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EMERGING AND FUTURE BIO-ENGINEERED COMMODITIES

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Thank you very much for inviting me to visit with you today about the future for bio-engineered commodities. I am pleased to be able to share the podium with your other panelists and especially with Terry Medley who has been a key contributor to the acceptance and development of biotechnology in the U.S. agricultural marketplace.

Four years ago I had the pleasure of speaking to the Outlook Forum on the subject of the future of the corn sweetener industry. At the time I previewed a number of market developments which seemed to be of primary importance to the corn processing and sweetener industry - only about half of which have actually panned out. So, given that track record at predicting the future, I hope you will take what follows for what it is and not rush out to place your bets on any particular new technology.

In addition to the topic I have been asked to address, I would also like to comment briefly on what the changes in plant biotechnology may bode for our multi-billion dollar grain handling and logistics system. One of the traps we all fall into in looking at biotechnology is to somehow disassociate the technology part from the bio part. As exciting as molecular biology is, there comes a point when the hard economics of commodity delivery must be fully examined, including the balance between value addition and cost to each part of the commodity delivery chain.

First let's take a look at what we might be seeing in future bio-engineered commodities. For this purpose, I'd like to divide future products developments into three very broad groups:

- Products with improved production traits
- Products with improved output traits
- Crops which produce materials replacing other production systems

The area of improved production traits is suddenly almost a mature business. Starting with Roundup-Ready soybeans and Bt corn in 1996, insect and herbicide resistant crops have proved to be a big hit with U.S. farmers and their adoption is growing exponentially. And for good reason. These products, despite the steep technology fees associated with them, offer farmers tools to increase yields and lower costs with little change in agronomic practices. One seed company president recently predicted that the expected rate of adoption of insect and herbicide-tolerant crops could cut U.S. fertilizer and pesticide use in half by the year 2012. Given this degree of change it is little wonder that the major players in development of new crop technologies are the very companies whose chemical inputs may become less necessary in the future.

Beyond the headline crops, there are a number of new areas which we can expect to see in the market in the next few years:

- New forms of insect resistance. European corn borer resistance will be supplemented with resistance to other crop pests such as root worm, fall armyworm, black cutworm and southern corn borer.
- Herbicide and pest resistance will move from corn, soybeans and cotton into commodities such as wheat, sugar beets and sunflowers.
- Virus resistance and mold resistance will move from fruit crops into the major grain and oilseed crops. Fungal contamination, and its associated mycotoxin

problems, may be dramatically reduced by varieties which resist stress induced by drought and insect invasion.

- The ability to help regulate changes and differences in water and soil quality will be introduced to major crops. Environmental factors such as drought and salinity have a marked effect on crop yields and quality and in coming years may be managed through hybrid selection. Minor changes in nitrogen fixation and utilization rates introduced through biotechnology are on the way.

- And, in 1998 we will see the first so-called "stacked" crop varieties incorporating both insect and herbicide resistance. Within the next few years, we can expect to see multiple stacked traits.

Crops with improved output traits are just coming to market this year. Nick Frey will discuss this type of product in much more detail later in the session, so I will just highlight a few of the possibilities of these crops. Five major types of output changes can be expected:

- Crops with increased amounts of macro-constituents. Crops designed to be high in traditional constituents such as oil, starch, sucrose or gluten may increase the value of crops to particular end-users such as swine feeders, starch and sugar processors and bakers.

- Crops in which the macro-constituents have been altered to increase their nutritional value or functionality. For example, high oleic-acid soybeans are coming to the market this year offering food processors oil with an improved nutritional profile.

- Crops in which micro-nutrients have been altered to improve nutritional properties. High lysine corn has been available for years from traditional breeding programs, but new technology may overcome cost problems. High lysine soy products should also be available in the next several years. Corn grain low in phytic acid may help animal feeders handle increasingly troubling animal waste problems.

- Crops which have been altered to improve quality and functional factors such as oil stability and flavor, starch and protein structure or fiber size and color.

