issues are addressed. When all of the field results are available and commercialization is imminent, a second workshop will be held with the purpose of developing a clear set of instructions for growers and consultants as to the best practices to adopt in managing the GM crop in various rotations, so as to extend the useful life of the GMO and ensure sustainability of the farm, acceptance by consumers,

and preservation of environmental values. It will also set out the monitoring regime required to control any unwanted spread of the introduced gene. It is recommended that the seed seller make it a condition of sale and license that the grower adopt the good agricultural practices arising from the results of the trials and the workshop.

What's in it for the Consumer?

The GM plants grown so far are largely those that benefit farmers or large multinational companies (resistance to insect-predation, herbicides, virus or fungal diseases). Whereas the technology reduces costs of production, the consumer does not see a direct benefit, especially as GM foods are not substantially different from their conventional counterparts, and the price differential is nonexistent or very small. However, when a 10% price advantage applied, a well publicized GM tomato paste sold very readily in the United Kingdom. The other change that will attract consumers is a GM product that has a clear quality advantage: e.g. a tomato that tastes as they once did. Consumers will accept what benefits them personally, as is very clear from the ready acceptance of therapeutics made by gene technology.

I believe that agriculturalists must respond to this reality and direct their research towards quality attributes that consumers value. This will be more difficult to achieve than the single-gene changes that have been exploited so far, but unless the consumer sees the gain, agriculture will bear the pain.

In addition to direct benefits to consumers, GM agriculture results in a number of important gains for the environment and the sustainability of the farm, with reduction in wind and water erosion, reduced use of pesticides and highly persistent herbicides, and an environmentally preferable control of insect-born viral infections. These benefits appeal to many consumers and indeed are complementary to the objectives of organic farmers; they need to be highlighted in discussions with consumers. In response, consumers often invoke the precautionary principle and seek an absolute guarantee of no risk.

Risks We Live With

I found a chart prepared by an insurance company to be very instructive. It plotted the age of the population against the probability of death within the year. The likelihood of death simply by being alive, increases rapidly with age—the best expectancy is about 1 in 1,000 in our early teens, and from then on it is all downhill. What disasters will kill us? Being hit by lightning is about 1 in 2 million, death in the air or by drowning is similar at around 1 in 60,000, death in a car is 1 in 8,000 and from contaminated air 1 in 1,000. We just live with risks that are beyond our control, but other hazardous activities that could be avoided, like driving a car, are shrugged off equally nonchalantly. The perceived benefit far outweighs the risk represented by the toll on the roads each weekend. So what about the precautionary approach?

Precautionary Principle

It is critical that the concept is fully understood. It is not a prescription for achieving zero risk. According to a European Union document, applying the principle requires:

- objective assessment of hazards and their probability,
- consideration of management options, and
- consistency and transparency in data collection and assessment.

Then the option adopted must:

- relate to the seriousness of risk,
- include a cost-benefit analysis, both economic and social,
- indicate who is responsible for risk assessment, and
- be provisional, so that management can be revised in the light of new scientific data.

My plea to agriculturalists and the food industry is to develop GM commodities that will benefit consumers directly, and to ensure that the precautionary approach is adopted by GM breeders, farmers and food manufacturers, both during trials and when in large-scale production. It is also essential to label GM products so that consumers have choice.

Q: You presented information on best practices for release of GM plants and for their management after release. However, in Australia only one GM crop has been released. Are regulations there too cumbersome?

A: Only Bt cotton has gained acceptance. Roundup-Ready cotton is coming along and canola will probably follow. Wheat is a major crop, but it has not had a lot of GM work done on it, as yet. On the food side, the rules are if a food is known to have been made from GM material, you must label it as such. If an ingredient is of GM origin, the ingredient must be so labeled. If it is intended that the food is conventional, but has a small inadvertent contamination, you can have up to 1% without requiring a label. In the case of cotton-seed oil, because it is refined and, therefore, does not contain novel DNA or protein, it does not require a label. This is true also of sugar and starch.

Q: You suggested that before field trials would be held, that there be a workshop. It seems to me that, in this country, we get at that in a different way. We have a virtual workshop through the *Federal Register* or other public notices, which provide opportunities for public comment. Do you believe that the actual workshop interaction is essential, or is the virtual workshop through the *Federal Register* and the comment period, *etc*., an acceptable substitute?

A: We use both. The *Government Gazette* is the vehicle in which notice is given of release of a live organism to the environment, and public comment is permitted. In addition, at the time of the workshop, we are trying to inform people “on the ground” what sorts of problems might arise.

Q: I have a comment and a question. You noted the tremendous potential value of genetic engineering in providing the food that will be needed for a more populous world. It is worth noting that, if the United States, Europe, Australia and certain other countries, stopped the production of grain-fed livestock, we would have a tremendously increased availability of food, which, for agencies concerned with food production that may be an approach worth investing in. (*Dr. Millis:* I couldn't agree more.) My question is with regard to labeling in Australia and New Zealand. What are food manufacturers saying about that? Will they market foods with genetically modified ingredients?

A: This is yet to be fully tested. I have spoken with CEOs of food companies who have said, "A drop of 5% of sales is critical to me—I won't touch it. I want 'GM-Free' on my label." Now, this is an interesting statement in that the 'GM-Free' on the label has to be fully documented such that it may be audited. Therefore, you could find yourself in trouble with that label if someone detects contamination with PCR.

Q: In this country it seems that companies are afraid of marketing foods with that label. In Australia, they don't have to say 'GM-Free,' they can just say nothing. Do you think that is the approach that food companies will take?

A: Yes, I do. And there will be a price differential, I suspect. I cannot imagine a situation where the company pays but the consumer doesn't.

Q: But, will the companies actually market that alternative line with the GM label?

A: I don't know. But, I have the same feeling as you that they are suspicious of declaring 'this is GM.'

The Genetically Modified Crop Debate in the Context of Agricultural Evolution[1]

C.S. PRAKASH
Tuskegee University
Tuskegee, AL

"Whoever could make two ears of corn, or two blades of grass grow upon a spot of ground where only one grew before would deserve better of Mankind, and do more essential service to his country, than the whole race of politicians put together."—The King of Brobdingnag, Gulliver's Travels by *Jonathan Swift*, 1727

"I believe that we have now reached a moral and ethical watershed beyond which we venture into realms that belong to God, and to God alone. Apart from certain medical applications, what actual right do we have to experiment, Frankensteinlike, with the very stuff of life?"—Prince Charles (Windsor, 1998)

Throughout history, there have been those who have embraced change and those who have clung to the old ways because they felt that at least the risks were known. Few Edisons or Einsteins were properly recognized during their lifetime. And, since feeding ourselves has been the primary occupation of humankind for most of recorded and prerecorded histories, changes in food production have been accepted slowly. The first person to try to scratch out a garden most assuredly heard derisive laughter as the mighty hunters headed off in pursuit of meat. So, we should not be surprised that eons of history are being replayed as we enter the era of biotechnology. As the fates of human society and crops have been inextricably intertwined since the dawn of civilization, an appreciation of our agricultural past may guide us in addressing societal concerns and also in ensuring minimal negative consequences from scientific pursuits.

[1]Edited from a commentary by the author in Plant Physiology 126 (2001) 8–15, and included here with the permission of the publisher.

Farmers have embraced biotechnology because it makes them more efficient, protects or increases yields, and reduces their reliance on chemicals that, other things being equal, they would prefer not to use. Crops enhanced by biotechnology are being grown on approximately 110 million acres in thirteen countries. Ingredients produced from biotech crops are found in thousands of food products consumed worldwide. However, although no unequivocal evidence of harm to our health or the environment from these crops is known or expected, an intense debate is focused on their value and safety.

Societal anxiety over so-called genetically modified (GM) food is understandable, and it is fueled by a variety of causes, including consumer unfamiliarity, lack of reliable information on the current safeguards, negative opinion from the news media, opposition from activist groups, growing mistrust of industry, and a general lack of awareness of how our food production system has evolved. The scientific community has neither adequately addressed public concerns about GM foods nor effectively communicated the value of this technology. Clearly, societal acceptance is pivotal to the continued development and application of biotechnology in agriculture and food.

Two decades ago, many agricultural scientists rightfully saw the emerging recombinant DNA technology as a potent tool for enhancing crop productivity and food quality, while promoting sustainable agriculture. The early excitement and expectation was followed by successive breakthroughs in identification of valuable genes, development of gene-transfer methods, and the eventual production of transgenic crops. Breeders saw the technology as a complementary means of achieving crop improvement, and, for the first time, the products of their efforts were subjected to rigorous testing, and a regulatory framework was developed to oversee the commercialization of GM crops on a case-by-case basis. There has been widespread acceptance of, and support for, biotechnology within the scientific community. Accumulated experience and knowledge of decades of crop improvement combined with expert judgment, science-based reasoning, and empirical research have given scientists confidence that GM crops may pose no new or heightened risks that could not be identified or mitigated, and that any unforeseen hazard will be negligible, manageable, or preventable. Risks from GM crops should be monitored and measured, but concerns about these risks must be balanced against the enormous potential benefits from this technology and weighed against alternative options. The strong trust of the American public in its regulatory agencies (the Food and Drug Administration, the United Stated Department of Agriculture, and the Environmental Protection Agency) has fostered higher public acceptance of GM food in this country than elsewhere.

Mutant Food and Monarch Butterflies

Despite promised benefits, global negative reaction to GM crops ranges from mild unease to strong opposition. Typical questions include:

- Is it ethical for scientists to modify living organisms?
- Is it morally right to tamper with our food supply?
- Is genetic modification of crops inherently hazardous?
- Despite built-in safeguards, can we unwittingly make our foods unsafe?
- What about the long-term consequences of consuming foods containing GM ingredients?
- Do GM crops affect the environment or wild ecosystems, reducing crop biodiversity, beneficial insects, or the revered monarch butterfly?
- Could GM crops lead to the development of noxious "super-weeds"?
- Are we introducing GM crops into our environment without fully understanding the consequences of such action?
- Should we be concerned about genetic pollution?
- Can these genes be transferred to other organisms, including humans and animals?

In addition, there are also larger and even more important sociopolitical issues such as anxiety about the control of food and agricultural systems, including questions about the pervasive impact of globalization.

How can scientists allay public concerns, given the complexities of these issues? Creating an awareness of agricultural history may provide a good beginning. It may also educate scientists about the relevance of the societal context to our research. Most risk issues related to current GM crops are not unique when placed in the context of how agriculture was developed through crop domestication over many millennia and how we have bred modern crop varieties in the past century. As Frary and Tanksley (2000) put it, "The issue is not whether we should modify the genetics of crop plants. We embarked on that road thousands of years ago when plants were first domesticated. Instead of simply judging the vehicle through which we make genetic changes, we need to weigh the potential consequences that such modifications hold for the society and the environment."

"The issue is not whether we should modify the genetics of crop plants. We embarked on that road thousands of years ago when plants were first domesticated. Instead of simply judging the vehicle through which we make genetic changes, we need to weigh the potential consequences that such modifications hold for the society and the environment."

Crop Evolution and Human Civilization

Agriculture evolved independently in many places on this earth, but the earliest evidence of farming dates to 10,000 years ago in present day Iraq (Heiser, 1990). For much of the 200,000 or so years prior to agriculture, humans lived as nomadic hunters, gatherers, and scavengers surviving solely on wild plants and animals. Subsequent domestication of these wild plants and animals from their natural habitats launched agriculture, thus radically transforming human societies. This occurred initially in the Fertile Crescent in the Middle East, the Andean region of South America, Mexico, and parts of Asia, and diffused throughout much of the globe. The change from a nomadic lifestyle to farming led us to become community dwellers, eventually spawning the development of languages, literature, and science and technology as people were freed from the daily task of finding food. These developments were more rapid in some regions than in others by thousands of years (Diamond, 1999). Plants evolved rapidly, or, more accurately, they were changed, as a result of human intervention (Harlan, 1992).

Every crop grown today is related to a wild species occurring naturally in its center of origin, and progenitors of many of our crops are still found in the wild. Early humans must have tried eating thousands of feral species from the pool of a quarter of a million flowering plants before settling on the thousand or so that were subsequently "tamed" and adapted to farming. A little over a hundred species are now grown intensively around the world, of which only a handful supplies us with most of what we eat. Through a process of gradual selection, our ancestors chose a very tiny section of the wild-plant community and transformed it into cultivated crops. Some profound alterations in phenotype occurred during such selection, including determinate growth habit; elimination of grain shattering; synchronous ripening; earlier maturity; reduction of bitterness and toxins; reduced seed dispersal, sprouting and dormancy; greater productivity, including larger seed or fruit size; and even an elimination of seeds, such as in banana. These changes reduced the survivability of crops in the wild, and thus a feature that transcends all of our crops is the reduction of weedy traits from wild plants. Present crops are totally dependent upon human care for their survival, and modern varieties would persist in the wild "no longer than a Chihuahua would last in the company of wolves" (Trewavas, 2000).

Most of the crops that supply our food were first domesticated at the end of the Stone Age, often from a relatively narrow pool of wild genetic diversity. Additional diversity arose within such cultivated crops through new mutations and natural hybridization, and through judicious selection and perpetuation by farmers who maintained them as land races. Varied uses and preferences brought forth further diversification such as with corn (popcorn, sweet corn, dent corn, broom corn, and flour corn for tortilla and corn bread) and cabbage (kale, kohlrabi, Brussels sprouts, cabbage, cauliflower, and broccoli).

With the advent of transoceanic navigation and the “discovery” of the New World, crops were moved rapidly around the globe, and some achieved acceptance far beyond their natural centers of origin or domestication. For instance, the United States is the leading producer of corn and soybean in the world, yet these crops are native to Mexico and China, respectively. The world's largest traded commodity, coffee, from its humble origins in Ethiopia now is grown in Latin America and Asia. Florida oranges have their roots in India, while sugarcane arose in Papua New Guinea. Food crops that are now so integral to the culture or diet in the Old World, such as the potato in Europe, chili pepper in India, cassava in Africa, and sweet potato in Japan, were introduced from South America. For that matter, every crop in the United States other than the blueberry, Jerusalem artichoke, sunflower, and squash is borrowed from elsewhere!

A few sources of our food are recent domesticates. Careful breeding rendered palatable the Chinese gooseberry, native to China, and it was rechristened “kiwi fruit” after introduction to New Zealand early in the twentieth century. The modern strawberry with large fruits is a product of accidental crossing of two wild species from Virginia (United States) and Chile in France in the mid-eighteenth century. Rapeseed, grown in India for centuries, was altered recently through classical breeding to eliminate the toxic erucic acid and malodorous glucosinolates to result in canola. Triticale, a completely new crop, was artificially synthesized a century ago by combining the genomes of wheat and rye (from two genera that do not interbreed in nature). It is now grown on over three million acres worldwide. Modern bread wheat itself is also a fairly recent crop in the evolutionary time scale, having arisen only about 4,000 years ago through hybridization of tetraploid (pasta or durum) wheat with inedible goat grass.

From Mesopotamia to Mendel

Farmers have molded the evolution of crop plants for several millennia, leading to rich diversity especially in traits related to their planting or consumption. At the same time, global population grew very slowly until the mid-nineteenth century. It took 1,800 years for the global population to climb from an estimated 300 million around the time when Christianity began, to reach its first billion. But it took only 12 years to add the last billion, rising from 5 billion people in 1987 to six billion in 1999. Fortunately, parallel scientific developments in agriculture ensured that food production kept pace with the population explosion of the past century (Conway, 1999).

Beginning with Mendel's study of peas, knowledge of genetics helped usher in scientific crop development, resulting in high-yielding varieties. Food production has increased in every part of the world in the past few decades, including Africa. Per-capita food consumption has also increased steadily everywhere except in parts of sub-Saharan Africa. In the United States, where

such scientific developments and their applications have been most intense, the average farmer now produces enough to feed nearly 150 people. In crops subject to intensive scientific attention—corn, soybean, wheat, and rice—the productivity levels have increased several fold. For example, American corn growers averaged 26 bushels/acre in 1928 and 134 bushels/acre in 1998 (National Corn Growers Association, 2001).

Such a prodigious increase in agricultural production was underpinned by scientific crop-improvement methods along with other developments, including irrigation, improved soil-fertility management, mechanization, and control of diseases and pests (Conway, 1999). To develop better crop varieties, scientists have used an array of tools. Artificial crossing, or hybridization, helped us assimilate desirable traits from several varieties into elite cultivars. When desired characteristics were unavailable in the cultivated plants, genes were liberally borrowed from wild relatives. When a crop variety refused to mate with the wild species, various tricks were employed to force intermingling, such as colchicine or by rescuing the hybrid embryos with tissue-culture methods. Hybrid vigor was exploited in crops such as corn and cotton to boost productivity. When existing genetic variation within the cultivated germplasm was not adequate, breeders created new variants using ionizing irradiation (gamma ray, X-ray, neutrons), mutagenic chemicals (ethyl methane sulfate, mustard gas), or through somaclonal variation (cell culture).

Most people who are concerned about modern biotechnology have little or no knowledge of the processes that have been used to transform crops in the past. Nor is it likely that they are aware that crops have been continually altered over time or that, without human care, they would cease to exist. Using a variety of tools over the past several decades, plant breeders have radically transformed our crops by altering their architecture (*e.g.* dwarf wheat and rice), shortening the time to flowering, developing greater resistance to disease and pests (all crops), and developing larger seeds and fruits (Figs. 1 and 2). These

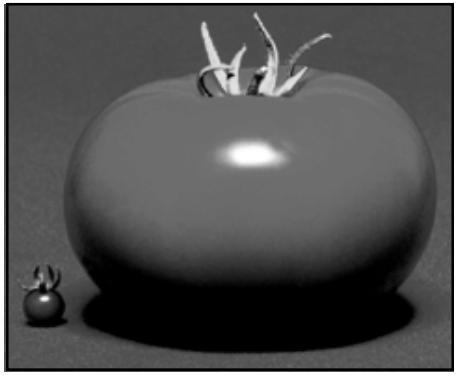

Figure 1. Wild *Lycopersicon pimpinellifolium* (left, diameter 1 cm) and a commercial tomato. (Kindly provided by Steve Tanksley.)

crops are also more responsive to management and are better adapted to diverse ecological conditions. Improved food quality has resulted through fewer toxins (canola), better digestibility (beans), increased nutrition (high-protein corn), better taste, longer shelf life (thus withstanding long transportation and storage), and enhanced freshness in many vegetables and fruits. A one-thousand-fold increase in the volume of the marble-sized wild *Lycopersicon* has resulted in the modern tomato that can now weigh as much as a kilogram (Frary and Tanksley, 2000). Modern farming has steadily increased the supply of relatively safe, affordable, and abundant food, not only in the developed world, but also in most developing countries. The average American family spends only 11% of its income on food, and yet has access to better choices with more variety and nutrition than ever before. Without scientific developments in agriculture, we would be farming every square inch of arable land.

Figure 2. Wild teosinte (left), a modern corn hybrid (right), and their hybrid (center). (Kindly provided by John Doebley.)

Using gene-transfer techniques to develop GM crops is a logical extension of the continuum of devices we have used to improve crop plants for millennia. When compared to the gross genetic alterations associated with wild-species hybridization or the use of mutagenic irradiation, direct introduction of one or a few genes into crops results in subtle and less disruptive changes that are relatively specific and predictable. The process also is clearly more expeditious, as the development of new cultivars by classical breeding typically takes from 10 to 15 years. The primary attraction of gene-transfer methods to the plant breeder, however, is the opportunity to tap into a wide gene pool to borrow traits, obviating the constraints of cross-species compatibility.

When compared to the gross genetic alterations associated with wild-species hybridization or the use of mutagenic irradiation, direct introduction of one or a few genes into crops results in subtle and less disruptive changes that are relatively specific and predictable.

Addressing Public Concerns

While direct gene transfer is still a relatively new approach, many concerns arising from its use may be addressed with the "benchmark" of conventionally bred varieties, as we have more than a century of accumulated experience and knowledge with the latter. Although it may seem logical to express the concern, "I don't know what I am eating with GM foods!" it must be remembered that we have never had that information with classically bred crops. With GM crops, at least we know what new genetic material is being introduced, so we can test for predictable and even many unpredictable effects. Consider, for example, how conventional plant breeders would develop a disease-resistant tomato. They would introduce chromosome fragments from its wild relative to add a gene for disease resistance. In the process, hundreds of unknown and unwanted genes would also be introduced, with the risk that some encode toxins or allergens—armaments that wild plants deploy to survive. Yet we never routinely tested conventionally bred varieties for any food safety or environmental risk factors, and they were not subject to any regulatory oversight. We have always lived with food risks, but in the last few decades we have become increasingly more adept at asking questions.

To address concerns about long-term health consequences of GM foods, it is instructive to recognize that we never worried about such impacts when massive amounts of new proteins (and unfamiliar chemicals) were introduced

To address concerns about long-term health consequences of GM foods, it is instructive to recognize that we never worried about such impacts when massive amounts of new proteins (and unfamiliar chemicals) were introduced into our foods from wild species, or when unknown changes were created through mutation breeding.

into our foods from wild species, or when unknown changes were created through mutation breeding. When new foods from exotic crops are introduced, we often assimilate them readily into our diets. What is more, we rarely, if ever, asked the same questions that we now pose about GM crops. Lately, many so-called functional foods, health foods, and nutraceuticals have entered the mainstream American diet with little or no regulation or testing. We do not question the long-term health implications of these food supplements, even though they involve relatively large changes in our food intake.

In contrast, the GM foods currently on the market have been tested extensively and judged to be substantially equivalent to their conventional counterparts, with just one or two additional proteins present in miniscule amounts (introduced into a background of thousands of proteins). And those proteins are broken down either during processing or digestion, with little long-term consequence. In food products such as oils, starches, and sugars, such proteins are not even present. A nagging potential problem with a new protein in food is that it could be a potential allergen. As most food allergens are now well studied, we know that they are found in a few defined sources (peanut and other grain legumes, shellfish, tree nuts, and a handful of other foods) and share many similar structural features. Moreover, they must be present in large proportions in our food, and we must be sensitized to them over time if they are to cause adverse effects. Thus, it is highly unlikely for new allergens to be introduced into our food supply from GM plants.

Historical Absence of Zero Risk

There is no such thing as safe food, and there never has been. That is not to suggest that all of our foods are dangerous, only an acknowledgment that trace levels of toxins and carcinogens are present in everything we eat. But a primary rule of toxicology, articulated over 400 years ago by Paracelsus, refers to the importance of dosage: “Every substance is a poison, but it is the dosage that makes it poisonous” (Poole and Leslie, 1989). Our food naturally contains

thousands of chemicals, many of which are hazardous in laboratory-animal studies in huge doses. Our diet includes 5,000 to 10,000 natural toxins, which plants have evolved as protection against pests, diseases, and herbivores (Ames et al., 1990a). For instance, roasted coffee has over a thousand chemicals of which twenty-seven have been tested and nineteen found to be carcinogens in rodents (Ames and Gold, 1997). The fat-soluble neurotoxins solanine and chaconine, present in potato, can be detected in the bloodstream of all potato eaters (Ames et al., 1990b). Naturally then, when crops are bred for resistance to pests by transferring genes through conventional methods, the resistance is often accompanied by increases in such toxic compounds.

Thus, it is erroneous to assume that we never had problems with conventionally bred varieties. Although any variety found to pose a real health risk was promptly removed from the market, they were never routinely tested (in contrast to GM crops). One pest-resistant celery produced rashes in agricultural workers and subsequently was found to contain 6,200 ppb of carcinogenic psoralens compared to 800 ppb in the control celery (Ames *et al.*, 1990). This celery was removed from cultivation as was the potato variety Lenape, which contained very high levels of solanine. With all innovations we learned by trial and error. Similarly, crop-improvement practices evolved over time with continued refinement. It is common, though, for human nature to generate an exaggerated fear of innovations while perceiving older or "natural" products as more benign. Huber (1983) discussed this double standard in the larger context of risk regulation. We have always been lenient toward existing known and greater hazards, even as we create "gatekeepers" to minimize new risks. Thus, we fail to recognize and "exorcise" much larger older risks.

While most food hazards arise from pathogens such as *Escherichia coli* 0:157, *Listeria*, and *Salmonella*, along with mycotoxins produced by fungi (and thus a function of food storage and handling), certain foods containing toxic compounds are known to produce adverse health consequences over time. Cassava, eaten by large numbers in Africa, contains cyanogenic glucosides that cause limb paralysis if consumed before extensive processing. Solanin in tomato and potato is known to cause spina bifida. Vetch pea, a common legume known for its hardiness and thus popular in India among poor farmers, contains highly dangerous neurotoxins that cause untold misery. Phytohemagglutinin, found in undercooked kidney beans, is toxic. And peach seeds are extremely rich in cyanogenic glucosides. None of these were subject to any mandatory testing before they were introduced into the food chain, nor are they subject to any regulation now. If the current regulatory standards imposed on GM crops were to be invoked for traditional crops, many would fail to meet requirements.

Humans have built-in natural defenses for protection against normal exposure to toxins. But, according to Ames and Gold (1997), we have not evolved to achieve "toxic harmony" with everything we eat, because natural selection occurs much too slowly and because much of what is in our diet today

was not eaten at all when we were hunter-gatherers. A balanced mixture of foods normally provides adequate nutrition. However, none of the crops grown today were selected with our nutritional requirements in mind. Instead, our ancestors chose them intuitively from among the edibles that could be found around them. Thus, the most important food crop in the developing world, rice, has no provitamin A and little iron in its endosperm. This has led to horrific problems, such as blindness among millions of children due to vitamin-A deficiency, and iron-deficiency anemia in nearly a billion women dependent on a rice diet. Biotechnology research, far from causing any new food-safety problems, has already demonstrated its potential in enhancing nutritional quality and is also being employed to reduce harmful toxic compounds that exist in our food.

Environmental Concerns

All of us have to eat to live, and organized food production is the most ecologically demanding endeavor we have pursued. Agricultural expansion over the millennia has destroyed millions of acres of forestland around the world. Alien plant species have been introduced into nonnative environments to provide food, feed, fiber, and timber, and as a result have disrupted local fauna and flora. Certain aspects of modern farming have had a negative impact on the biodiversity of crop plants and on the quality of air, soil, and water; nevertheless, it sustains and nurtures most of the world's six billion people with adequate nutrition and affordable food.

How can we address the environmental questions concerning GM crops in the context of our experience with traditional crop-variety deployment? Through conventional breeding, we have continuously introduced genes for resistance to diseases and pests into all of our crops. Traits, such as stress tolerance and herbicide resistance, have also been introduced in many crops, and the growth habits of every crop have been altered. The risk of crop "gene flow" to weedy relatives has always existed. Thus, it is comforting to recognize that no major "superweeds" have developed since the advent of modern plant breeding, although there have been a few instances of crops becoming weedy or of weeds becoming more invasive due to gene transfer from crops. Most noxious weeds, such as kudzu (*Pueraria lobata*), water hyacinth (*Eichhornia crassipes*), and parthenium weed (*Parthenium hysterophorus*) resulted from the introduction of whole genomes of exotic semi-domesticated wild species without the checks and balances of their native pests. Yet, there are probably no dwarf plants among the wild *Oryza* and *Triticum* populations in Asia and the Middle East, despite the fact that we have been growing diminutive rice and wheat varieties for decades.

The risk of gene transfer to wild species is exacerbated when crops are planted in an area with compatible weedy relatives (as often seen at their centers of origin), when such species are promiscuous out-crossers (canola),

or, most importantly, when the introduced genes enhance the reproductive fitness of the recipient weeds (although most genes introduced into crop plants, conventional or biotech, have little value in the wild). The risk of gene transfer to weeds is similar with conventional and GM crops and is not contingent upon how the genes are introduced to the crop. We must be vigilant to ensure that weeds do not become noxious as a result of any new crop variety. The current case-by-case testing and monitoring approach with biotech crops is a good regimen for the future, while experience with conventional crops provides assurance that such risks will be minimal and manageable.

Crop biodiversity is another issue of concern. The popularity of high-yielding varieties has already narrowed the genetic variation found in major crops. Biotechnology, if employed strategically, can reverse this through the recovery of older varieties that were discarded for lack of certain features (such as resistance to new disease strains), because modern gene transfer can restore such traits. Biotechnology research is also enabling the development of better methods for *ex situ* preservation of germplasm, such as cryopreservation, whereby valuable germplasm is being stored and thus saved from extinction.

The introduction of corn with a single transferred Bt gene has led to concern about its ecological impact. While this concern should not be dismissed, it should be balanced with hindsight and experience. Corn is an introduced alien species grown on 75 million acres in the United States, where none existed a thousand years ago. A crop grown in a new environment entails the wholesale introduction of thousands of new genes. When cultivated on huge areas of land, it exerts considerable ecological impact on the native fauna and flora, including beneficial insects. In contrast, the introduction of one or two genes into this background of the tens of thousands of genes present in corn will have relatively less effect on the environment. Whereas the initial fear about the reported damage to monarch butterflies from Bt corn has not held up in additional studies, one also needs to consider the negative impact of alternate practices (such as pesticide spraying) and recognize the potential for positive impacts on beneficial insects by the GM crop due to its specificity regarding targeted insects.

For that matter, any concern about “gene pollution” pales in comparison to the massive “risk” of alien crop introduction, as 95% of the crop area in the United States now consists of such introduced crops. Concern about horizontal transfer of genes from GM crops to other organisms, such as bacteria, also has been expressed. But it appears highly unlikely that any such risk is dependent upon the method of gene introduction. An inherent feature of biotechnology is that it lends itself easily to molecular detection of introduced genes, but a true measure of risk can only come in comparisons with classically bred crops where little or no such studies have been performed. Concerns over random gene insertion, gene instability, and genomic disruption due to gene transfer are unlikely to be unique to GM crops or of any significance considering our

Worries about mixing genes from unrelated species ignore the history of plant breeding and the existing overwhelming sequence similarity of genes across kingdoms. Nevertheless, scientific research aimed at risk analysis, prediction, and prevention, combined with adequate monitoring and stewardship, must continue so that negative ecological impact from GM crops will be kept to a minimum.

current knowledge of genomic flux in plants. Worries about mixing genes from unrelated species ignore the history of plant breeding and the existing overwhelming sequence similarity of genes across kingdoms. Nevertheless, scientific research aimed at risk analysis, prediction, and prevention, combined with adequate monitoring and stewardship, must continue so that negative ecological impact from GM crops will be kept to a minimum.

Most problems raised by science can be solved by additional science itself. For example, appropriate promoters may ensure that pollen will not express genes toxic to beneficial insects, while gene expression strategies, such as sterile pollen, could reduce the risk of gene flow. One must also recognize the potential positive impact of GM crops on the environment, such as decreasing agricultural expansion to preserve wild ecosystems; improving air, soil, and water quality by promoting reduced tillage, and reducing chemical and fuel use; improving biodiversity through resuscitation of older varieties; promotion of beneficial insects; and cleaning up contaminated soil and air through phytoremediation.

As we chart ahead with more exciting developments in biotechnology such as genomics, and grapple with issues arising from consumer acceptance of innovations, historical knowledge on societal adoption of technological innovations may provide some valuable perspectives to scientists. Many innovations that would be good candidates for generating consumer apprehension and concern today were introduced in the past without concern because the public was less informed about innovation. The precautionary principle was never invoked to ensure the scientific certainty that crop varieties developed using nuclear irradiation or chemical mutagens were safe. And food labeling was never demanded for bread wheat improved with the addition of hundreds of unknown goat-grass genes.

Many other innovations that are now commonplace in our lives were met with skepticism and opposition when first introduced. Such fear of technology has been especially pronounced in food-related innovations (*e.g*. pasteurization, canning, freezing, the microwave oven). However, once consumers recognized that these innovations enhanced the quality of life and once they understood that risks are either minimal or manageable, then these technologies enjoyed public acceptance. This includes even "disruptive" technologies that replaced older ones (*e.g.* automobile vs. horse buggy, compact disc vs. cassette tape). Nevertheless, there are historical instances of useful innovations that have not been readily accepted due to a variety of reasons, such as recalcitrance to adapt (*e.g*. Dvorak *vs*. QWERTY keyboard), entrenched economic interests opposing change (*e.g*. the metric system in the United States; Beta versus VHS videotape), ideological opposition (*e.g.* plant breeding by Lysenko during Stalin's rule of the Soviet Union), exaggerated notions of risk (*e.g*. food irradiation), ill-timed product introductions, and serious conflicts with societal values and beliefs.

The survival of humans and crops will always be mutually dependent, and the guided evolution of crops will be increasingly knowledge-based. An appreciation of the history of agricultural development, however, may provide us with a useful roadmap for devising appropriate strategies to informing and rationalizing societal responses to crop improvement. Paraphrasing the American philosopher George Santayana: ignoring history may condemn us to repeat it. On the other hand, an understanding of the past may well lead us to an enlightened future.

ACKNOWLEDGMENTS

I am grateful to many contributors to my Internet discussion list Agbioview (www.agbioworld. org) for enriching my knowledge on these issues. I thank Gregory Conko, Tom DeGregory, Paul Gepts, Dan Holman, Richard Levine, Alan McHughen, and Neal Stewart for helpful comments on the manuscript.

REFERENCES

Ames BN Gold LS (1990) Chemical carcinogens: too many rodent carcinogens. Proceedings of the National Academy of Sciences of the USA 87 7772–7776.

Ames BN Gold LS (1997) Pollution, pesticides and cancer misconceptions, in What Risk? (Bate R ed) 173–190. Boston: Butterworth Heinemann.

Ames BN Profet M Gold LS (1990a) Dietary pesticides (99.99 percent all natural). Proceedings of the National Academy of Sciences of the USA 87 7777–7781.

Ames BN Profet M Gold LS (1990b) Nature's chemicals and synthetic chemicals: comparative toxicology. Proceedings of the National Academy of Sciences of the USA 87 7782–7786.

Conway G (1999) The Doubly Green Revolution. Ithaca, NY: Comstock Publishing Associates.

Diamond J (1999) Guns, Germs and Steel: The Fates of Human Societies. New York: W.W. Norton.
Frary A Tanksley S (2000) The origin of crop species accelerated evolution with mankind at helm. SCOPEGM Food Controversy Forum. http:// scope.educ.washington.edu/gmfood/ commentary/show.php?author5Frary
Harlan J (1992) Crops and Man. Madison, WI: American Society for Agronomy and Crop Science.
Heiser CB Jr (1990) Seed to Civilization: The Story of Food. Cambridge, MA: Harvard University Press.
Huber P (1983) Exorcists vs. gatekeepers in risk regulation. Regulation 7 2332.
National Corn Growers Association (2001) http://www.ncga.com/03world/ main/index.html.
Poole A Leslie GB (1989) A Practical Approach to Toxicological Investigations. Cambridge: Cambridge University Press.
Trewavas A (2000) GM is the best option we have. Agbioview. http:// agbioview.listbot.com/ cgibin/subscriber?Act 5view message&list id5agbioview&msg num5395& start num5410.
Windsor C (1998) Seeds of disaster. London: Daily Telegraph, June 10.

PART IV

SESSION II

INFLUENCING THE CONSUMER LENS

Lessons from Risk Perception in Other Contexts

V. KERRY SMITH
North Carolina State University
Raleigh, NC

I will draw inferences from lessons that are associated not with biotechnology, but with how consumers deal with risks in other contexts. I will discuss insights gained from cognitive psychology and research on consumer attitudes. And I will also touch on economics, drawing principally on my own work with colleagues. We have addressed issues associated with how one can use environmental and health risks, both voluntary and involuntary, and the rules of risk communication, to inform the current discussion of GMOs and biotechnology.

Will consumer attitudes, in the United States and elsewhere, substantially retard biotechnological innovations that might ultimately affect the food supply? If that question is meaningful, then we must ask a subsequent one: does the accumulated experience and research in risk communication, and what we know about how to present risk information to consumers, suggest that there are ways to influence the answer? That is, can we, through policy measures, undertaken both in the public and in the private sectors, change the responses that we would otherwise expect if risk information were not presented? And then, ultimately: do we know enough now to take immediate action?

