Preparing for the Future

A report prepared by the USDA Advisory Committee
On Biotechnology and 21st Century Agriculture

The USDA Advisory Committee on Biotechnology and 21st Century Agriculture (AC21) has been charged with helping USDA and the Secretary of Agriculture understand how biotechnology will change agriculture and USDA's role over the course of the next decade. This is a daunting task. Agricultural biotechnology[1] sits at the crossroads of other debates on the future of American and world agriculture, on international trade relations, on biological diversity and the development of international instruments related to its preservation and exploitation, on the role of multinational corporations, and on how best to build public confidence in rapidly emerging technologies in general. And, as all this occurs, the science continues to advance rapidly.

Neither the AC21, nor anyone else, can say with certainty what U.S. agriculture will look like in a decade. But we can try to examine different scenarios. This does not imply that we are predicting or endorsing any given scenario,[2] but rather that we are trying to understand the implications of differing outcomes.

A range of external forces and factors, some of which can be identified today, will impact the future of technology adoption. To help understand the range of possibilities, we have divided our work into two major components. First, what are the key predetermined factors—the major driving forces—that will likely have a major impact on shaping the future? Second, what are the key uncertainties that may push future outcomes in one direction or another?

WHAT WE KNOW (OR THINK WE KNOW)

What are some key drivers likely to influence the next decade, regardless of other uncertainties?

The AC21 has honed in on the following:

An increasing world population, especially in poor, non-Western countries, is leading to growing global food and feed needs. World population is not expected to level off until mid-century. This will require increased productivity from agricultural lands and could increase encroachment on non-agricultural lands, especially if agricultural productivity (e.g. production per acre planted) does not keep pace with increases in global populations..[3]

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[1] Biotechnology is a range of tools, including traditional breeding techniques**,** that: (1) alter living organisms (or part of organisms) to make or modify products; (2) improve plants or animals; or (3) develop microorganisms for specific uses. Much of the discussion of biotechnology in this report focuses on "products of modern biotechnology" and "transgenic (or genetically engineered) organisms" (or their products), namely organisms produced through genetic engineering or recombinant DNA processes, and products derived from them.

[2] Several authors have detailed the methodology of scenario planning, including Peter Schwartz, in "*The Art of the Long View.*"

[3] Although population growth has slowed somewhat over the past decade it continues to expand in absolute numbers, particularly in the developing world. http://www.census.gov/ipc/prod/wp02/wp-02001.pdf

Regional prosperity leads to increased meat consumption. As income in developing countries rises, there has been and will continue to be a substantial increase in world demand for commodity crops, especially for animal feed use. India and China are likely to be the key drivers of additional demand for US agricultural commodities.[4] Food sufficiency (or excess) in developed nations will continue to be a major challenge.

There will be an aging Western population, relative to developing nations. This population will continue to exercise significant purchasing power. Countries will face growing demands on their medical system. Research and treatment-mitigation-prevention of chronic diseases will be ever more important. Many products will be launched in the attempt to maintain the health of this population. Massive Social Security and health care costs will become a substantial drain on national budgets, reducing resources for other sectors of the economy.

Farmers in the US and globally will continue to have broad options and make planting decisions based on the value of the products produced with their production systems on their farms. The cost of production coupled with commodity prices will drive farmer decisions on crops and seed varieties.

Increasing public concern with health and nutrition, and increasing scrutiny by consumers, especially in developed nations, will drive change in the food system. Many people are demanding ever more information about the food they're eating, stimulated in part by the wide availability of increasingly sophisticated information technologies. The combination of escalating interest in information and technological advancements will result in increasing traceability and sophisticated, multiple product channels from farm to shelf.

Faced with growing abundance and increasing variety of food products, consumers in wealthy countries will be become increasingly selective about the products they buy. There will be increasing consumer demands for convenience, information about ingredients, safety, and methods of production.

There will be a trend toward increased consumer interest in, and awareness of, methods of food production. Developed country marketplaces, in particular, will be crowded with production labels, some of which, like organic, may be based on third-party or government verification. Consumers will continue to rely on governments and regulatory agencies to assure the safety of our food and safety of our crops to the environment.