- Crops which have been altered to improve their processing characteristics. Grain and oilseed processors operate highly capital intensive facilities designed to separate the oils, fiber, starch and sugars in crops and new technologies are being explored to enable plants to express these constituents in ways in which they can be extracted with less energy input and lower environmental impact.

Last in the development chain, and still several years away, are bio-engineered commodities which express entirely new products or functions not generally associated with agricultural production. These products fall in the area of what may be called "bio-factories" where the power of sunlight and plant physiology are harnessed to replace expensive chemical synthesis processes. In most cases these kinds of products are little more than twinkle's in the eyes of researchers. Unlike alterations which can be controlled by manipulating a single gene, or stacking several single gene traits, these products may require a new level of sophistication in genetic manipulation. These products fall into a number of areas:

- Biologically-based polymers which can be substituted for petroleum products. Soy and corn plants may one day produce polymers which can serve as intermediates in the production of degradable plastics, bio-fuels or replacements for synthetic fibers.

- Foods designed to be used in disease prevention. So-called "nutraceuticals" are currently being developed through traditional food fortification methods, but in the future vegetable, fruit and grain crops may be the vehicle for boosting intake of carentenoids, antioxidants, vitamin E, folates and other micronutrients which have been linked to prevention of cancer, coronary disease and degenerative nerve diseases.

- Crops designed to produce high-value pharmaceuticals and antibiotics. Pharmaceutical firms are actively investigating plant-based production systems which could replace traditional fermentation processes.

A key question which remains is, how will all of these new technologies be integrated into the agricultural system?

First, for any of these products to become successful they must add value over and above the products or systems they are designed to replace. For example, it will do little good to introduce high lysine products if lysine can be produced through fermentation and delivered to feed processors at lower cost than improved crop varieties. Herbicide resistant crops need to be

more cost-effective than competitive weed control and tillage systems. In order to achieve this value addition, there must be financial incentives to five distinct segments of the chain:

- Technology and seed production companies
- Agricultural producers
- Commodity distributors
- Commodity processors
- End-users

At this point in the development of bio-engineered crops seed companies and agricultural producers clearly find value in these technologies. End-users such as commodity and food processors see opportunity but need to be convinced on a case-by-case basis that bio-engineered materials offer them increased value and not just an alternative route to make existing products. In the middle lies the huge commodity gathering and distribution system which has been designed to deliver large volumes of undifferentiated crops to end-users. So far, the commodity gathering network has taken only tentative steps to develop systems for handling bio-engineered products.

Even with the development of major bio-engineered crops, traditional commodity corn markets will always exists. The system we have built over many hundreds of years is the source of a high quality raw material, available every day of the year, in almost any location. While processing industries adapt new technologies, there is a large base of business which is absolutely dependent on this commodity market.

Beyond the current system, there are certainly new modalities developing which I would categorize into two new grain marketing systems.

One such system will be necessary to handle the new value-added grain and oilseed products. The nature of these crops provides an intrinsic value above commodity products, but the potential scale of the market is such that absolute isolation or segregation systems are not feasible, nor necessarily required to protect product quality. A delivery system utilizing existing elevator capacity which could be rotated through a variety of specialty crops could serve this function, and will certainly be the domain of existing elevator operators. A key determinant in how this system develops will be the availability of rapid analytical procedures to measure the constituents of these new grain varieties.

A second new system will be required to deal with the bio-polymer, pharmaceutical and nutraceutical type crops. The extremely high value of the products produced by such crops should be adequate to allow new capital expenditures for strict segregation systems, and the products contained in these crops will not be suitable for inclusion at even low-tolerances in commodity grain supplies. This kind of system may not end up being operated through current grain marketing channels, but will probably rely on direct farm to processor contracting and delivery. The traditional functions of risk management performed by the grain trading system will not necessarily be applicable to these kinds of crops. In some cases the actual crop production may not be the domain of traditional agricultural producers but may be a function of the processor or end-user.

I appreciate the chance to share this snapshot of where we're heading with bio-engineered crops with you and look forward to participating in the panel discussion.