Food-production decisions must be taken in the context that food is a world-wide commodity. Consumers are heterogeneous. They have diverse information bases, and culture is a very important contextual issue in Europe. Price and quality attributes, as well as information, are important for decision making. We have to provide value and change the perceptions of value either directly or indirectly through price, in order to see a consumer response. It is important to understand—not just in the area of GM and biotechnology, but in areas such as the environment—that the production technology used to deliver a food, or any

other product, often becomes a part of the product-attribute set. Consumers have preferences, and understanding them helps determine how information associated with that product should be delivered.

In this country, multiple domestic agencies affect food policy and perceived safety. In the world community we know from sanitary and phytosanitary standards that trading rules are affected by perceptions of risk and efforts to maintain or harmonize the information on, and the treatment of, risk. Also, it is important to understand that the science base of most reporting—not the *New York Times*, but the local and regional newspapers—is extremely limited. Consequently, the ability to explain technical information is also constrained. In delivering a message, it is necessary to recognize that media are the consumers' primary source of information about a whole host of issues.

Experiments in Risk Perception

I will describe three social-science experiments (not surveys) that provide evidence that consumers' subjective perceptions of risk should be taken seriously. These are matters that are not variable day to day, that do influence behavior, and that can be influenced. Information and its source clearly do modify risk perceptions, and I think we understand enough to provide specific guidance on how to structure that information. Clearly the process is context- and problem-specific. So one needs to understand how consumers see the problem in order to adapt what we know about what is important about the source of risk. The cultural context affects how one delivers a message and provides information.

You cannot consider risk perception in psychology without coming across the names of Paul Slovic, Daniel Kahneman, Amos Tversky, and Sarah Lichtenstein. Their central point is that risk has attributes. You cannot think of probabilities of events in isolation from whether the source of uncertainty is voluntary or involuntary, whether the process is perceived to be known or unknown, and whether the outcomes are dreaded. People do not necessarily behave like the calculating agents that economists and others imagine, but, where the issues are personal, the consumer is likely to behave rationally in acquiring and using information.

Where the issues are personal, the consumer is likely to behave rationally in acquiring and using information.

In the area of economics, there has been a lot of research on the effects of labels, for example when the Food and Drug Administration (FDA) changed advertising rules on fiber and cancer. Economists examined the change—the

demands for cereals with fiber before and after—and attempted to infer the consequences of the label. Likewise, we can consider organic and non-organic produce side by side and ask about differences in demand. However, it is hard to go meaningfully backwards from these observations, which is why I am in favor of more social-science experiments.

Tom Hoban's surveys in 1995 and 1997 in the United States, and in 1998 in Japan (see Table 1), demonstrated that when unprompted American and Japanese consumers were asked what they feel is the greatest threat to food safety, biotechnology was at the bottom of the list. When prompted, biotechnology remained near the bottom of the list.

TABLE 1. RESEARCH ON CONSUMER ATTITUDES: "WHAT DO YOU FEEL IS THE GREATEST THREAT TO THE SAFETY OF THE FOODS YOU EAT?" (HOBAN, 1999)

	United States 1995, 1997 (%)	Japan 1998 (%)
Unprompted		
Pesticide residues	16	45
Additives or preservatives	2	34
Microbial contamination	69	7
Antibiotics or hormones	1	4
Irradiated foods	0	1
Biotechnology	0	1
Prompted		
Pesticide residues	66	80
Additives or preservatives	20	52
Microbial contamination	77	49
Antibiotics or hormones	42	62
Irradiated foods	29	56
Biotechnology	16	8

Hoban adds an important qualifier—and this is the kind of information that comes from consumer-attitude research—we need to consider the fact that people answer these questions spontaneously, typically over the telephone. They have had little time to think about them, yet the responses may form the basis for policy decisions. Therefore, we should consider alternative sources of information in framing the policy debate.

Consumer attitudes alone are not enough. How about surveys and experiments? Economists are fond of surveys that offer stated-choice information, and are fond of trying to mimic natural scientists in conducting controlled

experiments in the laboratory that typically involve students who are offered different choices. And in another category called a simulated market, we sell real products in a control setting and have consumers actually buy them in this limited setting; of course, typically the consumer is told that it is an experiment, therefore, it is harder to accurately draw inferences.

I will describe three real-world, long-term, large-scale, social-science experiments. Two involve radon, which, as a naturally occurring gas associated with lung cancer, has an important attribute: it is an involuntary source of risk. In one of the two experiments, individuals were recruited to have their homes monitored for radon. The objective of our research team— including New York State Energy Research and Development Authority and the United States Environmental Protection Agency (EPA)—was to try to communicate effectively the risk message associated with radon to these homeowners as part of designing what ultimately became, in the mid-1990s, the EPA's *Citizens Guide to Radon*. It was a panel study involving four interviews of 2,300 households, and tracking their behavior over a period of four years, 1986 to 1989. We examined risk-perceptions, and looked for mitigating behavior.

The second study, undertaken by the same team, took place in Maryland, again in the late 1980s. Three thousand households were involved over a period of a year and a half to two years. The objective was to inform households that might not otherwise know anything about the risks of radon and induce them to take action by having their homes tested for it.

The third experiment was finished recently (with support from the Robert Wood Johnson Foundation). It involved approximately 12,600 households, in conjunction with a still-on-going survey—the Health and Retirement Survey—with a demographically matched sample. We examined a voluntary risk: cigarette smoking. Surely everyone knows that cigarettes are harmful. Why then do people of 51 to 61 years of age continue to smoke? What do they believe the consequences will be? What would be salient messages that would change smokers' beliefs?

From each of these experiments I will draw lessons relevant to biotechnology and GMOs.

Involuntary Environmental Risks — Radon

The experimental design for the New York study involved six brochures in specifically designed categories. The categories varied the amount of quantitative information and the amount of specific guidance given to each household about the risk or exposure to radon.

After four interviews and multiple years, we found clearly that an informational message that presented exceptionally clear guidance, that said, "Do 'X' and you will be safe," was the most effective message in communicating the risk. Also, we found that people subscribe to the notion that they can undo

damage they have done to themselves by inaction. Reversibility of the process was extraordinarily important to people's responses. Each brochure was randomly assigned to a different group just as for a field experiment. So, each member of the group during the course of the experiment received only one type of informational source from us.

About 10% more people took some action as a result of receiving the quantitative informational brochure in comparison to those who received a standard government fact sheet. In terms of radon level, an eight-fold increase would have been needed to have the same level of effectiveness as that information booklet.

The second study involved three sets of households in three communities in Maryland: Hagerstown, Frederick, and Randallstown. The experimental design was carefully constructed. Frederick and Hagerstown received different information campaigns, and Randallstown, the control, received nothing. Posters were put up around Frederick, and there was community involvement. We recruited the mayor and the town council to monitor their own homes; they were on television and radio, and were very much involved in the process. In Hagerstown, information was delivered with telephone bills to explain radon, and posters were displayed around the community, but nothing else was done.

The gray bars in Figure 1 show baseline-survey data: percentages of people who monitored their homes for radon, which was our outcome measure. The black bars show the results of the experiment. We saw a 10% increase in monitoring as a result of the intensive involvement in Frederick, and next to nothing in the other two communities. These data show that with close continuous involvement, contributions from community leaders, and a personalized message, positive results are possible.

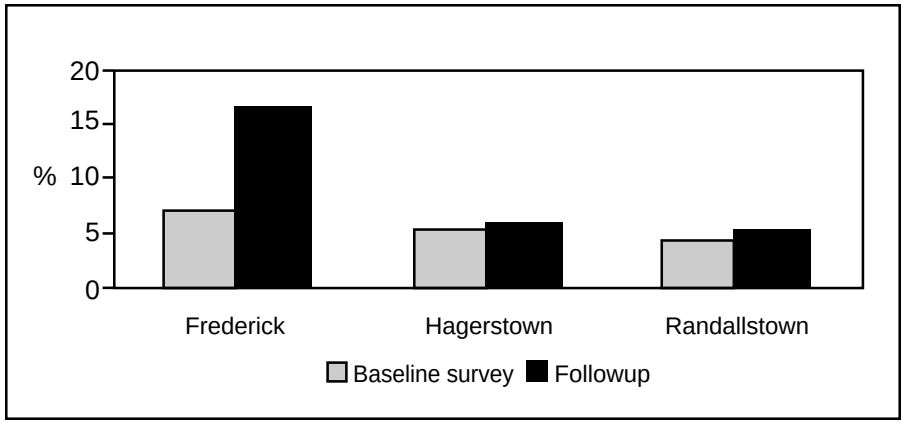

Figure 1. Fraction of people in baseline and follow-up surveys who had tested for radon.

VOLUNTARY HEALTH RISKS – SMOKING

How do smokers regard the risks from smoking? Advertisements by the American Lung Association and the American Cancer Association are frequent on radio and television, as well as in the print media, suggest that we interpret simple messages in a direct and narrow way. If a smoker quits the habit, then the adverse health effects will be reversed, eventually. Smokers use that message to guide their behavior incorrectly: "I will stop smoking when I am 73, get better in about 18 months, and then play tennis." Unless they have lost a spouse or parents, or seen someone else with a smoking-related disease, they do not accept the message that there is a risk to them.

Personalization is very important. Every two years since 1992 the same individuals were interviewed for an hour. The question reported here is, "What are the chances that you will live to 75 or more, on a scale of zero to 100?" Because these individuals were followed every two years and complete health records were kept, it was possible to observe the effects of health shocks on their longevity perceptions. We considered all possible health outcomes between two interviews, and classified shocks as either smoking-related—lung cancer, other serious lung diseases, and heart disease—or general. In Table 2 a negative sign implies a revision of the expectation of living to 75 or more as a result either of a general health shock or of a smoking-related health shock. Current smokers did not react to anything but a smoking-related health shock. Those who had never smoked and former smokers reacted to both types of shock equivalently.

TABLE 2. RISK UPDATING MODEL FOR 'LIVE TO 75' (T-TEST) DATA.

	Current smoker	Former smoker	Never smoked
Smoking-related health shocks	–0.1237 (–3.84)	–0.0692 (–3.18)	–0.1095 (–3.31)
General health shocks	0.0076 (0.27)	–0.0665 (–3.69)	–0.0551 (–2.74)

Sometimes you have to hit people over the head with a message. And that message should address what is at risk, not necessarily probabilities of the event at risk. In this context, the message should not be the probability of dying from smoking, it should address the mode of transition to death. You have to determine from the people specifically what concerns them. You must communicate with them in that context, and then work from there to develop a message. The bottom line is that perceptions are informative and they do affect behavior.

As for influencing the demand for cigarettes, we found that people do not passively accept information from experts. The information must be personal and tangible. Risk communication requires listening first.

Specific Lessons

Consumers generally want complete protection and not complex trade-offs. It is fruitless to tell them that they can do X, Y, and Z and reduce their marginal risk by a defined amount, although, as an economist, I wish it were otherwise. Unfortunately, they do not want to hear it. Honest, full disclosure is central to building trust. Trust can be very difficult to earn, and very quickly lost. Perceived irreversible choices—and the key issue is irreversibility—are central when concerns are serious.

Trust can be very difficult to earn, and very quickly lost. Perceived irreversible choices—and the key issue is irreversibility—are central when concerns are serious.

Reference

Hoban T (1999) Consumer acceptance of biotechnology in the United States and Japan. Food Technology 53 50–53.

Q: On one of the overheads you had a Japan/United States comparison on perceived risks associated with food. There was a tremendous difference. Microbial contamination was high in the US, and pesticides and other additives were important in Japan. What do you think the basis for those differences might be?

A: A considerable amount of research has been done by economists, psychologists, and sociologists on the role of culture in perception of what's safe. Sheila Jasanoff, a lawyer with a background in political science and sociology at the Kennedy School, suggests that it is important to understand the context associated with how risky activities are regulated in different countries, and how information is delivered as a starting point for understanding differences in perceptions. So it is not simply a question that Japanese and Europeans are different from Americans, it is the policy infrastructure that builds trust—that which delivers information, that which delivers process and product safety to consumers, that which monitors the sources of involuntary risk. That context builds up a set of prior expectations as to what comes from outside the market and inside the market. And that context is central to how they respond to different sources of risk.

Q: How do you go about defining a risk-communications strategy for perceived risk in the case of GMOs as opposed to real risk, for example, radon?

A: At the time we were doing this in the 1980s, there was very little public information on radon. The individuals involved in those studies, both in Maryland and New York, did not realize that they faced this risk. So there is a parallel. I don't mean that to be defensive. I am simply saying that in many situations, when risks are real, people will not know about them. The beginning point is listening and trying to understand from individuals what is important about the choices they made with respect to voluntary risks. This can be achieved via a series of activities: focus groups, cognitive interviews, and a whole series of other one-on-one interactions with consumers to identify a template of attributes that are important to the typical person. Then match that template with the attributes that are associated with the product or process that might be the source of a perceived risk. An economist will also tell you that you have to identify a set of choices that are consequential from a financial perspective to consumers and identify how they respond in those consequential choices to different information sets. That gives you the beginnings of a template for a risk-communication program. You have seen people take an action that means something to them with consequences in response to different kinds of information sets: you have an "if check," if you will, on the importance of the information process. It is hard to give you a blueprint for every single problem, because each one has a different attribute set to start with. What I have described is the process of developing a communication program.

Q: You mentioned that consumers prefer complete protection over trade-offs. Are you saying that they want to be assured of absolute safety?

A: I am not saying that they want to be assured of absolute safety. But they want a very clear message that says, if they do something there will be a response. Let's take a tangible example. In the case of radon, at the time we were presenting the information associated with mitigation, there was really no experience with the production technologies that were associated with removing radon from basements. So, we were, in effect, stating: if you ventilate your basement it will *probably* work, if you seal up the floor on the underside of the first floor, it might reduce radon. If you install a $3,000 ventilator in your basement, we know it will work but we don't know by how much. Those sorts of messages are not very effective. If, on the other hand, you can say that if you reduce your consumption of cigarettes by X packs in the course of a typical month, you'll reduce your chances of walking around with an oxygen tank from five out of ten to two out of ten—that's a salient, direct message. And they prefer the latter to the former. It's not complete protection. They don't want uncertainty over the mechanism that is going to protect them. They want to know what will work.

American Consumers' Awareness and Acceptance of Biotechnology[1]

THOMAS J. HOBAN
North Carolina State University
Raleigh, NC

Over the past two years, agricultural biotechnology has captured public attention in the United States, notably with news stories on the monarch butterfly studies and StarLink™ corn. In addition, interest groups have been engaged in an intensive struggle for consumers' hearts and minds. Opponents of biotechnology, such as Greenpeace and the organic-farming industry, have used a variety of tactics to frighten consumers about potential risks. On the other side, the biotechnology industry, through the Council for Biotechnology Information, has launched an intensive public-information campaign stressing potential benefits. Therefore, it is helpful at this stage to evaluate available survey research concerning American consumers' awareness and acceptance of agricultural biotechnology and foods with genetically modified (GM) ingredients.

Before beginning this assessment, it will be useful to put agricultural biotechnology into the larger context of innovation diffusion, which has been the subject of over 50 years of research (Rogers, 1995). The basic conclusion from that work was that anything new takes time to garner awareness and gain acceptance and adoption. Early studies of hybrid corn conducted in central Iowa during the 1930s found that over a decade passed before farmers in general were using the higher-yielding varieties. Some farmers objected to the fact that they could no longer save their seed for planting—similar to technology fees and crop-protection technology (*i.e.* the "terminator" gene) associated with modern plant biotechnology.

[1]Dr. Hoban presented an earlier version of this talk at NABC's Winter/Spring Council Meeting in Washington, DC, on March 6, 2001.

Consumer adoption of new food technologies also takes time. The microwave oven is an interesting example. When introduced, there were concerns over risks of radiation leakage into the kitchen. Over time, as consumers recognized the benefits and when concerns over risks were addressed, most people accepted microwave ovens in their homes. It is interesting that adoption of a new technology varies between cultures. French consumers are much less accepting of foods prepared by microwave than are Americans. Also, the French are appalled by another American innovation: the drive-through restaurant. Another example of societal resistance to new technology is pasteurization, as described by Joseph Hotchkiss in this volume.

Given the fact that no new technology will ever be 100% accepted by the public, it is important to examine some unique characteristics of the biotechnology controversy that make associated innovations more likely to meet with consumer resistance. First, agricultural biotechnology is a relatively complex subject. Full understanding of the technical issues associated with benefits and risks requires at least some knowledge of agriculture, food processing, and of the biological sciences. Not many consumers in the United States or elsewhere have direct connection with agriculture and food processing. Most take it for granted that food will be readily available and do not think, or care, much about how it gets to the store or restaurant. In addition, most people are unfamiliar with the advances in the biological sciences that have occurred over the past two decades. This lack of literacy makes some consumers apprehensive about developments in food biotechnology.

It is also important to consider how consumers receive information about food biotechnology, and the messages that they are hearing. Most of what consumers learn about any innovation comes through the filter of the mass media, which have a tendency to feature sensational news stories. Also, the media oversimplify issues to fit within their sound-bite framework. Stories about agricultural biotechnology tend to have a tone of conflict and controversy that makes people concerned. Once something is in the media it becomes part of the public agenda. Up to that point, most people have little awareness of, or interest in, a particular subject. Clearly, media coverage of biotechnology in the United States has increased over the past few years.

Another major factor that is slowing consumer acceptance of biotechnology involves the aggressive campaigns of a variety of special interest groups (Hoban, 1995). Groups such as Greenpeace and the Earth Liberation Front are trying to shake public confidence in science and the federal regulatory process. They do not find it necessary to prove their assertions, but are satisfied to raise doubts and fear. They also capture media attention with extreme tactics, such as destroying research plots, harassing food companies, and engaging in street theater. These groups have a variety of motives for their campaigns, including anti-corporate and anti-globalization ideologies. They have a vested interest in

building the controversy since it increases their donations and membership. In addition, the organic food industry supports the anti-biotechnology movement because some consumers are motivated to spend more money on organic foods.

Another problem for agricultural biotechnology is that benefits to consumers from the early products were not obvious. Many observers note that agricultural biotechnology tends to be less acceptable to consumers than is medical biotechnology. This makes sense given the fact that sick people are likely to accept risk from a medical treatment in order to regain health. Patients are likely to trust their doctors and follow their advice without question. The situation is quite different with food. People feel qualified to make their own decisions and are more risk-adverse, especially when they see few direct benefits from a new food-production technology.

For the most part, new medicines developed through biotechnology have been well accepted by consumers. However, developments in human genetics and genomics may prove to be even more controversial than food biotechnology. For example, media coverage of human cloning and stem-cell research has captured public attention recently, tending to push agricultural biotechnology into the background. Society has some important and real concerns to deal with. Policy makers and scientists are only now beginning to grapple with questions about genetic privacy, genetic discrimination, and eugenics. Given that the public and the media have a limited attention span, it is possible that agricultural biotechnology may well be viewed as more acceptable by comparison.

With this background in mind, I now turn to an assessment of recent research on consumer awareness and attitudes about agricultural biotechnology. In general, the studies that I will review involved telephone surveys of the Americans. Most involved approximately 1,000 interviews, representing a confidence level of just over 3%. Where possible, I will highlight trends in the results over time.

Consumer Awareness of Biotechnology

The process of innovation adoption starts with awareness. For almost a decade, consumers have been asked in various surveys, “How much have you heard or read about biotechnology—a lot, some, a little, or nothing?” (Hoban, 1996, 2001; IFIC, 2001.) It is reasonable to equate awareness with having heard something or a lot (Figure 1). There are several notable trends in consumer awareness of biotechnology in the United States. For the first half of the 1990s, it remained rather low at about one-third. It hit a peak in 1997 when a survey was conducted soon after the news about Dolly, the cloned sheep. Then awareness dropped until May 2000, but has grown gradually since, to 53% in June 2001.

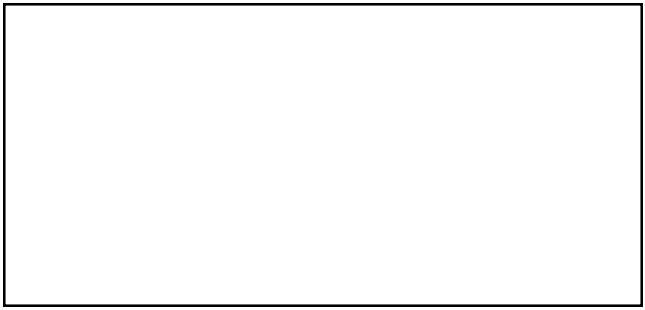

Figure 1. American consumers' awareness of biotechnology, 1992–2001 (Hoban, 1996, 2001; IFIC, 2001).

Most Americans are not aware of the extent to which biotechnology has become part of their food supply. According to a January 2001 survey conducted by the Pew Foundation for Agricultural Biotechnology, few consumers believed that GM foods are in wide use in the food supply, and even fewer believed that they have eaten them (Pew, 2001). Most consumers, 60%, believed that less than half of the food in grocery stores contains GM ingredients, while 38% thought that less than a quarter of food contains such ingredients. Only 14% of consumers believed that more than half of our food contains GM ingredients, which was the correct answer. Additionally, few Americans recognized that they had already eaten GM foods. Only 19% said they had eaten GM foods, 62% said they had not, and 19% said they did not know.

At the same time, consumers were uncertain about how safe GM foods are. When asked initially, with little background information, whether GM foods are safe, almost half said that they did not know, 29% said they are basically safe, and 25% said they are basically unsafe. However, after being informed that more than half of the products at the grocery store contain GM ingredients, almost half said that GM foods are safe, only 21% said that they are unsafe, and 31% said they were unsure (Figure 2). In fact, one in five of those who initially said GM foods were unsafe, changed their minds. Thus, when some consumers learn how widespread are GM foods, they are more likely to believe they are safe. However, it is also true that some consumers become angry when they realize that they have not been told about the widespread presence of GM ingredients.

. . . few Americans recognized that they had already eaten GM foods.

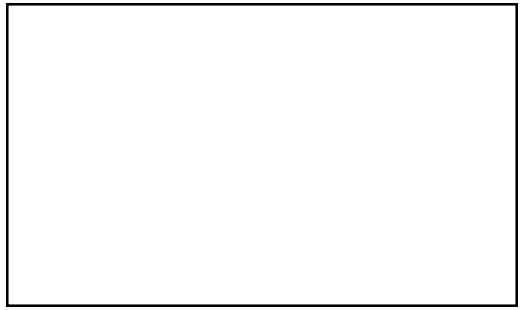

Figure 2. American consumers' views on the safety of genetically modified foods (Pew, 2001).

CONSUMER ACCEPTANCE OF BIOTECHNOLOGY

Consumer acceptance has been measured in a variety of ways in different surveys. I have had the opportunity to repeat the same set of questions with three surveys through my own research (Hoban and Kendall, 1994), as well as in a survey conducted by Angus Reid, Inc. in 2000 (personal communication). The objective was to assess the level of consumer acceptance of three applications of biotechnology (Figure 3). In the case of insect-protected crops, acceptance was higher in 1992 (63%) and 1994 (67%) than in 2000 (51%). The same overall trend was noted for disease resistance in farm animals and for larger, faster-growing fish; but these applications were relatively less acceptable than plants at all points in time. This is of particular concern, because disease-resistant animals and faster-growing fish are either on the market or close to commercialization.

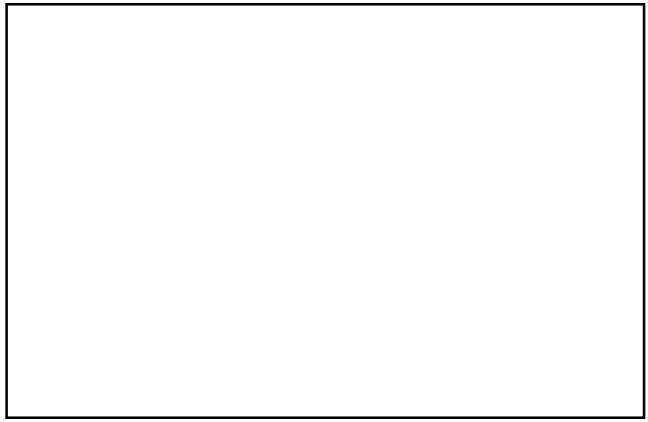

Figure 3. American consumers' acceptance of three applications of biotechnology (Hoban and Kendal, 1994; Angus Reid, Inc., pers. comm.).

Surveys conducted by Hoban and Miller (1998) and by Priest (2000) evaluated more-recent trends in American consumers' support for four applications of biotechnology (Figure 4). Compared to 1998, a greater percentage of consumers in 2000 believed that applications of biotechnology to crops and foods should be encouraged. It is interesting to note that consumers tended to view insect-protected crops as more acceptable than improved foods. Support for development of new human genetic screening techniques rose significantly between 1998 and 2000 (Figure 4). At the same time, concerns have been raised in the media about loss of genetic privacy and the potential for discrimination that could result from increased access to such genetic information.

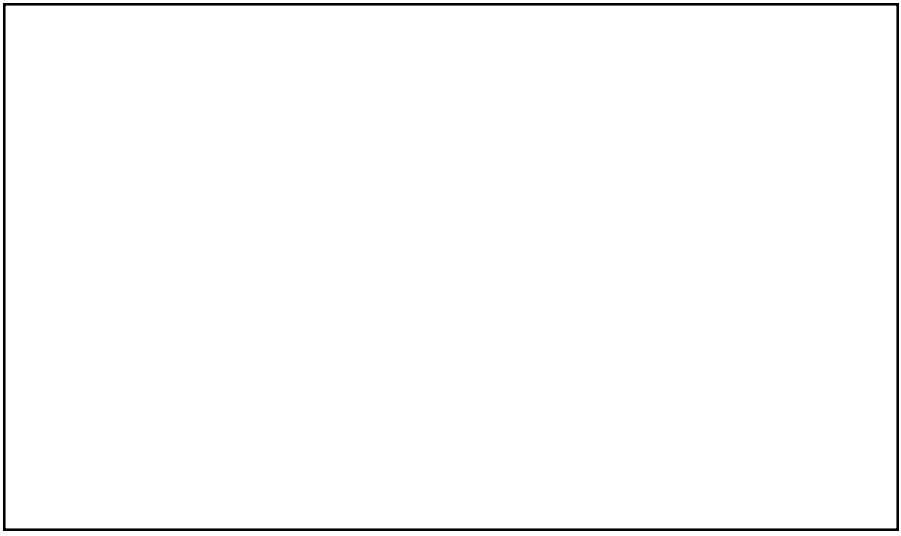

Figure 4. American consumers' support for four applications of biotechnology (Hoban and Miller, 1998; Priest, 2000).

It is instructive to compare these results from the United States with trends for the same questions asked on the Eurobarometer[2] in 1996 and 1999 (Figure 5). In Europe, public support for all four applications of biotechnology dropped significantly during this period, which corresponds to the growth of the public controversy. It is understandable that agricultural and food applications would become less acceptable given the fact that they were the focus of opponents' campaigns. However, it is noteworthy that support for the two medical applications of biotechnology also dropped significantly. Such a pattern could mean some difficult challenges for the European economy and diminished prospects for new advances in health care.

[2]European Commission public-opinion surveys, http://europa.eu.int/comm/dg10/epo/.

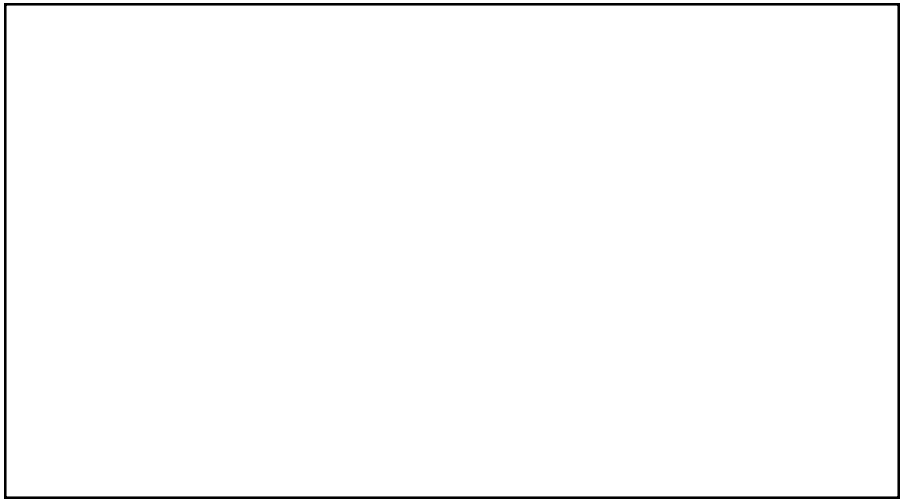

Figure 5. European consumers' support for four applications of biotechnology, 1996 and 1999 (Eurobarometer).

IMPACTS OF THE STARLINK™ CORN CONTROVERSY

One incident that captured the attention of the media in the United States involved the discovery in food of a protein from a corn variety that had not been approved for human consumption, i.e., StarLink™. To evaluate consumer response to the story, I conducted a survey for the Grocery Manufacturers of America in October 2000, immediately after the taco-shell recall was announced. Most of the questions were asked again in January 2001 by the International Food Information Council (IFIC, 2001). These results indicate no significant impact from the StarLink™ controversy on consumers' attitudes or behavior.

Early in the interview, before any mention of StarLink™ or biotechnology, respondents were asked the open-ended question, "Over the past few months, what, if anything, have you been avoiding or eating less of?" (Figure 6). The largest percentage indicated that they had not changed their eating habits in any way. This was particularly true in January, which may reflect holiday eating patterns. Of those who had limited their consumption of a particular food, responses were almost evenly divided among fats, carbohydrates, or meat and dairy products. No one in either survey said they had stopped eating taco shells or corn, nor was there any other reference to biotechnology. The next open-ended question was, "What if anything are you most concerned about when it comes to food safety?" The most common responses involved microbial contamination or pesticides. Only 2 to 3% mentioned anything related to biotechnology or genetic modification.

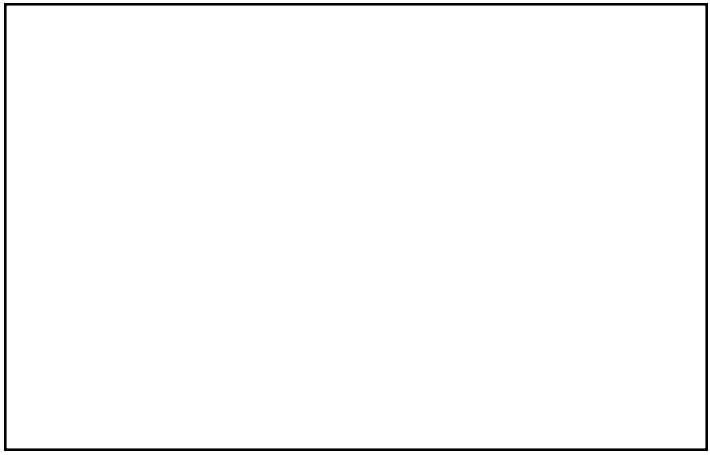

Figure 6. Foodstuff avoidance over the previous few months (Hoban, 2000; IFIC, 2001).

The most common responses involved microbial contamination or pesticides. Only 2 to 3% mentioned anything related to biotechnology or genetic modification.

The interview later posed specific questions about biotechnology and the StarLink™ issue. One question that I developed in 1995 has been repeated in other surveys (FMI, 1997; IFIC, 2001) to indicate the extent to which consumers are willing to buy tomatoes or potatoes developed through biotechnology for enhanced protection against insects (Figure 7). Overall, there was a modest drop in willingness to buy such products from the highest levels found between 1995 and early 1999. However, the results for October 2000 and January 2001 showed that consumers were just as willing to consume insect-protected plants after the StarLink™ incident as before.

As a final question, respondents were asked, "During the past few months have you done anything or taken any action because of any concerns you may have about genetically modified foods?" Despite this clear opportunity to answer "yes," only 5% of the respondents in the October 2000 and January 2001 surveys said they had done anything. In my October survey, we followed up and asked that small pool of respondents what they had done. Mainly, they had sought out more information or had talked to someone. No one reported boycotting any food company or changing their food-consumption behavior.

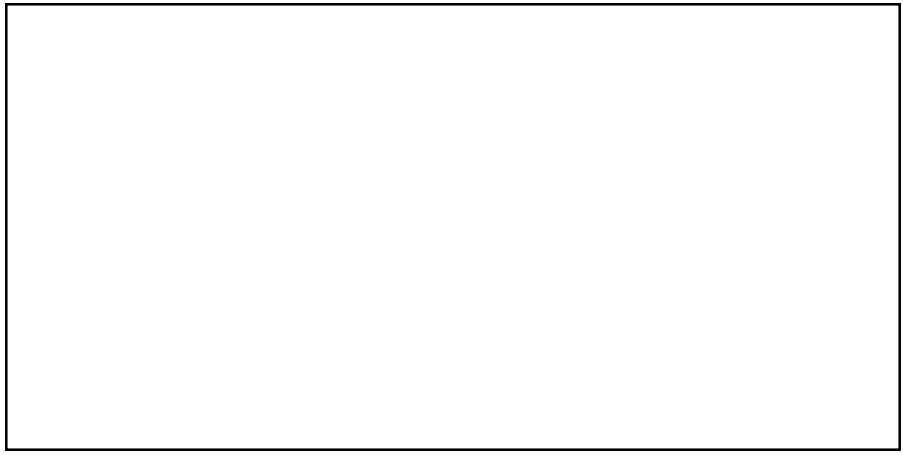

Figure 7. American consumers' willingness to buy potatoes or tomatoes genetically modified for enhanced resistance to insects (Hoban, 1996; FMI, 1997; IFIC, 2001).

CONSUMER VIEWS ON FOOD LABELING

A complex and contentious issue in the United States is whether foods developed through biotechnology should accordingly carry some type of label. On this particular subject, how questions are asked clearly has a major impact on how consumers respond. One neutral way is to simply ask, in an open-ended question, if they can think of any information not currently included that they would like to see on food labels. Surveys conducted in October 2000 (Hoban, 2000) and January 2001 (IFIC, 2001) found that only 2% of the people surveyed responded "genetically modified." In both cases, three-quarters of the respondents said they could not think of any additional information they would like to see on food labels. This is noteworthy in that the interviews took place after the StarLink™ controversy became a public issue.

Many consumers claim to want information on food labels about how foods and their ingredients are produced. The Center for Science in the Public Interest (CSPI) found in May of 2001 that about two-thirds of consumers wanted foods containing genetically engineered ingredients to be labeled (see pages 31, 32; CSPI, 2001). However, even more consumers (76%) wanted labeling for crops grown using pesticides, 65% for crops grown using plant hormones, and 56% for crops that are imported. In fact, 40% of respondents said that they would like products containing hybrid corn to be labeled, which would apply to any food containing oil, high-fructose syrup, or any other ingredients derived from corn.

One way to measure consumers' desire for labeling is to determine willingness to pay for that information. The CSPI survey found that 44% of consumers would pay "nothing" and another 17% would pay $10 per year on top of their family's current annual food bill for such labeling. Only 28% were willing to pay $50 or more. In fact, of the 17% of consumers who said that their highest labeling priority was genetic engineering, 50% would pay nothing or $10 per year for that labeling. Similarly, of the people who believed that labeling genetically engineered foods should be required, 56% would pay nothing or $10 per year for it. Although as many as two-thirds of consumers may desire labeling of GM foods, few appear willing to pay the real costs for that information, which would result from the need for identity preservation, testing, certification, *etc*.

One concern about labeling is that consumers may perceive the information to be a warning. In fact, when respondents to the CSPI survey were asked whether foods labeled as containing GM ingredients were just as safe as, not as safe as, or safer than, similar products without such a label, about 30% said that the labeled product was less safe. Only 7% said that the GM-labeled product was safer, and about 33% said that the labeled product was equally safe.

Conclusions and Implications

Review of recent research makes it possible to anticipate future consumer acceptance of agricultural biotechnology in the United States. Given that public perception of plant biotechnology has not changed much over the past few years, it is unlikely that acceptance will change much in the future, provided that no real health problems are encountered with GM foods. Research into food-shopping preferences and behavior shows that consumers in the United States tend to be pragmatic in their choices. They select food based upon taste, value (price), convenience, and nutrition. No one spontaneously reports that seed genetics influenced their purchasing.