The food marketplace will continue to experience rapid changes in demand based on consumer perceptions of health. These trends—pro- or anti-meat, pro- or anti-carbohydrates, will continue to produce big swings in food choices.

Global malnutrition and hunger will continue to be a major issue. Despite aggregate global food sufficiency, global hunger, malnutrition, and insecurity will persist, with the

[4] http://www.agribusiness.asn.au/review/1998V6/chinameat.htm

most pervasive impact in the world's poor countries but also among disadvantaged populations in wealthy countries.

Obesity will increase in importance as an issue. In the US over 64% of males and 62% of females are obese or overweight.[5] The increasing trend toward obesity shows little signs of abating, and is one of the factors driving up the costs of medical care. Concerns about this trend are focusing attention on current western diets and lifestyle practices, and may lead to changes in those diets that could lead to changes in demand for certain foods.

The trends toward urbanization and agricultural mechanization will continue. Fewer people will be involved in producing crops. This trend is driven by commercial agriculture and encourages standardization and consolidation.

Knowledge is driving changes in the economies of all nations. The dissemination of technology will continue to create momentum for innovation. New technologies and the resulting products are being picked up by scientists and entrepreneurs in countries all over the world (with or without respect for intellectual property). These new ideas and capabilities will drive social and economic change within and beyond the sphere of the industrialized countries. On the individual level, the advantages of widely available information will be counterbalanced by the problems of information overload and the unreliability of widely disseminated information.

Life sciences research will continue to expand on both the basic and applied fronts. Exponential increases in biological information contained in gene and protein databases will continue, although the rate of new product deployment based on that information is not likely to match the exponential rate of information generation over the next decade. In medicine, genomics data may lead to new disease treatment strategies and identification of new drug targets. In agriculture, such information will lead to a growing set of new tools and products, including biosensors and diagnostics, to enhance productivity. The biomedical research establishment will remain a powerful interest group in the United States.

Global trade and economic policies will remain important drivers of agricultural policies. There will be increasing pressure in the World Trade Organization on developed nations to liberalize agricultural policies. Bilateral trade agreements will continue to proliferate. Concerns about biotechnology are very likely to be used by U.S. competitors as non-technical trade barriers to modulate trade. Food will continue to be treated differently than other traded goods.

The United States will remain a dominant global power. The U.S. will retain its position as a leader in technological developments in medicine and agriculture. The U.S. will also continue to empower other nations and spread democracy, but our dominant world position will continue to breed resistance, resentment, and competition.

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[5] http://www.niddk.nih.gov/health/nutrit/pubs/statobes.htm#preval

EU regulations and consumer preferences will continue to impact world agricultural production systems. The expanded European Union will remain a huge market for global agriculture.

Increasing "South-South" dialogue in trade and political forums will increase the influence of China and India on other developing nations and enhance their global clout. The next decade will see the emergence of China as a growing challenge to US dominance.

Water issues will become increasingly important domestically and internationally. There will be increasing pressure on fresh water supplies, and less water will be available for agricultural uses. Overall world fresh water quality will decline. Linkages between water conservation, new agricultural technologies, and no-till agriculture will become increasingly important.

Global climate change will become increasingly important. The quantities of CO_2 and other greenhouse gases in the atmosphere will increase, and the window of opportunity for preventing global climate change will close. International efforts will increasingly focus on slowing and mitigating changes underway. The increase in global CO_2 levels will be exacerbated by rapid industrialization in many developing countries, especially China. Response to global warming could lead to major changes in agricultural production patterns or energy policies.

Globally, there will be decreasing availability of arable land currently cultivated, due to urban encroachment, conservation needs, non-sustainable farming practices, and soil degradation. This will increase the pressure on agricultural productivity, open new lands that may be less suitable for agriculture and/or will continue to increase species extinction pressures, especially in developing countries.

The increasing price and diminishing supply of fossil fuels will become an ever more urgent concern for U.S. agriculture. Worries about fossil fuels, coupled with new technology advances, will drive the development of bio-based fuels. In addition, high energy prices could constrain the use of synthetic fertilizers in the U.S. and also pose a challenge for the long-term viability of new agricultural lands that are dependent on large fertilizer inputs.

