TECHNOLOGY'S ROLE IN THE 21ST CENTURY:

Food Economics and Consumer Choice

Why agriculture needs technology to help meet a growing demand for safe, nutritious and affordable food

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Introduction

Today there are nearly 1 billion hungry people around the globe. Yet in only 50 years, our growing global population will require an estimated 100 percent more food than we produce today. Unfortunately, we will certainly not have 100 percent more high-quality land available to grow twice the amount of grain or two times more livestock. The U.N. Food and Agriculture Organization (FAO) reports that added farmland will help produce only 20 percent of the additional food our planet will need in 2050, and 10 percent will come from increased cropping intensity. Accordingly, the FAO concludes that 70 percent of the world's additional food needs can be produced only with new and existing agricultural technologies.

The consequences of failing to use these science-based technologies and innovations will be disastrous. Food producers in industrialized and developing nations alike require technology to ensure a sustainable supply of safe, nutritious and affordable grains and animal protein to satisfy a rapidly growing demand. For this reason, and many others, we all share in the responsibility to ensure that new agricultural technologies—as well as those proven safe and effective over decades—continue to be available.

Key Data

In **50** years, the world **population** will require ▶ **100%** more **food,**[1] and ▶ **70%** of this food must come from efficiency-improving **technology**[3]

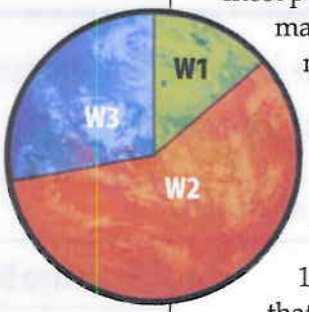
Executive Summary

- The U.N. projects world population will reach 9+ billion by mid-century and has called for a 100 percent increase in world food production by 2050. According to the U.N., this doubled food requirement must come from virtually the same land area as today.
- The U.N. Food and Agriculture Organization (FAO) further states that 70 percent of this additional food supply must come from the use of efficiency-enhancing technologies.
- Driven by food production efficiency, agriculture can achieve the *"ultimate win"* for consumers worldwide — affordability, supply, food safety, sustainability and ample supplies of grain for biofuels. Three key concepts — *collaboration, choice* and *technology* — emerge as the pathway to this success.

Feeding Our 3 "Worlds"[9]

Economists classify our world into three socioeconomic groups:

First World (W1): Affluent, industrialized nations and regions including the United States, Western Europe, Japan, South Korea and Australia.
Total estimated population, 2008: < 1 billion.



Second World (W2): Nations where the key challenge is balancing resources and needs; these include China, India, Eastern Europe and Latin America.
Total estimated population, 2008: 3-4 billion.

Third World (W3): Nations that are consistently in dire straits, such as Bangladesh, Haiti and most of Africa.
Total estimated population, 2008: 1-2 billion.

Population estimates used for this graphic:
W1 = 0.9B, W2 = 3.8B and W3 = 1.8B

Will global population growth outpace our ability to meet the demand for food?

Some argue it already has. In December 2008, an estimated 963 million people around the world didn't get enough to eat.[3] About 42 percent of these chronically hungry people live in two of the world's most populous developing nations: India and China.[4] Because of malnutrition, one in four children in second- and third-world nations (W2 and W3) is underweight for his or her age.[5]

This is an unacceptable situation today and will require a new approach to food production to avert an even worse scenario in the coming decades.