However, animal biotechnology will raise a host of complex issues that will make it less acceptable than plant biotechnology. Some people view animals as having feelings and due more respect than plants. Also, animal-rights activists will step up their protests as new products arrive on the market. Consumer reaction to transgenic animals, such as those used to produce human organs, will likely be extreme, particularly if the meat enters the food supply. Faster-growing fish may meet with poor acceptance, especially if they are labeled accordingly and/or the opposition groups have a significant impact on media coverage. Clearly, animal and veterinary scientists should learn from the experience of plant scientists about the importance of ongoing communication and social science research. Unfortunately, this may not be the case as evidenced by their lack of communication on these issues.

Media coverage of agricultural biotechnology over the past few years has generally been balanced in the United States, at least compared to Europe. It

seems that the media's focus is shifting to the range of complex issues related to human genomics, including the controversies of stem-cell research and human cloning. These issues may generate public concern as the products of medical biotechnology and genomics come to the market place. In particular, diagnostic tests and other screening tools will make it possible to identify genetic traits that predispose humans to disease. This will be controversial if people do not want to know, particularly where there is no cure for the disease that could be diagnosed. Also, concerns are already being raised about genetic privacy and the possibility for genetic discrimination by employers and health-insurance providers.

Relatively little social-science research has been done to assess public perceptions of either animal biotechnology or human genomics. Clearly, we need to start addressing these issues to understand public concerns and hopes, as well as information needs. In addition, no organizations have stepped forward to begin the challenging, but vital, job of informing the public about the future of animal biotechnology and human genetics, as the Council for Biotechnology Information, NABC, and others have done for plant biotechnology. We may look back and realize that the issues associated with plant biotechnology were easier to address than those with animal or human applications.

There are many reasons why opinion has remained more positive in America than in Europe, despite the best attempts of activist groups to promote fear and uncertainty. American consumers tend to have a greater level of confidence in scientists and government regulatory agencies, whereas in Europe confidence has been seriously eroded by mad cow disease and other problems. Scientists and others have been actively committed to providing the American public with information for over a decade, whereas EU leaders and scientists have generally been silent or ineffective. The activists who oppose biotechnology have relatively little credibility in the United States, partly as a result of terrorist tactics. In Europe these groups have filled the information vacuum and established credibility with the public.

America's relatively young culture tends to focus on the future, whereas Europeans generally look to the past. Our cultural values include a much greater appreciation for the role of science and technology in progress and economic growth. Americans also have feelings about agriculture and food that differ from those of Europeans. Many Europeans *live to eat* whereas most Americans *eat to live*. European consumers are more concerned with how food

---

Many Europeans live to eat whereas most Americans eat to live.

---

is produced and by whom, and they have closer connection to farming, due in part to the fact that they have few public wilderness areas. Their concept of natural is tied to small-scale farming. This ideology is also present in the United States among the relatively elite consumers of organic food.

Research and experience have provided some guidelines for providing relevant information to interested consumers about agricultural biotechnology. The first thing that people generally want to know is why scientists are using biotechnology. In other words, what are the benefits? In fact, many American consumers appreciate the potential of biotechnology for helping people in developing countries to feed themselves, which is a less persuasive message for Europeans. American consumers also have a greater appreciation of the fact that food produced with biotechnology is as safe as, or safer than, food produced through traditional breeding methods and grown with more chemical inputs. It is also important to make the point that no technology is without risk and that those associated with biotechnology are being managed and regulated.

Finally it is worth considering the implications of consumer attitudes toward biotechnology for land grant university research and extension programs. For the past year I have been chairing a national task force looking at ways in which universities can play a more meaningful and credible role in the discussions and deliberations about biotechnology. In some respects the future of biotechnology is closely linked to the future of our colleges of agriculture. Most universities have made major investments in biotechnology research and now have obligations to openly explain what they are doing and to ensure they are providing benefits to society in an ethical manner. We also will have a major role in developing and implementing education programs and fostering two-way communication. This is appropriate because American consumers and leaders still trust our universities. We must make sure we maintain that level of confidence.

REFERENCES

Center for Science in the Public Interest (CSPI) (2001) National Opinion Poll on Labeling of Genetically Engineered Foods, http://www.cspinet.org.

Food Marketing Institute (FMI) (1997) Trends in the United States: Consumer Attitudes in the Supermarket. Washington, DC: Food Marketing Institute.

Hoban TJ (1995) Construction of food biotechnology as a social issue, in Eating Agendas: Food and Nutrition as Social Problem (Maurer D Sobal J eds) 189–209. New York: Aldine de Gruyter.

Hoban TJ (1996) Trends in consumer attitudes about biotechnology. Journal of Food Distribution Research 27 1–10.

Hoban TJ (2000) US Consumers' Reactions to the StarLink Controversy. Report to the Grocery Manufacturers of America.

Hoban TJ (2001) Public Perceptions of Biotechnology. Presentation to the American Farm Bureau Federation, Nashville.

Hoban TJ Kendall P (1994) Consumer Attitudes about Food Biotechnology: Final Project Report. Raleigh: North Carolina Cooperative Extension Service.
Hoban T Miller J (1998) Attitudes about Science and Technology. Report to the National Science Foundation.
International Food Information Center (IFIC) (2001) US Consumer Attitudes toward Food Biotechnology, http://www.ific.org.
Pew Initiative on Food and Biotechnology (2001) Public Sentiment about Genetically Modified Food, http://www.pewagbiotech.org.
Priest S (2000) US Public Opinion Divided over Biotechnology, Nature Biotechnology 18 939–942.
Rogers EM (1995) Diffusion of Innovations. New York: Basic Books.

What You See Depends On How You Grind the Lens

CAROL TUCKER FOREMAN[1]
Consumer Federation of America
Washington, DC

> "The promise of agricultural biotechnology is immense. Advances in this technology will result in crops with a wide range of desirable traits that will directly benefit farmers, consumers, and the environment and increase global food production and quality."—*Seeds of Opportunity: an Assessment Of The Benefits, Safety, and Oversight of Plant Genomics and Agricultural Biotechnology*, United States House of Representatives, 1999
>
> "Food biotech is dead."—Henry I. Miller, Hoover Institute, Stanford University (Eichenwald *et al*., 2001)

I believe agricultural biotechnology does indeed offer the promise of substantial benefits to farmers, consumers, and the environment. However, after almost twenty years of industry advocacy and government promotion, the American people have not embraced this new technology. Spurred by such events as the StarLink™ corn contamination and European rejection of genetically modified foods, there is an increasingly visible and contentious debate in this country about the potential risks and benefits of agricultural biotechnology and its appropriate role in our lives. Radical environmentalists trash biotech fields. Obdurate biotech advocates trash the intelligence and integrity of anyone who disagrees with them.

If we want to realize the potential benefits of agricultural biotechnology, we must achieve agreement and compromise. Beginning that process requires taking a realistic view of the public's willingness to accept agricultural biotechnology, appreciating some of the factors that contribute to continuing public concern, and considering changes in government regulation that might increase the public trust that is so vital to greater acceptance and full realization of agricultural biotechnology's promise.

[1]Ms. Foreman was scheduled to deliver this presentation at the meeting, but was unable to do so.

Public Acceptance of Agricultural Biotechnology and Genetically Modified Foods

Dozens of polls have examined the level of public acceptance of agricultural biotechnology and genetically modified foods in United States. Each poll is structured differently, asking slightly different questions, and getting somewhat different answers. If you support biotechnology, you can find a poll that agrees with your point of view. If you oppose the technology, you can find a poll that condemns it. Not surprisingly, poll questions are often structured in a manner to assure a response consistent with the views of the poll's sponsor.

But it is possible to get a snapshot of the general level of public acceptance. I reviewed five polls, taken between 1999 and 2001, and totaled the positive and negative responses (see below). There is good news and bad in the results of these surveys. The good news is that only one poll showed more people with negative than positive opinions. The bad news is that none of the polls showed strong public support for genetic engineering. Only one question came close to eliciting a positive response from two-thirds of those polled.

Survey/Questions	Total positive	Total negative
International Food Information Council Foundation (January 19–21, 2001)		
Would you purchase foods modified by biotechnology in ways that provided direct and obvious consumer benefits such as: fresher, tastier produce?	58%	38%
reduced saturated fat?	46%	17%
Do you expect benefits to your family from biotech within 5 years?	64%	22%
Pew Foundation Initiative on Food and Biotechnology (January 22–28, 2001)		
Are genetically modified foods: basically safe / unsafe	48%	21% (unsafe)
Harris Poll (June 8–12, 2000)		
Do benefits of developing / growing GE plants outweigh risks?	38%	48% (risks greater)
Gallup Poll (March 30–April 2, 2000)		
Do you support use of biotechnology in food / agriculture?	48%	41%
National Science Foundation / Texas A&M Public Policy Research Institute (April–May 2000) (Priest, 2000)		
Do you believe GE will improve our way of life in next 20 years?	53%	30%

Perhaps more troubling, Susan Horning Priest (2000), writing in *Nature Biotechnology,* reported that Americans are less enthusiastic about genetic engineering than about other recently introduced technologies.

Favorable Attitudes Toward New Technologies

The NSF/Texas A&M survey asked respondents their views of whether particular technologies would improve their lives:

Technology	Positive response
Computers/information technology	88%
Solar energy	88%
Telecommunications	82%
The Internet	72%
Space exploration	62%
Genetic engineering	53%

Unfavorable Attitudes: Genetic Engineering Versus Nuclear Energy

The NSF/Texas A&M survey found that Americans are equally as negative about genetic engineering as they are about nuclear energy, a technology that has had limited application in the United States because of a lack of public acceptance:

Technology	Positive response
Genetic engineering	30%
Nuclear energy	32%

Now many biotech advocates take comfort in the fact that polls show many Americans are still not aware of genetic engineering. They assume that, as people become more familiar with the technology, they will feel more comfortable with it. Unfortunately, research indicates that familiarity with agricultural biotechnology does not breed affection. Priest (2000) compared responses to genetic engineering over seventeen years. The number of people who had negative attitudes toward agricultural biotechnology almost doubled, rising from 16 to 30%:

Genetic Engineering Will Make the Quality of Life Worse	Positive response
1982	16%
1986	22%
1999	30%

Last year we accepted the election of the President of the United States by something less than a convincing majority. We are much more demanding when it comes to new products. They do not survive unless they gain popularity and do it quickly. A new technology that affects the safety and quality of our food supply will almost surely have to secure an overwhelming level of public acceptance if it is to survive.

Why Americans Are Unenthusiastic About Genetically Modified Foods

I can identify three reasons why Americans have embraced computers and cell phones and medical biotechnology, but are less accepting of genetically modified foods.

First, food is special. The manufacturers of genetically modified products think they are purveying commodities. Consumers believe they are tinkering with something more basic to the human psyche: a "cultural metaphor for life."

We eat to live, but we also live to eat. Food provides energy and essential nutrients, but food is more than fuel for the body. It is sustenance for the soul. From the Apple in the Garden of Eden to the golden arches on the highway, food is a key component of human civilization. Food is a cultural and religious icon. Throughout history, people have been defined by what they are obligated or forbidden to eat. Even in twenty-first century America what you eat reveals who you are and where you are from. If you want to experience true cultural isolation, walk into a New York deli and order corned beef on white with mayo.

Food is intensely personal. In 1996, the Agriculture Council of America commissioned an intensive study of our emotional attachments to food. They found that food is integrally tied to nurturance, bonding and love. Participants in the study viewed unsafe food as a hostile invader of their homes and an assault on themselves and their families.

Second, agricultural biotechnology presents an unbalanced distribution of risks and benefits. When it comes to food, most of us are risk-averse. This is especially true if the risk is imposed on us by someone else, is invisible, and lacks a countervailing direct and specific personal benefit.

It is easy to see why genetically modified foods light up all the risk-aversion receptors. The products on the market today have no direct consumer benefit. They were developed to enhance the economic fortunes of farmers and

When it comes to food, most of us are risk-averse. This is especially true if the risk is imposed on us by someone else, is invisible, and lacks a countervailing direct and specific personal benefit.

chemical companies. Lowering farmers' input costs is important to farmers, but not to American consumers. Lowering the cost of producing corn, does not translate to cheaper meat at the supermarket.

There are promises of nutritionally superior products, but we cannot eat promises. And, the adamant refusal to label genetically modified products cannot help but increase consumer suspicion that these foods carry some risk. Most consumers believe that if you have to hide it, there must be something wrong with it. In short, there is no reason for consumers to willingly accept any risk from genetically engineered food.

Third, acceptance of agricultural biotechnology is affected by the social and political context into which it has been introduced, including instantaneous communication and globalization. No product or technology comes to market in a vacuum. Unfortunately, the advent of genetically modified crops has coincided with a rash of food-safety disasters. Because we live in an era of instantaneous communication, the details of those disasters are flashed into our homes. Because we eat from a global plate, we can never be sure that a food safety disaster half-way around the world will not end up on our dining-room table.

Finally, the very fact of globalization creates discomfort for many people. Agricultural biotechnology is associated with increasing global corporate power. This, coupled with a diminishing level of trust in both private and public institutions compounds the problem for those seeking to gain acceptance of agricultural biotechnology.

The Role of Government in Assuring Safety and Acceptance

Given all these impediments to public acceptance of genetically modified food products, it would seem reasonable that supporters of agricultural biotechnology would benefit from, even insist upon, a food safety regulatory system in the United States so rigorous and credible and above reproach that it cannot fail to dispel doubt and instill public trust.

The United States government and agricultural biotechnology industry chose another course. Our government, especially the Food and Drug Administration (FDA):

- opted for a system that favored a rush to market over assurance of safety and acceptance. The White House, in an election year, became actively involved in writing FDA's 1992 Policy Statement on Foods Derived from New Plant Varieties. Vice President Quayle described the Statement as "regulatory reform," designed to help American agricultural biotechnology companies gain advantage in a new field. This effort to speed genetically modified foods to market has served instead to deny genetically modified products the most valuable assets they could acquire: a rigorous and transparent pre-market safety approval by FDA, and resulting public comfort level.

- contorted existing statutes to regulate a technology that was never contemplated when the relevant laws were written in 1906 and 1958. Contrast this to the course chosen in the European Union, which enacted new law specifically designed to deal with "novel foods."
- established what amounts to a system of "nonregulation" (based on McGarity and Hansen, 2001). Foods altered by agricultural biotechnology are not subject to rigorous premarket safety testing and FDA approval. Today FDA does not require notice that a firm intends to market a genetically modified food organism so long as the firm concludes that its product is "generally recognized as safe" (GRAS). Changes under consideration by the agency will not require FDA to approve products before they are marketed.

How FDA Avoids Regulation of, and Responsibility for, Genetically Modified Foods

The FDA has determined that adding a new gene to a conventional food falls under the 1958 Food Additive provisions of the Food Drug and Cosmetic Act, unless the resulting genetically modified food is "substantially equivalent" to a conventional food that is GRAS.

Substantial equivalence—limiting the factors that would cause a product to be considered different. The new genetically modified food is considered "substantially equivalent" to its conventional counterpart unless the transfer involved genes coding for fats, proteins, or carbohydrates that might cause allergic reactions, are known to be toxic, or change the nutritional value of the food. Some FDA scientists urged that at least basic toxicological testing be done on all genetically modified foods. The FDA has established no protocols to detect unanticipated effects, no chemical analyses of the molecular characteristics of the altered food, no tests for stability of the transferred gene or of the key nutrients and toxicants.

Accepting the manufacturer's assertion that a product is GRAS. For all practical purposes a company that produces a genetically modified food is the judge of whether the product falls within the "GRAS" category. The GRAS determination relies almost exclusively on a manufacturer's finding that the food meets this requirement.

When the FDA approves a petition for a new food additive, it publishes a regulation stating that FDA finds that the additive is safe, making public the data that support its decision, establishing requirements for the use and labeling of the additive.

If a company claims that its product is GRAS, FDA must either accept the data presented to it by the company or take on the burden of disproving the safety of the product. If the FDA accepts the company's data, it takes no

If a company claims that its product is GRAS, FDA must either accept the data presented to it by the company or take on the burden of disproving the safety of the product. If the FDA accepts the company's data, it takes no responsibility for the safety of the product. There is no Federal Register *notice and no explanation of reasoning.*

responsibility for the safety of the product. There is no *Federal Register* notice and no explanation of reasoning. Virtually all of the FDA-regulated genetically modified products now on the market got there because the producing company claimed the product is GRAS. The company receives a letter from FDA, the operative language of which is that the company has determined that the product is the same as a safe product.

For example, on January 27, 1995, FDA wrote to Monsanto regarding the Roundup Ready® soybean, stating, "…it is our understanding that, based on the safety and nutritional assessment you have conducted, you have concluded that the new soybean variety is not materially different in composition, safety, or any other relevant parameter from soybean varieties now on the market… as you are aware, it is Monsanto's continued responsibility to ensure that foods the firm markets are safe, wholesome and in compliance with all applicable legal and regulatory requirements."

FDA and the biotechnology industry express surprise that anyone objects to the current system of bringing modified foods to market. The argue that all the new products are tested are rigorously reviewed. However, the products are tested by the company that makes them, and, although FDA reviews summaries of the tests, the agency does not provide a formal pre-market safety approval of genetically modified foods. The FDA never states that it finds a new genetically modified product is safe. It is hard to account for the inability of the FDA and industry to see that allowing a company that produces a GM food to determine that it is safe—based on data collected by the company and opinions of experts that the company may have hired—creates the potential for serious problems.

The GRAS process assumes that a company with a large investment in a new product will never be unduly influenced by its self-interest in the product's development and success. It assumes that a company and its experts will never make a mistake in their assessments. A regulatory system that does not require the regulatory agency to take public responsibility for allowing a new and

The FDA never states that it finds a new genetically modified product is safe. It is hard to account for the inability of the FDA and industry to see that allowing a company that produces a GM food to determine that it is safe—based on data collected by the company and opinions of experts that the company may have hired—creates the potential for serious problems.

untried product on the market, and explaining its reasons why, assumes that a company that must meet its profit goal will never put its own interest above that of the public and excludes the possibility of human error, is a regulatory system that is likely to fail both the regulated industry and the public.

The FDA's decision, in its 1992 Policy Statement, to examine genetically modified foods on the basis of GRAS has been determined by at least one court to fall within FDA's regulatory discretion. The GRAS process has been around for a long time. It was devised in part to shorten the period of time needed to move new, but uncontroversial, food additives to market. The question is why FDA decided to apply this doctrine to move the products of a new and controversial technology to market.

Again, the record indicates that the Bush administration was eager to give American companies an advantage in getting a new technology on the market quickly. In addition, the FDA apparently was driven to pursue this policy of "nonregulation" in order to avoid asking Congress either to write new law needed to address the new technology appropriately or to provide the additional staff and resources required to perform more intensive safety reviews.

The decision was shortsighted and unwise. The policy has failed the test of public trust. Under the pressure of increasing public criticism, FDA asked for comments on the existing system. It received 35,000 responses, most unfavorable. The agency is now trying to buy a little more credibility by making small changes to its review process, but it adamantly refuses to make the changes necessary to assure the kind of scrutiny that builds public trust. Instead it has given those who oppose the technology a powerful weapon to use against the new products.

If the products of agricultural biotechnology are as benign as both industry and government insist, why not subject them to the most searching scrutiny?

Is it Possible to Regrind the Lens and Secure Consumer Acceptance of Biotechnology?

Scientists and public officials have advocated a regulatory system that inspires public trust. Perry Adkisson, chair of the National Academy of Sciences Committee on Genetically Modified Pest-Protected Plants, has stated, "Public acceptance of these foods ultimately depends on the credibility of the testing and regulatory process" (Bettleheim, 1999).

And in 1999, Secretary of Agriculture Dan Glickman urged, "With all that biotechnology has to offer, it is nothing if it's not accepted. That boils down to a matter of trust—trust in the science behind the process . . . trust in the regulatory process that ensures a thorough review. . . ."

Proponents of agricultural biotechnology have tended to dismiss critics as either ignorant, intellectually dishonest, or extremist. It is a serious mistake. In the end, the biotechnology industry and its supporters will succeed neither in insulting people into buying these products nor concealing their presence.

We would all benefit if we could find some way to improve the regulatory regime, increasing public confidence in the safety of genetically modified foods without imposing such expense and delay that the industry fails. There is at least one example where representatives of the stakeholder groups demonstrated that it is possible to reach some agreement on key issues related to agricultural biotechnology, as follows.

Cognizant of the increasing disagreement between the trans-Atlantic partners on this subject, President Prodi of the European Union and President Clinton appointed a Consultative Forum comprising twenty private individuals, ten from each side of the Atlantic, to meet and try to reach some consensus. It was an extremely diverse and impressive group—including a former Prime Minister of the Netherlands, Nobel Laureate Norman Borlaug, officials of DuPont and Unilever; a farmer from Portugal and one from Missouri, a consumer advocate from the United Kingdom and one from the United States, and three scientists actively engaged in agricultural biotechnology. It also included a scientist from Environmental Defense, a representative from European Friends of the Earth, and a bioethicist from Georgetown University. I was privileged to be part of the American delegation.

We reached agreement and produced a report. None of us loved every line. Each of us disliked some part of it. But we were able to agree on the following about agricultural biotechnology:

- It has promise that must not be squandered.
- It can be a major contributor to fighting hunger in the developing world.
- It presents the threat of unforeseen, unintended, negative consequences that must be addressed.

- Its successful use requires public trust and that trust will be generated by a rigorous, comprehensive and open regulatory process, including mandatory pre-market safety review of each product and a determination by the appropriate government agency that the product is safe.
- Final products containing novel genetic material should be labeled.

In December 2000 we presented our recommendations (US-EU, 2000), which—at the urging of industry and government agencies—have been ignored by Presidents Clinton and Bush. The EU has begun to respond to the recommendations, positively in most cases.

I disagree with Henry Miller that agricultural biotechnology is doomed. The recommendations of the US-EU Consultative Forum offer a way to have the technology and some assurance of safety. The report is evidence that a wide range of people would like to see agricultural bioechnology move forward and can agree on changes that would facilitate progress.

Without actions similar to those recommended by the US-EU Biotechnology Consultative Forum, it is unlikely that agricultural biotechnology will gain the public trust essential to the fulfillment of its promise.

REFERENCES

Bettleheim A (1999) Reluctant congress drafted into bioengineering battle. CQ Weekly April 22 939.

Eichenwald K Kolada G Peterson M (2001) Biotechnology food: from the lab to a debacle. New York Times January 25.

Glickman D (1999) How Will Scientists, Farmers, And Consumers Learn To Love Biotechnology And What Happens If They Don't? Speech to the National Press Club, Washington DC July 13.

McGarity TA Hansen PI (2001) Breeding Distrust: An Assessment and Recommendations for Improving the Regulation of Plant Derived Genetically Modified Foods. Washington, DC: Consumer Federation of America Foundation.

Priest SH (2000) US public opinion divided over biotechnology. Nature Biotechnology 18 939–942.

Rulis A (1995) Letter from the Acting Director, Office of Premarket Approval, Center for Food Safety and Applied Nutrition, Food and Drug Administration to Ms Diane Re, Regulatory Affairs, The Agricultural Group of Monsanto, January 27.

US-EU (2000) US-EU Biotechnology Consultative Forum Final Report.

Genetic Engineering and the Concept of the Natural

MARK SAGOFF
University of Maryland
College Park, MD

Why do many consumers view genetically engineered foods with suspicion? I want to suggest that it is largely because the food industry has taught them to do so. Consumers learn from advertisements and labels that the foods they buy are all natural—even more natural than a baby's smile. "The emphasis in recent years," *Food Processing* magazine concludes, "has been on natural or nature-identical ingredients" (Food Processing, 1988). According to *Food Product Design*, "The desire for an all natural label extends even to pet food" (Saunders, 1995).

The food industry, I shall argue, wishes to embrace the efficiencies offered by advances in genetic engineering. This technology, both in name and in concept, however, belies the image of nature or of the natural to which the food industry constantly and conspicuously appeals. It should be no surprise that consumers who believe genetically modified foods are not "natural" should regard them for that reason as risky and as undesirable. Consumers might be as suspicious of many other foods, however, if they were less misled about the extent to which technology—not nature—is responsible for producing them and especially for endowing them with color and flavor.

ALL-NATURAL TECHNOLOGY

Recently, I skimmed through issues of trade magazines, such as Food Technology and Food Processing, that serve the food industry. In full-page advertisements, manufacturers insist that the ingredients they market come direct from primordial Creation or, at least, that their products are identical to nature's own. For example, Roche Food Colors runs in these trade magazines a full-page ad that displays a bright pink banana over the statement: "When nature changes her colors, so will we." The ad continues:

Today more and more people are rejecting the idea of artificial colors being used in food and drink. . . .

Our own food colors are, and always have been, strictly identical to those produced by nature.

We make pure carotenoids which either singly or in combination achieve a whole host of different shades in a range of yellow though orange to red.

And time and time again they produce appetizing natural colors, reliably, economically, and safely.

Just like nature herself.

Advertisement after advertisement presents the same message: food comes directly from nature or, at least, can be sold as if it did. Consider, for example, a full-page ad that McCormick and Wild, a flavor manufacturer, runs regularly in *Food Processing*. The words "BACK TO NATURE" appear under a kiwi fruit dripping with juice. "Today's consumer wants it all," the advertisement purrs, "great taste, natural ingredients, and new ideas... Let us show you how we can put the world's most advanced technology in natural flavors at your disposal..."

This advertisement clearly states the mantra of the food industry: "Today's consumer wants it all." Great taste. Natural ingredients. New ideas. The world's most advanced technology. One can prepare a flavor artificially with just a little chemistry know-how, for example, that of almond by mixing oil of clove and amyl acetate to produce benzaldehyde. To get exactly the same compound as a "natural" flavor, one must employ far more sophisticated technology to extract and isolate benzaldehyde from peach and apricot pits. The "natural" flavor, an extract, contains traces of hydrogen cyanide, a deadly poison evolved by plants to protect their seeds from insects. Even so, consumers strongly prefer all-natural to artificial flavors, which sell, therefore, at far lower prices.

In its advertisements, the Haarman and Reimer Corporation ("H&R") describes its flavor enhancers as "HypR Clean Naturally." With "H&R as your partner, you'll discover the latest advances in food technology" that assure "the cleanest label possible." A "clean" label is one that includes only natural ingredients and no reference to technology. In a competing advertisement, Chr. Hansen's laboratory announces itself as the pioneer in "culture and enzyme technologies. And because our flavors are completely natural, you can enjoy the benefits of 'all-natural' labeling." Flavor manufacturers tout their stealth technology—*i.e*. technology so advanced it disappears from the consumer's radar screen. The consumer can be told he or she is directly in touch with nature itself.

The world's largest flavor company, International Flavors & Fragrances (IFF), operates manufacturing facilities in places like Dayton, NJ, an industrial corridor of refineries and chemical plants. Under a picture of plowed, fertile soil, the IFF Laboratory, in a full-page display states, "Where Nature is at Work, IFF is at work." The text describes "IFF's natural flavor systems." The slogan follows: "IFF technology. In Partnership with Nature." Likewise, Meer

Corporation of Bergen, NJ, pictures a rainforest under the caption, "It's A Jungle Out There." The ad states that "true-to-nature" flavorings "do not just happen. It takes... manufacturing and technical expertise and a national distribution network... for the creation of natural, clean label flavors."

Food colors are similarly sold both as all-natural and as high tech. "Vegetone' colors your foods *naturally* for a healthy bottom line," declares Kalsec Corp. of Kalamazoo, MI. Its ad shows a technician standing before a computer and measuring chemicals into a test tube. The ad extols the company's "patented natural color systems." The terms "natural" and "patented" fit seamlessly together in a conceptual scheme in which there are no trade-offs and no compromises. Only the most sophisticated technology will assure your product a clean, all-natural label. The natural is patentable.

If you think any of this is contradictory, you will not get far in the food industry.

Organic TV Dinners

As a typical American suburbanite, I can buy not just groceries but "Whole Foods" at Fresh Fields and other upscale supermarkets. I am particularly impressed by the number of convenience foods that are advertised as "organic." Of course, one might think that any food may be whole and that all foods are organic. Terms like "whole" and "organic," however, appeal to and support my belief that the products that carry these labels are less processed and more natural—closer to the family farm—than are those that might be sold by multinational megacorporations, such as Pillsbury or General Foods.

My perusal of advertisements in trade magazines helped disabuse me of my belief that all-natural, organic, and whole foods are closer to nature in a substantive sense than are other manufactured products. If I had any residual sentiments, they were removed by an excellent cover story, "The Organic-Industrial Complex," that appeared in the May 13, 2001, issue of the *New York Times Magazine*. The author, Michael Pollan, was shocked to find that the prepackaged microwavable all-natural organic TV dinners at his local Whole Foods outlet are not gathered from the wild by red-cheeked peasants in native garb. They are highly processed products manufactured by multinational corporations. Contrary to the impression created by advertisements, organic and other all-natural foods are often fabricated by the same companies—using comparable technologies—as those that produce Velveeta and Miracle Whip. And the ingredients come from as far away as megafarms in Chile, not from local farmers' markets.

Reformers who led the organic food movement in the 1960s wished to provide an alternative to agribusiness and to industrial food production. But some of these same reformers bent to the inevitable. As Pollan pointed out, they became multimillionaire executives of Pillsbury and General Mills in charge of organic-food production systems. This makes sense. A lot of advanced

technology is needed to produce and market an all-natural or an organic ready-to-eat meal. Consumers inspect food labels to ward off artificial ingredients; yet they also want the convenience of a low-priced, pre-prepared, all-natural dinner.

General Mills Senior Vice President, Danny Strickland, told Pollan, "Our corporate philosophy is to give consumers what they want with no trade-offs." Pollan interpreted the meaning of this statement as follows. "At General Mills, the whole notion of objective truth has been replaced by a value-neutral consumer constructivism, in which each sovereign shopper constructs his own reality."

Mass-marketed organic TV dinners do not compromise; they combine convenience with a commitment to the all-natural, ecofriendly, organic ideology. The most popular of these dinners are sold by General Mills through its subsidiary, Cascadian Farms, whose advertising slogan, "Taste You Can Believe In," as Pollan observed, makes no factual claims of any sort. It "allows the consumer to bring his or her personal beliefs into it," as Vice President for Marketing, R. Brooks Gekler, told Pollan. The absence of any factual claim is essential to selling a product, since each consumer buys an object that reflects his or her particular belief-system.

What is true of marketing food is true of virtually every product. A product will sell if it is all-natural and ecofriendly and, at the same time, offers the consumer the utmost in style and convenience. A recent *New York Times* article, under the title "Fashionistas, Ecofriendly and All-Natural," points out that the sales of organic food in the United States topped $6.4 billion in 1999 with a projected annual increase of 20%. Manufacturers of clothes and fashion accessories, such as solar-powered watches, are cashing in on the trend. Maria Rodale, who helps direct a publishing empire covering "natural" products, founded the women's lifestyle magazine *Organic Style*. Rodale told the *Times* that women want to do the right thing for "the environment but not at the cost of living well." Advances in technology give personal items and household wares an all-natural ecofriendly look and feel that is also the last word in fashion. Consumers "don't want to sacrifice anything," Ms. Rodale told a reporter. Why should there be trade-offs between a commitment to the natural and a commitment to the good life? "Increasingly there are options that don't compromise on either front" (La Ferla, 2001).

The food industry does not sell food any more than the fashion industry sells clothes or the automobile industry sells automobiles. They sell imagery. The slogan, "Everything the consumer wants with no tradeoffs," covers all aspects of our dream-world. Sex without zippers, children without zits, lawns without weeds, wars without casualties, and food without technology. Reality involves trade-offs and rather substantial ones. For this reason, if you tried to sell reality, your competitor would drive you out of business by avoiding factual claims and selling fantasy—whatever consumers believe in—instead. Consumers should

not be confused or disillusioned by facts. They are encouraged to assume that they buy the products of Nature or Creation not industry. In view of this fantasy, how could consumers view genetic engineering with anything but suspicion?

NATURE'S OWN METHODS

Genetic engineering, with its stupendous capacity for increasing the efficiencies of food production in all departments, including flavors and colorings, raises a problem. How can genetic recombination be presented to the consumer as completely natural—as part of nature's spontaneous course—as have other aspects of food technology? A clean label is needed to tell consumers that there is nothing unnatural or inauthentic about genetic engineering. Industry has responded in two complementary ways to this problem.

First, the food industry has resisted calls to label bioengineered products. Gene Grabowski of The Grocery Manufacturers Association, for example, worries that labeling "would imply that there's something wrong with food, and there isn't" (Lambrecht, 1999). Michael J. Phillips, an economist with the Biotechnology Industry Organization (BIO), adds that labeling "would only confuse consumers by suggesting that the process of biotechnology might, in and of itself, have an impact on the safety of food. This is not the case" (Wilson, 2000).

Second, many manufacturers point out that today's genetic technologies do not differ, except in being more precise, from industrial processes that result in the emulsifiers, stabilizers, enzymes, proteins, cultures, and other ingredients that do enjoy the benefits of a clean label. Virtually every plant consumed by human beings, canola, for example, is the product of so much breeding, hybridization, and genetic modification that it hardly resembles its wild ancestors. This is a good thing, too, since these wild ancestors were barely edible if not downright poisonous. Manufacturers argue that genetic engineering differs from conventional breeding only in that it is more accurate and, therefore, changes nature less.

For example, Monsanto Corporation, in a recent full-page ad, pictures a bucolic landscape reminiscent of a painting by Constable. The headline reads, "FARMING: A picture of the Future." The ad then represents genetic engineering as all-natural, or at least as natural as are conventional biotechnologies that have enabled humanity to engage successfully in agriculture. "The products of biotechnology will be based on nature's own methods," the ad assures the industry. "Monsanto scientists are working with nature to develop innovative products for farmers of today, and of the future."

In this advertisement, Monsanto applies the tried-and-true formula to which the food industry has long been committed by presenting their technology as revolutionary, innovative, highly advanced, and as "based on nature's own methods." *Everything* is natural. Why not? As long as there are no distinctions,

there are no trade-offs. Consumers can buy what they believe in. A thing is natural if the public believes it is. "There is something in this more than natural," as Hamlet once said, "if philosophy could find it out."

Four Concepts of the Natural

If consumers reject bioengineered food as "unnatural," what does this mean? In what way are foods that result from conventional methods of genetic mutation and selection, which have vastly altered crops and livestock, more "natural" than those that depend on gene splicing? Indeed, is anything in an organic TV dinner "natural" other than, say, the rodent droppings that may be found in it? Since I am a philosopher, not a scientist, I am particularly interested in the moral, aesthetic, and cultural—as distinct from the chemical, biological, or physical—aspects of the natural world. I recognize that many of us depend in our moral, aesthetic, and spiritual lives on distinguishing those things for which humans are responsible from those that occur as part of nature's spontaneous course.

Philosophers have long pondered the question whether the concept of the natural can be used in a normative sense, that is, whether to say a practice or a product is "natural" is to imply that it is better than one that is not. Why should anyone assume that a product that is "natural" is safer, more healthful, or more aesthetically or ethically attractive than one that is not? And why is technology thought to be intrinsically risky when few of us would survive without quite a lot of it?

Among the philosophers who have questioned the "naturalistic fallacy"—the assumption that what is natural is, for that reason, good—John Stuart Mill (1969) has been particularly influential. In his "Essay on Nature," he argued that the term "nature" can refer either to the totality of things ("the sum of all phenomena, together with the causes which produce them") or to those phenomena that take place "without the agency... of man." Plainly, everything in the world, including every technology, is natural and belongs equally to nature in the first sense of the term. Mill commented:

> *To bid people to conform to the laws of nature when they have no power but what the laws of nature give them—when it is a physical impossibility for them to do the smallest thing otherwise than through some law of nature—is an absurdity. The thing they need to be told is, what particular law of nature they should make use of in a particular case.*

Of nature in the second sense, *i.e.* that which takes place without the agency of man, Mill had a dour view: "Nearly all the things which men are hanged or imprisoned for doing to one another, are nature's every day performances." Nature may have cared for us in the days of the Garden of Eden. In more recent years, however, humanity has had to alter Creation to survive. Mill concluded, "For while human action cannot help conforming to nature in one meaning of

the term, the very aim and object of action is to alter and improve nature in the other meaning."