Increased global trade and travel will continue to increase the potential for new emerging diseases as well as more rapid disease transmission for plants, animals, and humans. Changing agricultural systems, new lands opened to agriculture, and climate change create new opportunities for agricultural diseases. Human infectious diseases, including, prominently, AIDS, and perhaps malaria, tuberculosis, and influenza, will increase in importance as issues. Allergies (including food allergies) and asthma are also likely to increase.

Enormous new agricultural commodity production areas will come on line in South America, particularly in Brazil and Argentina. There will be tremendous pressure and structural change in the soybean market. This could have implications on the U.S. export of soybeans.

The agricultural commodity system will continue to be dominated by 4 crops: corn, soy, wheat, and rice. Tensions may develop as non-food uses for some or all of these crops compete with food and feed uses for agricultural land and resources.

The trends toward consolidation and globalization will continue. These trends will increase vertical integration along the food chain, and increase the use of monocultures in crop production on larger farms. Consolidation in the global food industry, and the increasing market power of large food retailers, such as Wal-Mart or McDonald's, will continue to exacerbate the domestic or worldwide influence of a few marketing decisions on the availability or use of transgenic-derived ingredients and products.

High levels of debt and large budget deficits will persist in industrialized nations. Resultant budgetary pressures will increase the importance of agricultural trade, historically a major contributor to the export side of the U.S. trade ledger.

WHAT IS MUCH LESS CERTAIN

While the list of things we don't know is necessarily far longer than the previous list, the AC21 would like to focus on some of the key uncertainties whose outcomes could directly shape the future for agricultural products, including biotechnology products.

Disruptive events.
A broad variety of events could have a strong positive or negative impact on the public's perception of the application of biotechnology to agriculture. Potentially, these range from rapid global adoption and support for biotechnology from countries like China, Brazil, Russia, India, etc. and rapid production of biotechnology products to issues that could negatively impact biotechnology acceptance like acts of bioterrorism (directed toward agriculture or not) to the emergence of significant new agricultural diseases that cannot be controlled through conventional means. Regional famines could require significantly increasing food aid shipments. Accidents involving contamination of the food supply with a product(s) not intended or appropriate for use in food could have serious consequences.

Demographic uncertainties.
Increases in food and commodity consumption linked to world population are also tied to global wealth creation. Increasing world demand for food, especially meat, will be linked to the level of growth and wealth creation in key countries like China and India. Changes (whether short- or long-term) in dietary preferences in developed countries, e.g., low-carbohydrate diets, could also impact the demand for key agricultural commodities. Aging populations in developed countries may express changed dietary preferences: one could as easily expect to see increased demand for new, "health-improved" products,

and/or a trend toward consumption of organic-based products, or to see no particular net shifts.

Political uncertainties.
Political and economic decisions by key trading partners or competitors can have a major impact on the ability of biotechnology products to be produced and sold competitively. The political stability of key market countries such as China and India could significantly impact agricultural trade. Further escalation of Middle East conflicts could also affect trade. Will the European Union, a decade from now, be increasing access for biotechnology-derived crop varieties and growing them as well? What will be the impacts on the use of transgenic varieties of implementing multilateral agreements, such as the Cartagena Protocol on Biosafety or future agreements under the World Trade Organization?

Technological and regulatory uncertainties.
The product landscape and the regulatory landscape for new transgenic-derived products are evolving. With an evolving regulatory system, it is uncertain how quickly new applications (as food, seeds, drugs, or new industrial compounds) will reach the marketplace, here or in other countries. Which products will make it to the U.S. or global marketplaces, who will reap the benefits, and where? Will new products developed using the wealth of new genomic information be transgenic varieties, or will they be non-transgenic varieties developed through knowledge-based, marker-assisted selection techniques? Will food safety issues arising in conventional, organic, biotech, or other new production systems lead to a need for new regulation? Will US farmers continue to be concerned about their ability to compete with farmers in South America and China?

Will concerns regarding the deployment of transgenic plants producing plant-based pharmaceuticals in food crops inhibit or severely restrict their cultivation? Will production of these or other products move offshore in response to economic or regulatory considerations? Will transgenic products with significant consumer pull, perhaps "nutriceutical products" or others, reach the marketplace in any quantity? To what extent will parallel technologies emerge that may compete with transgenic products for use in agriculture?