That's because world food demand is expected to increase 100 percent by 2050.[1] Consequently, the U.N. FAO projects that global production of meat and dairy protein will almost double by 2050.[6] This increased global demand will be driven by a steady increase in population growth from today's 6.7 billion to 9+ billion at the midpoint of the 21st century.[7]

This rise in population will be characterized by a growth in affluence, primarily in W2 nations, that will create the largest increase in global meat and milk consumption in history. Much of this increase parallels a rise in living standards in developing nations where more people can afford to replace low-cost grains in their daily diet with higher-cost sources of protein. China is a prime example of this trend. Compared to other W2 nations such as India, China has made more progress in reducing hunger among its growing population. In 1985, meat consumption in China was roughly 44 pounds per person per year. By 2000, this had increased to 90 pounds per person annually, a figure that's projected to more than double again by 2030.[8]

Land: the one resource we can never produce more of

Coinciding with increases in worldwide demand for animal protein is the reality of growing constraints on natural resources, with land a key limiting factor.[13] Based on U.N. FAO projections,[2] 13 percent more land in developing countries will be converted to agricultural use over the next 30 years. On a *global* basis, this represents a net increase in available cropland of only 1 percent—from the 39 percent of global land area used in 2008 to a total of 40 percent. This land expansion will account for only 20 percent of future increases in food production. According to the U.N., 70 percent of the rest must come from increased use of new and current yield-enhancing technologies. About 10 percent will come from increased cropping intensity (harvesting more crops per year from every acre).[2]

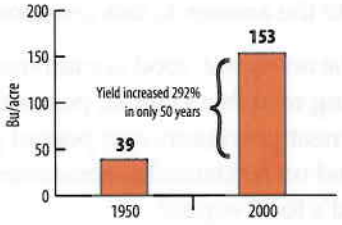
With respect to increasing output, there is good news. During the last half of the 20th century, agricultural productivity in many W1 nations expanded at a phenomenal rate. For instance, the average yield of corn in the U.S. rose from 39 to 153 bushels per acre[14] (Figure 1). In addition,

a comparison of U.S. farm output for 1948-1994 showed substantial productivity increases for all livestock and grain products, including an 88 percent increase in meat production and a 411 percent increase in the output of eggs and poultry. Combined, these improvements resulted in a 145 percent increase in total factor productivity (TFP)* for the U.S. agriculture industry (Figure 2).[15]

Figure 1

U.S. Corn Yield per Acre: 1950-2000

(USDA Economic Research Service Data)



The USDA calls new technologies a "primary factor" in improvements in agricultural productivity, such as a 292 percent increase in U.S. corn yields from 1950 to 2000.[14]

This should give us ample reason to believe we can meet the world's growing need for food. Why? Because according to the USDA Economic Research Service, the development of new agricultural technologies—including advances in genetics, nutrition, disease and pest control and livestock management—was an important factor in these 20th-century productivity improvements.[14,15] Refining these technologies, and discovering new ones, will be critical to our success in expanding on productivity improvements in this century.

With respect to *optimizing* land use for agriculture in the coming decades, however, the news is not so encouraging. The reasons for this are many and complex, but two of them are of paramount importance. First is the growing need to balance the use of agricultural land with the need to minimize the impact of agriculture on the global environment—particularly with regard to greenhouse gas emissions, soil degradation and the protection of already dwindling water supplies. Few would argue against the imperative to employ only those agricultural technologies that have a neutral or positive impact on our environment. To do otherwise is to sacrifice our long-term survival in favor of short-term gains.

The second reason involves the conflicting pressure to reallocate the use of current cropland from growing food to producing grains for biofuels (see sidebar on page 4).

Successfully responding to both these additional challenges—protecting the environment and balancing the world's need for energy and food—will require a complex and multifaceted approach. For now, regardless of how we respond to these challenges, both will inevitably affect the cost of food in W1, W2 and W3 nations alike.

A Growing Consensus:

The growing challenge of feeding the world

What a few experts have to say:

"Science and technology must spearhead agricultural production in the next 30 years at a pace faster than the Green Revolution did during the past three decades."

– Dr. Jacques Diouf, *Director-General, Food and Agricultural Organization of the United Nations*[10]

"Policy responses to protect the poor from food price rises are urgent and need to be designed in a way that is conducive to stimulating greater agricultural production in the long run."