Following Mill, it is possible to distinguish four different conceptions of nature to understand the extent to which bioengineered food may or may not be natural. These four senses of the term include:

- Everything in the universe. The significant opposite of the "natural" in this sense is the "supernatural." Everything technology produces has to be completely natural because it conforms to all of nature's laws and principles.
- Creation in the sense of what God has made. The distinction here lies between what is sacred because of its pedigree (God's handiwork) and what is profane (what humans produce for pleasure or profit).
- That which is independent of human influence or contrivance. The concept of "nature" or the "natural" in this sense, e.g., the "pristine" is understood as a privative notion defined in terms of the absence of the effects of human activity. The opposite of the "natural" in this sense is the "artificial."
- That which is authentic or true to itself. The opposite of the "natural" in this sense is the specious, illusory, or superficial. The "natural" is trustworthy and honest, while the sophisticated, worldly, or contrived is deceptive and risky.

These four conceptions of nature are logically independent. To say that an item or a process—genetic engineering, for example—is consistent with the laws of nature, for example, is by no means to imply it is "natural" in any other sense. That genetically manipulated foods can be found within the totality of phenomena does not show that they are "natural" in the sense that they are part of primordial Creation, free of human contrivance, or authentic and expressive of the virtues of rustic or peasant life.

The problem of consumer acceptance of biotechnology arises in part because the food industry advertises its products as natural in the last three senses. The industry wishes to be regulated, however, only in the context of the first conception of nature, which does not distinguish among phenomena on the basis of history, source, or provenance. The industry argues that only the biochemical properties of its products should matter to regulation; the process (including genetic engineering) is irrelevant to food safety and should not be considered.

The food industry downplays the biochemical properties of its products, however, when it advertises them to consumers. The industry—at least if the approach taken by General Mills is typical—tries to give the consumer whatever (s)he believes in. If the consumer believes in a process by which rugged farmers on the slopes of the Cascades raise organic TV dinners from the soil by sheer force of personality, so be it. You will see the farm pictured on the package to suggest the product is close to Creation, free of contrivance, and

authentic or expressive of rural virtues. What you will not see on any label, if the industry has its way, is a reference to genetic engineering. The industry believes regulators should concern themselves only with the first concept of nature—the scientific concept—and thus with the properties of the product. Concepts related to the process are used to evoke images that "give consumers what they want with no trade-offs."

SHAKESPEARE ON BIOTECHNOLOGY

I confess that, as a consumer, I find organic foods appealing and I insist on "all-natural" ingredients. Am I just foolish? You might think that I would see through labels like "all natural" and "organic," not to mention "whole" foods, and that I would reject them as marketing ploys of a cynical industry. Yet like many consumers, I want to believe that the "natural" is somewhat better than the artificial. Is this just a fallacy?

Although I am a professional philosopher (or perhaps because of it), I would not look first to the literature of philosophy to understand what may be an irrational, or at least an unscientific, commitment to buying "all natural" products. My instinct would be to look in Shakespeare, who has been correctly called the world's most underrated poet, to understand what may be contradictory attitudes or inexplicable sentiments.

Shakespeare provides his most extensive discussion of biotechnology in *The Winter's Tale*, one of his comedies. In Act IV, Polixenes, King of Bohemia, disguises himself to spy upon his son, Florizel, who has fallen in love with Perdita, whom all believe to be a shepherd's daughter. In fact, though raised as a shepherdess, Perdita is the castaway daughter of the King of Sicily, a close, but now estranged, friend of Polixenes. Perdita welcomes the disguised Polixenes and an attendant lord to a sheep-shearing feast in late autumn, offering them dried flowers "that keep / Seeming and savour all winter long." Polixenes merrily chides her: "well you fit our ages / With flowers of winter." She replies that only man-made hybrids flourish so late in the fall:

> *…carnations, and streak'd gillyvors,*
> *Which some call nature's bastards. Of that kind*
> *Our rustic garden's barren; and I care not*
> *To get slips of them.*

Polixenes asks why she rejects cold-hardy flowers such as gillyvores, a dianthus. She answers that they come from human contrivance, not from "great creating nature." She complains there is "art" in their "piedness" or variegation. Polixenes replies:

> *Say there be;*
> *Yet nature is made better by no mean*
> *But nature makes that mean; so over that art*
> *Which you say adds to nature, is an art*
> *That nature makes... This is an art*

Which does mend nature—change it rather; but
The art itself is nature.

The statement, "The art itself is nature" anticipates the claim made by Monsanto that "the products of biotechnology will be based on nature's own methods." Polixenes, Mill, and Monsanto remind us that everything in the universe conforms to nature's own principles, and relies wholly on nature's powers. From a scientific perspective, in other words, all nature is one. The mechanism of a lever, for example, may occur in the physiology of a wild animal or in the structure of a machine. Either way, it is natural. One might be forced to agree, then, that genetic engineering applies nature's own methods and principles; in other words, "the art itself is nature."

The exchange between Perdita and Polixenes weaves together the four conceptions of nature I identified earlier in relation to John Stuart Mill. When Polixenes states, "The art itself is nature," he uses the term "nature" to comprise everything in the universe, that is, everything that conforms to physical law. Second, Perdita refers to "great creating nature," that is, to Creation, *i.e.*, the primordial origin and condition of life before the advent of human society. Third, she contrasts nature to art or artifice by complaining that hybrids do not arise spontaneously, but show "art" in their "piedness." Finally, Perdita refers to her "rustic garden," which, albeit cultivated, is "natural" in the sense of simple or unadorned, in contrast to the ornate horticulture that would grace a royal garden. The comparison between the court and the country correlates, of course, with the division that exists in Perdita herself: royal in carriage and character by her birth, yet possessed of rural virtues by her upbringing.

Shakespeare elaborates this last conception of "nature" as the banter continues between Perdita and the disguised Polixenes. To his assertion, "The art itself is nature," Perdita concedes, "So it is." Polixenes then drives home his point: "Then make your garden rich in gillyvors, / And do not call them bastards."

To which Perdita responds:

I'll not put
The dibble in earth to set one slip of them;
No more than were I painted I would wish
This youth should say 'twere well, and only therefore
Desire to breed by me.

Besides comparing herself to breeding stock—amusing in the context, since she speaks to her future father-in-law in the presence of his son—Perdita reiterates a fourth and crucial sense of the "natural." In this sense, what is "natural" is true to itself; it is honest, authentic, and genuine. This conception reflects Aristotle's theory of the "nature" of things, which refers to qualities that are spontaneous because they are inherent or innate.

Perdita stands by her insistence on natural products—from flowers she raises to cosmetics she uses—in spite of Polixenes' cynical but scientific reproofs. Does this suggest Perdita is merely a good candidate for Ms. Rodale's organic chic? Should she receive a free introductory copy of *Organic Style*? Certainly not. There is something about Perdita's rejection of biotechnology that withstands this sort of criticism. Why have Perdita's actions a moral authority or authenticity that the choices consumers make today may lack?

Having It Both Ways

Perdita possesses moral authority because she is willing to live with the consequences of her convictions and of the distinctions on which they are based. By refusing to paint herself to appear more attractive, for example, she contrasts her qualities, which are innate, with those of the "streak'd gillyvor," which result from technological meddling. This comparison effectively gives her the last word because she suits the action to it: she does not and would not paint herself to attract a lover. Similarly, Perdita does not raise hybrids, though she admits, "I would I had some flow'rs" that might become the "time of day" of the youthful guests at the feast, such as Florizel.

She does not try to have it both ways, to reject hybrids but expect to grow cold-hardy flowers. She ridicules those who match lofty ideals with ordinary actions, whose practice belies their professed principles. For example, Camillo, the Sicilian lord who attends Polixenes, compliments Perdita on her beauty. He says, "I should leave grazing, were I of your flock, / And only live by gazing." She laughs at him and smartly replies, "You'd be so lean that blasts of January / Would blow you through and through."

Many people today share Perdita's affection for nature and her distaste for technology. Indeed, it is commonplace to celebrate Nature's spontaneous course and to condemn the fabrications of biotechnology. Jeremy Rifkin speaks of "Playing Ecological Roulette with Mother Nature's Designs," and Ralph Nader has written the foreword to a book titled, "Genetically Engineered Food: Changing the Nature of Nature." Prince Charles, in a tirade against biotechnology, said, "I have always believed that agriculture should proceed in harmony with nature, recognizing that there are natural limits to our ambitions. We need to rediscover a reverence for the natural world to become more aware of the relationship between God, man, and creation."

Insofar as consumers reject genetically engineered food, this need not be understood as an animadversion to recombinant DNA as such. In fact, consumers are equally likely to reject "mutated" foods even if the mutation occurs (as it does in nearly every food product) through cross-breeding, hybridization, and other conventional methods. In a typical survey of consumer attitudes, "only 28% (of respondents in New Jersey) thought they had ever eaten a hybrid fruit or vegetable that was the product of traditional cross-breeding. Moreover, 40% did not approve of making hybrid plants." The consensus view held it was best "not to meddle with nature" (Hamstra, 1998).

While consumers today share Perdita's preference for the natural in the sense of the authentic and unadorned and spurn technological meddling, they do not share her willingness to live with the consequences of their commitment. Even in winter, they expect to enjoy fruits and vegetables of unblemished appearance and consistent taste and nutritional quality. Gardeners wish to plant lawns and yards with species that are native and indigenous, and they support commissions and fund campaigns to throw back the "invasions" of exotic and alien species. Yet they also want lawns that resist drought, blight, and weeds, and—to quote Perdita again—to enjoy flowers that "come before the swallow dares, and take / The winds of March with beauty." In other words, the consumer wants it both ways. As Ms. Rodale knows, they "don't want to sacrifice anything." Today's consumers insist, as did Perdita, on the local, the native, the spontaneous. Yet, they lack her moral authority because they are unwilling to live with the consequences of their principles or preferences. Consumers today refuse to compromise; they expect fruits and flowers that survive "the birth / Of trembling winter" and are plentiful and perfect all year round.

NAKED LUNCH

Those who defend genetic engineering in agriculture are likely to regard as irrational consumer concerns about the safety of genetically manipulated crops. The oil and other products of Roundup Ready® soybeans, according to this position, pose no more risks to the consumer than do products from conventional soybeans. Indeed, soybean oil, qua oil, contains neither DNA nor protein and so will be the same whether or not the plant is herbicide resistant. Even when protein or DNA differs, no clear argument can be given to suppose that this difference—e.g., the order of a few nucleotides—involves any danger. Crops and livestock are the outcome of centuries or millennia of genetic crossing, selection, mutation, breeding, and so on. Genetic engineering adds but a wrinkle to the vast mountains of technology that separate the foods we eat from wild plants and animals.

Genetic engineering adds but a wrinkle to the vast mountains of technology that separate the foods we eat from wild plants and animals.

The same kind of argument may undermine consumer beliefs that "natural" colors and flavors are safer or more edible than artificial ones. In fact, chemical compounds that provide "natural" and "artificial" flavors can be identical and may be manufactured at the same factories. The difference may lie only in the processes by which they are produced or derived. An almond flavor that is

produced artificially, as I have mentioned, may be purer and, therefore, safer than one extracted from peach or apricot pits. Distinctions between the natural and the artificial, then, need not correspond with differences in safety, quality, or taste, at least from the perspective of science.

An almond flavor that is produced artificially may be purer and, therefore, safer than one extracted from peach or apricot pits. Distinctions between the natural and the artificial, then, need not correspond with differences in safety, quality, or taste, at least from the perspective of science.

Distinctions consumers draw between the natural and the artificial, and preferences for the organic over the engineered, reflect differences that remain important nonetheless to our cultural, social, and aesthetic lives. We owe nature a respect that we do not owe technology. The rise of objective, neutral, physical and chemical science invites us, however, to disregard all such moral, aesthetic, and cultural distinctions and act only on facts that can be scientifically analyzed and proven. Indeed, the food industry, when it is speaking to regulators rather than advertising to consumers, insists on this rational, objective approach.

In an essay titled, "Environments at Risk," Mary Douglas (1975) characterized the allure of this objective, rational, value-neutral science:

> *This is the invitation to full self-consciousness that is offered in our time. We must accept it. But we should do so knowing that the price is William Burroughs' Naked Lunch. The day when everyone can see exactly what it is on the end of everyone's fork, on that day there is no pollution and no purity and nothing edible or inedible, credible or incredible, because the classifications of social life are gone. There is no more meaning.*

Advances in genetic engineering invite us to the full self-consciousness that Douglas described and aptly analogizes to the prison life depicted in *Naked Lunch*. It is the classifications of social life—not those of biological science—that clothe food and everything else with meaning. Genetic engineering poses a problem principally because it crosses moral, aesthetic, or cultural—not biological—boundaries. The fact that the technology exists and is successful shows, indeed, that the relevant biological boundaries (*i.e.* between species) that might have held in the past now no longer exist.

Given advances in science and technology, how can we maintain the classifications of social life, for example, distinctions between natural and artificial flavors and between organic and engineered ingredients? How may we, like Perdita, respect the difference between the products of "great creating nature" and those of human contrivance? She honors this distinction by living with its consequences. Her severest test comes when Polixenes removes his disguise and threatens to condemn her to death if she ever sees Florizel again. Florizel asks her to elope, but she resigns herself to the accident of their origins—his high, hers (she believes) low—that separates them forever. Dressed up as a queen for the festivities, Perdita tells Florizel: "I will queen it no further. Leave me, sir; I will go milk my ewes and weep."

Perdita, of course, both renounced her cake and ate it, too. In Act IV, she gives up Florizel and his kingdom, but in Act V she gets them. Her true identity as a princess is eventually discovered, and so the marriage happily takes place. If you or I tried to live as fully by our beliefs and convictions—if we insisted on eating only those foods that come from great creating nature rather than from industry—we would not be so fortunate. "You'd be so lean that blasts of January / Would blow you through and through."

Perdita is protected by a playwright who places her in a comedy. Shakespeare allows her to live up to her convictions without compromising her lifestyle. This is exactly what the food industry promises to do: "to give consumers what they want with no trade-offs." It is exactly what Ms. Rodale offers: to protect the environment, "but not at the cost of living well." The food, fashion, and other industries work off-stage to arrange matters so that consumers can renounce genetic engineering, artificial flavors, industrial agriculture, and multinational corporations. At the same time, consumers can enjoy an inexpensive, all-natural, organic, TV dinner from Creation via Cascadian Farms

Perdita lives in the moral order of a comedy. In that moral order, no compromises and no trade-offs are necessary. You and I are not so fortunately situated. Indeed, we must acknowledge the tragic aspect of life, the truth that good things are often not compatible and that we have to trade off one for the sake of obtaining the other. The food industry, by suggesting that we can have everything we believe in, keeps us from recognizing that tragic truth. The industry makes all the compromises and hides them from the consumer.

REFERENCES

Douglas M (1975) Environments at risk, in Implicit Meanings: Essays in Anthropology, 247, London-New York: Routledge, ISBN 0415065615.

Food Processing (1988) February, p 28.

Hamstra IA (1998) Public Opinion about Biotechnology: A Survey of Surveys. Delft: European Federation of Biotechnology, Task Group on Public Perceptions of Biotechnology, ISBN 90-76110, http://www.kluyver.stm.tudelft.nl/efb/tgppb/pdf/survey.pdf.

La Ferla R (2001) Fashionistas, ecofriendly and all-natural. New York Times Fashion and Style Section, July 15.
Lambrecht B (1999) Magazine reveals food-makers' secret. St. Louis Post-Dispatch August 22, http://www.healthresearchbooks.com/articles/labels2.htm.
Mill JS (1969) Nature. Three Essays on Religion New York: Greenwood Press, p. 16 (reprint of the 1874 edition).
Saunders L (1995) Selecting an enzyme. Food Product Design, May.
Wilson J (2000) Scientific food fight. Popular Mechanics, February.

Q: In a debate that has become confrontational through and through, how do you introduce trade-offs without weakening your position immediately?

A: It would help to have a greater availability of literature on the history of crops, such as corn, that people accept as being safe, and show the vast differences that have resulted from technology—breeding and selection. Then people would begin to understand that technology is a normal part of food production and there would be less embarrassment about admitting it with respect to biotechnology.

PART V

SESSION III

DIVERGENT LENSES OF STAKEHOLDERS

A Farmer's Perspective: Producing Food and Fiber for an Unforgiving World

David C. Erickson
LANDcorp, Inc.
Altona, IL

I had to come up with a title for the abstract, and this one might seem rather dramatic. But, considering the experiences of farmers, including their connection with biotechnology—its origins and where it may lead us—this title may be more fact than fiction. Many times in the past, producers were left holding the bag, so to speak, as new technologies ran into unforeseen problems.

I will start with a brief overview of our farming operations to provide background on how my thinking has developed and how we use technologies that are being discussed at this conference. We farm in a family corporation. That is a nasty word to some people, but our corporation involves my wife, Nancy, and myself. The board of directors of our corporation has two members, and all decisions are unanimous. "LAND" in LANDcorp stands for Leland, Ann, Nancy, and David, *i.e.* it originally included Nancy's parents, who are now retired. We also manage farmland on a crop-share basis for absentee landowners in Illinois and, to a small extent, in flooded river valleys in Missouri.

Our Current Farming Practices

For a corn-soybean farmer, nothing looks better than a weed-free field of beans as far as the eye can see. All of our soy is no-till planted; we drill directly into the standing corn stalks from the previous year. And the majority of our corn is grown with minimum till. For those unfamiliar with no-till, you can see the residue from the previous corn crop under the canopy of the soybean. Where the lie of the land allows it, some of our fields are in continuous no-till with a corn/soybean rotation. Although this practice definitely has benefits, we do not adopt it in every case.

We use a combination of different types of products. Corn and soybeans sound pretty straightforward, but there are variations. For example, different

varieties mature at different times in close proximity in the same field. We tailor-fit the management system for each field. We have some ground that is highly erodable, which means that it falls under a required conservation plan for government programs. But even on ground that is not highly erodable, we maintain grassed waterways to help improve the environment, not only on our farm but also downstream from it. Over the past several years, we have been adopting new types of seed. High-oil corn—quite prevalent in our area although not as much as in some others—is used mainly for livestock feed because of its higher energy content. And we grow Bt corn, but not strictly for prevention of corn-borer damage. Some varieties with the BT gene are healthier and produce more grain than the non-Bt counterpart. Although I cannot prove this to you scientifically, I know from personal experiences that it is the case. We use Roundup Ready® soybeans and Bt corn as part of a management program, but not across all of our acres. This year we are about 10% Bt corn and about 55% Roundup Ready® soybean. I have neighbors who are 100% Bt corn and Roundup Ready® soybean and I have neighbors who have never used either technology. Farmers should not be defined on the basis of national, regional, or even local averages.

We grow Bt corn, but not strictly for prevention of corn-borer damage. Some varieties with the BT gene are healthier and produce more grain than the non-Bt counterpart.

All of our grain is stored on-farm. We have a drying system at our corn facility. All of our grain, corn and soybean, goes to either terminal markets or processor markets. The vast majority of our corn goes to Peoria or Pekin on the Illinois River, most of which is made into ethanol. The corn-gluten feed is shipped out of Peoria, *e.g.* for export, depending on market dictates.

Some in the industry think that smaller storage units are needed to identity-preserve grain for niche markets. I agree, but only if it is economically viable. We have three smaller grain bins for soybean as well as a large bin. Last year, we raised high-pro soybean, soybean for seed, and we raised clear-hilum soybeans for tofu. But, in the end, the economics were unfavorable, and the smaller grain bins have sat empty. You have to be willing to make some adjustments in farming, and that is a good example.

Since 1993, we have employed a grid-based soil-sampling system on all of the farms that we own and manage. We sample the soil at least every 4 years, using a 2½-acre grid. One farm was soil-tested in 1993 and again in 1995. In 1993

we did not have complete global positioning satellite capability, so we tested again in 1995. Our goal for potassium is a reading of about 400 lb/acre, and the variability range was 316 to 1,037. We apply the fertilizer on the basis of the soil-test figures, therefore, many areas receive no potassium at all, otherwise it is applied in response to the measured shortfall. We realize that, in the long term, we have to be responsible and accountable for the fertilizer that we use, not only from a cost-savings standpoint, but also for environmental reasons. Of course we carry the soil-test and fertilizer-application information on to yield mapping: we collect second-by-second yield data that, hopefully, is correlative. In fact, our yields are pretty stable, including those zero-input areas.

BIOTECHNOLOGY: SILVER BULLET? . . .

Nancy and I began farming in 1985, just ahead of the passage of the 1985 farm bill. With the 1990 farm bill, it was probably the most environmentally sensitive—or most restrictive, depending on your point of view—farm bills ever passed. We have been told by consumers to reduce pesticide use and to reduce soil run-off. And, as producers, we must be more efficient: use less, produce more, while spending less money. As the products of biotechnology came to the market place in the late 1980s and early 1990s, I thought that we had found the silver bullet. It was exciting.

When you look at biotechnology as a whole—how it has affected our lives—it makes a lot of sense. In some cases, it has helped improve crop productivity. It probably has reduced pesticide usage; if you think of it in terms of active ingredient, it certainly has. And possibly most importantly, it has affected us in terms of health-care. Our 14-year-old son was stricken with juvenile diabetes when he was 9 months old. The new type of insulin is so close to what his body would produce, if it were able to produce it, that it may add 10 to 15 years to his life. It's a "no-brainer!" It works and he is healthy. In a room with other 14-year olds, you cannot tell the difference. And I have a brother with a congenital heart condition. I am convinced that research in human genetics has helped improve the care that he has received. New treatments have resulted from knowledge created from gene mapping. For me, the results of biotechnology have been incredible, from the medical standpoint as well as from the production-agriculture standpoint.

When I joined the American Soybean Association, I had the opportunity to travel to abroad, and spoke with consumers, officials in government, and farmers in Mexico, Canada, Germany, Austria, France, Belgium, Japan, and China. Many times, when they talked about the United States food supply, their first two questions had nothing to do with technology. In an importing country, they asked, "Do you have food that we can buy?" And their second question was, "Is it a stable supply?" They are interested in those two aspects first, and then come other questions. My experience tells me that, while we do need to educate consumers and give them information on a world-side basis of what

we are doing, we also have to be aware that their interests, at least initially, are basic. There is trust—regardless of what you might see in the media—in the American system of developing and testing new technologies, and removing them or their products from the marketplace when they fail to perform as expected. We have proven it time and again: hamburger recalled from the marketplace, pesticides removed from sale after further review, for example. I do not believe that there is a system better than ours. For one thing, it is not political, and that is important. You may not like the systems that are in place, but, at least they are not political.

If farmers knew 5 years ago what they know today about biotechnology, would they still be using it? I would say, one hundred percent. Growers will use a technology when it makes sense from the business standpoint. They believe in a system that requires testing and approval up-front, from the companies that bring them to the marketplace plus from third parties—university testing in many cases.

If farmers knew 5 years ago what they know today about biotechnology, would they still be using it? I would say, one hundred percent. Growers will use a technology when it makes sense from the business standpoint. They believe in a system that requires testing and approval up-front, from the companies that bring them to the marketplace plus from third parties—university testing in many cases.

. . . Or Management Tool?

Ask farmers what percentage of the corn crop planted last year was genetically modified, and they would probably have to think about it. They can tell you exactly, maybe to a tenth of an acre, what area of corn or soybean they planted, or wheat or alfalfa, or the number of cattle or hogs they have on feed. But if you ask them what percentage of their corn crop is genetically modified, they would not necessarily know because to them it is still corn. They view genetic modification as a management tool in the vast majority of cases, and not different from the norm. It as a tool to help make them more efficient as producers, and if it fits, it fits, and if it does not, then so be it. They do not make decisions based on that issue alone.

Gaining Global Acceptance

Is there a solution to the controversy? One thing that I learned a long time ago, through organizational work, is that the process is every bit as important as the end product. If the biotech companies have been guilty of anything, it is that the process was not all that it should have been. They failed to make the system transparent, and failed to get all of the "stakeholders" involved. From the farmer's point of view, the key ingredient is predictability in the products that he buys. Predictability in being able to buy and in being able to sell. In my opinion, global acceptance of the processes that review and regulate the products of biotechnology is necessary. I do not know how that will be achieved, but I believe it is possible if those involved are of the mindset to do so. With that process in place, then let it work. If they keep changing the rules, no one knows if they are still on the "A" set or if the "B" set now applies.

So, with the process in place and allowed to work, the third aspect—possibly a bitter pill for some—is to make stakeholders accountable. Farmers should sign agreements knowing that the harvested crops cannot be put into the normal marketing channels. If they do, they ought to be held accountable, because they are hurting my credibility. The same applies to companies that develop such varieties, if they do not fully disclose to farmers that the crop probably cannot be sold in the market-stream, that it does not have all of the approvals. I have heard and seen commercials on radio and television about how you can channel these through normal marketing processes if you just look for them. But, in my area, they cannot be sold within thirty miles. Therefore, people must be held accountable. After the agreement is made, there should be no turning back unless there is new evidence that supports a change in the process for developing approvals. In my mind, it is not so very difficult; with the system in place, you have to get people to believe that it can work, you have to let it work, and then you hold people accountable. If we do not, we run the risk of being what the "nay" sayers say that we are: interested solely in our own well-being and not in the well-being of the consumer.

Q: Thank you for the farmer perspective. For me it was the first. I have three questions.

- You mentioned that you had neighboring farms that were GM or non-GM crops. What is your opinion about the lawsuit in Canada? Are you concerned over the possibility of similar lawsuits on pollen drifting into neighboring fields?
- You mentioned that you are using GM crops for pest or weed control, but as management tools. If genetic engineering were to stall, are there alternative technologies, techniques, or ways of accomplishing the environmentally sensitive goals of the 1985 and 1990 farm bills? Do you think that you could have accomplished those things without too much imposition?

- Assuming that we have the second and third generations of genetic modifications, and you have a variety of output traits—say vaccines and altered starch and protein traits—if I tell you here are ten seeds and there is a market for them somewhere, what kind of costs or flexibility would you have as a farmer to manage that kind of variety of crop; handling them in your silos and moving them to the elevator, *etc.* Do you think that it is practical?

A: I'll respond in reverse order.

- On your last point, farmers can handle new technologies when given the proper information, such as on handling and storage. There's a big difference between asking someone to store and keep a crop identity-preserved for a dollar per bushel more than for ten cents more. The problem in production agriculture right now is the people who are paying a dollar—their guidelines are not a whole lot more stringent than those who are paying five or ten cents. There are huge inequities, and farmers are the ones paying the difference.
- When looking at environmental concerns, yes, there would be products without biotechnology. The marketplace in general has its set of needs, which would be met even without biotechnology. Without making guesses as to whether it would have happened as quickly or as easily or as effectively, by the nature of private enterprise I think that alternative products would be available.
- I am not a plant breeder, but as a farmer I do understand that corn self-pollinates at about 90%. Yes, pollen will drift, as seen in seed fields or seed-corn production. But I do not believe that it will drift far enough to infect a neighbor's field beyond a tolerable level.

Q: I read in your bio that you farm about 3,000 acres, but you are also an administrator in the American Soybean Association. So you must deal with some smaller farmers as well. Do you think that they hold the same beliefs as you in terms of this technology?

A: Agriculture is having a hard time defining what is a small farm, a medium farm, and a large farm. Our operation may be a little above average in terms of the number of participants. We have one full-time employee besides ourselves, and some part-time workers. And we are in transition, going from one generation to the next, and not yet involving the next generation. My experience through the American Soybean Association was as an unpaid volunteer. Sure, there are differences of opinion among producers. That old adage, once you've met one farmer you've met one farmer, is very true. They have a broad range of opinions. Being forward in your thinking is not limited by farm size. I refuse to believe that you cannot be an active, progressive farmer with fewer acres than some others. You may do things differently. You may do

things with neighbors and you may hire out more services, but I think that farmers who are looking toward the growth and the future of the industry have to look at new technologies. I do not think that they *have* to use a new technology, but if they do not examine it they will never know if they are right or wrong in the decision-making process.

Q: Can you give us some sense of the economics of biotechnology vs. non-biotechnology? How much extra do you have to pay for GM soybean and corn seed, and how does that work out? And secondly, how much is the premium for non-biotech soybean or corn in your area?

A: From a cost stand-point, I think you have to look at the complete system of how a farmer would farm under Plan A and how she or he would farm under Plan B or C, to make a comparison. In our situation we have conventional soybeans, STS soybeans, and Roundup Ready® soybeans. Across the board, there is little difference in cost. But you need to include all of the costs, such as the seed, and whether or not that includes a technology fee. You need to look at additional trips across the field with one system over another. So, across the board, there isn't much price difference. That is why it comes down to a management decision as to what fits best for each field.

There isn't a lot of market premium for non-GM corn, because of where we are located, and the markets we have. You might get two or five cents for non-GM corn, but it might have to be delivered in a very short period of time, and it might have to be at 13% moisture instead of 15%. You're giving up maybe three cents per bushel in moisture that you are allowed under grain standards in order to get the premium. For soybeans, at Decatur Illinois, they may have the best thing going. They are probably in the range of fifteen to twenty cents, maybe eighteen cents for non-GM soybean. In that area it works well, because not a lot of Roundup Ready® soybean is grown there. The effort involved in keeping the crop separate is worth that eighteen or twenty cents.

Q: If you take off your grower hat for a minute and put on your farm-manager hat, what kind of discussions about biotechnology do you have with your absentee landlords?

A: As much as we can, we keep our absentee landowners apprised of current issues in the industry, such as biotechnology and the present farm bill debate. The only advice we have ever given absentee landowners and tenants about what to plant is that they should plant varieties that are approved for export to major markets for the United States. We will not take a crop that might not be marketable; we have told tenants that we won't accept the risk of them selecting such crops. Other than that, I tell them pretty much what I've said today. We try to keep them informed of the issues and give them a clear picture of where we think we are and where we're going.

A Scientist's Perspective: the International Arena

ANATOLE F. KRATTIGER
bio*Developments LLC (International Consultants)* and *Cornell University*
Ithaca, NY

While preparing this paper, I pondered what a scientist's perspective should be. Although I no longer work at the bench, I am closely involved in the continuum of scientific research through technology to its application, and especially in its transfer to developing countries. I will briefly consider six aspects of science and end with a challenge: to come up with new proposals for action. How can people in the over-stocked grocery stores be made to change their attitudes to the new science and technology so that its benefits will accrue to those who are most deserving—the disadvantaged millions in the developing world?

SCIENCE AND PUBLIC POLICY

The modern world-view includes science as a central element. Indeed, almost everyone demands scientific certainty, *e.g.* with regard to global warming, ozone depletion, and biotechnology's safety. Yet, many people do not hold scientific views as to the origins of life and other areas that affect our daily lives. On one hand, we "demand" scientific certainty, yet on the other hand we reject scientific information, data, and conclusions. How does that paradox continue to exist? Evidently, it persists because we all seem to have a high degree of tolerance for contradictions, and because we select the areas in which we demand scientific certainty to suit our impulses. Consequently, it seems impossible for policy makers to formulate science-based policies.

Paradoxically, although Europeans reject biotechnology that affects their food, they accept it in the pharmaceutical area. But in developing countries the most pressing health hazard is malnutrition. Diseases related to under-nourishment kill approximately 40,000 children per day. So what is a luxury for Europeans—safer food with fewer pesticide residues, more plentiful and less expensive—is a matter of survival for the majority of the inhabitants of this Earth.

A sufficiency of high-quality food is the most basic element of good health. By denying the transfer of this technology to developing countries through restrictive policies so prevalent in Europe and elsewhere, we deny it also to most of the people on this planet. But how does one cope with the environmental luddites and anti-industry activists who claim to be cleaning things up as they misquote, misrepresent, misunderstand, or knowingly fail to read the scientific literature? How should we respond to their propagation of error-riddled rhetoric?

Even those who see biotechnology as a potential "problem" at least acknowledge current population/resource problems. Yet many fail to recognize that agricultural biotechnology is an imperative for the 2.4 billion people—40% of the world's population—who survive on less than $2 per day. They somehow fail to see the potential for biotechnology to increase the productivity of existing farmland and thereby reduce the impact of agriculture on the environment, particularly in marginal and fragile ecosystems.

Many fail to recognize that agricultural biotechnology is an imperative for the 2.4 billion people—40% of the world's population—who survive on less than $2 per day. They somehow fail to see the potential for biotechnology to increase the productivity of existing farmland and thereby reduce the impact of agriculture on the environment, particularly in marginal and fragile ecosystems.

The critics of biotechnology, with their often-mindless comments, are doing little to meet the developing world's growing food needs, and, in a paradoxical twist, this will result in even more environmental destruction. We need to make it clear to people, such as Prince Charles, that the latest environmental catastrophe in Mozambique will seem like a royal garden party compared to the consequences of the social shifts and environmental degradation to come. Denying the poor access to the benefits of biotechnology will deny them the means of lifting themselves out of poverty. Denying technological advances is surely one way of sustaining subsistence farming, which farmers do not want and which does not help the environment.

I conclude from these few considerations and thoughts about science and policy that the power of politics has trumped the truth of science. Therefore, we must better communicate the science of biotechnology to the public and to

Denying the poor access to the benefits of biotechnology will deny them the means of lifting themselves out of poverty. Denying technological advances is surely one way of sustaining subsistence farming, which farmers do not want and which does not help the environment.

politicians, and supplant current views with more-convincing arguments. In view of the paradox outlined in the first paragraph of the section, if biotechnology is to flourish, it will not be science-based arguments that will win the day.

Science and Communication

Scientists are notoriously inept at communicating their progress. This is partly because science is often far removed from technology. Debating positive effects of technology on society and on the consumer is a very different matter from debating scientific advancements.

The general public's views of science and technology are strongly influenced by overall education level, science education, and cultural and social background, to name but a few criteria. Yet, divergent social groups are united by common cultural values. Hence, for each group, communication strategies have to be adapted to reflect the target audience's cultural values. Communicating values is vital for public acceptance of new technologies, and requires widening of scientists' perspectives. An attempt to widen perspectives of the impacts of biotechnology is long past due. The goal, however, should not be to take the issue away from environmentalists, but to ensure that more voices from more constituencies are included in the discussion. Similarly, the "negative" debate that industry has initiated in the context of organic agriculture—by pointing out its limitations and dangers—is also a shortsighted approach that may backfire.

We could attempt to characterize what different constituencies want, ranging from farmers, commodity traders, food processors, consumers, environmentalists, and parents, to ministers of agriculture and heads of state (Table 1). It is immediately apparent that the primary concerns of the various constituencies are varied; hence, the messages to them must be different. Unfortunately, the benefits of biotechnology have been conveyed to the public mainly by scientists, whose talents, generally, do not include ability to communicate effectively with lay people. Scientists must step outside the province of science itself and abandon the belief that the truth is their bailiwick. The truth is, nobody holds the truth.

Indeed, according to Roger Highfield, Science Editor of the *Daily Telegraph*, "Many journalists would like you to think that they are seekers of the truth, but I suspect that most are like me: curious gossips who like to show off by sharing hot news with a big audience. That audience distrusts hacks as much as boffins. But scientists could still learn from journalists. Journalists think carefully about their audience and communicate accordingly."

TABLE 1.

Constituency	Objectives/Goals	Environmental/Development impact
Farmers	High-yielding crops. Less use of pesticides. More-efficient use of inputs (*e.g.* water, less transport). High-quality products.	Decreased environmental impact. Decreased secondary environmental impact. Productivity increases, value added, healthier crops.
Plant breeders	Better tools to make their work more efficient. Produce varieties that farmers want and need. Provide consumers with more nutritious and all-round better varieties.	Scientists in developed and developing countries are now able to breed disease-resistant, delayed-ripening, and hardier varieties of crops.
Scientists	To advance the frontiers of science. Discover and invent exciting new technologies. Benefit humankind.	Progress has been made, especially in medicine, where disease diagnostics and the production of substances that were too expensive, such as insulin, are now allowing people everywhere to lead healthier lives.
Consumers	Plenty of food with good and increasingly better nutritional value at relatively affordable prices.	Biotechnology is making progress in that direction possible—these are the most exciting applications in the research and development pipeline.
Company (large and small) CEOs	To sell what the consumer needs in a way that ensures that the company is sustainable and profitable.	The economic potential of biotechnology is enormous, for industrialized and developing countries. It can be a win/win proposition if we work together and resist fear and distrust.
Government officials	To ensure that the people of their country equitably enjoy the benefits of science and technology. To cast out the specter of national poverty.	Biotechnology could help worldwide, but only if the politicians are true friends of the earth!
Parents	To ensure that their children can enjoy a better life on this planet.	Biotechnology is helping already, in agriculture, health, and the environment, to make the world a better place.