Environmental uncertainties
Will serious effects of global warming become pressing within the next decade? What will be the price of fuel or energy? Will agricultural systems be increasingly looked at as solutions to global problems, such as energy needs or global warming?

Consumer uncertainties
The public's receptiveness to increasingly novel products that may come to market is unknown. Such products could include transgenic animal-derived products, plant-derived food products engineered to offer specific health benefits to consumers, and plants and livestock producing pharmaceutical and industrial compounds. Will such products drive consumer acceptance or raise new concerns and/or resistance?

Will consumer opinion regarding biotechnology remain changeable, or will views harden? Will there be a consumer backlash against the market power of some large conglomerates? Will concern over the implication of other applications of new technologies, e.g., human cloning, spill over into perceptions related to the use of transgenic organisms in agriculture?

Agriculture and food system uncertainties.
How will agricultural land use change over the next decade? What proportion of agricultural land will continue to be used for food production versus other uses? Economics or technological innovations could drive significant expansion of crop production for bio-energy, industrial feedstock purposes, or other novel uses. Could such uses change the overall economics of commodity production? What will be the global distribution of large-scale bulk commodity production in a decade? Will new transgenic crops that are commercialized be mostly intended for bulk use or will there be increasing commercialization of products for niche markets?

Down the food chain, actions by major players in the food system could dramatically alter the landscape for new transgenic products. Food franchises, supermarket chains, and mega-retailers will evolve over the next decade. What will they look like, how much consolidation (or global expansion) will there be, what will the future companies look like, and what will be their attitudes towards products containing transgenic-derived ingredients and what ingredients will be generated that may influence consumer attitudes?

ENVISIONING A FEW POSSIBLE FUTURES

The numerous uncertainties above (and probably a host of others) could propel a myriad of possible futures, depending on how events play out regarding each of them. Neither the AC21 nor USDA is in a position to predict what will actually happen. However, the AC21 believes it is useful to provide examples of possible futures, which are intended to illustrate how resolution of key uncertainties in particular ways could shape the future for the use of transgenic organisms in agriculture and the work of USDA. The scenarios share the certainties, but how the uncertainties play out influence how the scenarios are shaped.

Each scenario is intended as a coherent description of what the world might look like a decade from now, after events driven by the certainties and some of the key uncertainties listed above play out.

These are <u>not</u> predictions of the future, nor are probabilities or likelihoods assigned to them. They were created to provoke thought over a wide range of possibilities, so no single scenario should be considered in isolation.

Indeed, we can be relatively certain that when we look back a decade from now, none of the scenarios will have accurately represented what actually occurred in the interim. Nor do they represent the full range of conceivable outcomes. However, they do demonstrate the sensitivity of agriculture and the food system to events that can tip the future in different ways, and, looked at together, provide an opportunity to extract additional knowledge about broader impacts into the future.

Here, then, are three scenarios we have created, among the many that could be developed. We have entitled them "Rosy Future," "Continental Islands,", and "Biotech Goes Niche." Using and adding to the list of certainties and uncertainties, you can build your own scenarios.

Because each of these scenarios has implications for farm income, consumers, the environment, trade, private investment, USDA agendas, and resources, we advise you to read these scenarios without making value judgments or picking a favorite. Instead, we advise you to consider the consequences of each if the scenario or some version thereof came to pass. After outlining the three scenarios, we will pose a series of specific questions that could help you work out some of the implications.

I. "Rosy Future"

By 2015, life science research delivered beyond anyone's expectations. Like those involved in the information technology revolution, even those doing the research and investment were overwhelmed by the scale and speed of change. Among the new products were crops with increased yield, resistance to key stresses like drought, plants engineered for new energy uses, including production of biodiesel, and new food products that provide valuable health benefits. In addition, plants with various combinations of traits significantly increased the utility or impact of these new crops.

Agricultural biotechnology began being employed all over the world, not only in agricultural exporting countries. Research and development continued in the Western world and in those developing countries whose governments quickly recognized the opportunities and were able to provide an appropriate investment climate. European nations continued their development of new ag biotech uses for pharmaceutical, industrial, and energy products. European opposition to food uses decreased significantly as EU governments, non-governmental organizations, and consumers realized the value of increasing agricultural productivity on GDP and competitiveness.