– Dan Leipziger, *World Bank Group Vice President for Poverty Reduction and Economic Management*[11]

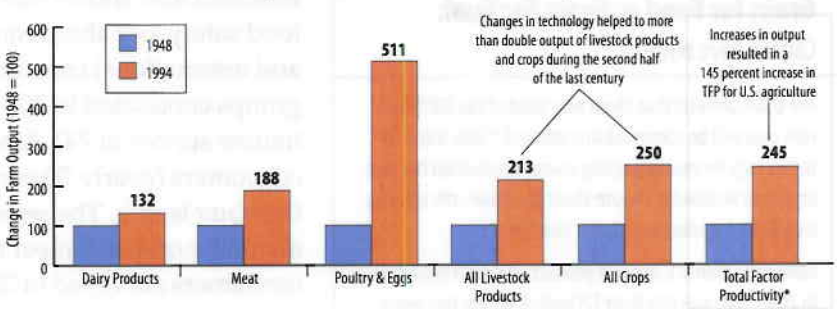
"Backyard vegetable gardens are fine. So are organics... But solutions to the global food crisis will come from big business, genetically engineered crops and large-scale farms."

– Jason Clay, *World Wildlife Fund*[12]

Figure 2

U.S. Farm Output & Productivity: 1948-1994

(USDA Economic Research Service Data)



With 1994 farm output for livestock and grain products more than doubling the baseline output of 1948, total factor productivity (TFP) for U.S. agriculture during the last half of the 20th century improved by nearly 150 percent. According to the United States Department of Agriculture (USDA), this difference in TFP resulted from factors including changes in technology, efficiency and scale of production.[15]

*Overall rate of productivity is most commonly expressed as total factor productivity (TFP), a ratio of outputs to inputs (both measured as an index). TFP captures the growth in outputs not accounted for by the growth in production inputs.

FARMING IN 2050 WILL OCCUPY ONLY ABOUT 1 PERCENT MORE LAND THAN IS USED IN 2008.

– BASED ON U.N. FAO PROJECTIONS

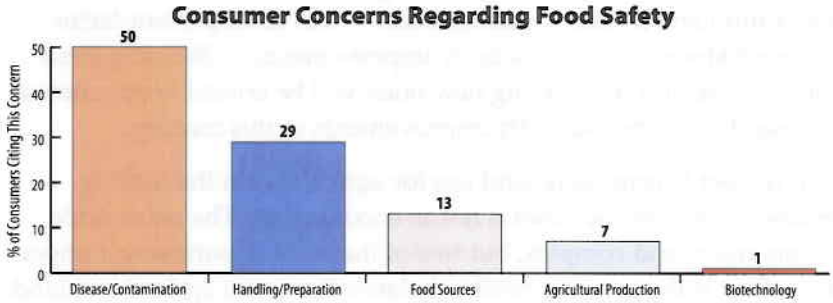
The consumer perspective

When it comes to the global food supply, what does the average person think about? Does he or she worry daily about food safety and agricultural technologies and methods? Experts continue to debate the answer to this question.

On the one hand, food contamination scares—such as those involving milk from China, peppers from Mexico, beef from some U.S. meat processors and peanut products from Georgia—have created understandable consumer concern about the safety of the world's food supply.

On the other hand, a 2008 survey by the International Food Information Council revealed that when consumers are asked about specific food concerns, half indeed cited "disease and contamination" at the top of the list. Yet only 7 percent reported that they worry about agricultural production methods, and 1 percent cited biotechnology as a top-of-mind concern (Figure 3).[17]

Figure 3



Though research shows most consumers aren't overly concerned about food safety, when asked to share potential worries, 50 percent cite disease and contamination. In contrast, only 1 percent cite biotechnology as a food safety concern.[17]

Research also shows that most people are not greatly concerned about food safety, nor about modern food production technologies. U.S. and international consumer research, involving a total of 45 focus groups conducted in 2001, 2004 and 2008[18]—and including a quantitative survey of 741 Americans taken in 2008—revealed that most consumers (nearly 70 percent in 2008) assume the meat and poultry they buy is safe. The research also showed that consumers care little about the origin of meat they purchase. And only 17 percent of the consumers surveyed in 2008 expressed a strong interest in knowing about modern food animal production, while nearly 60 percent had little or no interest, preferring instead to trust the food supply chain to ensure the food they consume is safe.