Scientists have failed to recognize that, for the lay public, biotechnology is neither a technical nor a scientific matter. It is now part of the intricate question of life itself. Hence, we must communicate this science and technology in all-encompassing ways, invoking both traditional concepts of human culture and economic development, and that of stewardship. Also, we must give credence where it is due, including to organic agriculture. Contrary to what activists and industry try to make the public believe, these are not two opposing principles, but complementary ideals that should guide the creation of our vision of the future and the steps we take to reach it.

Finally, communication has to begin at the school level. I believe it will take a generation before biotechnology will be fully accepted.

Science and Intellectual Property

It is evident that resolving the intellectual property (IP) aspects of this science and technology is a rather multifaceted matter that daily increases in complexity. The typical plant biotechnology company has a budget of millions of dollars, sometimes into the hundreds of millions of dollars, for legal costs. But scientists fail to see this as their concern—and indeed it is not—they would rather avoid it and use the funds for research.

One of the fundamental problems is that the knowledge revolution enabled by biotechnology has not been followed by a revolution in IP law. Once a sacred right of the inventor, IP was stimulated both by metaphysical arguments over ownership and by a desire to take practical measures to make inventions quickly available. But times have changed. Consider Linux, the open-source software to which everyone can contribute. It has seen the fastest software evolution ever. At first Linux was developed as a response to Microsoft Corporation's domination of the operating-system world. Although driven by this ideology, it makes good business sense too. The collaborative efforts of programmers from around the world have created an impressive operating system that is rapidly gaining market share. This "open-source," group effort has turned a fundamental business assumption on its head: people now see that the value in software is not the software *per se*, but the productivity gains it affords.

The same may apply to DNA and genes. One might well argue that we need an open platform where everyone can contribute, where everyone benefits. What a difference it would make if everyone could contribute to, and benefit from, the productivity gains enabled through a better understanding and knowledge of DNA and genes!

What proposals for action make sense? To make such an "open platform" happen, a new definition of patents is needed to foster continued investment in the science and technology and products. Perhaps a working group is needed to try to come up with something new to save companies hundreds of millions of dollars in legal fees. Yet, today we are bogged down in discussions about the morality of ownership. We need less dogma and more common sense.

Bringing Technology to the Consumer

Food labeling is a typical aspect that may help or hinder the transfer of technology to the consumer. It can be a barrier, including a trade barrier. In the context of the title of this paper, who will make the decisions for the world? Wealthy, middle-aged, white, well fed, well clothed, well educated activists in Seattle? Bureaucrats in Brussels? Let us remember that at least 60% of the world's consumers do not care about labeling—they simply want food on the table. And of these, nearly 40% cannot read anyway. In any case, the majority of foods sold to local consumers comes without packaging. Who is representing the hungry and poor in such debates?

This gives us another criterion for our proposals for action: they must be based on the world as it is rather than based on a romantic image of how the world should be. We need to stop holding more than half the world's population hostage to poverty under the guise of debates about "safe" foods or "safe trade." In any case, safe food is not on offer; only safer food is on offer.

We need to stop holding more than half the world's population hostage to poverty under the guise of debates about "safe" foods or "safe trade." In any case, safe food is not on offer; only safer food is on offer.

The "debates" are more about lifestyle choices in the industrialized, western countries than they are about science-based analyses of new agricultural technologies or of socio-economic realities affecting the 2.4 billion poorest of our world. Further, the biotechnology debate is about technological acceptance and not about science. This is something scientists find extremely difficult to understand and even more so to accept. They prefer to indulge in the well entrenched celebratory discourse because of the technological power that biotechnology bestows.

Science and Business

Whereas large companies spend huge amounts on legal fees, research *per se* is being conducted more and more by smaller companies, often start-ups. Large companies increasingly depend on small companies as sources of new products and enabling technologies. Hence science—and research—is far from moribund. There are many ways by which companies acquire research results. They range from purchasing other companies to contract research to various intermediate forms. The strategic alliance, one such intermediate form, is a most critical part of technology-based industries. For example, 60% of Merck's products in the pipeline stem from alliances and partnering. This is nothing

new. Similar shifts took place in other industries such as computers and automobiles, and are still taking place in different forms in the chemical industry.

Hence, in agricultural biotechnology, major shifts are likely, such as mergers for consolidation. Some of these shifts have already been brought about by those who oppose multinational companies. Other changes will be forced by governments due to public opinion, which will significantly shape the decade to come.

Some of these changes are due to the fact that agricultural biotechnology is being deployed so incredibly quickly. Monsanto today earns perhaps as much as $650 million from its biotechnology-based products. This has never been seen in agriculture with any other product only five years after the first large-scale commercial launch. In an area where change has been notoriously slow, how come we are so surprised that the consumer has been unable to keep pace?

Naturally, scientists are as baffled as consumers are confused and as those in developing countries are mystified, about the many corporate changes. And more are to come.

Science and International Development

When considering international development, one invariably thinks of the "Third" World, of small-scale farmers, of poverty, of hunger, of neo-colonialism, of exploitation, of the Brazilian rain forest, of over-consumption, and of the WTO, to name but a few. Biotechnology rarely enters the debate.

Changed attitudes are needed to introduce biotechnology in an appropriate way in this area. And changing attitudes may result from two related approaches. First, for northern countries, biotechnology needs to be understood better in terms of its significance for the lives of individuals in industrialized countries and their children. One means of accomplishing this is to present the issues in tangible terms, emphasizing actions that can be taken in industrialized countries. Biotechnology needs to be understood as a global issue. Examples abound primarily in the biodiversity area. The mold for penicillin, for example, was discovered in North America, and a major Swiss pharmaceutical company has found useful soil organisms in Scandinavia. Yellowstone Park, a center of hot-spring activity, is a major source of heat-resistant microbes.

Care must be taken to present biotechnology as a concept. This message can be enhanced by the second approach: the advancement of environmental stewardship. Individuals, even those with limited contact with natural environments on a daily basis, seem to understand the need to conserve natural systems as the basis for life. And biotechnology must be presented more predominantly in the debates as an integrated form of production that reduces the farmer's imprint on the environment. This can be explained in terms of a legacy for future generations. Biotechnology can be presented as a component of good stewardship.

Biotechnology must be presented more predominantly in the debates as an integrated form of production that reduces the farmer's imprint on the environment. This can be explained in terms of a legacy for future generations. Biotechnology can be presented as a component of good stewardship.

The challenge is to bridge the gap between economic realities in the North and the aspirations of the billions of people living in developing countries, largely in the South. Clearly, the first problem to overcome is the communication gap due to differences in social and political heritage. Organizations that speak (or claim to speak) for local or indigenous communities, however, are often merely of the reactionary type with little or no support in those communities. Such are also the most vocal in international political forums with the effect of further delaying *rapprochement* among the systems, *i.e.* the establishment, corporations, and local/indigenous communities.

No matter how worthwhile the claimed aspirations of such activist entities may be, they contribute little in today's world but polarize the debates. True change in attitudes does not, and will not, come from the actions of environmental pressure groups nor from multinational conglomerates, but from a systematic sensitization of the public. This, in turn, will influence policy makers and corporations alike, and will yield results in the longer term.

The first conclusion from this discussion should be that the issues are complex, not so much in themselves but because they all meet at one place: the new technology of biotechnology.

Science and History

Oscar Wilde said, "The one duty we owe to history is to rewrite it." I say it is better to make history rather than to rewrite it!

How might we make history in the area of biotechnology and international development? What institutional arrangements could ensure that benefits are "equitably" shared among companies and countries and individuals and the environment? How can we even define "equitable sharing" when equitable is so much a concept that depends more on the eye of the beholder than on measurable characteristics? Clearly, we need to bring about shifts in the perception of values, including prejudices about modern biotechnology. Perhaps a new type of biotech enterprise, one publicly owned and managed

like a private enterprise, would allow us to sway public opinion. We certainly need something big and bold if we are to bring about needed change.

The solution, perhaps, lies in the creation of an entirely new type of enterprise. We all recognize the exceptional achievements of the CGIAR in the latter part of the twentieth century, yet I challenge the CGIAR system that it is no longer appropriate for the twenty-first century. The CGIAR system's success was based on the transfer of public technologies, but it has not been able to "recover" from its successes and adapt to the changing environment in which it operates. After years of internal debate on the impact of IP and biotechnology, the CGIAR still does hot have a consistent policy towards either, yet alone a comprehensive strategy on how to deal with the proprietary nature of the science on which it relies. The CGIAR operates in a global context, but so far it has failed to "use" globalization to its own advantage and thus it has failed to serve the poor most effectively with its dwindling financial and technological resources.

We all recognize the exceptional achievements of the CGIAR in the latter part of the twentieth century, yet I challenge the CGIAR system that it is no longer appropriate for the twenty-first century.

Yet, with the advent of the life sciences, the potential to improve the human situation was unprecedented in history. Globalization is enabling the mobilization of worldwide science and technology for the betterment of humankind. Yet the promise is ours only if we manage to deploy improved products to the poor and wealthy alike. A new vision and initiative is warranted for biotechnology to produce and deliver its capabilities not only for the most vulnerable billion people but also the wealthy. The developing world is superbly and uniquely positioned to translate this vision into reality.

At a seminar at Cornell University in September 1999, I proposed the creation of a novel, highly efficient and sustainable organization as a model for the next century, with the potential to exceed many-fold the impact of the CGIAR and the green revolution of the twentieth century. In short, the vision is to "sustain globalization in the life sciences" by creating a new form of private/public partnership with the life science capabilities of a large biotechnology company as the keystone. Development, both economic and scientific, would be accelerated through the synergy of private/public energies.

At the centerpiece of the "privic" strategy would be, for example, a large biotechnology company's agricultural life sciences division. The science and technology would be poised to deliver the long-promised benefits of biotech,

gradually, to the entire world. Meanwhile, the value embedded in other divisions of the biotech company, including chemicals and seeds, would be returned to shareholders as these business units of the current enterprise are spun off.

Financing for the "privic" would come from public (government, multilateral), foundations, and private sources, and from future licensing of its technologies (to corporations and at a discount to developing countries). All would benefit from this strategy as the most effective means of sustaining agricultural and economic advancement, and human well-being.

Market growth would come by expanding biotech into developing-world markets where the technology is needed most. Current revenue streams would be maintained and expanded through licensing arrangements with corporations (current competitors), the CGIAR, universities, and national programs around the world.

Public opposition to plant biotech would be curbed rapidly as a result of the display of its startling value for the world's poorer people, thus realizing biotech's promise in the near term.

Research and development would be efficiently expanded by focusing on a mix of commercial (for licensing) and developing-country needs and priorities. Human capital would be enhanced by ensuring that researchers in developing countries would participate in the R&D and would have ready access to biotech's tools to solve their national and regional agricultural and nutritional problems.

The staff, talent, strategies, R&D priorities, and finances of the "privic" would be managed according to corporate principles by a CEO supported by an executive and management board. A small non-executive oversight board of senior people serving in their individual capacities would represent national and topical interests.

CONCLUSIONS

Only two questions remain. First, is there a better idea on the table to bring about the change needed to make biotechnology flourish and deliver its promise to the world's citizens at large? And if there is no better idea, then the question is: what is to be done next to make the "privic" work? Seven simple steps would be needed:

- Seek limited funding for a feasibility study.
- Prepare issues and options briefs (financing the deal, governance, management, R&D strategy, cash-flow projections, etc.).
- Commission an investment bank's preliminary assessment of valuation and financial options.
- Approach the Chairpersons and CEOs of the other major agricultural biotechnology companies.

- Organize a “retreat”-type meeting with senior people and advisers to:
  - — determine feasibility, refine concept, and set policy and implementation strategy,
  - — elaborate specific areas for further investigation/determination and allocate follow-up tasks, and
  - — identify members for a formal steering committee.
- Convene the formal steering committee meeting to implement strategy.
- Launch the “privic.”

It could all be done in 9 months, or perhaps even less. Because biotechnology is at the heart of the long-term sustainability of our environment, because biotechnology is at the heart of our survival in the long term, it represents an opportunity today to forge new partnerships for tomorrow.

Because biotechnology is at the heart of the long-term sustainability of our environment, because biotechnology is at the heart of our survival in the long term, it represents an opportunity today to forge new partnerships for tomorrow.

Q: As you mentioned, the green revolution resulted from research at CGIAR institutes in the Philippines and Mexico. I happen to know that biotechnology research is in progress at the International Institute of Tropical Agriculture in Nigeria and at the International Rice Research Institute in the Philippines, and, I assume that significant effort is being expended in biotechnology at the other international institutes. Please elaborate on that, and address the question: to what extent is it possible for the international institutes to make a significant contribution to increasing food production in developing countries, using the tool of biotechnology, without any involvement of industry?

A: Intellectual property rights are often blamed as a stumbling block, but I think that reveals a lack of understanding of IP and patents. The annual budget for the CGIAR centers, CIMMYT in Mexico, IITA in Nigeria, IRRI in the Philippines, CIAT in Colombia, *etc*. is about $310 million, of which $28 million are spent on biotechnology. A few years ago, the R&D budget of a typical company like Novartis may have been three to four times that amount for agricultural biotechnology alone. Based on published data, private investment in biotechnology in agriculture is approximately $1.1 billion, whereas the entire developing world spends just over $100 million, of which most goes into

capacity building and not into product development. So, the CGIAR system is not in a position to develop major biotechnology applications for the developing world. It can best do so by forging stronger alliances with the private sector. But progress in this has been very slow because, for the past seven or eight years, the CGIAR has been debating what their policy should be on biotechnology, so far without resolution. The reason is that, around the table are funding donors, bilateral agencies, representatives of developing countries, environmental pressure groups, and companies, all with conflicting agendas. It seems impossible for such an institution to elucidate a clear vision, which is very regrettable. The green revolution was successful because relatively few individuals were involved, Norman Borlaug among others. I think it is possible for the CGIAR to contribute a great deal, but not within the strictures of its current governance. That is why new institutions are needed, possibly as brokers or go-betweens, with dramatic new approaches, such as the development of the “privic” concept.

What the European Union Wants the United States To Understand About European Biotech Imports

ANTOINE VAN DER HAEGEN
European Commission's Washington Delegation
Washington, DC

Globalization, while offering the advantages of increasing trade, prosperity, and choice, has created problems and new uncertainties. Genetically modified organisms (GMOs) in agriculture have been available for about ten years. Their commercial use has been expanding rapidly in the United States, creeping quietly and stealthily into the consumer's food. According to recent figures, 75% of food on the shelves contains at least one genetically engineered ingredient. Since 1998, difficulties in placing GM products on the market in the European Union (EU) have given rise to trade tensions with the United States.

THE EU CONSUMER, FOOD SAFETY, AND LABELING

Safety, the most important food issue for European consumers, is currently the number-one political issue in Europe—a large majority is worried about transgenic food. More than 60% of the 1997 Eurobarometer[1] respondents were concerned about risks associated with GM food, compared with 40% in the case of the medical applications of biotechnology. This result is consistent with those of private polling institutes. The 2000 Eurobarometer helped in assessing reasons for consumer concerns over GM food. Items gaining the highest degree of support were: "even if GM food has advantages, it is against nature"; "if something went wrong, it would be a global disaster"; "GM food is simply not necessary."

Seventy-four percent of EU consumers favored clear labeling of GM food (Eurobarometer, 1997). Fifty-three percent of respondents said that they would pay more for non-GM food whereas 36% would not (Eurobarometer, 2000).

[1]European Commission public-opinion surveys, http://europa.eu.int/comm/dg10/epo/.

The Psychology of the EU Consumer

One can argue at length about the rationality or irrationality of the EU consumer's attitude towards GMOs. Some even call it "neurotic." This attitude is due largely to a series of factors that are fundamental to understanding the European situation:

- There is a food surplus, thus consumers have choice.
- Food involves far more than mere sustenance. Generally speaking, the European has a relationship with food that is emotional and even a fundamental part of the local culture. Every town has its regional products, and sitting together for hours eating good food is part of the pleasures of life.
- Americans are more prone to adopt modern technology, whereas Europeans are more conservative.
- The blood scandal (blood tainted with the AIDS virus), which occurred in the EU at the end of the 1980s, as well as later food scares related to bovine spongiform encephalopathy (BSE or mad cow disease, since 1995, which is still a terminal disease), dioxin (1999), and currently hoof and mouth disease (HMD). Beef is no longer on the menu of most schools in Europe. Politicians said there was no danger. British Minister of Agriculture, Mr. John Gummer, gave a hamburger to his 5-year-old daughter in front of television cameras—but he and others were wrong. Of course, their risk assessments were based on information provided by scientists (*e.g.* BSE could not jump the species barrier, sheep to cattle to humans).

  In the case of BSE (approximately ninety already dead), uncertainty about the incubation period makes extrapolation by British scientists distressing: they project between 150,000 and 200,000 deaths. Every year 50,000 Europeans are killed on the roads and 500,000 die from smoking-related diseases. The difference in attitude seems to lie in the risk factor. People are not averse to taking risks, but do not want them to be forced on them.

  The BSE and dioxin crises have cost the jobs of two Belgian and two German government ministers, and has seen the arrival of a Green minister at the head of the new Ministry for Agriculture and Consumer Affairs in Germany, which in some ways is a revolution.
- These scares have been greatly amplified by environmental activists and by the tabloid press, which demonize plant biotechnology, particularly in the United Kingdom and in Austria, where resistance to GMOs is greatest. The tabloid press has invented the destructive expression "Frankenstein food, no trust," *i.e.* no trust in scientists and no trust in politicians. No longer is "science-based" necessarily a quality label in Europe. Apart from the blood scandal and BSE, some consumers remember the precedents of DDT and thalidomide.

- Faced with growing popular pressure to phase out GMOs, many retailers have adopted a restrictive stance on GM food. The first to respond in the United Kingdom were supermarkets, and the movement spread to continental Europe in 1999.

  The retailing industry is the linchpin in the food market due to its proximity to the consumer. Retailers are in a key market position that allows them to amplify consumer preferences and relay them to the food industry. Retailers are not anti-GM in principle—they are responding to consumer demands. Already, McDonald's in Europe, and British supermarkets such as ASDA and Tesco (42% market share), have decided that their lines of meat or poultry will come from animals raised on GM-free feed. Furthermore, companies such as Kraft Foods, Nestlé, Kellogg, and PepsiCo have promised not to use GM grain or corn in their production plants.

  This restrictive approach to GM food has had cascading effects on the upstream side of the food chain, in domestic as well as in foreign markets. Food processors and grain companies have been hard-pressed to segregate GM from non-GM products.
- The disastrous and, for some, arrogant PR campaign of biotech companies (supply-driven, totally ignoring the final consumer, considered by some as forcing down their throats food they do not want to eat) was definitely counter-productive.

The heart of the matter: to the EU consumer, GM food is neither cheaper nor does it taste or ripen better, nor are their quasi-pharmaceutical benefits (prevention of decaying teeth, weight reduction, *etc*.). With no added value and plenty of other choice, why take the risk? “Do we really know the potential long-term risks and health hazards?” asks the EU consumer, although no one has died from eating GM foods.

The retailing industry is the linchpin in the food market due to its proximity to the consumer. Retailers are in a key market position that allows them to amplify consumer preferences and relay them to the food industry. Retailers are not anti-GM in principle—they are responding to consumer demands.

World Trade Organization

The risk is real that the American GMO industry, or at least some of its representatives, will ask the United States administration to take the case of the *de facto* moratorium on approving GMOs in Europe to the WTO.

It would be a bad idea for the United States to go to the WTO and create a new EU-US dispute. First of all, I am not sure that the United States would win [technical barriers to trade (TBT) and sanitary and phytosanitary (SPS) texts are not clear on this], which would undermine further the confidence that American citizens and Congress have in the WTO. The same would, however, be true were the United States to win; since food is the number-one political issue in Europe, I do not see how policy-makers there could comply with such a WTO ruling.

Resuming the Approval Procedure

Under pressure from public opinion, five EU Member States blocked the GMO approval procedure in October 1998. At that time, eighteen GMOs had been approved and fourteen were pending. In July 2000, however, the Commission decided to break the deadlock and proposed to Member States a strategy to regain public trust in the procedure for approval of GMOs. The objective was and is to resume the authorization process.

The idea was to put in place a series of new regulatory building blocks replacing the GM legislation of 1990, in order to address public concerns and to give clear responses to political and legal concerns, which favor consumer safety and choice. The first of these new blocks is the revised directive 90/220 on deliberate release of GMOs into the environment, approved in February 2001 by the European Parliament and the Council of Ministers, and now called Directive 2001/18. Once the new Directive was adopted, the European Commission believed that the GMO approval procedure could be resumed.

The new Directive covers food and feed, and confirms premarketing-authorization and risk-assessment procedures for all GMOs. It strengthens previous Directives and foresees an exception for pharmaceutical products. The new Directive not only applies to the fifteen member countries of the EU, but also to the twelve candidate countries, which have to adopt EU legislation and are already in the process of doing so—in total, twenty-seven countries with the same GM legislation, introducing:

- mandatory traceability and labeling at all stages of movement to market,
- mandatory monitoring requirements after placing on the market,
- mandatory consultation with the public (as with the United States *Federal Register*)
- mandatory consultation of the EU Scientific Committee,
- application of the precautionary principle when implementing the Directive, and
- a time-limited consent of a maximum ten years.

The country of origin of the food and whether it has been imported into the EU has no bearing on the enforcement of the legislation, in particular as far as traceability and labeling requirements are concerned. These measures apply equally to American and EU biotech products.

While adopting Directive 2001/18, six Member States (France, Italy, Austria, Greece, Denmark, and Luxembourg) declared that they would accept the relaunch of the GMO approval procedure only on condition that the Commission would come forward with more specific proposals regarding traceability and labeling. The Commission is now in the process of preparing regulations on traceability and on labeling of food and feed. The new proposals are expected to extend the existing labeling requirements to nearly all foods derived from biotechnology and to extend labeling requirements to animal feed. These two draft regulations are expected to be adopted by the European Commission (Executive) on June 6, 2001, and then be sent to the Council of Ministers and the European Parliament for adoption in order to become effective EU law.

Traceability concerns the whole food and feed chain. The idea is to have a unique identification through a code for the life of the GMO and to be able to recall the products in case of problems (*cf.* StarLink™).

Labeling is process-based (in the United States it is content-based). In other words, even if no trace of DNA or protein can be found in a GMO-derived product, it must still be labeled, the basic concept being consumer choice. It should be noted that, in Europe, labeling is not meant to be, and has never been, a warning.

Regarding traceability and labeling, Commissioner David Byrne wanted a system that is workable also for the United States, which is why the draft regulation on food and feed foresees a 1% threshold for the adventitious presence of American-approved GMs that are not yet EU-approved.

Furthermore, in order to speed up the approval process, the Commission intends to follow a special procedure, according to which the main provisions of the two draft regulations could become the conditions for approval of individual approval requests, in order to allow the approval process to be resumed as soon as possible.

Some say that labeling will stigmatize GM foods. But to restore confidence, we need transparency even if there are no traces of GM DNA or proteins. We do not want any activist organization scaring consumers again by announcing that a food is of GM origin and that the EU tried to conceal it.

Some say that labeling will stigmatize GM foods. But to restore confidence, we need transparency even if there are no traces of GM DNA or proteins.

We are conscious that people, both *pro* and *con*, may not find our solution fully acceptable. But both sides should recognize that it is an honest exercise balance between the interests of the consumer and of industry. If companies want to sell their products, then they must comply. If consumer trust is to be gained, they must be assured that there is strong regulation to meet their concerns.

A Changing World and Perhaps Even a Copernican Revolution

A Green minister heads Agriculture in Germany and Greens are members of the governmental coalitions in Germany, France, Belgium and, until the spring of 2000, in Italy. Agriculture is no longer regarded in a positive light by many European governments. The days when European food policy was determined by the need to increase output and efficiency in order to achieve food security are probably over. The new motto is *Food Safety and Food Quality.*

Farmers have become less important than consumers. But will these consumers pay more for higher quality products? How much more? Do modern production methods militate against tasty and wholesome food produce? These questions are simple and straightforward, but I expect that the answers will be complex, particularly given the complexity of the modern food chain and the higher expectations of the modern consumer. All this may, in time, have policy implications for the European Common Agricultural Policy.

Many things can happen if consumer confidence is not restored in Europe, or if a food scare (*e.g.* BSE or HMD) were to erupt in the United States. In the field of food safety, trust in regulators can be lost overnight.

Where the EU was isolated with its GM legislation a year ago, today eighteen of the main trading partners of the United States have adopted GM legislation or are in the process of doing so.

Segregation

If the American farmers want to maintain their export shares to Europe and other parts of the world, they should look carefully for lessons from the StarLink™ problem. In the long run, consumers around the world will decide what premiums they will pay for non-biotech products. On the other hand, some exporting countries are likely to produce and export both types of crops (GM and non-GM) and to develop marketing systems that offer consumers products that are differentiated according to their biotech status. But the problem will always be the risk of commingling GM-free with GM crops, or GM-approved crops with GM-non-approved crops (especially if there is no, or a very low, threshold). That will mean that efficient segregation will have to be in place, with concomitant investment and costs.

"Give time to time"

As for the irrational attitude of the EU consumers, I think one should apply the French saying, *il faut donner du temps au temps*, "one should give time to time," and try to educate the consumer in this field in order to gradually restore confidence.

The biotech industry should also become much more proactive. It should repudiate misinformation. It should educate the consumer—without television campaigns with nice music, but with facts—stressing the tremendous environmental advantages of GM crops. And the consumer should no longer be scared to death by activist organizations.

Second, third generation biotechs

There will be no real incentive for consumers to buy bio-engineered food unless (a) it is cheaper: until now, the benefit of a better yield from GM crops has not been passed on to the retailer or consumer (perhaps the premium for GM-free commodities will be such that consumers will start buying cheaper GM food); or (b) unless a second or third generation of GMOs brings real added value to the consumer such as medical and nutritional benefits. If this happens, I am convinced that genetically engineered food will break through during the next decade. At that point, I believe that these companies will want their GM products to be labeled.

I am convinced that genetically engineered food will break through during the next decade. At that point, I believe that these companies will want their GM products to be labeled.

Q: Europeans want perfect traceability of genetically engineered products. Is there any interest in having traceability or labeling regarding pesticide use, particularly in view of concerns over dioxin and DDT?

A: No. We are thinking of traceability in a lot of fields, we are thinking of labeling GM-free products according to the White Paper published in January of last year. We will also have labeling of other products—in principle all products will be labeled. But, for the moment, we are dealing mainly with GM foods.

Q: Has anybody, either in the European Government or at a university, made a cost/benefit analysis of the current or future laws on GM foods, looking at externalities and so on?

A: Not to my knowledge. I wonder if such has been done in the United States—that would be interesting.

Q: A two-part question: you mentioned the European consumer's desire for choice in relation to products from GM crops. Does the same apply to meat products? Can the European consumer try American pork or beef—even if they are labeled as such—bearing in mind that growth promotants are not used for pork in this country. Also: you mentioned Europeans' disbelief in scientists. Yet, I traveled recently in Europe and found pervasive belief in the science of global warming. Would you comment on these inconsistencies?

A: You are right. It is amazing that there is no belief in science as far as food is concerned, but there is trust in the science that indicates climate change—although President Bush doesn't believe it. The contradiction may result from the fact that food is an emotional issue. As far as meat is concerned, we are not against importation of American beef provided it is hormone-free. A greater beef quota has been proposed, as compensation to the United States, but at this time there is a glut of beef in Europe. There is overproduction of pork in Europe also; and it is coming in by the ton from Poland.

Q: What about some of the other manipulations that are used in crop genetics? Recently in the press, attention has been paid to irradiation, for example.

A: We intend to label it. We intend to label everything. Perhaps we are overdoing it, but the lesson from BSE is such that we see no other political solution.

Q: What are your thoughts on the future of non-food products that are genetically modified?

A: There is a promising future for such non-food products. Cotton is now the most successful of the GM crops in the United States, at 66% on an area basis. In attending several biotech conferences in the United States recently, I have been amazed to learn what is in store in the field of non-food GM products. This information would serve to demonstrate to Europeans that biotech has far-reaching advantages, yet it has had very little coverage in the media even here in the United States.

Q: What is your prognosis on European attitude to the development and use of GMOs in countries in which food is not in excess?

A: First of all, Europeans are much more cynical. There is no such thing as "compassionate conservatism" there, for example. When biotech companies claim that they will feed the world, Europeans don't buy it and see it as a strategy for expanding business opportunities. This issue is much more complicated than it looks at first sight. I don't see subsistence farmers in Africa or Asia being able to buy seeds every year. Will biotech companies sell seeds at prices that are affordable to developing countries? I don't think so. As an aside, which has nothing to do with your question: sometimes it seems that biotech companies want it both ways. In the United States when a GM product is considered similar, it doesn't have to be labeled, in which case, why is the difference patentable?

Q: You brought up what I see as one of the great disconnects in this. You did a wonderful job in covering the sensitivities of the Europeans, their high level of awareness of the issues, and aspects that we might all agree on regarding mishandling by the biotechnology industry. The disconnect lies in the fact that most of these biotech companies are owned by Europeans.

A: Many European biotech companies are moving operations to the United States. In the Research Triangle of North Carolina, for example, most of the biotech companies are European because they fear for their future in Europe. I am in the process of discussing with companies here in the United States what thresholds, *etc*., they would like to see, and my counterparts in Europe are having similar discussions with the same companies. They don't provide the same answers, which makes our job more difficult.

Q: Is there any European vehicle that provides an open forum where interested stakeholders can come together in a non-threatening environment for dialogue? They may disagree on issues, but they may build trust—it sounds like trust is lacking.

A: Some months ago, a conference was organized by the European Parliament, and all of the stakeholders were in attendance, including Green Peace and other advocates. Everybody explained their positions, but there was no real dialogue.

Q: I've always thought that you need to have a vehicle to begin to have dialogue. Regulation helps build trust, but without dialogue and the ability to relate to real people, it is difficult to solve differences.

A: Yes, our regulation is only part of the solution. I feel strongly that biotech companies should make a concerted effort. I participated in a brain-storming session at a large company here in the United States, and it was striking that the biotech division was in dispute with the chemical division because the latter was still producing pesticides. This underlines how the environmental benefits of biotech are not being explained to consumers.

Q: I've been wondering why it wouldn't be consistent to extend the same traceability requirements to crops produced by conventional breeding in which—particularly if you use exotic germplasm—you actually introduce many more new proteins, most of them unknown, that might be allergens for example. Alternatively radiation or chemical mutagenesis might have been used. If these manipulations result in resistance to pests, for example, that phenotype can be translated to wild relatives. Therefore, I am having trouble seeing why you would place extreme traceability and other requirements on genetically modified plants with which you have a good understanding of the characteristics of the limited numbers of new proteins that are produced.

A: In Brussels, a lot of thought is being devoted to the legislative bricks that I mentioned. One of the ideas is to require traceability for all new products.

Q: Did you say that traceability will be required also for animal feed?

A: Yes. That has been decided.

Q: So, will you start testing corn gluten meal?

A: As of next year we'll have a European Food Authority, but it won't have the powers of the FDA to do testing for instance. Testing will remain with the member states. The legislation being drafted will have the advantage of applying to the whole of the European Union, otherwise we'd probably have fifteen different legislations.

Q: Corn gluten meal from the United States will be GM. What will happen to it? Will people buy it?

A: I'm not a buyer. I don't know. It will be labeled, but we really don't know what is going to happen. Some extremists in my administrations want us, for instance, to label eggs from chickens given GM feed.

The European Situation

DIRK-ARIE TOET
Nestec Ltd.
Vevey, Switzerland

My opinions on biotech and of what is happening in Europe are from a general industrial perspective rather than from Nestlé's perspective in particular. To avoid any misunderstanding, the Nestlé corporate position on biotechnology is very clear: we believe that we need to develop and use it, and we will support it wherever and whenever we can. Only a few days ago, our CEO in Switzerland said that not developing biotechnology would be a greater risk than developing it. That is an unmistakable position, but we have to realize that we operate in the real world, and sometimes there are things that you want to do but cannot.

I gave a presentation on this subject here in the United States about a year and a half ago, and, in response, people saw me as a doomsayer, out of touch with reality. It is rather unfortunate, but the situation today is no more rosy than I pictured it then; if anything, it is probably worse than I predicted it would be. Take, for example, the shift in European soybean imports from the United States to Brazil. We believe that a major motive was that Brazil positioned itself as a "non-GM" country. Four million tons that previously came from United States now come from Brazil. Apparently, no one was hurt by that move, because global trade increased enormously with China. What could not be sold to Europe is being sold to China. Ironically, the Chinese use that genetically modified soy to grow chickens that are exported to Europe.

Not developing biotechnology would be a greater risk than developing it

LABELING

About twenty countries in the world now either have labeling regulations or are considering them. They are all different. The following is a short, perhaps imprecise, summary. One country has enacted a complete ban: Sri Lanka banned all GM ingredients as of May 1, 2001. We have been in discussion with Saudi Arabia for some time, because they are considering a ban. Their very restrictive labeling legislation will come into effect in November, 2001. Obviously, this is a significant barrier to trade. If you have centralized production and want to export to those countries, you face problems similar to those of about 20 or 25 years ago with additives and other ingredients.

PERSPECTIVE

I will spend a little time on how we got to this point, just a few remarks. We have seen food scares and mounting public distrust. Opinion polls on biotechnology in Europe, showed an across-the-board decrease of 10% in public acceptance between 1996 and 2000. This was not limited to agriculture and food, it included pharmaceuticals. More striking was that it focused on moral or ethical aspects of acceptability. Opinions being formed at the moment are not very positive. Uncertainty was at the root of the problem. When GM products came to the market in Europe, we were faced with contradictory statements or even silence both from regulators and from industry. This contributed substantially to the lack of confidence now prevalent.

European culture, food culture, and agriculture have been mentioned at this meeting. It would not be so bad if we Europeans were more modest. European food culture is extremely important, but, on the other side of coin, are the food scandals and scares of the past ten years, such as BSE and foot and mouth disease.

A little modesty would also help with European agriculture. I have the impression, when talking to Europeans — it does not matter which member state you are in — that farming is seen as part of the fabric of daily life. I commute seven minutes from my home to work and pass many farms, with sheep, horses, cows, grapes, corn, wheat, and potatoes. There is a feeling that European agriculture is purer and much closer to nature compared to industrial agriculture in the United States. Yet, if you look at data that are available on various web-sites, you will find that use of chemicals in Europe is much higher than it is in America. When I use this argument in Europe, they are not pleased to hear it. But, it is a fact. Therefore, more modesty would be beneficial.

POSITIVE DEVELOPMENTS

So far, it has been all gloom and doom. Let us consider positive developments, because there definitely have been some. It looks as if the ban on thinking and speaking about biotech has been broken! For years politicians did not dare

speak out on this subject, or they were very secretive. People who were supportive dared to say so only in closed meetings far away from publicity. That has changed. The European Parliament recently published a report on the future of biotechnology in Europe. There is a strong emphasis on pharmaceutical biotechnology and applications in the medical sector, but attention is given also to applications in the agri-food sector with a strong encouragement to look at it, to work on it, and to take what is applicable in a European situation. The same is true of an opinion drafted by Mikko Pesälä, a Finnish member of the European Parliament, which focuses on agriculture applications and is positive regarding environmental benefits in the short term and food-quality advantages in the longer term.

In the European Commission there is great deal of activity. Several commissioners are involved in getting biotechnology going again; one group is headed by the Commission President, Romano Prodi himself. Sound regulation that will authorize the possibility to grow genetically modified crops has finally been adopted. Currently under discussion is the framework for research, which is focusing on genomics and genetics.

The European Council, which consists of representatives of the European member states, convened in Stockholm and made very clear statements on the advantages of biotechnology, focusing mainly on pharmaceuticals, but including agricultural and food applications.