More food could be produced on less land, which was fortunate because, as Chinese and Indian incomes rose, demand for animal feed exploded. Had the new transgenic products not come on line, meeting demand would have required bringing enormous amounts of new agricultural land under cultivation.

Farmers now faced a much more complex world with an even broader array of crop and seed variety options. Their acreage could now be used not just for food, feed, and fiber production, but also for chemical, pharmaceutical, and energy production. This meant that they could participate in, and had to understand and follow, a wider range of markets, financial instruments, and opportunities. Niche and small family farming became profitable because of the high value of some transgenic products grown on farms. Non-food uses for crops became increasingly economically important, but remained high value, low acre opportunities.

Overall farm and agribusiness income increased and there was ever less dependence on subsidies. Alternatives like converting biomass to energy meant there was now a floor price on grains. Why sell a bushel of corn for food or feed at the government loan rate if energy companies would pay more? In addition, because the increased number of agricultural biotechnology products and uses reduced the need for subsidies, trade wars became less of an issue.

An increasingly sophisticated and broad set of companies established partnerships with various segments of the agribusiness chain. Pharmaceutical companies used their new networks of seed producers to begin growing various medicines and vaccines. Some forms of animal husbandry became far more specialized, regulated, and profitable as areas like medical and materials production grew. Information, computing, and diagnostic companies became increasingly involved in this process. Energy companies began to invest in bio-based energy. Governments began permitting the establishment of carbon trading enterprises based on an increased focus on global warming. Farmers, particularly those using biotech products in no-till agriculture, began to capitalize on these new market opportunities.

As various conglomerates began to integrate technologies and outlets, mergers and acquisitions blossomed on a very broad scale. Bioinformation companies merged with financial companies. Mergers between seed companies and chemical-pharmaceutical companies continued. Some energy companies began developing broad portfolios of alliances and acquisitions outside the traditional energy business.

Companies began seeing more and more diverse business opportunities. Even with increased global competition, for U.S. companies the overall opportunity "pie" was growing faster than the increase in competition.

Some medicine-producing goats were worth hundreds of thousands of dollars and were cared for as carefully as human patients in a hospital. Highly specialized animal products for xenotransplantation[6] merged the most sophisticated laboratories and boutique farms.

Within the food system, a series of niche markets serving different "nutriceutical" needs provided farmers with far more specialized markets and opportunities. Foods engineered to help people lose weight or ward off certain diseases exploded off supermarket shelves. This created consumer pull for a wide range of new farm products and a much broader acceptance of biotechnology. Further integrating the grocery industry and food processors with projected crop needs became ever more important. As niche crops became more important, often a farmer's whole crop was sold prior to planting, as long as it met strict quality criteria. Some environmentalists throughout the developed world continued to worry that the increasing rate of new product introductions could lead to a serious accident, but so far this had not occurred.

Farmers adapting to the new technologies became more profitable regardless of farm size. Those who did not adapt had a harder time and were replaced by more technically sophisticated producers. For high value crops, production became highly vertically integrated, continuing existing trends in that direction.

Most of the innovations took place in major crops, but some improvements to minor crops took place and began to change cropping patterns in the U.S. and elsewhere.

Maintaining the integrity and traceability of the streams of products coming off the farm and into various supply chains including chemicals, energy, cosmetic, and food became ever more important. This meant that much of the production during the first years of this broad biotech

[6] "Xenotransplantation" refers to transplantation of organs derived from other animal species for therapeutic purposes. As of 2004, there is active biotechnology research to "humanize" animal organs to make them less likely to be rejected by organ recipients.

revolution continued within the US market and expanded to other agricultural exporting countries. Countries with a long history of technologically intensive, greenhouse-based production, became formidable competitors for specific products. Higher margins and a need for tight control over all aspects of the food chain made the idea of moving production of the specialty applications of crop biotechnology to the developing world less attractive for U.S. companies.