Whom do consumers trust most to ensure science-based food safety? Perhaps not surprisingly, it's the food producers—those who rely on modern technologies to help them grow food safely and efficiently. Interestingly, consumers trust producers to help maintain food safety to a much greater degree than they trust advocacy groups (Figure 4).

Grain for Food or Grain for Fuel:
Can we have both?

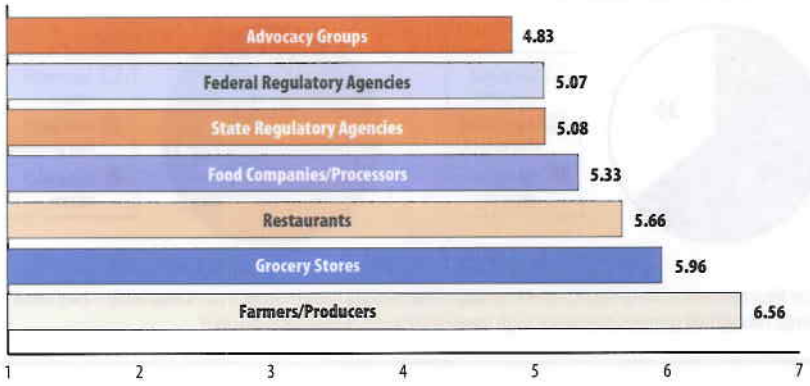
The USDA projects that about one-third of the 2009 U.S. corn crop will be converted into ethanol.[16] Still, this new technology for revolutionizing energy production has also produced worldwide debate about the trade-offs in using cropland to produce fuel rather than food.

Consider: when U.S. ethanol production began ramping up in 2005, corn was less than $2/bushel. Within two years, this had doubled to $4 and a year later peaked at nearly $8/bushel, resulting in significant pressure on the food industry.

Can we raise enough food to feed the world while helping the U.S. and other nations achieve a higher level of energy independence? If history is any guide, the answer is yes, but only as long as we continue to invest in the technology necessary to make ethanol production, grain production and food production even more efficient.

Figure 4

Whom Do Consumers Trust to Ensure Food Safety?
(1 = Trust Least, 10 = Trust Most)



With regard to ensuring food safety, consumers put the most trust in farmers and food producers.[22]

Protecting the confidence and trust consumers place in the food supply chain is critical. Although consumer confidence remains relatively strong, research shows it is decreasing slightly.[17] High-profile food recalls almost certainly helped to erode this confidence. But is the emergence of genetically modified (GM) foods also to blame? Probably not.

Research reveals that, unprompted, consumers do not put GM products high on their list of food worries.[19] Moreover, in the EU—an area of the world that typically champions organic farming—few consumers actually avoid GM foods when shopping. In fact, regardless of what consumers say about GM foods in opinion polls, the vast majority of them readily buy the few available GM foods without apparent hesitation.[19] It should be noted, however, that global demand for organic products continues to grow. Worldwide sales of organic products doubled from 2000 to 2006, with the EU emerging as one of the top three import markets for organic goods.[20, 26]

Consumers want high-quality, affordable food

So if most consumers trust their food to be safe and accept GM foods with little concern, what do they worry about? When asked open-ended questions about what they want most in their food, consumers consistently say they want it to be high-quality and affordable. As one example, recent polling in the U.S., U.K., Germany, Argentina and China found that taste, quality and price were the top considerations when choosing food products.[21]

Of these, affordability continues to move to the forefront as the global economy remains in a state of heightened volatility. According to an October 2008 survey by the Center for Food Integrity, 60 percent of respondents are more concerned about food prices than they were just one year ago[22]—"the highest level of concern… since World War II" according to the Center's CEO, Charlie Arnot.