These are all positive elements; however, quite a few "buts" remain. The moratorium continues. Six member states have indicated that they will stop the moratorium only when traceability labeling and liability are regulated. The new proposals from the commission may or may not satisfy demands from those six member states, from activist organizations, from consumers, and from the biotech industry. There is fear that this collection of new proposals may overshoot the target because it is focusing completely on GMOs and includes fundamental change in certain policies.

Seed to Fate

What are the major changes? The framework goes further than "seed to plate"; it covers release into the environment including seed thresholds, traceability, labeling of food and feed, and monitoring and post-marketing of the final product. This is "seed to fate" rather than "seed to plate." The food industry is concerned that the focus is on GMOs, as if they have become the scapegoat for everything wrong in our legislation, and in our European food culture and agriculture: thus, in bearing responsibility for all of these sins, biotechnology will be sacrificed. Singling out biotech will have a negative effect on the public. We do not have to look far to see that other problems are related to our agri-food chain.

What will change? First of all there is traceability, which is often confused with identity preservation. Traceability depends on the informatics, the

infrastructure of a country, and it already exists. Normally when you buy an ingredient, you know from whom you are buying and you know what you are buying. The producer of the ingredient knows from whom he is buying, and so on and so forth. There is a requirement in hygiene legislation and there will be a requirement in the new European food law for all of the players to preserve that information and to make it available. However, at this time, a gap exists and the gap is feed, and we think that that gap should be filled because many of our problems have originated from that sector.

So, traceability should be extended to the full chain for reasons of safety and quality. It is not information that is usually communicated—it is not information that is transported along the chain. There is no master dossier that goes with each ingredient to the end-producer. Some of the systems now in place are such that we can trace back to a certain time, say between 12:43 and 12:57, for a specific problem (of course not all parts of the chain are so precise).

Identity preservation is entirely different. To give you one example: yogurt made with apples or pears from Anjou is marketed in France. For a certain period of time, the yogurt is made using only those fruits. There you have a system with identity preservation, meaning that you go to the supplier, tell them what you want and get the information, which travels along the chain and is communicated to the consumer, and, eventually, that yogurt will be 10, 15, or 20% more expensive. In the discussions on-going in Brussels, this identity-preservation idea, where you limit your purchasing flexibility, where you increase costs, where you increase the amount of data and information to be managed, is seen as traceability and is explained as traceability. But I see it as being at odds with the concept of traceability.

The next aspect, labeling, has seen an important change. In the EU, as of mid-1999, we had to label all ingredients that were derived from raw materials with a GMO content of more than 1% based on DNA. Proteins also were mentioned, but no analytical methods are available. If you are below that 1% and have documentation to prove efforts to separate or segregate, labeling is not needed. If the ingredient is negative by PCR, you do not have to label. These are the three criteria for current European legislation. Along with other food producers, we at Nestlé introduced labeled products to the market that came heavily under fire and were removed from the shelves by the supermarkets. Genetically modified ingredients were slowly phased out, and, by and large, the European market no longer uses GM ingredients.

We saw a rapid decrease in consumer calls. In 1999, Nestlé France received more than 15,000 phone calls on GM: Are you using GMOs? What is it? Are they safe? Can you guarantee that it's not in there? *etc*. Labeling regulations brought clarity about what was happening, and we stopped receiving consumer calls on GM. In 2000, we had about 1,500 calls referring to GM, but they were all triggered by concern over BSE. From our perspective, calm had returned and consumers were reasonably happy with the situation.

However, Europe is not GM free. In Switzerland checks are made regularly by local inspectors who usually find that 10 to 20% of samples are positive, but well below the threshold of 1%. So, although Europe is non-GM, it is not GM-free.

Checks are made regularly by local inspectors who usually find that 10 to 20% of samples are positive, but well below the threshold of 1%. So, although Europe is non-GM, it is not GM-free.

The Future

If I understand the proposals correctly—I saw the first draft only a week and half ago—then detectability, as a criterion, has disappeared. There is a move to process labeling, meaning that even if an ingredient is negative by PCR and you do not have documentation, you must label. It includes food ingredients, additives, and flavorings. As I see it, we are moving from practical labeling, based on facts, to ethical labeling. Practical labeling indicates when GM ingredients are present. If GM ingredients are not detectable, then the product is not labeled; however, realizing that the world is not an ideal place, a GM ingredient may be present—below a certain threshold—that you wish to avoid. With ethical labeling, the use of biotechnology anywhere in the process must be indicated on the label. This different proposition exists already, but only for some niche markets. Many people offer "organic" as an example of it, which is not entirely true since organic has a 5% tolerance. Ethical, or process, labeling is an entirely different approach from practical labeling, in my view.

We are concerned about the enforceability of this legislation. If there no longer is detectibility then reliance on a paper trail is necessary and we are afraid that, in practice, for highly processed products containing large numbers of ingredients, enforcement will be difficult.

It looks as if products that have already been authorized will have to be reauthorized within a period of four years after the law is enacted. I do not understand why. It may be that concerns remain about safety or that we want to adopt a ten-year limit also on those products.

The other new element is post-market monitoring or surveillance. I have had a number of very confusing discussions on post-market surveillance. A few weeks ago, a group of eminent European scientists, food-safety experts, and molecular biologists, gathered in an EC research center in Italy. I was there as a representative of the food industry. Consumers were represented also. Discussion ensued on the safety of "one-gene" products currently on the market and those expected in the next five to ten years. Within a few hours

there was agreement that these do not constitute a serious safety issue. We have the tools, we have the people, and we have the equipment to come to consistent conclusions about safety. But when discussing more complicated products, the group felt that reviews of equipment and available tools would be needed, to verify safety. Some people said that there is a need to look for unknown long-term effects of ingredients and components that come from the consumption of GM raw materials in the long term. This confuses me. I can imagine that you would have post-market monitoring if you have a product that is said to have a certain effects, such as decreasing blood pressure or reducing cholesterol. If you want to monitor those effects, you can devise tools accordingly. A product might have a negative side effect that you would want to monitor in a certain sensitive group, although I have difficulty envisaging a company marketing such an item. If the idea behind post-market surveillance is that the product might not be safe, then, in my opinion, it should not be on the market. If you have post-market surveillance for safety reasons, you might also ask, why do we have food-safety authorities? I do not believe that any responsible company would bring a food product to market if it was to be monitored for general safety reasons. Certainly it would not be done in the United States, where liability is commonly an issue. I would be happy to discover that I misunderstand the intent here, because this development seems dangerous.

What will be the effect of this package? If all goes well, if questions are resolved about traceability, about labeling, and about liability, we may see approvals of GM crops. But if labeling will be extended to virtually every product, given the current situation, it will result in increased demands for non-GM foods. I believe the European market will follow the clean-label policy in the current climate. We will also see increased pressure on GM animal feed and derived animal products. The moment you have an ethical basis for labeling, it is very difficult to keep it contained to the original intent because there seldom exists a good argument not to extend it to other areas.

The situation regarding processing and use of components such as enzymes is also unclear. Currently they are not within the scope of the legislation, but we do not know how this will evolve. We see world-trade implications as major issues for the future that may involve the WTO. Importation of a composite product is going to be extremely difficult to monitor and control. Enforcement is going to be extremely difficult also. Availability of ingredients may become an issue. And finally, formulating legislation on the premise that GM is fundamentally dangerous engenders public concern. Therefore, I am afraid that safety will re-enter the general discussion.

Q: Having looked a lot at nutrition surveys, the thing I don't understand is how do people imagine you can do a post-market surveillance? How would you recognize a cause-and-effect relationship in the complexity of the human diet, considering the small amount of any one particular product that people eat?

A: Frankly, I haven't a clue. There is a system that involves physicians. It differs with each member states, but if there is a persistent pattern of problems, then at a certain point, after having passed a number of hurdles, it goes into the health system and, based on epidemiological studies, a link may be found. Certain cases are known over the past twenty years even, where this has happened. Based on clusters of symptoms, the system reacts. But it is largely passive, and I fail to see how it could be made active when the symptoms are unknown at the outset.

Q: About labeling: if it does go into effect as you suggest, wouldn't almost everything get the "GM" label and then the stigma would be lost?

A: It is true that if you do have massive labeling, it's over. If everybody would label there would no longer be a problem. First of all you could question the value of having massive labeling. Secondly, we saw with the labeling exercise we went through in the late 1990s, that despite all of the agreements, all sorts of people wiggled out. You get a very disturbed market and a situation that is very difficult to handle.

Q: Along those lines, what kind of label were people responding to? Was it a big label on the front of the package? Was there any law on how you had to display the fact that there was a GMO in there?

A: The labeling in Europe is quite clear. If you have a soy protein, then immediately following the soy protein name on the label it must be stated that it comes from genetically modified soya, or you can do it with an asterisk if there are other ingredients. The asterisk indicates that it contains GM soya. We should not forget one thing, however that the initial introduction provoked no reaction whatsoever from the public. Only after activists discovered long-term food safety in the supermarket as their battlefield, did problems arise.

Q: Will any food processor in Europe ever market a product containing GMOs, given these conditions?

A: That depends on the product. There are practical considerations why you would not use GM ingredients. You do not offer the consumer a choice of two similar products if the GM ingredient is not characteristic or critical; you look for the simple solution. Where you have an ingredient that is characteristic for the product, an ingredient to which the consumer attaches value, then you offer the choice. I am not saying that you will never see any GM product in Europe. We will go through a prolonged difficult period during which we will see avoidance efforts. But, the moment something appears that is attractive or the moment somebody comes to the conclusion that it will be better for the environment to use GM crops in Europe, and that idea is sold, there will be a turn-around.

Q: It seems rather amazing to many of us in the United States that a process label could be put in place—an ethical label could be put in place. How can you limit then what goes on to a label if people are concerned about pesticide use, if people are concerned about what ethnic group produced their food, *etc*.?

A: That's a question mark.

Ethics and Genetically Modified Foods

GARY COMSTOCK
Iowa State University
Ames, IA

Much of the food consumed in the United States is genetically modified (GM), *i.e.* derived from microorganisms, plants, or animals that have been manipulated at the molecular level to provide them with traits that farmers or consumers desire. These foods often are produced using techniques in which "foreign" genes are inserted into the microorganisms, plants, or animals. Foreign genes are those taken from sources other than the organism's natural parents. In other words, GM plants contain genes they would not have contained if researchers had only used traditional plant breeding methods.

Some consumer advocates object to GM foods on ethical grounds, and in such cases they typically have reasons for their opposition. In scrutinizing their reasons, we are practicing applied ethics. Applied ethics involves identifying peoples' arguments for various conclusions, and then analyzing those arguments to determine whether they support the conclusions. A critical goal here is to decide whether an argument is sound. A sound argument is one in which all of the premises are true and no mistakes have been made in reasoning.

Ethically justifiable conclusions inevitably rest on two kinds of claims: (a) empirical claims, or factual assertions about how the world *is*—claims ideally based on the best available scientific observations, principles, and theories, and (b) normative claims, or value-laden assertions about how the world *ought to be*—claims ideally based on the best available moral judgments, principles, and theories.

Is it ethically justifiable to produce genetically modified crops and foods? There is an objective answer to this question, and we will try here to figure out what it is. But we must begin with a proper, heavy, dose of epistemic humility, acknowledging that few ethicists at the moment seem to think that they know the final answer.

Should the law allow GM foods to be grown and marketed? The answer to this, and every, public-policy question rests ultimately with us, citizens who will, in the voting booth and shopping market, decide the answer. To make up our minds, we will use feelings, intuitions, conscience, and reason. However, as we citizens are, by and large, not scientists, we must, to one degree or other, rest our factual understanding of the matter on the opinions of scientific experts. Therefore, ethical responsibility in the decision devolves heavily upon scientists engaged in the new GM technology.

Ethical Responsibilities of Scientists

Science is a communal process devoted to the discovery of knowledge, and to open and honest communication of knowledge. Its success, therefore, rests on two different kinds of values.

Epistemological values are those by which scientists determine which knowledge-claims are better than others. The values include clarity, objectivity, capacity to explain a range of observations, and ability to generate accurate predictions. Claims that are internally inconsistent are jettisoned in favor of claims that are consistent and in accord with established theories. (At times, anomalous claims turn out to be justifiable, and an established theory is overthrown, but these occasions are rare in the history of science.) Epistemological values in science also include: fecundity, the ability to generate useful new hypotheses; simplicity, the ability to explain observations with the fewest additional assumptions or qualifications; and elegance.

Personal values, including honesty and responsibility, are a second class of values that allows scientists to trust their peers' knowledge-claims. If scientists are dishonest, untruthful, fraudulent, or excessively self-interested, the free flow of accurate information so essential to science will be thwarted. If a scientist plagiarizes the work of others or uses fabricated data, that scientist's work will become shrouded in suspicion and otherwise reliable data will not be trusted. If scientists exploit those who work under them, or discriminate on the basis of gender, race, class, or age, then the mechanisms of trust and collegiality under-girding science will be eroded.

The very institution of scientific discovery is supported—indeed, permeated—with values. Scientists have a variety of goals and functions in society, so it should be no surprise that they face different challenges.

University and government scientists must be scrupulous in giving credit for their research to all who deserve it, careful not to divulge proprietary information, and painstaking in maintaining objectivity, especially when funded by industry. Industry scientists must also maintain the highest standards of scientific objectivity—a particular challenge since their work may not be subject to peer-review procedures as strict as those faced by university scientists. Industry scientists must also be willing to defend results of their

research that are not favorable to their employer's interests. Scientists employed by nongovernmental activist organizations face challenges, as well. Their objectivity must be maintained in the face of an organization's explicit advocacy agenda, and in spite of the fact that their research might provide results that seriously undermine the organization's fund-raising attempts. All scientists face the challenges of communicating complex issues to a public that receives them through media channels that often are not equipped to communicate the qualifications and uncertainties attached to much scientific information.

At its core, science is an expression of some of our most cherished values. The public largely trusts scientists, and scientists must in turn act as good stewards of this trust.

A Method for Addressing Ethical Issues

Ethical objections to GM typically center on the possibility of harm to persons or other living things. Harm may or may not be justified by outweighing benefits. Whether harms are justified is a question that ethicists try to answer by working methodically through a series of questions[1]:

1. What harm is envisaged? To provide an adequate answer to this question, we must pay attention to how significant the harm or potential harm may be (severe or trivial?); who the "stakeholders" are (who are the persons, animals, even ecosystems, that may be harmed?); the extent to which various stakeholders might be harmed; and the distribution of harms. The last question directs attention to a critical issue, the issue of justice and fairness: are those who are at risk of being harmed by the action in question different from those who may benefit from it?
2. What information do we have? Sound ethical judgments go hand-in-hand with thorough understanding of the scientific facts. In a given case, we may need to ask two questions. Is the scientific information about harm being presented reliably? Is it fact, hearsay, or opinion? And, what missing information should we have before making the decision?
3. What are the options? In assessing the various courses of action, emphasize creative problem solving, seeking to find "win-win" alternatives in which everyone's interests are protected. Here we must identify each stakeholder's objectives; how many methods are available to achieve those objectives; and what advantages and disadvantages attach to each?

[1]In describing this method, I have drawn on an ethics assessment tool devised by Dr. Courtney Campbell, Philosophy Department, Oregon State University, and presented at the Oregon State University Bioethics Institute in Corvallis, OR, Summer 1998.

4. What ethical principles should guide us? There are at least three secular ethical traditions:
    - Rights theory holds that we ought always to act so that we treat human beings as autonomous individuals, and not as mere means to an end.
    - Utilitarian theory holds that we ought always to act so that we maximize good consequences and minimize harmful consequences.
    - Virtue theory holds that we ought always act as would a just, fair, good person.

Ethical theorists are divided about which of these three is best. We manage this uncertainty through the following procedure. Pick one of the three principles. Using it as a basis, determine its implications for the decision at hand. Then, adopt a second principle. Determine what it implies for the decision at hand. Repeat the procedure with the third principle. Should all three principles converge on the same conclusion, then we have good reasons for thinking our conclusion morally justifiable.

How do we achieve moral closure? Does the decision we have reached allow all stakeholders either to participate in the decision or to have their views represented? If a compromise solution is deemed necessary in order to manage otherwise intractable differences, has the compromise been reached in way that has allowed all interested parties to have their interests articulated, understood, and considered? If so, then the decision may be justifiable on ethical grounds.

There is a difference between consensus and compromise. Consensus means that the vast majority of people agree about the right answer to a question. If the group cannot reach a consensus, but must, nevertheless, take some decision or other, then a compromise position may be necessary. But neither consensus nor compromise should be confused with the right answer to an ethical question. It is possible that a society might reach a consensus position that is unjust. For example, some societies have held that women should not be allowed to own property. That may be a consensus position, or even a compromise position, but it should not be confused with the truth of the matter. Moral closure is a sad fact of life; we sometimes must decide to undertake some course of action even though we know that, ethically, it may not be the right decision, all things considered.

Ethical Issues Involved in the Use of Genetic Technology in Agriculture

Discussions of the ethical dimensions of agricultural biotechnology are sometimes confused by a conflation of two quite different sorts of objections to GM technology: intrinsic and extrinsic. It is critical not only that we distinguish these two classes, but keep them distinct throughout the ensuing discussion of ethics.

Extrinsic objections focus on the potential harms consequent upon the adoption of GMOs. Extrinsic objections hold that GM technology should not be pursued because of its anticipated results. Briefly stated, the extrinsic objections go as follows. GMOs may have disastrous effects on animals, ecosystems, and humans. Possible harms to humans include perpetuation of social inequities in modern agriculture, decreased food security for women and children on subsistence farms in developing countries, a growing gap between well capitalized economies in the northern hemisphere and less capitalized peasant economies in the south, risks to the food security of future generations, and the promotion of reductionistic and exploitative science. Potential harms to ecosystems include possible environmental catastrophe, inevitable narrowing of germplasm diversity, and irreversible loss or degradation of air, soils, and waters. Potential harms to animals include unjustified pain to those used in research and production.

These are valid concerns, and nation-states must have in place testing mechanisms and regulatory agencies to assess the likelihood, scope, and distribution of potential harms through a rigorous and well funded risk-assessment procedure. For this reason, I contend that GM technology must be developed responsibly and with appropriate caution. However, these extrinsic objections cannot by themselves justify a moratorium, much less a permanent ban, on GM technology, because they admit the possibility that the harms may be minimal and outweighed by the benefits. How can one decide whether the potential harms outweigh potential benefits unless one conducts the research, field tests, and data analysis necessary to make a scientifically informed assessment?

In sum, extrinsic objections raise important questions about GMOs, and each country using GMOs ought to have in place the organizations and research structures necessary to ensure their safe use.

There is, however, an entirely different sort of objection to GM technology, which, if it is sound, would indeed justify a permanent ban.

Intrinsic objections allege that the process of making GMOs is objectionable in itself. This belief is defended in several ways, but almost all of the formulations are related to one central claim—the "unnaturalness objection" (UE): It is unnatural to genetically engineer plants, animals, and foods.

If UE is true, then we ought not to engage in bioengineering, however unfortunate may be the consequences of halting the technology. Were a nation to accept UE as the conclusion of a sound argument, then much agricultural research would have to be terminated and potentially significant benefits from the technology sacrificed. A great deal is at stake.

In *Vexing Nature? On Ethical Case Against Agricultural Biotechnology*, I discuss fourteen ways in which UE has been defended (Comstock, 2000). For present purposes, those fourteen objections can be summarized as follows:

- To engage in ag biotech is to *play God.*
- To engage in ag biotech is to *invent world-changing technology.*
- To engage in ag biotech is *illegitimately to cross species boundaries.*
- To engage in ag biotech is to *commodify life.*

Let us consider each claim in turn.

To engage in ag biotech is to *play God.* In a western theological framework, humans are creatures, subjects of the Lord of the Universe, and it would be impious for them to arrogate to themselves roles and powers appropriate only for the Creator. Shifting genes around between individuals and species is taking on a task not appropriate for us, subordinate beings. Therefore, to engage in bioengineering is to play God.

There are several problems with this argument. First, there are different interpretations of God. Absent the guidance of any specific religious tradition, it is logically possible that God is a Being who wants to turn over to us all divine prerogatives; or explicitly wants to turn over to us at least the prerogative of engineering plants; or who does not care what we do. If God is any of these beings, then the argument fails because playing God in this instance is not a bad thing.

The argument seems to assume, however, that God is not like any of the gods just described. Assume that the orthodox Jewish and Christian view is correct, that God is the only personal, perfect, necessarily existing, all-loving, all-knowing, and all-powerful being. In this traditional western theistic view, finite humans should not aspire to infinite knowledge and power. To the extent that bioengineering is an attempt to control nature itself, the argument is that bioengineering is an unacceptable attempt to usurp God's dominion.

The problem with this argument is that not all traditional Jews and Christians think that this God would rule out genetic engineering. I am a practicing evangelical Christian and the chairperson of my local Church Council. In my tradition, God is thought to endorse creativity, scientific and technological development, including genetic improvement. Other traditions have similar views. In the mystical writings of the Jewish Kabbalah, God is understood as One who expects humans to be co-creators, technicians working with God to improve the world. At least one Jewish philosopher, Baruch Brody (personal communication), has suggested that biotechnology may be a vehicle ordained by God for the perfection of nature.

Personally, I hesitate to think that humans can “perfect” nature. However, I have become convinced that GM might help humans to rectify some of the damage we have already done to nature. And I believe God may endorse such an aim. For humans are made in the divine image. God desires that we exercise the spark of divinity within us. Inquisitiveness in science is part of our nature. Creative impulses are not found only in the literary, musical, and plastic arts.

I hesitate to think that humans can "perfect" nature. However, I have become convinced that GM might help humans to rectify some of the damage we have already done to nature. And I believe God may endorse such an aim.

They are part of molecular biology, cellular theory, ecology, and evolutionary genetics, too. It is unclear why the desire to investigate and manipulate the chemical bases of life should not be considered as much a manifestation of our god-like nature as the writing of poetry and the composition of sonatas. As a way of providing theological content for UE, then, this argument is unsatisfactory because it is ambiguous and contentious.

To engage in ag biotech is to *invent world-changing technology*, an activity that should be reserved to God alone. Let us consider this in conjunction with a similar objection: to engage in ag biotech is to *arrogate historically unprecedented power* to ourselves. The latter argument here is not the strong one, that biotech gives us divine power, but the more modest one, that it gives us a power we have not had previously. Also it would be counterintuitive to judge an action wrong simply because it has never been performed. In this view, it would have been wrong to prescribe a new herbal remedy for menstrual cramps, or to administer a new anesthetic. But that seems absurd. More argumentation is needed to call historically unprecedented actions morally wrong. What is needed is to know to what extent our new powers will transform society, whether we have witnessed prior transformations of this sort, and whether those transitions are morally *acceptable.*

We do not know how extensive the ag biotech revolution will be, but let us assume that it will be as dramatic as its greatest proponents assert. Have we ever witnessed comparable transitions? The change from hunting and gathering to agriculture was an astonishing transformation. With agriculture came not only an increase in the number of humans on the globe, but the first appearance of complex cultural activities: writing, philosophy, government, music, the arts, and architecture. What sort of power did people arrogate to themselves when they moved from hunting and gathering to agriculture? The power of civilization itself (McNeill, 1989).

Ag biotech is often oversold by its proponents. But suppose that they are right, that it will bring us historically unprecedented powers. Is this a reason to oppose it? Not if we accept agriculture and its accompanying advances, for when we accepted agriculture we arrogated to ourselves historically unprecedented powers.

In sum, these objections are not convincing.

To engage in ag biotech *is illegitimately to cross species boundaries.* The problems with this argument are both theological and scientific. I will leave it to others to argue the scientific case that nature gives ample evidence of generally fluid boundaries between species. The argument assumes that species boundaries are distinct, rigid and unchanging, whereas, in fact, species now appear to be messy, plastic, and mutable. To proscribe the crossing of species borders on the grounds that it is unnatural seems scientifically indefensible.

It is also difficult to see how this objective could be defended on theological grounds. None of the scriptural writings of the western religions proscribe genetic engineering, of course, because genetic engineering was undreamt of at the time the holy books were written. Now, one might argue that such a proscription may be derived from Jewish or Christian traditions of scriptural interpretation. Talmudic laws against mixing "kinds," for example, might be taken to ground a general prohibition against inserting genes from "unclean" species into clean species. Here is one way the argument might go: for an observant Jew to do what scripture proscribes is morally wrong; Jewish oral and written law proscribe the mixing of kinds (*e.g.*, eating milk and meat from the same plate; yoking donkeys and oxen together); bioengineering is the mixing of kinds; therefore, for a Jew to engage in bioengineering is morally wrong.

But this argument fails to show that bioengineering is intrinsically objectionable in all of its forms for everyone. The argument might prohibit *Jews* from engaging in certain *kinds* of biotechnological activity but not all; it would not prohibit, for example, the transferring of genes *within* a species, nor, apparently, the transfer of genes from one clean species to another clean species. Incidentally, it is worth noting that the Orthodox community has accepted transgenesis in its food supply. Eighty to ninety percent of cheese produced in the United States is made using a GM product, chymosin. This cheese has been accepted as kosher by Orthodox rabbis (Gressel, 1998).

In conclusion, it is difficult to find a persuasive defense for this objection either on scientific or on religious grounds.

To engage in ag biotech is to *commodify life.* The argument here is that genetic engineering treats life in a reductionistic manner, reducing living organisms to little more than machines. Life is sacred and not to be treated as a good of commercial value only, to be bought and sold to the highest bidder.

Could we apply this principle uniformly? Would not objecting to the products of GM technology on these grounds also require that we object to the products of ordinary agriculture on the same grounds? Is not the very act of bartering or exchanging crops and animals for cash vivid testimony to the fact that every culture on earth has engaged in the commodification of life for centuries? If one accepts commercial trafficking in non-GM wheat and pigs, then why should we object to commercial trafficking in GM wheat and GM pigs? Why should it be wrong for us to treat DNA the way we have previously treated animals, plants, and viruses (Nelkin and Lindee, 1995)?

Although this objection may be true, it is not a sufficient reason to object to GM technology because our values and economic institutions have long accepted the commodification of life. Now, one might object that various religious traditions have never accepted commodification, and that genetic engineering presents us with an opportunity to resist, to reverse course. Leon Kass (1988, 1998), for example, has argued that we have gone too far down the road of dehumanizing ourselves and treating nature as a machine, and that we should pay attention to our emotional reactions against practices such as human cloning. Even if we cannot defend these feelings in rational terms, our revulsion at the very idea of cloning humans should carry great weight. Mary Midgley (2000) has argued that moving genes across species boundaries is not only "yukky" but, perhaps, a monstrous idea, a form of playing God.

Kass and Midgley have eloquently defended the relevance of our emotional reactions to genetic engineering but, as both admit, we cannot simply allow our emotions to carry the day. As Midgley writes, "Attention to . . . sympathetic feelings [can stir] up reasoning that [alters] people's whole world view" (Midgely, 2000, p. 10). But as much hinges on the reasoning as on the emotions.

Are the intrinsic objections sound?Are they clear, consistent, and logical? Do they rely on principles we are willing to apply uniformly to other parts of our lives? Might they lead to counter-intuitive results?

We hesitate to accept counter-intuitive results because they run counter to widely-shared considered moral intuitions. If a moral rule or principle leads to counter-intuitive results, then we have a strong reason to reject it. For example, consider the following moral principle, which we might call the doctrine of naïve consequentialism (NC): always improve the welfare of the most people. Were we to adopt NC, then we would be not only permitted but required to sacrifice one healthy person if by doing so we could save many others. If six people need organ transplants (two need kidneys, one needs a liver, one needs a heart, and two need lungs) then NC instructs us to sacrifice the life of the healthy person so as to transplant their six organs to the other six. But this result, that we are *obliged* to sacrifice innocent people to save strangers, is wildly counter-intuitive. This result gives us a strong reason to reject NC.

I have argued that the four formulations of the unnaturalness objection considered above are unsound insofar as they lead to counter-intuitive results. I do not take this position lightly. Twelve years ago, I wrote an article, *The Case Against bGH* (Comstock, 1988), which, I have been told, was one of the first papers by a philosopher to object to ag biotech on explicitly ethical grounds. I then wrote a series of other articles objecting to GM herbicide-resistant crops, transgenic animals, and, indeed, all of agricultural biotechnology (reprinted in Comstock, 2000). I am acquainted with worries about GM foods. But, for reasons that include the weakness of the intrinsic objections, I have come to change my mind. The sympathetic feelings on which my anti-GMO worldview was based did not survive the stirring up of reasoning.

Why Are We Careful with GM Foods?

I do not pretend to know anything like the full answer to this question, but I would like to be permitted the luxury of brief speculation about it. The reason we are careful with GM foods may have to do with a natural, completely understandable, and wholly rational tendency to take precautions with what goes into our mouths. When we are in good health and happy with the foods available to us, we have little to gain from experimenting with a new food, and no reason to take a chance on a potentially unsafe food. We may think of this disposition as the precautionary response.When faced with two contrasting opinions about issues related to food safety, consumers place great emphasis on negative information. The precautionary response is particularly strong when a consumer sees little to gain from a new food technology. When a given food is plentiful, it is rational to place extra weight on negative information about any particular piece of that food.It is rational to do so, as my colleague Dermot Hayes has pointed out, even when the source of the negative information is known to be biased.

There are several reasons to take a precautionary approach to new foods. First, under conditions in which nutritious tasty food is plentiful, we have nothing to gain from trying a new food if, from our perspective, it is in other respects identical to our current foods. Suppose, on a rack in front of me, there are eighteen dozen maple-frosted Krispy Kreme doughnuts, all baked to a golden brown, all weighing three ounces. If I am invited to take one of them, I have no reason to favor one over the other. Suppose, however, that a naked man runs into the room with wild-hair flying behind him yelling that the sky is falling. He approaches the rack and points at the third doughnut from the left on the fourth shelf from the bottom and exclaims, “This doughnut will cause cancer! Avoid it at all costs, or die!” There is no reason to believe this man's claim and yet, since there are so many doughnuts freely available, why take a chance? It is rational to select other doughnuts, since all are alike. Now, perhaps one of us is a mountain climber who loves taking risks. They might be tempted to say, “Heck, I'll try that doughnut.” In order to focus on the right question here, the risk-takers should ask themselves whether they would select the tainted doughnut to take home to feed to their two-year-old daughter. Why impose any risk on your loved ones when there is no reason to do so?

The Krispy Kreme example is meant to suggest that food tainting is both a powerful and an extraordinarily easy social act. It is powerful because it virtually determines consumer behavior. It is easy, because the tainter does not have to offer any evidence of the food's danger at all. Under conditions of plentiful food, rational consumers do and should take precautions, avoiding possibly tainted food no matter how untrustworthy the information source.

Our tendency to take precautions with our food suggests that a single person with a negative view of GM foods will be much more influential than many people with a positive view. The following experiment lends credibility to this

hypothesis. In a willingness-to-pay experiment, Hayes and colleagues (in press) gave eighty-seven primary food shoppers $40 each. Each participant was assigned to a group ranging in size from a half-dozen to a dozen members. Each group was then seated at a table at lunch-time and given one pork sandwich. In the middle of each table was one additional food item, an irradiated pork sandwich. Each group of participants was given one of three different treatments: (a) the *Pro-irradiation* treatment; (b) the *Anti-irradiation* treatment; or (c) the *Balanced* treatment.

Each treatment began with all of the participants at a table receiving the same, so-called "neutral" description of an irradiated pork sandwich. The description read, in part:

> *The United States Food and Drug Administration has recently approved the use of ionizing radiation to control* Trichinella *in pork products. This process results in a 10,000-fold reduction in* Trichinella *organisms in meat. The process does not induce measurable radioactivity in food.*

After the participants read this description, they would proceed to conduct a silent bid in order to purchase the right to exchange their non-irradiated sandwich for the irradiated sandwich. Whoever bid the highest price would be able to buy the sandwich for the price bid by the second-highest bidder. In order to provide participants with information about the opinions of the others at their table so that they could factor this information into their future bids, the lowest and highest bids of each round were announced before the next round of bidding began. At the end of the experiment, one of the ten bidding rounds would be selected at random, and the person bidding the highest amount in that round would have to pay the second-highest price bid during that round for the sandwich.

After five rounds of bidding, the second-highest bids in all three groups settled rather quickly at an equilibrium point, roughly, twenty cents. That is, someone at every table was willing to pay twenty cents for the irradiated pork sandwich, but no one in any group would pay more than twenty cents. The bidding was repeated five times in order to give participants the opportunity to respond to information they were getting from others at the table, and to ensure the robustness of the price.

After five rounds of bidding, each group was given additional information. Group (a), the so-called *Pro* group, was provided with a description of the sandwich that read, in part:

> *Each year, 9,000 people die in the United States from food-borne illness. Some die from* Trichinella *in pork. Millions of others suffer short-term illness. Irradiated pork is a safe and reliable way to eliminate this pathogen. The process has been used successfully in twenty countries since 1950.*

The *Pro*-group participants were informed that the source of this positive description was a pro-irradiation food-industry group. After the description was read, five more rounds of bidding began. The price of the irradiated sandwich quickly shot upward, reaching sixty cents by the end of round ten. A ceiling price was not reached, however, as the bids in every round, including the last, were significantly higher than in the preceding round—the price was still going up when the experiment was stopped (Figure 1).

Figure 1. Effect of information on average bid for irradiated pork [reprinted from Hayes *et al.* (in press)].

After its first five rounds of bidding, Group (b), was provided with a different description. It read, in part:

> *In food irradiation, pork is exposed to radioactive materials. It receives 300,000 rads of radiation—the equivalent of thirty million chest X-rays. This process results in radiolytic products in food. Some radiolytic products are carcinogens, and linked to birth defects. The process was developed in the 1950s by the Atomic Energy Commission.*

The source of this description was identified to the bidders as "Food and Water," an anti-irradiation activist group in England. After Group (b) read this description, it began five more rounds of bidding. The bid went down, quickly reaching zero. After the first five rounds produced a value of twenty cents in Group (b) for the pork sandwich described in a "neutral" way, *no one* in this group would pay a penny for the irradiated sandwich described in a "negative" way. This result obtained even though the description was clearly identified as coming from an activist, non-scientific group.

After five rounds of bidding on the neutral description, the third group, Group (c), received *both* the positive and negative descriptions. One might expect that this group's response would be highly variable, with some participants scared off by the negative description and others discounting it for its unscientific source. Some participants might be expected to bid nothing while others would continue to bid highly. However, the price of the sandwich in the third, so-called *Balanced* group, also fell quickly. Indeed, the price reached zero almost as quickly as it did in Group (b), the negative group. That is, even though the third group had both the neutral and the positive

description in front of them, no one exposed to the negative description would pay two cents for the irradiated sandwich.

Hayes' study illuminates the precautionary response, and carries implications for the GM debate. These implications are that, given neutral or positive descriptions of GM foods, consumers initially will *pay more* for them. Given negative descriptions of GM foods, consumers initially will *not* pay more for them. Finally, and this is the surprising result, given *both* positive and negative descriptions of GM foods, consumers initially will *not* pay more for them. Both sides in the GM food debate should be scrupulous in providing reasons for all of their claims, especially negative claims.

In a worldwide context, the precautionary response of those facing food abundance in developed countries may lead us to be insensitive to the conditions of those in less fortunate situations. Indeed, we may find ourselves in the following ethical dilemma.

In a worldwide context, the precautionary response of those facing food abundance in developed countries may lead us to be insensitive to the conditions of those in less fortunate situations.

For purposes of argument, let us make the following three assumptions, none of which is implausible. First, assume that GM food is safe. Second, assume that some GM foods, such as rice enhanced with iron or vitamin A, virus-resistant cassava, or aluminum-tolerant sweet potato, may be of great potential benefit to millions of poor children. Third, assume that widespread anti-GM information and sentiment, no matter how unreliable on scientific grounds, could shut down the GM infrastructure in the developed world.

Under these assumptions, consider the possibility that by condemning GM foods in the countries best suited to conduct GM research safely, activists could bring to a halt the range of money-making GM foods marketed by multinational corporations. This result might be a good or a bad thing. However, an unintended side-effect would be that the new GM crops mentioned above might not be forthcoming, assuming that their development and commercialization depends upon the addressing of fundamental questions in plant science and molecular biology that will be answered only if research in private industry is allowed to progress along with that in public research institutions.