Not all was positive however: changes in global consumption and production patterns – increased global demand for animal feed, increased demand for energy uses and continued population growth and urbanization - created its own set of pressures. As farmers increasingly used commodity crops for other uses besides food, commodity prices rose and there was increased clamor to bring ever more land under cultivation. Environmentalists throughout the developed world lobbied to limit this trend. Biotechnology was utilized as a tool to increase the efficient use of agricultural land. There was continuing concern over long-term environmental degradation resulting from the exclusive focus on output optimization. However, the overwhelming impact of biotech crops grown on large areas was to reduce the environmental impacts of agriculture. Less overall water, fuel, chemical pesticides and packaging were used compared to non-biotech agriculture, and soil erosion problems were reduced.

Governments adopted compatible regulatory systems, essential for development of, and trade in, new products. However, the poorest developing countries found themselves ever more marginalized. Much of the benefits and profits of this revolution went to those who had done the biotechnological research and provided sophisticated services. There was increased talk and concern of a life sciences divide as well as the digital divide.

While the increased number of new patented seeds, animals, and techniques reflected a broader acceptance of the importance of intellectual property, intellectual property remained a significant battleground between developed and developing countries. However, a few developing countries saw the future and joined the developed world with respect to these techniques. Some countries also began producing generic versions of popular products.

II. "Continental Islands"

New products of biotechnology continued to be developed and introduced into the marketplace. Farmers in a number of countries in the Americas and Asia continued to adopt biotech crops, based on significant positive economic impacts. Many of these new products were plant varieties with two or more new traits in a single variety, providing additional value for growers, and some new agronomic and consumer focused products have come to the market. Development of transgenic animals continued for niche applications, including xenotransplantation, but not for food uses. Given smaller markets, little investment was made in minor crop biotechnology.

The process for bringing transgenic agricultural products through the regulatory approval process to commercialization remained efficient in the U.S., Canada, and Argentina, and China, Mexico and Brazil joined their ranks. In some other countries with much slower regulatory processes, such as India, Australia, the European Union, and some African countries, additional products were only commercialized slowly. In other countries the approval processes remained non-existent or cumbersome.

Despite continued efforts, no international harmonization of regulations occurred and restrictive regulations continued to serve as trade barriers. Different countries or regions had varying regulatory systems and procedures. Labeling of biotechnology products varied by country and was non-standard.

The United States continued to be a major producer and distributor of biotechnology products. Other major growers and producers were Canada, Argentina, China, India, Brazil, and South

Africa. One or more of these countries commercialized a major transgenic crop not commercialized in the U.S. Asia and the rest of Africa remained divided, with some countries accepting or promoting the technology, and others rejecting it (even as food aid).

The EU (including the accession countries) continued not to accept food products in general, though they accepted products for feed uses and approved some products for field testing and importation. Despite the approvals, though, no products were actually tested (except for very small-scale field trials) nor were many food products imported and offered for sale.

Commodities destined for food use and those for feed use continued to be handled differently in different continents or regions.

The impacts seen in the farming community varied from farmer to farmer, depending on whether their principal markets were domestic or export. The domestic market continued to utilize transgenic products. Some exporters continued to test for their absence since non-transgenic certified products could be sold at a premium to food manufacturers wanting to avoid labeling and other compliance issues. Premium contracts with growers were often used to meet these non-transgenic crop needs.

Along the agricultural food chain, the pattern was similar. Products containing ingredients derived from transgenic varieties were acceptable and widely used for domestic markets, while food products for export largely sourced for non-transgenic-derived ingredients. Multinational food companies also used non-transgenic ingredient sources where there was mandatory biotech food labeling, or used non-transgenic ingredient sourcing globally. Since much of the biotech corn, soy and cotton produced in the U.S. was destined for domestic markets or markets with approval of biotech crops, farmers continued to plant large amounts of biotech corn, cotton and soybeans and realize the associated economic returns. With an increased demand for ethanol, the demand for corn in the U.S. continued to increase, creating additional growth and consumption of biotech corn.

Research and development activities by multinational technology providers and developers focused more on basic research since the market for new transgenic products was limited, and there was more emphasis on leveraging genetic understanding into targeted breeding programs, etc. There was continued consolidation among technology providers, but little additional capital for expansion. Research and development activities by public universities now focused on basic research.