Lessons from the European Center of Competitive Excellence

In 2003, a think tank called the Center of Competitive Excellence was assembled to assess a number of challenges. One of these was to evaluate the European meat industry and develop strategies for enhancing its competitive position across Europe and in the global marketplace. Surveys and panel discussions by highly respected agricultural experts, veterinarians and food producers from across Europe were conducted by the Center. Three key insights emerged:[25]

1. **It's crucial to have a credible, authoritative regulatory body.**
   The model for this is the U.S. Food and Drug Administration (FDA), a regulatory body that, despite some criticism, remains a highly respected authority by consumers in the U.S. and around the world. A central authority such as the FDA helps maintain consumer confidence—something Europeans recognized the need for as they addressed food contamination and animal disease issues. Ultimately, they created the centralized Food and Veterinary Office (FVO) and the European Food Safety Authority (EFSA).

2. **Allow use of approved technologies and modern farming techniques to continue.**
   As an example, U.K. farmers learned in the 1990s that rewriting laws to appease the political demands of a vocal minority is a recipe for economic disaster. A decade after yielding to pressures to ban (or not approve) growth enhancers, biotech products, GMOs and certain production practices, the U.K. has transformed from a key global leader and competitor to a high-cost, low-productivity domestic producer that now relies on poultry and beef imports to meet consumer demand.

3. **Food producers should avoid "differentiating on the negative."**
   Labeling food products with claims such as NO additives, NO this, NO that, etc., results in a costly contest among manufacturers to "out-NO" each other while only confusing consumers who neither understand, desire, nor prefer these types of foods. Further, this practice can create an unfounded fear among consumers that products without such labels are less safe when, in fact, they can be even safer to consume. In any case, it's the consumer who should make the final decision about which food products to purchase.

RECENT POLLING IN THE U.S., U.K., GERMANY, ARGENTINA, AND CHINA FOUND THAT TASTE, QUALITY AND PRICE WERE THE TOP CONSIDERATIONS WHEN CHOOSING FOOD PRODUCTS.[21]

Figure 5

Consumer Agreement That Today's Food Supply Is Safer Than It Was During Their Childhood

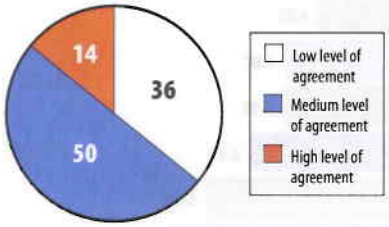
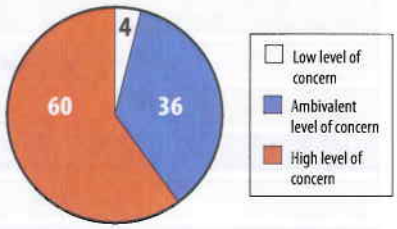


Figure 6

Consumer Concern About Food Prices



Sixty-four percent of Americans believe today's food supply is even safer than it was when they were young, though 60 percent express a high level of concern about food prices.[22]

Consumers want choice

Of course, affordability matters less to some consumers, particularly those in affluent W1 countries where food costs account for only 10 percent of the average income.[23] This includes consumers who prefer foods that are produced organically, i.e., with the use of few (if any) modern agricultural tools and technologies. Organic food production, however, typically requires *more* resources and produces *less* food—which currently makes it a questionable solution to meeting the world's growing food supply needs. As we prepare to enter the second decade of the 21st century, most organic foods remain a high-cost luxury that three-quarters of the world's population cannot afford, particularly those in developing nations where food costs consume 50 percent of the average income.[23]

Needless to say, consumers who desire organic foods—which help the food industry satisfy demand and capture more value—should have that choice. Likewise, consumers who need an abundance of efficiently produced, high-quality and affordable food deserve that choice as well. All consumer preferences can and should be protected. Most of all, the undernourished in developing nations who are improving their diets by increasing consumption of animal proteins, deserve the affordable foods that can be produced with carefully monitored, efficiency-improving agricultural technologies.