Our precautionary response to new food may put us in an uncomfortable position. On the one hand, we want to tell "both sides" of the GM story, letting people know both about the benefits and the risks of the technology. On the other hand, some of the people touting the benefits of the technology make outlandish claims that it will feed the world while some of the people decrying

the technology make unsupported claims that it will ruin the world. In this situation, however, those with unsupported negative stories to tell carry greater weight than those with unsupported positive stories. Our precautionary response, then, may well lead, in the short term at least, to the rejection of GM technology. Yet, this rejection could indirectly harm those children most in need.

Are we being forced to choose between two fundamental values, the value of free speech versus the value of children's lives?

On the one hand, open conversation and transparent decision-making processes are critical to the foundations of a liberal democratic society. We must reach out to include everyone in the debate, and allow people to state their opinions about GM foods, whatever those opinions happen to be, whatever the level of acquaintance with the science and technology happens to be. Free speech is a value not to be compromised lightly.

On the other hand, simply stating negative opinions about GM food can clearly have a tainting effect, a powerful and extraordinarily easy consequence of free speech. Tainting the technology might result in the loss of this potentially useful tool. Should we, then, draw some boundaries around the conversation, insisting that each contributor bring some measure of scientific data to the table, especially when negative claims are being made? Or are we collectively prepared to leave the conversation wide open? That is, in the name of protecting free speech, are we prepared to risk losing an opportunity to help some of the world's most vulnerable?

Religion and Ethics

Religious traditions provide an answer to the question, "How, overall, should I live my life?" Secular ethical traditions provide an answer to the question, "What is the right thing to do?" When in a pluralistic society a particular religion's answers come into genuine conflict with the answers arrived at through secular ethical deliberation, we must ask how deep is the conflict. If the conflict is so deep that honoring the religion's views would entail dishonoring another religion's views, then we have a difficult decision to make. In such cases, the conclusions of secular ethical deliberation must over-ride the answers of the religion in question. The reason is that granting privileged status to one religion will inevitably discriminate against another religion. Individuals must be allowed to follow their conscience in matters theological. But if one religion is allowed to enforce its values on others in a way that restricts the others' ability to pursue their values, then individual religious freedom has not been protected.

Moral theorists refer to this feature of nonreligious ethical deliberation as the *overridingness* of ethics. If a parent refuses a lifesaving medical procedure for a minor child on religious grounds, the state is justified in overriding the parent's religious beliefs in order to protect what secular ethics regards as a value higher than religious freedom: the life of a child.

The overridingness of ethics applies to our discussion only if a religious group claims the right to halt GM technology on purely religious grounds. The problem here is the confessional problem, of one group attempting to enforce its beliefs on others. I mean no disrespect to religion; as I have noted, I am a religious person, and I value religious traditions other than my own. Religious traditions have been the repositories and incubators of virtuous behavior. Yet each of our traditions must in a global society learn to coexist peacefully with competing religions, and with nonreligious traditions and institutions.

If someone objects to GM technology on purely religious grounds, we must ask on what authority they speak for their tradition, whether there are other, conflicting, views within their tradition, and whether acting on their views will entail disrespecting the views of people from other religions. It is, of course, the right of each tradition to decide its attitude about genetic engineering. But in the absence of other good reasons, we must not allow someone to ban GM technology for narrowly sectarian reasons alone. To allow such an action would be to disrespect the views of people who believe, on equally sincere religious grounds, that GM technology is not necessarily inconsistent with God's desires for us.

Minority Views

When, in a pluralistic society, the views of a particular minority come into genuine conflict with the views of the majority, we must ask a number of questions. How deep is the conflict? How has the minority been treated in the past? If the minority has been exploited, have reparations been made? If the conflict is so deep that honoring the minority's views would entail overriding the majority's views, then we have a difficult decision to make. In such cases, the conclusions of the state must be just, taking into account the question of past exploitation and subsequent reparations, or lack thereof. This is a question of justice.

The question of justice would arise in the discussion of GM technology if the majority favored GM technology while the minority claimed the right to halt GM technology. If the minority cited religious arguments to halt GMOs, yet the majority believed that halting GMOs would result in loss of human life, then the state faces a decision very similar to the one discussed in the prior section. In this case, secular policy decisions may be justified in overriding the minority's religious arguments insofar as society deems that human life has a value higher than that of religious freedom.

However, should the minority cite past oppression as the reason that their values ought to predominate over the majority's, then a different question must be addressed. Here, the relevant issues have to do with the nature of past exploitation, its scope and depth, and the sufficiency of efforts—if there have there been any—to rectify the injustice and compensate victims. If the problem is long-standing and has not been addressed, then imposing the will of the majority would seem a sign of an unjust society insensitive to its past misdeeds.

If, on the other hand, the problem has been carefully addressed by both sides and, for example, just treaties—arrived at through fair procedures and enforced—are rectifying past wrongs and are preventing new forms of exploitation, then the minority's arguments would seem to be far weaker. This conclusion would be especially compelling if it could be shown that the lives of *other* disadvantaged peoples might be put at risk by honoring a particular minority's wish to ban GMOs.

CONCLUSION

Earlier I described a method for reaching ethically sound judgments. On the basis of that method I personally came to change my mind about the moral acceptability of GM crops. My opinion changed as I took full account of three considerations: (a) the rights of people in various countries to choose to adopt GM technology (a consideration falling under the human rights principle); (b) the balance of likely benefits over harms to consumers and the environment from GM technology (a utilitarian consideration); and (c) the wisdom of encouraging discovery, innovation, and careful regulation of GM technology (a consideration related to virtue theory).

Is it ethically justifiable to pursue genetically modified crops and foods? I have come to believe that three of our most influential ethical traditions converge on a common answer. Assuming we proceed responsibly and with appropriate caution, the answer is yes.

ACKNOWLEDGMENTS

I learned much from discussing these ideas with several colleagues, including Gary Varner, Tony Smith, Ned Hettinger, Marc Saner, Rob Streiffer, Dermot Hayes, Kristen Hessler, Fred Kirschenmann, and C.S. Prakash. I was also fortunate to participate in several conversations on the topic during the past few months, and would like to express gratitude to my hosts, including:

- Three local chapters of the American Chemical Society at: Eastern Oregon University (Richard Hermens); Washington State University (Roger Willett); and Seattle University (Susan Jackels), in October 2000.
- The "New Zealand Royal Commission on Genetic Modification"; a public audience in Wellington, New Zealand (sponsored by the New Zealand Life Sciences Network, and Francis Wevers); and St. John's College, Auckland, NZ (Graham Redding), November 2000.
- The "Plant Sciences Institute Colloquium," Iowa State University, February 2001 (Stephen Howell).
- "Biotech Issues 2001," an Extension In-Service conference at Colorado State University (Bob Zimdahl and Pat Kendall); and a seminar in the CSU Philosophy Department (Phil Cafaro and Holmes Rolston); both in February.

- The 2001 Annual Meeting of the American Association for the Advancement of Science, San Francisco, in February (Katherine R. Smith and Nicole Ballenger).
- A seminar at the Center for International Development and Science, the Technology and Public Policy Program, and the Belfer Center for Science and International Affairs, Harvard University, March, 2001 (Calestous Juma and Derya Honca).
- The Center for Judaism and the Environment, and Center for Business Ethics, Jerusalem College for Technology, Israel (Akiva Wolff, Pinchas Rosenstein, and Jacqueline Rose); and "Symposium 2001: Plant Biotechnology, Its Benefits Versus Its Risks," Tel Aviv University, Israel, May 2001 (Bernie Epel and Roger Beachy).

"Ethical Issues Involved in the Use of Genetic Technology in Agriculture" is reprinted from pp. 182–195 of Comstock (2000), with the kind permission of the publisher.

Other portions of the paper were written with support of the Cooperative State Research, Education, and Extension Service, U.S. Department of Agriculture, under Agreement No. 00-52100-9617.

References and Notes

Comstock G (1988) The case against bGH. Agriculture Human Values 5 36–52.

Comstock G (2000) Vexing Nature? On the Ethical Case against Agricultural Biotechnology. Boston/Dordrecht: Kluwer Academic Publishers.

Gressel J (1998) Observation at the annual meeting of the Weed Science Society of America Chicago 10 February.

Hayes D et al. (in press) Consumer preferences for food irradiation: how favorable and unfavorable descriptions affect preferences for irradiated pork in experimental auctions. Journal of Risk and Uncertainty.

Kass L (1988) Toward a More Natural Science: Biology and Human Affairs. New York: The Free Press.

Kass L (1998) Beyond biology: Will advances in genetic technology threaten to dehumanize us all? The New York Times on the Web, August 23, http://www.nytimes.com/books/98/08/ 23/reviews/980823.23kassct.html.

McNeill W (1989) Gains and losses: an historical perspective on farming. The 1989 Iowa Humanities Lecture (National Endowment for the Humanities and Iowa Humanities Board, Oakdale Campus, Iowa City, IA, 1989), p 5.

Midgley M (2000) Biotechnology and Monstrosity: Why We Should Pay Attention to the 'Yuk Factor.' Hastings Center Report 30 no. 5, 7–15.

Nelkin D Lindee MS (1995) The DNA Mystique: The Gene as Cultural Icon. New York: Freeman.

Q: I have a background as an ethicist, and I have yet to hear an ethical principle enunciated clearly, such that it has clear practical implications that are not subject to some clear counter example. Exactly how seriously should we take the claim that intrinsic objections are really supposed to provide an absolute bedrock for morality, as opposed to just one of the many values we have to take into account and balance with lots of other values?

A: As I understand it, your question is exploring a defense of the intrinsic objections along the following lines—look, no one bases their objections to GMOs just on the fact that they think it is playing God, or just on the fact that it is tinkering with nature. Rather, all of these go together to form a package, and the cumulative result of worrying about all of them is the basis of their view. Is that close enough?

Q: Something like that. But also, just from an epistemological or an ethical perspective, we don't know yet of any fundamental ethical theory that is not counter-intuitive. So, isn't your method going to basically prove that all ethical principles are wrong, if your method is correct? Take one of the principles that you enunciated at the end. Ensure that all stakeholders are heard—do you really want to endorse that as stated, that every single stakeholder has to be heard? We are going to be sitting around for thousands of years waiting for everybody to finish.

A: Yes, it's a good question. Let me answer the one that I articulated before, then I'll try to respond to that one. It is appealing to me to think that the whole is greater than the sum of the parts, but I just don't think that is true. In this case, what we have to do, if we want to think responsibly about these objections, is to look at each one. And if each one turns out to be radically counter-intuitive then the whole is less than the sum of the parts. On the question of whether we have *any* principles that don't lead to counter-intuitive results, I am much more optimistic than you are about that. I agree that ethical theorists haven't yet articulated such a theory, but, in terms of secular ethics, we haven't been at it very long—less than three or four decades by my reckoning—and I think we will get closer to it than you seem to think. And finally, notice that these really aren't ethical *principles* that lead to counter-intuitive results, they are more like rules of thumb—how shall we act in this or that case—and there you are probably right, that we can find *a* counter example to any such rule of thumb. But I am less certain that real principles are subject to defeat so easily.

Q: I think it is fair to say that at least some critics do take their principles to be absolute, in the sense that they think that saying that suffices to show that these things are wrong. And so, if you do get a single counter example, then I think that does cause trouble for them. I think I agree with you on that point.

A: I am impressed, by the way, by how quickly critics run from these principles. That is, once they are enunciated—I have had this happen to me—

someone always stands up and says, “That's not why we are opposed to GMOs!” And I say, “Okay, good. What are the reasons?” And then they typically turn to the ones that NABC addresses in depth—safety, environmental consequences, and so on—which is where the attention should be, in my view.

Q: As I understood your talk, you said that you have changed your view, from being more *anti* to *pro* genetically engineered crops. When you held your previous view, was it based in any way on these intrinsic objections, or was it solely based on extrinsic considerations of the risks and benefits?

A: I think I had the intrinsic objections in the back of my mind. But, in my writings, my objections were typically more consequentialist. I was concerned about the effects of the new technology on family farmers, primarily—extrinsic concerns about economic and social dislocating effects. I was concerned about animal welfare, and still am; that's an extrinsic concern. Does that address your question?

Q: Yes. I was curious if it was based on an intrinsic one, what changed your mind on that. It sounds like what changed your mind was a broader look at the technology and its potential benefits. I wanted to confirm that.

A: Yes, thank you.

Q: Your previous writings, when you were an opponent of biotechnology, have been used by people to back up their beliefs. Now that you have changed your views, do you have to become more of an activist for the other side? Or do I have to read the book?

A: Reading the book is a good start! Given the consequences of negative information that I just showed you, I have a duty now to be as active for my current views as I used to be for my old views. Which is why I try to get out as much as I can, and talk.

Q: I appreciate the talk. But you leave nothing of nature standing. People want to distinguish between the natural and the unnatural, and one way they do it is to talk about species boundaries. And your entire argument against those who would not cross species boundaries is, “That would rule out mules.” So be it. I'll accept that consequence. But the more important question: is there any way we can use the concept, or the idea of nature and the natural, in ethical or esthetic discourse, if we accept biotechnology as natural? And if we don't accept it as natural, then it would seem that the people who criticize it on the grounds that it is against nature may be right.

A: The questioner, Mark Sagoff, has done more than perhaps anyone in the world to think about what is natural and unnatural, so I hesitate to try to respond quickly. I do have arguments to offer other than if you accept mules you must accept GMOs, which I didn't have time to go through. But, in general, I am very skeptical about the natural/unnatural distinction. I don't think it will

cut much ice in the end, once we try to sort out what is natural and what is unnatural. There are so many different places to cut the joints. In the end, there are better conceptual categories to use, such as sentient or non-sentient, living or non-living, humanly influenced or not humanly influenced, wild or domesticated, and those, I suspect, in the long run will get us further faster. And I learned that from Mark.

Further Reading

Comstock G (2000) Make plans on the hoof, Times Higher Education Supplement, December 22–29.

Comstock G (in press) Life Science Ethics. Ames: Iowa State University Press.

Reiss M Straughan R (1996) Improving Nature: The Science and Ethics of Genetic Engineering. Cambridge: Cambridge University Press.

Shrader-Frechette K (1991) Risk and Rationality: Philosophical Foundations for Populist Reforms. Berkeley: University of California Press.

Thompson P (1997) Food Biotechnology in Ethical Perspective. London: Blackie.

The Food Industry

SUSAN HARLANDER
BIOrational Consultants, Inc.
New Brighton, MN

Since their commercial introduction in 1996, genetically modified (GM) crops have been rapidly adopted in the United States. Because the Food and Drug Administration (FDA) considers them "substantially equivalent" to their traditional counterparts, GM crops require no special labeling and are managed as commodities with no segregation or identity preservation. This is not the case in other parts of the world where products containing genetically modified ingredients must be labeled if their content exceeds specified threshold levels. This dichotomy creates challenges for the food industry in complying with various labeling guidelines in the countries in which they conduct business. Compliance with such guidelines requires the availability of identity-preservation systems and robust, accurate, specific, reliable, standardized, and validated testing methods to ensure compliance with established threshold levels for GM ingredients. Some food companies have indicated that they will avoid the use of some or all GM ingredients in their products, although the majority have not followed suit. Various consumer-interest groups are calling for labeling of all products containing GM ingredients. The implications of such labeling will be discussed. The food industry has been monitoring the opinions of their consumers on the GM issue for the past several years, and the results of these surveys will be shared.

ACCEPTANCE OF GM

Genetically modified crops are ubiquitous in the United States. In 2001, it is predicted that 26% of the corn, 68% of the soybeans, and 69% of the cotton grown in this country will be GM varieties. They have gone through rigorous food- and environmental-safety tests; the FDA has reviewed fifty-nine GM crops. Numerous scientific organizations and United States and international regulatory agencies have endorsed their safety.

Examples of GM crops include insect-resistant (Bt) corn, cotton, potato, and tomato; herbicide-tolerant soybean, corn, rice, sugar beet, flax and canola; and virus-resistant squash, papaya, and potato. Advantages of insect- and virus-resistant crops include improved yields and reduced use of pesticides. Advantages of herbicide-tolerant crops include improved weed control, reduced crop injury, use of short-lived herbicide, reduction in foreign matter, reduced fuel use, and significant reduction in soil erosion. For these reasons, GM has become the most rapidly adopted technology in the history of agriculture.

Genetically modified crops are managed as commodities in the United States, and thus have made their way through commodity-distribution channels into thousands of ingredients used in processed foods. Examples of soy-derived ingredients include oil, lecithin, protein isolates, and mono- and diglycerides. Examples of corn-derived ingredients include oil, starch, flour, meal, dextrose, and high-fructose syrup. It has been estimated that 70 to 85% of processed foods contain one or more ingredients potentially derived from GM crops.

Acceptance of GM products varies throughout the world, creating a challenge for multinational food companies that have made commitments to take into account consumer preferences when making decisions regarding the ingredients in their products. Many countries have or are developing mandatory GM-labeling guidelines. Retailers in the United Kingdom have banned the use of GM ingredients in their private label products, causing major food companies to respond in kind. GM-labeling guidelines differ throughout the world, creating a complex situation for food manufacturers.

Labeling of GM Foods

Most food manufacturers are avoiding the use of GM ingredients in those countries that have instituted mandatory GM-labeling, because consumers perceive a label as a warning. To avoid such labeling requires the use of ingredients derived from non-GM varieties that have been identity-preserved throughout the entire supply chain: from seed to final product. Identity-preservation (IP) systems add cost and complexity to the supply chain, and are reliant upon adequate chain-of-custody documentation and GM-testing systems. Unfortunately, there are few good estimates on the cost of IP ingredients, but they may range from 5% to 150% over farm-gate prices. Food manufacturers must develop new specifications for non-GM ingredients, and audit systems to ensure compliance by ingredient suppliers. Manufacturers must understand the complete profile of all primary and secondary ingredients used in their products. For example, cornstarch is frequently used as a carrier of vitamins in fortified products, but may not be identified as an ingredient in the vitamin mix.

Mandatory labeling also demands the availability of robust standardized and validated sampling and GM-testing systems that are quantitative, reliable, accurate, and reproducible. Adventitious contamination due to cross-

pollination is inevitable; therefore, quantitative assays will be required for setting tolerances or threshold levels of contamination. Tests must be simple, inexpensive, and capable of detecting GM contamination in the range of products in the marketplace. Unfortunately, validated and standardized sampling and testing methods do not exist, except for a protein test for Roundup Ready® soybean. Authenticated reference standards are not available, and testing protocols vary from laboratory to laboratory. False-positive and false-negative rates are unacceptably high. There is no standardization on how the results are reported to food companies. The food matrix has a dramatic impact on extractability of DNA and protein, and protocols will need to be developed to take this into account. Since labeling is not required in the United States, detection methods have not developed as rapidly has as GM technology. This deficiency will cause significant issues as disputes arise about GM status of foods.

Most food companies have decided to remove GM ingredients from products marketed in countries with mandatory GM-labeling laws. Some companies are sourcing raw agricultural commodities from countries (*e.g.* Brazil) that have not yet approved the commercial cultivation of GM crops. However, this does not provide adequate assurance of non-GM status, since it has been estimated that 13% (some estimates are as high as 25%) of Brazil's 7.5 million acres of soybean are planted to GM varieties, even though their use is not approved in that country. Some companies (*e.g.* Gerber and Heinz) have decided to remove GM ingredients from baby foods marketed in the United States. Frito Lay has instructed its farmers not to grow GM corn varieties, and McDonald's will avoid GM potatoes. Neither Frito-Lay nor McDonald's has said that it will avoid other GM ingredients in its products, or that it will advertise or label its products as non-GM.

The FDA recently published draft guidance on the voluntary labeling of foods containing or not containing GM ingredients. In this document, the FDA affirmed that mandatory labeling is not required for bioengineered food, unless the food is "materially different." Since the majority of bioengineered foods reviewed by the FDA are substantially equivalent, no labeling is required in the United States. For manufacturers who wish to voluntarily label their products, the agency provides the following guidance: labels must be truthful and non-misleading, therefore, data are required to substantiate label claims. The FDA provided advice on terminology; "genetically modified" is not recommended since it is not technically accurate; all food has been genetically modified through conventional plant breeding. "Genetically modified organisms" is also misleading as most foods do not contain viable organisms. The FDA believes that it would be misleading to label a food as "GM-free" due to the potential for adventitious contamination due to cross-pollination. They did not establish a threshold level of contamination because accurate and reliable testing methods do not exist. A statement that a food is not bioengineered nor does it contain

bioengineered ingredients may be misleading if it implies the food is superior to foods that are not so labeled. Further, to make a "non-bioengineered" claim, all ingredients in the product must be from non-GM varieties, and if no bioengineered varieties of that category of foods or ingredients are marketed, such a claim would be misleading. Some companies are overtly labeling their products as GMO-free or non-GM. They procure ingredients from suppliers who certify that non-GM varieties have been used for ingredient manufacture. However, a recent study by the Wall Street Journal reported that, of twenty products labeled "non-GM," sixteen contained measurable quantities of GM DNA. Therefore, even under best-case scenarios, it is very difficult to guarantee that the "non-GM" label is truthful.

"Organic" and Other Concerns

Organic growers have expressed concern that cross-pollinating GM crops such as corn can jeopardize their crops. The USDA Organic Guidelines preclude the use of genetic modification for anything to be labeled as organic. Since it is impossible to prevent cross-pollination, it may be necessary to establish a tolerance or threshold level for adventitious contamination.

Genetically modified foods do not appear to be as big a consumer issue in the United States as in other parts of the world. Food manufacturers have been monitoring their 800 numbers for an indication of how their consumers feel about GM foods. To date, the number of calls on biotechnology remains very small (0.1% to 0.2%) for most major food companies in this country. Awareness has increased slightly over the past 18 months, and consumers are evenly divided between support and opposition. Calls increase during periods of intense media coverage. Companies targeted by activist groups report periodic increases in numbers of calls. If a brief explanation of biotechnology is provided, acceptance increases significantly, indicating that education is an important factor in consumer acceptance.

Most food companies in the United States are not avoiding bioengineered ingredients for domestic production. In general, the food-processing industry has confidence in the safety of bioengineered foods. Because GM crops have been readily adopted in the United States, availability of non-GM crops has been limited and these ingredients are more expensive. Even when efforts are

Most food companies in the United States are not avoiding bioengineered ingredients for domestic production. In general, the food-processing industry has confidence in the safety of bioengineered foods.

made to procure non-GM ingredients, adventitious contamination is an issue, and IP systems have not been perfected as was illustrated with the StarLink™ incident in 2000. The food industry would need to be able to accurately forecast their supply needs for non-GM ingredients so farmers could be instructed on the quantities required. In addition, the food industry lacks separate storage, processing, labeling and transportation capabilities required to ensure separation of GM and non-GM raw materials and final products. There is little confidence in the adequacy of current GM sampling and testing methodology to substantiate label claims and there is substantial liability if label claims are inaccurate. Finally, the food industry hopes that the next generation of bioengineered products will deliver compelling consumer benefits.

The food industry hopes that the next generation of bioengineered products will deliver compelling consumer benefits.

Future of Ag and Food Biotech

The next generation of bioengineered foods will focus on "output traits" that provide processing advantages and tangible consumer-relevant benefits. Biotechnology can be used to remove allergens, natural toxicants and antinutritional factors from foods like peanuts, soybeans, rice, and wheat. Taste, texture, aroma, ripening time and shelf life of fresh fruits and vegetables can be improved. It will be possible to improve the nutritional quality of foods. Examples include modification of the saturation level of oils to produce products high in mono-unsaturated fatty acids that are more stable, resist oxidation, do not require hydrogenation and reduce cholesterol levels when consumed. It is possible to increase the content of vitamin E and other antioxidants, and to insert the capability of producing plant-based omega-3 fatty acids into oil seeds. Biotechnology can be used to elevate levels of vitamins A, C, and D, and folate, and enhance iron bioavailability in vegetables, fruits and grains. It is also possible to increase levels of various phytochemicals in plants that have been associated with disease prevention, e.g. lycopene in tomatoes and sulfurofane in broccoli for reducing cancer risk, and lutein in vegetables for reducing risk of macular degeneration. The advancing fields of human and plant genomics and proteomics will identify additional plant-based compounds that could have positive effects on human health. These are the kinds of products that excite food companies and ultimately will excite consumers.

The advancing fields of human and plant genomics and proteomics will identify additional plant-based compounds that could have positive effects on human health. These are the kinds of products that excite food companies and ultimately will excite consumers.

The future of agricultural and food biotechnology will depend on a number of factors including continued grower support, food-industry and retailer unanimity on policies regarding the use of GM ingredients, government consistency, documentation of tangible consumer benefits without undue risk, and consumer education and acceptance. Additionally, until there is international harmonization on GM foods, turmoil in the marketplace will continue. Without consumer acceptance and a coordinated approach across all segments of the food-supply chain, the promises of agricultural and food biotechnology could be limited.

A Legal View: Promoting Product Stewardship and Regulation

STANLEY H. ABRAMSON
Arent Fox Kintner Plotkin & Kahn, PLLC
Washington, DC

With little understanding of how food, feed and fiber products are developed and produced, and even less knowledge of the science of genetics, most consumers are ill prepared to sift through the deluge of misinformation bombarding them on a daily basis. Members of NABC have a unique opportunity to help set the record straight and challenge the myths that are circulated by those who oppose, or question the use of, agricultural biotechnology.

Representatives of land-grant universities and other research institutes have a deservedly high degree of credibility. Without being advocates, they can play a vital role in educating the public, government officials, and the media, on basic agricultural practices and scientific concepts that are critical to an objective analysis of agricultural biotechnology.

Looking to the future, and in light of the rapid rate of adoption of crop biotechnology and the diversity and complexity of products in the development pipeline, I believe that product stewardship and regulation will play an increasingly important role in promoting public confidence in the products of biotechnology. Technology providers, growers, processors, and researchers all have key roles to play in supporting strong governmental oversight of crop biotechnology and implementing proactive product-stewardship programs.

Six key arguments are commonly raised in opposition to the use of biotechnology-derived crops. None of them withstand close scrutiny.

What We Really Know About the Safety and Benefits of Biotechnology Crops

Six key arguments are commonly raised in opposition to the use of biotechnology-derived crops. None of them withstand close scrutiny.

Myth #1: Lack of regulation—products are rushed to market with little or no government oversight. The reality: unprecedented regulation of plants and plant products. Products are reviewed by at least two federal agencies, the United States Department of Agriculture (USDA) and the Food and Drug Administration (FDA) and often by three, *i.e.* including the Environmental Protection Agency (EPA) (US, 2001) These reviews take place over a period of several years while carefully controlled and monitored greenhouse and field tests are conducted. All of this must occur before a product can ever enter the marketplace. There is no comparable oversight for conventional hybrids and cultivars. The jurisdiction of the regulatory agencies has been exercised since 1986 and universally recognized by regulated parties. The National Institutes of Health (NIH) research guidelines have been followed since 1976 for laboratory and greenhouse research.

Myth #2: No data. The reality: volumes of data. Health, safety and environmental data representing years of laboratory, greenhouse, and field research are routinely submitted to and reviewed by the USDA, EPA, and FDA (NAS, 2000). New data are requested by the agencies as needed.

Myth #3: No public participation. The reality: multiple public participation opportunities. Multiple public participation opportunities have been provided over the past 25 years by EPA, USDA and FDA, including via public meetings, public comment on proposed rules and policies, agency web sites, scientific peer review, and in response to published data.

Myth #4: No benefits. The reality: established benefits. Products have shown clear agronomic, environmental, and health benefits, including high-oleic soybean; slower ripening fruits and vegetables; improved protection from insects and disease (reduced use of chemical insecticides and fungicides, fewer acres cultivated, and less fuel, water, and fertilizer used); and improved tolerance to herbicides (reduced need for chemical applications, promotion of reduced tillage, control of soil erosion, and use of reduced-risk herbicides) (Alliance, 2001; USDA, 2001).

Myth #5: Harm to health and environment. The reality: no evidence of actual harm. With intensive governmental, academic, and commercial oversight for the past 15 years, not a single instance of actual harm to health, safety, or the environment has ever been confirmed for biotechnology crops on the market today (EPA, 2000).

Myth #6: No labeling. The reality: health and safety labeling is required. Federal labeling requirements are identical for all foods. Labeling solely for consumer choice is not required by government in the United States (Federal Register, 1992, 2001).

Key Issues in Promoting Product Stewardship and Regulation

- To the producer of biotechnology-derived products and others in the chain of commerce, government regulation provides assurance that appropriate safety standards have been met in bringing a product to market. But even the best efforts of regulators may prove inadequate, particularly when dealing with a new technology, without the development and implementation of proactive product-stewardship programs.
- In its broadest terms, product stewardship can be thought of as the legal, ethical and moral obligation to assess products and technologies to ensure that they are safe as well as socially and environmentally responsible. Stewardship includes the assessment—based on sound scientific principles—of the potential impact of a particular product or technology on human health and the environment, as well as those actions and principles necessary to protect the integrity and viability of a particular product or technology.
- Not all stewardship efforts are necessarily confined to individual companies, nor should they be. Many activities are more appropriately industry-wide responsibilities, which are necessary or appropriate for the protection of products or technologies as a class. Many industries operate on the basis of voluntary consensus standards, including a broad array of standards developed by nationally and internationally recognized standard-setting organizations. Government agencies routinely recognize such standards, and federal law requires agencies to use technical standards that are developed or adopted by voluntary consensus standards bodies, unless it would be inconsistent with applicable law or otherwise impractical.
- From a legal perspective, the organizational unit responsible for oversight of product stewardship must be empowered to ensure compliance with the letter and spirit of applicable regulatory requirements and to prevent potential product-related liabilities. Legal obligations in the United States include the submission of applications, notifications, data, and information in order to obtain the appropriate approvals and clearances from the USDA, FDA and EPA under the Coordinated Framework for Regulation of Biotechnology. Those obligations also extend to the post-market surveillance of agricultural biotechnology and crop-derived products and to compliance with appropriate reporting requirements, such as those imposed by EPA for plant-incorporated protectants.
- In addition to biodiversity, examples of crop biotechnology stewardship issues include: risk assessment and risk management plans; seed quality and purity; protein safety, including potential for allergenicity; protein levels in food and feed; insect-resistance-management plans for certain plant-incorporated protectants; outcrossing and open pollination; identity preservation, product channeling and trade.

- A successful risk-management process should be a fundamental part of the product-stewardship program, incorporated into each phase of product development and commercialization. Key elements of the risk-management process include: identifying every potential source of harm (hazard); assessing the probability of occurrence of that harm (exposure); assessing the risk, if any, resulting from the potential combination of hazard and exposure; and the development of alternatives for the minimization and management of the assessed risks.
- For products of agricultural biotechnology, the risks and risk-management alternatives must be evaluated in the context of factors such as health, safety, and environmental and agricultural impacts; regulatory acceptance; public acceptance; market acceptance; and civil liability. Prior to commercialization of any new plant-biotechnology product, the developer would conduct a full, science-based risk assessment to identify and, to the extent possible, quantify every risk presented. Each risk would be reviewed in all relevant contexts and an appropriate management plan would be established, including an effective strategy to mitigate any risk that becomes a reality.
- Regulatory oversight and industry stewardship of crop-biotechnology products, both pre-market and post-market, have occurred notwithstanding the fact that new conventionally bred varieties of food, feed, and fiber crops receive virtually no governmental oversight in the United States or any other nation. Moreover, the National Academy of Sciences (NAS) has repeatedly held—most recently in an April 2000 report on pest-protected plants—that being a product of biotechnology does not make a plant hazardous. Specifically, the NAS has found: (1) no evidence that unique hazards exist either in the use of rDNA techniques or the movement of genes between unrelated organisms; (2) that the risks associated with the introduction of rDNA engineered organisms are the same in kind as those associated with the introduction of unmodified organisms and organisms modified by other methods; and (3) that assessment of the risks of introducing rDNA-engineered organisms into the environment should be based on the nature of the organism and the environment into which it is introduced, not on the method by which it was produced.
- Rigorous, science-based safety assessments must be conducted for each new product or product category, first by the product developers and then by agency scientists. Conditions carefully tailored to address identified risks should be placed on approvals where warranted, and approvals should always be subject to review based on new data and information from any credible source.

- It is the very nature of oversight of a rapidly developing technology that regulation and stewardship must be dynamic processes, always subject to reevaluation and modification based on new information and understanding.
- Proactive product stewardship together with strong regulatory oversight will be critical to the minimization of liability and, ultimately, to domestic and global acceptance of products of modern biotechnology.

REFERENCES

Alliance (2001) Biotechnology. Alliance for Better Foods, Washington, DC, http://www. betterfoods.org.

EPA (2000) Greenpeace petition response submitted 4/19/00. Biopesticide News, Environmental Protection Agency, Washington, DC, http// www.epa.gov/oppbppd1/biopesticides/news/news-greenpeace.htm.

Federal Register (1992) 57 FR 22984 May 29, Washington, DC.

Federal Register (2001) 66 FR 4839 January 18, Washington, DC.

NAS (2000) Report on Genetically Modified Pest-Protected Plants Appendix B. National Academy of Sciences, Washington, DC, http://books.nap.edu/html/ gmpp/gmppappb.pdf.

USDA (2001) Biotechnology News. United States Department of Agriculture, Washington, DC, http://search.nps.ars.usda.gov/ search.htm?ct=ars_web_site&scope=http%3A%2F%2F www.ars.usda.gov%2Fis%2F&qu=biotechnology.

US (2001) United States Regulatory Oversight in Biotechnology. United States Department of Agriculture, Washington, DC, http://www.aphis.usda.gov/ biotech/OECD/usregs.htm.