Consumers worldwide remained divided and/or ambivalent. Those in the U.S. and most of the Americas continued to accept products containing ingredients derived from the first generation of transgenic plants without special labeling. Those in the EU and some other parts of the world were either opposed to the technology (and supported mandatory labeling as a means of product avoidance) or were ambivalent. Consumers in other countries varied in their sentiments, depending on the views of their governments. The situation was most confused in Africa, given the dire need for food and given confusion regarding trade-related issues, especially with the EU.

There continued to be no negative health implications from transgenic-derived food products. Continued positive environmental impacts were realized in the U.S., particularly with respect to decreases in pesticide use and increases in conservation tillage.

International trade remained complicated given regulatory and acceptance differences. USDA, the State Department and other agencies continued to expend a significant amount of resources in fighting for biotechnology in the trade arena. Several other countries opposing the spread of the technology devoted comparable resources on the opposite side.

III. “Biotech goes niche”

After a splashy debut, genetically engineered crops products did not turn out to be major components of world commodity agriculture, but continued to thrive in important niche markets. The first two products of crop biotechnology--- Bt and herbicide tolerance products, widely adopted in the U.S., Canada, and South America, were not followed by other blockbuster products. Some major agricultural regions continued to reject genetically engineered crops.

No transgenic varieties of wheat were ever commercialized. None of the promised new traits—drought tolerance or cold tolerance—panned out for corn, soy, cotton, or canola. The first generation of adopters remained enthusiastic about herbicide-tolerant and insect resistant (Bt) crops but was gradually forced to turn away from them because of lack of global acceptance and increased use of marker assisted technologies for development of improved germplasm in conventional seeds, but not “transgenic crops”.

The public did not accept the genetic engineering of animals for food uses, and given the technical difficulties associated with many of the modifications, there was no enthusiasm for commercializing genetically engineered animals for those uses. However, applications involving genetic engineering of animals for producing pharmaceuticals or tissues for xenotransplantation came on line.

The reasons for the fading away of transgenic products were complicated. First, the technology never overcame the barriers inherent in engineering useful traits involving multiple genes. Research costs remained high. The few products with claims to improved nutrition were never attractive enough to enjoy large price premiums. Without those price premiums it was hard to justify big investments in continued research and identity preservation schemes.

In the regulatory arena, mandatory food safety approval and transboundary movement requirements continued to increase as did the cost and time it took to go to market. There were some efforts amongst countries to harmonize requirements. However, the majority of countries developed their own regulatory systems based on local needs and market protection preferences. Consequently product developers had to deal with multiple diverse regulatory schemes in order to do international business. This was further complicated by farm-to-table traceability and labeling requirements and country-of-destination requirements imposed by the Cartagena Protocol on Biosafety and several other international treaties. Frequent detections of transgenes in both traditional and other transgenic crops posed interrelated policy challenges. Attempts to address those challenges with new approaches to adventitious presence, approved detection and sampling methods, and what constitutes a “novel” product never met with consensus.

Another part of the equation was consumer resistance. Consumers in the United States continued to be generally receptive or somewhat indifferent to transgenic crops, but consumers in many other countries remained opposed to the technology. In the increasingly interconnected global marketplace, international retail companies simply found it easier to source non-transgenic material. There was no consumer demand for genetically engineered products, so there seemed little reason for food companies to take on the extra burden of selling “GMOs” to customers who did not want them.

Food manufacturers, fast-food chains and mega-retail enterprises began specifying non-transgenic-sourced food ingredients and raw materials for their branded products. Many consumers failed to recognize potential benefits of the technology and questioned whether benefits from transgenic commodities were being directed to big business. Business economics demonstrated that new transgenics would only be profitable in the specialty “niche” market. Concerns grew stronger over the potential discovery of a pharmaceutical gene product in a food product. Although scientists said it did not present any human health risks, customers nevertheless tended to reach for other food options.

Although interest in new commodity transgenics faded, agricultural innovation continued. On the scientific front the complete genomes of the major food, feed and oil crops were made available through public databases to scientists, researchers, breeders and others in developed and developing economies. There was welcome progress in the ability to translate sequence information into agricultural improvements. Agricultural advances were facilitated by exponential growth of data delivered from various technologies, such as genomics, proteomics, gene expression assays, and bioinformatics.