High food prices will worsen the global food crisis

The question of how food is grown became even more relevant in 2008, when the entire world saw pressures on food production accelerate as never before. According to the International Monetary Fund (IMF), world market prices for food commodities rose more than 75 percent from early 2006 to July 2008.[23] Of course, any increase in grain prices inevitably causes meat, egg and dairy costs to rise, because grain is used to feed livestock. As painful as these increases are in

industrialized (W1) nations, they can be devastating in poor nations where even modest increases in food prices can mean the difference between sustenance and starvation.

Josette Sheeran, head of the World Food Programme, reports that from 2002 to 2007 the cost of procuring basic foods for her program increased by 50 percent—and then by another 50 percent only one year later. As a consequence of these unprecedented cost increases, Sheeran warns that "high food prices are not only causing a humanitarian crisis but also putting at risk the development potential of millions of people."[24]

The challenge of helping these millions of people requires us to ask ourselves: Can we afford *not* to use the technologies at our disposal to produce food as efficiently as possible?

Why is technology such an important key to meeting the global demand for food and consumer choice?

There are a wide variety of answers to this question, and here are three of the most important:

1. Technology enables food producers to provide more high-quality grains and protein sources using fewer resources.

Ironically, those who believe "all-natural" farming techniques (e.g., pre-1950) were superior to those used today could not, in many ways, be more mistaken. For example, a combination of modern feeding practices and efficiency-enhancing feed additives enables today's cattle growers to use two-thirds less land to produce a pound of beef as it takes to produce a pound from "all-natural" grass-fed cattle.[26] In addition, we can now produce at least 58 percent more milk with 64 percent *fewer* cows than dairy farmers could produce in 1944.[27] Researchers have also found that nationwide use of an FDA-approved swine feed additive could enable the U.S. to maintain pork production levels while raising 11 million fewer hogs. This would also reduce demand for cropland used to grow feed grains by more than 2 million acres.[28]

Similarly, for every million dairy cows managed with another widely used technology, the world saves 2.5 million tons of feed that would have required 540,000 acres of land to produce. This increase in efficiency saves enough electricity to power 15,000 households[29] and can substantially lower milk prices.

Technology has also played an important role in the poultry industry, which has seen a four- to six-fold increase in the slaughter weight of broiler chickens since 1957. Researchers attribute this increase to careful genetic selection and improvements in nutrition.[30]

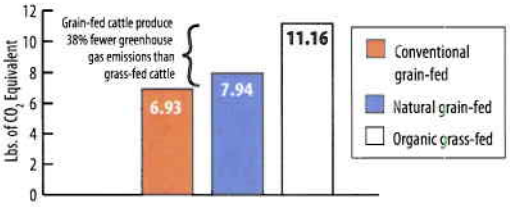
"HIGH FOOD PRICES ARE NOT ONLY CAUSING A HUMANITARIAN CRISIS, BUT ALSO PUTTING AT RISK THE DEVELOPMENT POTENTIAL OF MILLIONS OF PEOPLE."

– Josette Sheeran
World Food Programme

TECHNOLOGY CAN HELP SIGNIFICANTLY REDUCE ANIMAL WASTE PRODUCTION THAT CAN THREATEN VITAL WATER RESOURCES IN DEVELOPING NATIONS WHERE MODERN POLLUTION-CONTROL STANDARDS AND TECHNOLOGIES ARE NOT IN USE.

Figure 7

Total Greenhouse Gas Emissions per Lb. of Beef (excludes NOx)



Today's conventional production methods help reduce total greenhouse gas emissions compared to organic methods.[26]

2. Technology can help keep food affordable while ensuring maximum consumer choice—especially in developing nations.

Organic foods are a fine option for people who can afford to pay a premium for them. According to USDA researchers, these premiums can average 100 percent or more for vegetables,[31] 200 percent for chicken and nearly 300 percent for eggs.[32] On a global scale, however, most consumers can't afford to pay such premiums and instead demand less expensive food choices.