PART VI

LIST OF PARTICIPANTS

Stanley Abramson
Arent Fox Kintner Plotkin & Kahn, PLLC
1050 Connecticut Avenue, NW
Washington DC 20036

Jeffrey Adkisson
Grain and Feed Association of Illinois
3521 Hollis Drive
Springfield IL 62707

Francis Adriaens
Renessen LLC
3000 Lakeside Dr. Suite 300S
Bannockburn IL 60015

John Anderson
Monsanto
1609 Iredell Drive
Raleigh NC 27608

Wendy Anderson
Food Chemical News

Amy Ando
326 Mumford Hall
University of Illinois
1301 W. Gregory Dr.
Urbana IL 61801

Mary Arends-Kuenning
University of Illinois
408 Mumford Hall
1301 W. Gregory Dr.
Urbana IL 61801

Paul Backman
Penn State University
College of Agricultural Sciences
217 Agricultural Administration Building
University Park PA 16802

Clifton Baile
University of Georgia
444 ADS Complex
425 River Rd.
Athens GA 30602

Candace Bartholomew
University of Connecticut
Cooperative Extension System
1800 Asylum Ave.
West Hartford CT 06117

Giuseppe Battaglino
Ministry of Health
Via Della Sierra Nevada 60
Rome 00144 Italy

Roger Beachy
Donald Danforth Plant Science Center
7425 Forsyth Blvd.
Box 1098
St. Louis MO 63105

Margaret Becker
NYS Department of Agriculture and Markets I Winners Circle
Albany NY 12205

P.S. Benepal
Association of Research Directors
Virginia State University
Box 9061
Petersburg VA 23806

Gerona Berdak
United Soybean Board
401 N. Michigan Ave.
Chicago IL 60611

Duane Berglund
North Dakota State University
Box 5051
Fargo ND 58105

Chris Bigall
Canadian Consulate General
180 N. Stetson Ave. Suite 2400
Chicago IL 60601

Wayne Bill
Missouri Department of Agriculture
PO Box 630
1616 Missouri Blvd
Jefferson City MO 65102

Diane Birt
Iowa State University
Department of Food Science & Human Nutrition
2312 Food Sciences Building
Ames IA 50011

Phyllis Blackford
National Soybean Research Lab
170 NSRC
1101 W. Peabody
Urbana IL 61801

James Bloedel
Iowa State University
Office of Vice Provost for Research
211 Beardshear Hall
Ames IA 50011

Martha Blum
Illinois Agri-News
420 Second Street
LaSalle IL 61301

John Bowman
Canadian Food Inspection Agency
59 Camelot Drive
Nepean
Ontario K1A0Y9 Canada

Fred Bradshaw
Route 1
Box 259
Griggsville IL 62340

William Brown
University of Florida
PO Box 110200
Gainsville FL 32611

William Browne
Enterpriz Cook County
69 W. Washington Suite 1422
Chicago IL 60602

Stuart Budd
Ontario Ministry of Ag, Food and Rural Affairs
1 Stone Road West
Guelph
Ontario N1G4Y2 Canada

Laurent Buisson
General Consulat of France
737 N. Michigan Ave. Suite 1170
Chicago IL 60610-2694

Brian Burke
ADM 4666 Faries Parkway
Decatur IL 62525

Michael Burke
Oregon State University
College of Agricultural Sciences
137 Strand Ag Hall
Corvallis OR 97331

Jennifer Callahan
USDA/OCE/ORACBA

Carla Carlson
University of Minnesota
Room 277 Coffey Hall
1420 Eckles Ave.
St. Paul MN 55108

Liane Casten
Writers Guild

Hsin-Hsiung Chang
TECO/Science Division
180 N. Stetson Ave. Suite 5760
Chicago IL 60601

Bruce Chassy
University of Illinois
238 NSRC
1101 W. Peabody
Urbana IL 61801

David Chicoine
University of Illinois
122 Mumford Hall
1301 W. Gregory Drive
Urbana IL 61801

Lori Clark
DCCA Suite 3-400
100 W. Randolph Street
Chicago IL 60601

Sharon Cohen
AP Chicago

Gary Comstock
Iowa State University
421 Catt Hall
Ames IA 50011-1306

Leon Corzine
2485 E 1200 N Rd
Assumption IL 62510

Nancy Cox
University of Kentucky
Ag Science North, S107
Lexington, KY 40506

Duane Cramm
Illinois Soybean Association
RR 2 Box 21
Mendon IL 62351

Richard Denhart
Illinois Seed Trade
Box 722
Champaign IL 618240722

Linda DeVerno
National Resources Canada
580 Booth Street 12D2
Ottawa
Ontario K1A0E4 Canada

Patricia Donald
University of Missouri
1-87 Agriculture Building
Columbia MO 65211

David Downs
Illinois Farm Bureau
402 Sycamore Lane
Allerton IL 61810-9728

Lisa Drake
Monsanto
9785 S. Maroon Circle Suite 300
Englewood CO 80112

Thayne Dutson
Oregon State University
College of Agricultural Sciences
126 Strand Agriculture Hall
Corvallis OR 97374

Allan Eaglesham
NABC
300 Hayts Road
Ithaca, NY 14850-9269
aeaglesham@msn.com
tel 607-272-2158
fax 607-272-2172

David Erickson
LANDcorp, Inc
2859 Knox Hwy 3
Altona IL 61414

Jack Erisman
781 US Hwy 51
Pana IL 62557-6451

Betsy Faga
North American Millers' Assn.
600 Maryland Avenue #305 W.
Washington DC 20024

Barbara Fairchild
Farm Journal Magazine
PO Box 958
Mexico MO 65265

Walter Fehr
Iowa State University
Office of Biotechnology
1210 Molecular Biology Building
Ames IA 50011-3260

John Finley
Kraft Foods
801 Waukegan Rd.
Glenview IL 60025

James Fischer
Clemson University
Agriculture and Forestry Research
104 Barre Hall
Clemson SC 29634-0151

McArthur Floyd
ARD, Alabama A&M University
PO Box 1087
Normal AL 35810

Julie Forster
Newsweek

Jonathan Friebert
The Quaker Oats Company
PO Box 049001
Chicago IL 60604-9001

Roy Fuchs
Monsanto
700 Chesterfield Parkway North
St. Louis MO 63198

Michael Fumento
Hudson Institute/Forbes Magazine
1015 18th St. NW
Washington DC 20036

Conrad Gilliam
Virginia State University
Box 9204
Petersburg VA 23806

Todd Gleason
University of Illinois
75 Mumford Hall
1301 W. Gregory Drive
Urbana IL 61801

Harvey Glick
Monsanto
800 Lindbergh
St. Louis MO 63167

Juan Gobel
U.S. General Accounting Office
350 S. Figueroa Street Suite 1010
Los Angeles CA 90071

Peter Goldsmith
University of Illinois
433 Mumford Hall
1301 W. Gregory Drive
Urbana IL 61801

Peter Gorner
Chicago Tribune

Nels Granholm
South Dakota State University
Agricultural Experiment Station
Box 2207
Brookings SD 57007-0291

J. Ian Gray
Michigan State University
109 Agriculture Hall
East Lansing MI 48824

Michael Gray
University of Illinois
AW-101 Turner
1102 S. Goodwin
Urbana IL 61801

Mark Griep
University of Nebraska-Lincoln
N300 Beadle Center
19th and Vine Street
Lincoln NE 68588

Greg Hainline
Illinois Soybean Checkoff Board
32336 Olympia Road
Minier IL 61759

Ross Hakes
Monsanto
18487 Maple Leaf Drive
Eden Prairie MN 55346

Phyllis Hall
Floyd Farm
6851 Knollwood Rd
Fayetteville NY 13066

Sonya Varea Hammond
University of California
Cooperative Extension
1432 Abbott Street
Salinas CA 93901

David Hansen
University of Minnesota
405 Coffey Hall
1420 Eckles Ave.
St. Paul MN 55108

Doug Hard
Renessen LLC
3000 Lakeside Dr. Suite 300S
Bannockburn IL 60015

Ralph W. F. Hardy
NABC
PO Box 509
Clarence Center NY 14032-0509

Duane Hauck
North Dakota State University
311 Morrill Hall
PO Box 5437
Fargo ND 58105

Bob Hauser
University of Illinois

Gary Heichel
University of Illinois
Department of Crop Science
AW-101 Turner, MC-046
Urbana IL 61801

Richard Heimsch
University of Idaho
PO Box 442337
College of Agriculture
Moscow ID 83844

Adrianna Hewings
USDA-ARS-MWA
1815 North University St.
Peoria IL 61604

Thomas J. Hoban
Center for Biotechnology in Global Society
North Carolina State University
Raleigh NC 27695

Donald Holt
University of Illinois
40 NSRC
1101 W. Peabody Drive
Urbana IL 61801

Joseph Hotchkiss
Cornell University
Stocking Hall
Ithaca NY 14853

Judy Hume
Ag-West Biotech Inc.
101-111 Research Drive
Saskatoon
Saskatchewan 57N 3R2 Canada

Penny Hunst
Dow AgroSciences
9330 Zionsville Road
Indianapolis IN 46268

Mary Pat Huxley
California Community Colleges
Biotechnology Initiative at Ventura College
4667 Telegraph Rd
Ventura CA 93003

Michael Imboden
ioGenetics LLC
PO Box 156
Prairie du Sac WI 53578

Andy Isserman
University of Illinois

Dale Jackson
Renessen LLC
3000 Lakeside Dr.
Suite 300S
Bannockburn IL 60015

Michael Jacobson
Center for Science in the Public Interest
1875 Connecticut Avenue N.W. #300
Washington DC 20009

Gregory Jaffe
Center for Science in the Public Interest
1875 Connecticut Avenue N.W. #300
Washington DC 20009

Mohammad Jalaluddin
University of Arkansas
1200 N. University Dr.
Mail Slot #4913
Pine Bluff AR

Jennifer James
Penn State University
Department of Ag Econ and Rural Sociology
201E Armsby Building
University Park PA 16802-5601

Ernie Jaworski
11 Clerbrook Lane
St. Louis MO 63124

Jack Jeffers
The Quaker Oats Company
321 N. Clark St.
PO Box 049001
Chicago IL 61610

Peter Johnson
USDA, ARS, NCAUR, MWA
Center Director
1815 N. University St.
Peoria IL 61604

Richard Jones
University of Florida
PO Box 110200
Gainsville FL 32611-0200

Napolean Juanillo
University of Illinois
139 Bevier Hall
905 S. Goodwin Avenue
Urbana IL 61801

Carol Keiser
Illinois Beef Association
Dues Division
18686 Country Club Lane
Carlinville IL 62626

Gary Keller
Xomix Ltd.
4554 North Broadway Suite 248
Chicago IL 60640

Pradeep Khanna
National Soybean Research Lab
1101 W. Peabody
Urbana IL 61801

Scott Kilman
Wall Street Journal

Richard Kirchhoff
National Assn. of State Depts. of Agriculture
1156 15th St. N.W. Suite 1020
Washington DC 20005

Schuyler Korban
University of Illinois
310 ERML
1201 W. Gregory
Urbana IL 60801

Anatole Krattiger
*bio*Developments LLC
Cornell University
PO Box 4235
Ithaca NY 14852

Roger Krueger
Monsanto
800 N. Lindbergh E2SE
St. Louis MO 63167

Greg Lamp
Soybean Digest
7900 International Drive Suite 300
Minneapolis MN 55425

Denise Legvold
University of Illinois Extension
Cook County/South Suburban Unit
5527 Miller Circle Drive, Suite A
Matteson IL 60443

Gary Lemme
Michigan State University
109 Agriculture Hall
East Lansing MI 48824

Martin Lemon
Monsanto
2240 Douglas Blvd Suite 260
Roseville CA 95661

Susanne Lipari
NABC
Boyce Thompson Institute
Tower Road
Ithaca NY 14853-1801
nabc@cornell.edu
tel 607-254-4856
fax 606-254-1242

Joe Lobell
The Samuel Roberts Noble Foundation, Inc.
PO Box 2180
Ardmore OK 73401

Constance Locher-Bussard
Illinois Dietetic Association
28 Pinehurst Drive
Springfield IL 62704-3121

Terri Lomax
Oregon State University
Dept. of Botany and Plant Pathology
2082 Cordley
Corvallis OR 97331-2902

Steve Lommel
NC Agri Research Service
Box 7643
North Carolina State University
Raleigh NC 27695-7643

James Lovelace
University of Maryland Biotechnology Institute
9600 Gudelsky
Rockville MD 21045

Raymond Martyn
Purdue University
Department of Botany and Plant Pathology
West Lafayette IN 47907

Murray McLaughlin
Foragen Technologies Management, Inc.
74 Wyndham Street North 2nd Floor
Guelph
Ontario N1H4E6 Canada

Sally Metz
Monsanto
700 Chesterfield Parkway North
Chesterfield MO 63198

Nancy Millis
University of Melbourne
Department of Microbiology and Immunology
Melbourne
Victoria Australia 03010

John Miranowski
Iowa State University
Department of Economics
382B Heady Hall
Ames IA 50011

Melissa Moore
Mississippi State University
PO Box 9581
Mississippi State MS 39762

Michelle Moore
4-H Farm Resource Center
158 Auer Farm
Bloomfield CT 06002

J.L. “Bert” Morrow
Mississippi State University
PO Box 9581
Mississippi State MS 39762

Barbara Mullarkey
Acres U.S.A
PO Box 91299
Austin TX 78709

Seth Murray
Michigan State University
4316 Aztec Way
Okemos MI 48864

Charles Muscoplat
University of Minnesota
277 Coffey Hall
1420 Eckles Avenue
St. Paul MN 55448

Marilyn Nash
National Soybean Research Lab
165a NSRC
1101 W. Peabody
Urbana IL 61801

Carol Neilson
National Soybean Research Lab
170 NSRC
1101 W. Peabody
Urbana IL 61801

Carl Nelson
University of Illinois
Department of ACE
1301 Gregory Drive
Urbana IL 61801

Darrell Nelson
University of Nebraska
207 Agricultural Hall
Lincoln NE 68583

Gerald Nelson
University of Illinois
305 Mumford Hall
1301 W. Gregory
Urbana IL 61801

Sue Nichols
Michigan State University
403 Olds Hall
East Lansing MI 48824

David Niekamp
Illinois Soybean Checkoff Board
2029 E 1750 Street
Coatsburg IL 62325

Susan Offutt
USDA
1800 M St. NW Room 4146
Washington DC 20036-5831

Tom Ogilvie-Graham
Cornell University
College of Veterinary Medicine
Ithaca NY 14853

John Oliver
Foragen Technologies Management, Inc.
74 Wyndham Street North 2nd Floor
Guelph
Ontario, N1H4E6 Canada

Phil Orwick
National Soybean Research Lab
164 NSRC
1101 W. Peabody
Urbana IL 61801

Wade Ostrander
Monsanto
1526 Sunset Drive
Belle Plaine IA 52208

Steve Parker
University of Illinois
75 Mumford Hall
1301 W. Gregory
Urbana IL 61801

Alfred Parks
Prairie View A&M University
PO Box 4079
Prairie View TX 77446

Anne Patterson
Nutrition Advantage
23707 E. Autumn Road
Farmington IL 61531

Philip Peters, Jr.
University of Missouri-Columbia
School of Law
Columbia MO 65203

Steven Petersen
Monsanto
1526 Sunset Drive
Belle Plaine IA 52208

C.S. Prakash
Center for Plant Biotechnology Research
Tuskegee University
Tuskegee AL 36088

Debra Pretty-Straathof
Ontario Federation of Agriculture
R.R. #2, 260 Pine Grove Road
Arnprior
Ontario K7S3G8 Canada

Steve Pueppke
University of Illinois
211 Mumford Hall
1301 W. Gregory
Urbana IL 61801

Megan Puzey
National Soybean Research Lab
165 NSRC
1101 W. Peabody
Urbana IL 61801

Xiao Qing Han
Kraft R&D Center
Associate Technology Principal
801 Waukegan Rd
Glenview IL 60025

Kenneth Rauscher
Michigan Department of Agriculture
PO Box 30017
Lansing MI 48909

Phil Reid
WGN

Sandra Ristow
Washington State University
CAHE Agricultural Research Center
403 Hubert, PO Box 646240
Pullman WA 99164

Lyle Roberts
Illinois Soybean Program Operating Board
1605 Commerce Parkway
Bloomington IL 61704

Wendy Rosberg
Renessen LLC
3000 Lakeside Drive Suite 300S
Bannockburn IL 60015

A. Bruce Roskens
The Quaker Oats Company
321 N. Clark St.
PO Box 049001
Chicago IL 60610

Joan Rothenberg
Pew Initiative on Food and Biotechnology
1331 H. Street NW Suite 900
Washington DC 20005

Michael Ruff
USDA/ARS Office of Technology Transfer
1400 Independence Avenue
Mail Stop 0302, Room 358A
Washington DC 20250

Ryan Ruh
WGN

Mark Russell
EDEN Bioscience Corp
121 Cathedral Street
Annapolis MD 21404-2703

Mark Sagoff
University of Maryland
Institute for Philosophy and Public Policy
3111 Van Munching Hall
College Park MD 20742

Beth Salsedo
4-H Farm Resource Center
158 Auer Farm Rd
Bloomfield CT 06002

Colin Scanes
Iowa State University
Department of Animal Science
2356 Kildee Hall
Ames IA 50011-3150

Bernice Schacter
1003 Oriente Avenue
Wilmington DE 19807-2260

Robert Schanefelt
AE Staley
2200 E. Eldorado
Decatur IL 62521

Erica Schatz
JETRO NY
1221 Ave. of the Americas 42nd Floor
New York NY 10020

Doug Schemmer
Monsanto
15 Apple Loop
Petersburg IL 62675

Kathleen Schmidt
University of Wisconsin

Ken Schneeberger
University of Missouri-Columbia
College of Ag. Food and Natural Resources
2-3 Agriculture Building
Columbia MO 65211

Calvin Schoulties
Clemson University
111 Poole Ag Center
Clemson SC 29634

Robert Schubert
ACRES USA

Phillip Schwab
USDA-CSREES
1400 Independence Ave., S.W.
Room 305-A Whitten Building
Washington DC 20250

Koushik Seetharaman
Penn State University
107A Borland Lab
University Park PA 16802

Tony Shelton
Cornell University
245 Roberts Hall
Ithaca NY 14853

Dave Shoup
Southern Illinois University Carbondale
College of Agriculture
Carbondale
IL 629014416

Steven Slack
Ohio State University, OARDC
209 Research Services Building
1680 Madison Avenue
Wooster OH 44691

Katherine Smith
Economic Research Service, USDA
1800 M. Street N.W. Room 4182
Washington DC 20036-5831

Kerry Smith
Center for Environ. & Res.
Econ. Policy
Dept. of Agric'l & Resource Economics
North Carolina State University
Raleigh, NC 27695

Mary Ann Lila Smith
University of Illinois
Dept. Natural Resources & Environ.
Sciences 1201 S. Dorner Drive
Urbana IL 61801

Steve Sonka
National Soybean Research Lab
170 NSRC
1101 W. Peabody
Urbana IL 61801

Robert Streiffer
University of Wisconsin-Madison
5185 Helen C. White
600 N. Park Street
Madison WI 53706

Mickie Swisher
University of Florida
Dept of Family, Youth & Community
Services
PO Box 110310
Gainsville FL 32611

Louisa Tabatabai
Iowa State University
PO Box 2484
Ames IA 50010-2484

Dennis Thompson
University of Illinois
Illinois Crop Improvement
Association
PO Box 9013
Champaign IL 61826-9013

Randy Thompson
Doane Marketing Research Inc.
1807 Park 270 Drive
PO Box 46904
St. Louis MO 63146

Dirk-Arie Toet
Nestle
Ave Nestle 55
Vevey, Vaud 1800
Switzerland

Cheryl Toner
International Food Information
Council
1100 Connecticut Ave., N.W. Suite 430
Washington DC 20036

Ronald Triani
Kraft Foods
801 Waukegan Avenue
Glenview IL 60025

Donald Uchtmann
University of Illinois
335 Mumford Hall
1301 W. Gregory Drive
Urbana IL 61801

Allen Underwood
Helena Chemical Company
7664 Moore Road
Memphis TN 38120

Neal Van Alfen
University of California
College of Agric. and Environmental Sciences
One Shields Ave
Davis CA 95616

Antoine Van der haegen
European Commission Delegation
2300 M St., NW
Washington DC 20037

Alison Van Eenennaam
Calgene LLC
1920 Fifth Street
Davis CA 95616

John van Es
University of Illinois
214 Mumford Hall
1301 W. Gregory Drive
Urbana IL 61801

Seymour Van Gundy
University of California Riverside
1200 University Ave. #336
Riverside CA 92507

Kent Velde
Velde Capital Advisors, LLC
3424 N. Shepard Avenue
Milwaukee WI 53211

Dennis Vicchiarielli
World Business Chicago
Director of Business Development
203 N. LaSalle St., Suite 2300
Chicago IL 60601

Kraig Wagenecht
Illinois Council on Food and Agricultural Research
University of Illinois
1101 W. Peabody
Urbana IL 61801

Tony Waldrop
University of Illinois
420 Swanlund
601 E. John
Champaign IL 61820

Brian Wansink
University of Illinois
350 Wohlers Hall
Champaign IL 61820

A.L. Warren
Monsanto
700 Chesterfield No. Pkwy.
Chesterfield MO 63198

Prem Warrior
Valent BioSciences Corp
6131 RFD Oakwood Rd.
Long Grove IL 60047

Joyce Watson
100 S. Campbell
PO Box 160
Macomb IL 61455

Sam Weaver
The Quaker Oats Company
617 West Main Street
Barrington IL 60010

Don Weeks
University of Nebraska
Room N158 Beadle Center
Lincoln NE 68588

Greg Weideman
University of Arkansas
Bumpers College of Ag, Food &
Life Science
AFLS E108
Fayetteville AR 72701

Lynn Westgren
National Soybean Research Lab
165b NSRC
1101 W. Peabody
Urbana IL 61801

Randy Westgren
University of Illinois
Mumford Hall
1301 W. Gregory Drive
Urbana IL 61801

James Weyhenmeyer
University of Illinois
377 Henry Administration Building
506 S. Wright St.
Urbana IL 61801

Mike Williams
Illinois Department of Agriculture
State Fairgrounds
PO Box 19281
Springfield IL 62794-9281

Wendy Wintersteen
Iowa State University
138 Curtiss Hall
Ames IA 50014

H. Alan Wood
Life Sciences & Biotechnology
Institute
Mississippi State University
Box 9758
Mississippi State MS 39762

Randy Woodson
Purdue University
1140 AGAD Building
West Lafayette
IN 479071140

Gouchen Yang
North Carolina A&T State University
231 Carver Hall
1601 E. Market St.
Greensboro NC 27411

Robert Zeigler
Kansas State University
4024 Throckmorton Hall
Manhattan KS 66502

Appendix I

Script for the Mock Debate

MARY ANN LILA SMITH
University of Illinois,
Urbana, IL

COLIN SCANES
Iowa State University,
Ames, IA

The mock debate was presented to introduce the theme and structure of the upcoming workshop sessions to the assembly of NABC 2001 attendees. The participants were:

- Moderator, Ralph Hardy, NABC President
- The affirmative team, both portrayed by Mary Ann Smith
  — Professor Norton, land grant university faculty member and proponent of GM technology,
  — Ms. Braun, corporate representative for a major biotech firm, and proponent of GM technology
- The negative team, both portrayed by Colin Scanes
  — An incognito aristocratic English gentleman/organic farmer, and opponent of GM technology
  — Damon Proudon, founder of an anti-technology activist group, and opponent of GM technology

Moderator: Good morning. I am Ralph Hardy, President of the NABC, and I will be acting as the moderator this morning for a brief mock debate that will set the scene for the workshop breakout sessions to follow.

Let me make the following disclaimer before we begin: although we are, in fact, dealing with real issues and controversies here, the following presentation is a *mock* debate, between fictitious characters. Any resemblance of any of the participants to real people, dead or alive, is purely coincidental. Let me tell you, I cannot imagine that any of you could ever mistake any of these characters for real people, but I just wanted to make this crystal clear.

We are gathered today to hear informed arguments on both sides of the issue in The Great Agricultural Biotechnology Debate. The resolution is:

> *Be it resolved: that GM technology is a sound and safe innovation, and should be permitted in the food chain without restrictions.*

We will feature two opposing teams. Our first spokesperson is Professor Norton, a member of the faculty at a large land grant university. She is a strong proponent of GM technology and a long-time researcher in molecular techniques for improvement of vegetable crops. Professor Norton will speak in favor of the resolution.

Our first negative spokesperson this morning is a distinguished gentleman from the United Kingdom who wishes to remain anonymous. However, I will say that he is a part-time organic farmer, and a member of a very prominent, upper-crust family. His Highness—excuse me, I meant to say—our anonymous gentleman is strongly opposed to the resolution, and will give arguments why biotechnology must not be permitted into the food chain.

Professor Norton will begin with a statement in favor of GM technology.

Professor Norton (in white lab coat, latex gloves, and safety goggles): Good morning. As a seasoned member of the scientific community, I can tell you that recombinant DNA techniques are nothing to be alarmed about. There is nothing remotely dangerous about this simple, straightforward technique that careful scientists like myself use brilliantly to improve your foods, and contribute substantially to your quality of life! I really don't understand what all the fuss is about!

There seems to be a lot of confusion about agricultural biotechnology, and I'm sure that I can help by explaining the basics of the science in simple, easy-to-comprehend terms that will make it clear to all of you. Surely once you realize how harmless this process is, all your fears will disappear!

Lets go to a few slides please—

Moderator: But professor, this is a formal debate, we weren't planning on showing slides.

Professor Norton: Pay attention, son. I'm a university professor. Of course I'm going to show slides. If you'd just dim the lights please…

We begin with deoxyribonucleic acid, or you can call it DNA for short. In plants and animals, genes are packaged here in chromosomes that carry the DNA—all the genetic information.

(slide: a DNA molecule)

Quite simply, we take a valuable, good slice of DNA from one organism, and transfer it to another organism, in order to give the wholesome qualities of one plant to another. Let's just say we've taken a valuable gene from a healthy wild weedy plant, and use it to transform a garden vegetable or fruit. Usually we insert the gene of interest into the new plant with a nifty little device called a "gene gun."

(slide: a bullet passing through an apple)

Then we go through a simple series of steps to ensure that the gene of interest is present in the new and improved fruit or vegetable—this involves a series of specific steps—

(slides: a series of a dozen rapid-fire, highly complex figures from molecular genetics journals)

—I really don't have the time to go into the specifics here—you wouldn't understand it anyway—just trust us. We are scientists and are trained to do these steps flawlessly. Really very little could go wrong here. It is really quite marvelous. And after the process is completed, the final product is a dramatically improved fruit or vegetable variety for the betterment of mankind!

(slide: a truck-sized tomato)

Thank you very much.

Moderator: Thank you, professor. Next, we'll give our incognito gentleman a brief opportunity to question the professor's argument: your highness?

Anonymous gentleman organic farmer (in designer suit with cravat, and with an obvious regal bearing): Professor, I really must take issue with your statements. There is a sacred trust between mankind and our Creator, under which we accept a duty of stewardship for the earth! The task of growing food must not take place in the laboratory, but must be left where it belongs, in the hands of the Almighty helped by the traditional farmer!

Professor Norton: I assure you that the farmers are quite happy to be growing our improved GM vegetable crops!

(slide: happy farmer with large tomato)

Anonymous gentleman: Professor, if literally nothing is held sacred, what is there to prevent us treating our entire world as some "great laboratory of life," with potentially disastrous results? We want some control over the changes you are proposing! We want some assurance that indeed this process is safe! We want testing, and we want labeling of genetically altered products!

Professor Norton: Well, we can't always have just what we want, can we?

(slide: Harrison Ford)

Moderator: All right, it's time to move on. Next, we'll hear counter arguments from the anonymous regal gentleman.

Anonymous gentleman: My good people, it is a very distinct pleasure to be in this august body. I am going to speak on areas of belief and faith. I am going to advocate a dismissal of this *(disdainfully)* "biotechnology." I am greatly distressed by this frivolous, artificial and uncontained transfer of genes between species of plants and animals. I advocate a return to the tried and true methods of our past.

In the area of medical biotechology, pharmaceutical companies spend vast sums on the manufacture and testing of synthetic drug products that can yield even vaster profits. Complementary and alternative medicine are as good as orthodox medicine, or, even in some instances, are better.

Similarly in agriculture, the future will need people who understand that sustainable development is not re-engineering Nature in an extension of global industrialization, but a reconnection with Nature—re-discovery of the essential unity and order of the living and spiritual world as in the case of organic agriculture and integrative medicine.

I happen to believe that if a fraction of the money currently being invested in developing genetically manipulated crops were applied to understanding and improving traditional systems of agriculture—which have stood the all-important test of time—results would be remarkable.

One of the most commonly raised arguments by those in favor of GMOs is that they are necessary to feed the world. No one in their right mind would resist a technology that would solve the world's food shortages, if that were the one way forward. But where people are starving, lack of food is rarely the underlying cause. It is likely lack of money to buy food, distribution problems or geopolitical issues.

Agricultural research stations, all over the world, have begun to concentrate almost exclusively on biotech approaches. I can see why this is happening. To a researcher, such work is new, it is *modern*, it is exciting, and it attracts lucrative commercial sponsorship.

The best place to start looking for sustainability is in the traditional farming systems that have stood the test of time. But, of course, they can be improved

by the application of new knowledge and modern equipment. The common features of sustainable approaches include making the best possible use of natural and regenerative processes and human ingenuity and teamwork.

Of course, whether sufficient surpluses can be generated to feed the teeming millions in the world's cities is another matter.

There is a sacred trust between mankind and our Creator, under which we accept the duty of stewardship for the earth. I oppose the artificial and uncontained transfer of genes between species of plants and animals. We should show greater respect for the genius of Nature's designs—rigorously tested over millions of years.

In summary, I wholeheartedly advocate that we scorn and abandon this GM technology in its entirety, and move back into a pure, wholesome, organic method of farming.

Moderator: Next, our second affirmative speaker has a chance to briefly question this gentleman's arguments. Ms. Braun is, in fact, an executive in a major commercial biotech industry. Ms. Braun, you may proceed with questions for your opponent.

Ms. Braun (in business suit, with a briefcase and a pocket bulging with cash): Well, I had intended to offer rebuttal comments to refute the arguments of my obviously arrogant opponent here, but shoot—that accent of his—I couldn't understand half of what he said, could you? In any case, I do not believe that his lame arguments have any real validity. They do not deserve a response. Who is he to question what we are doing? He's just another scientific illiterate.

I would rather just deliver my counter-arguments in favor of GMOs now, Mr. Hardy.

Moderator: Very well. Ms. Braun will now provide rebuttal statements, and provide additional evidence to make a case for GM adoption. Ms. Braun, please proceed.

Ms. Braun: I would like to point out to this audience that we in the biotechnology industry are on a mission of great consequence to help meet the demands for food and fiber in this rapidly expanding global economy.

Our sales in the US of bioengineered crops are $200 million a year, and growing. These products—all thoroughly and rigorously tested—are now everywhere on your supermarket shelves.

The campaign of fear now being waged against genetic modification is based largely on fantasy and a complete lack of respect for science and logic. Genetic modification can reduce the chemical load in the environment, reduce the impact on non-target species, and reduce the amount of land required for food crops. There are so many real benefits from genetic modification, compared to

the largely hypothetical and contrived risks, that it would be foolish to ban genetic modification.

Farmers across the country know that the benefits of biotechnology are real and very significant—not just for agriculture, but for consumers as well. For example, the Bt trait provides corn and cotton crops with natural resistance to pests that can cause tremendous damage. This in-plant protection provides a terrific environmental benefit because it lets farmers use less pesticide and in a more precise manner. Herbicide resistance in certain corn hybrids, and in some varieties of cotton and soybean, gives farmers the opportunity to effectively control weeds with fewer applications of more-benign products. These are just a few of the reasons why American farmers strongly support continued access to products of biotechnology, including all of those produced by our company.

This reduced use of chemicals and the fact that we now make a lot fewer trips over our fields with equipment are big pluses for the environment. These products also improve our efficiency tremendously. Economically and environmentally, American farmers and consumers cannot afford to lose access to the products of biotechnology. Those are the facts, pure and simple, in black and white, and in dollars and cents. I am sure that my opponent will be unable to find any way to disagree with the value biotech adds to our lives.

Moderator: And now a rebuttal and further opposition case-building from our second negative spokesperson, Damon Proudon, who is a founding member of an activist organization opposed to all technology and globalization.

Mr. Proudon (in tie-dyed shirt, with long, wild hair, and a placard stating Ban the Genes*):* I don't know why I'm here. I guess it's a token gesture. The establishment always plays these games. Well I can play the game as well as anyone.

I'm going to defend my position that GMOs need to be banned from this earth. I even wrote stuff down from the web. A teacher at Hunter College in New York described it for real:

> *We are rolling to ecological collapse: rapid climate change and rising seas; ozone holes; loss of species and habitat; accelerated cancer rates; terminal forms of air, water, and soil pollution, as well as social, political and personal alienation and despair. All are rooted in the excesses of technology.*

In the era of economic globalization, the problems are magnified a million-fold. All-powerful global bureaucracies, such as the World Trade Organization, are preventing communities and nation-states from slowing the rate at which global corporations freely exploit the planet, dominate social systems, destroy local economies, and deploy the most powerful and dangerous technologies in history.

Why have there been no referenda on the most dangerous technological trends: nuclear, biotechnology, transport, the globalization of industrial agriculture, corporate power, and global media concentration?

Ralph Nader—who spoke to this group last year during his heroic campaign for the presidency—is very clear about biotech:

> *Genetic engineering has far outrun the science that must be its governing discipline…unknowns beg for investigation, before biotech corporations or their indentured researchers introduce unintended hazards into the environment.*
>
> *Corporate greed has eclipsed sound science and the humility and caution that should be manifest. The result has been a rush to introduce genetically altered seed into the environment without adequate testing; a frenzy to patent genes, seeds and life forms and to extend monopolistic control over the very material of life (and) to foist genetically food on an unknowing public who would reject biotech food if notified and given alternatives.*

These genetically modified crops are such a con. Farmers have to buy seed every year. They can't just keep their seed. They have to buy pesticide—more and more of it—and it gets in my food. They've even come up with a way of making seeds that won't grow. The so-called terminator technology. I call it robbing poor farmers.

You say you'll feed the world, but biotechnology will increase hunger as farmers will be forced off their land or become serfs to the global ag-business monopolies.

Genetic engineering destroys the fragile environment; look at the monarch butterfly! I bet the scientists involved have felt pressure from the corporations! A scientist in Scotland got kicked out for coming up with the wrong results! Why should farmers in Africa and India be forced to buy genetically altered seed? You get monocultures and low yields unless they buy pesticides and artificial fertilizer from the same corporations.

I read somewhere that organic food can have much higher yields than these GMOs and hybrids, but farmers don't believe it because of the conspiracy between the monopoly corporations and the government—most of whom come out of big corporations and then go back to them with lots of money—and those supposed universities with all their corporate dollars. “Frankenfoods” are the result of corporate greed.

You scientists are in league with these global corporations and their governments. You want science based policy, yet when it comes to global warming caused by the same monopolies, what happens? I'll tell what happens: nothing! Kyoto scrapped! Surprised?

Why should we have hidden genes lurking in our food? “Frankenfoods” are being forced on us. If the “frankenfoods” are so good and safe why don't you label them? Give me an answer! What are you so afraid of? What are you hiding?

Why are you experimenting with my food? Tampering—playing around? You just can't trust corporations who brought us global warming, nuclear power and bombs, pesticide-laden food, and high gas prices. Again we see evidence for a conspiracy between the multinational corporations and the government.

Moderator: We can now entertain cross-examination questions from our two teams: Ms. Braun? Mr. Proudon?

> (They throw jibes and taunts at each other and argue out of format. Eventually the exchange ends with hotel security escorting Mr. Proudon from the room.)

Moderator: (to the audience) This brief mock debate was intended to demonstrate that in the raging controversy over GMOs, there are strong positions ‘for’ and ‘against,’ but often the proponents are not on the same wavelength and don't address the same sets of facts or beliefs.

Our task in the workshops will be to examine the GM debate from a number of different viewpoints. We will have the opportunity to explore the debate arguments—those we think are valid, and those we may think are frivolous—in greater detail, and will have the chance to thoughtfully develop arguments and counter-arguments on the issues from the distinct perspective of a particular camp: consumer advocate, European politician, developing country farmer, corporate biotech spokesperson, university scientist, environmentalist, government regulatory agency, and so on. Hopefully, no matter which side you are asked to take, you will be able to develop arguments that are at least as cogent as those managed by the spokepersons we just heard.

Appendix II

Partisan Assessments of Information Concerning Genetically Modified Foods: Preliminary Results

ALBERT C. GUNTHER AND KATHLEEN SCHMITT
University of Wisconsin
Madison, WI

The hostile-media perception—the tendency for partisans on an issue to judge mass media coverage of that issue as hostile to their own point of view—has been vividly demonstrated, but not well explained. This is a particularly intriguing and important question because this perceptual bias seems to contradict a robust literature on assimilation biases: the tendency to find information more supportive, rather than more opposed, to one's own position.

We attempted to verify this bias as a media effect and reconcile it with assimilation biases by presenting identical information in both a mass-media and a student-essay context, something no research has previously attempted. (We also tested several processing explanations, but those tests are not included in these results.)

Attendees at *High Anxiety and Biotechnology: Who's Buying, Who's Not, and Why?* and attendees at an annual meeting of an organic food cooperative were invited to take part in a survey. Responses of those who indicated that they held a strongly partisan position—either as GM-food proponents (some of the participants at NABC meeting) or as GM-food opponents (at the organic food cooperative meeting)—were selected for analysis (N=153).

Participants were randomly assigned to read identical information presented as either a news article or a college student's essay. They answered a questionnaire about their perceptions of bias in the article/essay: whether the article/essay was

- biased in its portrayal of GM foods,
- biased in portrayals of supporters or opponents of GM foods,
- biased in the percentage of favorable vs. unfavorable content,

and whether the author was personally biased.

We found that partisans on opposing sides of the issue generally saw the same information as disagreeably biased in a news-story format, but as neutral or even favorably biased in the student-essay format. In addition, there was suggestive evidence that the media aspect of the hostile-media perception can be explained by the perceived reach of the information source.

The data will be published in full elsewhere.

Index

NATIONAL AGRICULTURAL BIOTECHNOLOGY COUNCIL
Boyce Thompson Institute, Rm. 419
Tower Road
Ithaca, NY 14853
Telephone: 607.254.4856 Fax: 607.254.1242
E-mail: NABC@cornell.edu
http://www.cals.cornell.edu/extension/nabc

Printed on recycled paper