Some innovations resulted from marker-assisted or traditional breeding. While the fruits of genomics were a while in coming, the mountains of data were eventually digested. Because traditional breeding could more readily accomplish selection for interacting sets of genes, the new products wound up providing a broader variety of traits than did genetic engineering. In addition, because they were traditionally bred, the new products could be brought to market with little regulatory oversight. However, some problematic new diseases, for which enhanced traditional approaches were not effective, emerged. Except for some groups focused on patenting and monopoly concerns, most of the new, innovative products escaped consumer opposition.

Some innovations depended on new non-biotech systems of agriculture and included new ways of enriching soil, protecting against pests and increasing yields. Many of these ideas were generated in the research done in support of organic and other new systems made possible by research funds diverted from investment in biotechnology products. With steady increases and double digit annual growth, these new food production systems rose to constitute 6 percent of total food production. Several large multinational food companies launched new product lines. Marker-assisted breeding programs became integrated with farmer and producer needs and were welcomed into these new systems.

Scientists did not abandon genetic engineering, but aimed their research at niche markets that generally did not involve the food system. The new genetically engineered products included a few energy crops, although most energy crops were produced using traditional or marker-assisted breeding. The production of pharmaceuticals in transgenic non-food crops also became a niche market. Two genetically engineered foods, for which developers were able to make compelling claims for prevention of heart disease and Alzheimer's, performed well in clinical trials and were expected to be commercialized soon. Companies redirected their efforts onto new niche markets, like energy-based or pharmaceutical products. These markets offered viable survival strategies for seed and technology companies.

The trade arena continued to be dynamic. China emerged as both a market and a competitor to the U.S. in the global commodity arena—huge and unpredictable. The demand for commodity products increased but so did global agricultural production as new areas in South America and Central Europe came on line. The result was an unpredictable seesaw of prices. There was growing concern globally that farmers in China were benefiting from the widespread use of biotechnology products in China without any regulatory oversight in the international markets. Some U.S. biotech companies transferred their research and development efforts to China and other developing countries with more open trade policies and greater food security needs.

With regard to farm subsidies, deadlines for agreed-upon reductions in payments were not met. National and regional trade restrictions continued, as did high tariffs. Through two election cycles since the last Farm Bill, both the U.S. farm policy and the European Common Agriculture Policy remained surplus-friendly. A number of developing economies led by several small Asian and African countries continued to fight against subsidies in the WTO round of discussions by demanding that subsidies and protective tariffs be eliminated and markets opened to products grown in these developing economies. Global trade in agricultural products continued to be characterized by a maze of national/regional phytosanitary standards, but the adoption of genetic engineering technology faded as a factor in global competition..

Developing countries—the poorest countries of the world—remained poor, because the world community remained unable to help them develop the infrastructure, access to markets, and targeted agricultural research investments that would result in an agriculture that could increase incomes and exports.

Without a barrage of new transgenic products on the horizon, the State Department and USDA and other agencies did not need to expend resources in fighting for market access for commodities and other agricultural products generated through biotechnology in the trade arena, in Codex Alimentarius and in other arenas. Overall, the drop-off in introduction of new transgenic commodity crops decreased the U.S. policy focus on international acceptance of those crops, and consequently lessened global agricultural trade frictions. This freed up some resources for other purposes, including assistance to poor countries.

A decrease in biotechnology crop plantings resulted in a return to agricultural farm practices based on conventional crops. This resulted in an increase in overall volumes of insecticides and herbicides used to protect crops, and an increase in the use of energy and water in the manufacture, transport and application of these products. Additionally, soil erosion began to increase as more farmers used tillage in their fields.

You have now visited three very different worlds. Here are a few questions you might wish to consider for these and other scenarios you might envision. These questions are designed to provoke discussion and help prepare for an uncertain future.

1. What is the economic impact of the scenario?
   - Competitive drivers
   - Economic growth
   - Trade development/exports
   - Farmer income and rural development
   - Market segmentation

2. What is the impact of the scenario on the natural environment?

3. What are the implications of the scenario for USDA?
   - Resources
   - Regulatory structure
   - Trade and promotion
   - Impacts on other government agency resources that could affect USDA
   - Public research agenda

4. What are the implications of the scenario for consumers and for public acceptance?

5. What are the implications of the scenario for addressing global food sufficiency/food security?