It bears noting that not all organic production methods are less efficient and provide foods that invariably cost more. According to a U.N. FAO report, in some countries, well-designed organic systems can provide better yields and profits than traditional systems. In Madagascar, for example, farmers have increased rice yields fourfold by using improved organic management practices. In Bolivia, India and Kenya, farmers have shown that yields can be double or triple those obtained using traditional practices.[2]

Nonetheless, the report also recognizes the need for more research to solve technical problems faced by organic growers, and suggests that organic agriculture could become a realistic alternative to traditional agriculture over the next 30 years, but only on a local level.[2]

Still, given the magnitude of the food crisis the world faces in the coming decades, efforts to maximize choice and achieve high production efficiencies (and lower costs) for all foods—including organic products—deserve the support of all constituencies in the global food chain.

3. Technology can help minimize the global environmental impact of increased food production.

Using modern production methods and technologies not only helps produce more high-value protein from less land, but can also have a net positive impact on the environment. For instance, what today's beef producers call "conventional" (i.e., modern) production techniques can actually reduce greenhouse gas emissions per pound of beef by 38 percent compared with an "all-natural" production method[26] (Figure 7).

Moreover, technology can help significantly reduce animal waste production that can threaten vital water resources in developing nations where modern pollution-control standards and technologies are not in use. Case in point: use of an FDA-approved feed additive for swine can reduce manure production in pigs by 8 percent.[33] Feeding this additive to every hog harvested in the U.S. in 2002 would have reduced annual production of swine manure by more than 3.4 billion gallons[28]—or enough to fill about 5,600 Olympic-size swimming pools.

Conclusions

1. The global food industry needs technology.

Without advancements in agricultural technology, humanity would likely not have progressed through the 20th century without major famines or devastating food wars. Will we be able to say the same thing at the end of this century, given that a food crisis is already here?

I believe the answer is *yes*, because I concur with the U.N. that 70 percent of this food must come from the use of new and existing technologies and methods. And these technologies and methods must have no negative impact on the environment, animal welfare or food safety.

2. Consumers deserve the widest possible variety of safe and affordable food choices.

In general, consumers trust food producers to keep the food supply safe, and they're more concerned about food contamination than about technology used on the farm. Instead, one of the most pressing human concerns about food is affordability.

For this reason, consumers from all classes and geographies—from those who can afford organic foods to those who struggle to maintain a diet that sustains them—must be allowed to choose from an abundance of safe, nutritious and, most importantly, inexpensive food options.

3. The food production system can mitigate the food economics challenge and achieve an "ultimate win."

Facing a global food crisis, the world is at risk through the midpoint of this century. We already see the signs: our population consumed more grain than we produced during seven of the last eight years.[34]

The good news: an "ultimate win" is still possible. What will it look like? Five key achievements will mark its success:

1. **Improving the affordability of food** by using new and existing technologies and optimal productivity practices.
2. **Increasing the food supply** by instituting a vastly improved degree of cooperation across the entire global food chain.
3. **Ensuring food safety** with a combination of technology and high-quality standards and systems, coupled with a greater measure of worldwide collaboration.
4. **Increasing sustainability** through a highly productive and efficient system that simultaneously protects the environment by means of sensitive and efficient use of natural resources.
5. **Producing more biofuels** to reduce dependence on fossil fuels while creating no negative effect on global food supplies.

In summary, three key concepts—**collaboration, choice** and **technology**—emerge as the pathway to success. Not only will they provide the direction, they will be necessary requirements for an ***"ultimate win"*** in the food economics challenge.

Jeff Simmons is the President of Elanco Animal Health, the animal health division of Eli Lilly and Company. Jeff is a member of the Animal Health Institute's (AHI) Executive Committee and serves on the Board of Directors of both AHI and the International Federation for Animal Health (IFAH). He is also a member of the Harvard Business School's Private and Public, Scientific, Academic, and Consumer Food Policy Group (PAPSAC) committee and the 2009 Chairman of the FFA Foundation Board. Jeff received a bachelor's degree in Agricultural Economics and Marketing from Cornell University in 1989.

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