FARMING IN THE 21ST CENTURY

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Preface

The U.S. agricultural industry is in the midst of major structural change — changes in product characteristics, in worldwide production and consumption, in technology, in size of operation, in geographic location. And the pace of change seems to be increasing. Production is changing from an industry dominated by family-based, small-scale, relatively independent firms to one of larger firms that are more tightly aligned across the production and distribution chain. And the input supply and product processing sectors are becoming more consolidated, more concentrated, more integrated.

Agriculture in the 21st century is likely to be characterized by: 1) adoption of manufacturing processes in production as well as processing, 2) a systems or food supply chain approach to production and distribution, 3) negotiated coordination replacing market coordination of the system, 4) a more important role for information, knowledge and other soft assets (in contrast to hard assets of machinery, equipment, facilities) in reducing cost and increasing responsiveness, and 5) increasing consolidation at all levels raising issues of market power and control.

These profound changes in the agricultural industry present new challenges and new opportunities that require new ideas and concepts to analyze and implement. They require new learning and thinking. Some of those new ideas and concepts are presented here, not as empirically verified truths, but as "thoughts" to stimulate different and better thinking. They have been developed based on observations, analysis and discussions with numerous managers and colleagues in agribusinesses in North America and Europe. This series focuses on Farming in the 21st Century; companion series are also available on Financing and Supplying Inputs to the 21st Century Producer (Staff Paper 99-11), and Value Chains in the Food Production and Distribution Industries (Staff Paper 99-10).

Our purpose in sharing these "thoughts" is to invite discussion, dialogue, disagreement — in general to encourage others to develop better "thoughts".

Keywords: qualified supplier, biological manufacturing, strategic risk, process control, economies of size, franchise grower

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Implications of Biotechnology for Agriculture

Biotechnology has been one of the most profound scientific advances in the last twenty years. And it has moved very rapidly from the scientific laboratory to farmers' fields; for example, bioengineered corn and soybean varieties were first introduced in 1996, and by 1999 almost 25% of the corn and 50% of the soybean acreages were planted to varieties created with biotechnology. Acceptance of biotech food products by consumers has become a controversial issue, so future adoption may be slowed somewhat. But it is unlikely that this significant technological development will be stopped completely.

Biotechnology has the potential to completely change the agricultural industry—to change agriculture's role in the overall economy as well as how agriculture goes about fulfilling that role. In essence, it has the potential to redefine and realign the agricultural industry—change dramatically who we are and how we do it.

Who We Are

Biotechnology will redefine the role of agriculture for two fundamental reasons. First, it replaces and/or complements chemistry and the mechanical sciences as the fundamental science base for new technological and productivity advances. In essence, whereas most of the technological advances that increased productivity and contributed to growth and economic development in the past 50 years have had their science base in the physical and mechanical sciences, the science base for future technological advance, productivity growth and economic development will come from the biological sciences. This places agriculture in the mainstream of productivity growth and economic development in the developed as well as the less developed economies.

The second profound implication of biotechnology in redefining agriculture is that it dramatically expands agriculture's role as a raw material supplier for a broader set of industries. The agriculture of the past 100 years has been a raw material supplier for the food and nutrition industry and, to a limited degree, the fiber and textile industry. But biotechnology and the advances in biochemistry expand dramatically the potential uses for agricultural products. In fact, some are suggesting that in the future agriculture will be a significant supplier of raw materials for: (1)food and nutrition products, (2) health and pharmaceutical products, and (3) industrial products including synthetic fibers, plastics, wall coverings, and other products that have historically been derived from the petrochemical industry. This significant broadening of the economic sectors that will use agricultural products as raw materials increases agriculture's importance in the overall economy. It also provides a broader base for the demand for biologically-based raw materials (i.e., agricultural products) as well as an opportunity to think of agriculture as a core source of integration of the total economy. The end result is that agriculture and the biological sciences that create agricultural products have the potential to not only redefine the sector's role in overall economic systems, but to substantially expand that role.

How We Do It!

Biotechnology also has the potential to profoundly change how agriculture operates in the future—how the industry accomplishes that larger role in the total economy. Biotechnology is a critical component of process control technology that is transforming agriculture from an industry that produces and processes commodity products to one that biologically manufactures specific attribute raw materials for the broader set of end uses noted earlier. Biological manufacturing is characterized by industrialized production which uses modern manufacturing approaches including procurement, inventory management and process control techniques. Three types of process control technology are critical in biological manufacturing:

Monitoring/measuring and information technology — The focus of this technology is to trace the development and/or deterioration of attributes in the animal and plant growth process, and to measure the impact of controllable and uncontrollable variables that are impacting that growth process. In crop production, yield monitors, global positioning systems (GPS), global information systems (GIS), satellite or aerial photography and imagery, weather monitoring and measuring systems, and plant and soil sensing systems are part of this technology. In animal production, systems to monitor humidity, temperature, air quality and other characteristics of the feedlot or building environment along with systems to monitor feed formulations, water characteristics, and animal waste and feed ingredient composition are included. In future years, in-animal sensors to detect growth rates and disease characteristics may be part of such information and monitoring/measuring systems. And these systems will be tied to growth models to detect ways to improve growth performance, as well as to financial and physical performance accounting systems to monitor overall performance. The computer technology to manipulate the massive amounts of information is readily available; new monitoring/measuring technology including near-infrared (NIR) and electromagnetic scanning is now being developed to measure a broad spectrum of characteristics of the animal and plant growth process.

Biotechnology and nutritional technology — The focus of biotechnology and nutritional technology is to manipulate the attribute development and deterioration process in plant and animal production. An improved scientific base to understand how nutrition impacts not only growth but attribute development is providing additional capacity to manipulate and control that process. And biotechnology is advancing our capacity to control and manipulate animal and plant growth and development including attribute composition through genetic manipulation. By combining nutritional and biotechnology concepts with mechanical and other technologies to control the growth environment (temperature, humidity and moisture, pest and disease infestation, etc.), the process control approach and thinking that is part of the assembly line used in mechanical manufacturing becomes a reality in biological manufacturing.

Intervention technology — The concept of intervention technology is to intervene with the proper adjustments or controls that will close the gap any time actual performance of a process deviates from potential performance. For example, servo mechanisms in a hog building automatically turn on the ventilation system, the coolers or a heating system if the temperature deviates from what is desired for optimal animal growth. Greenhouse production increasingly utilizes such technology to manipulate sunlight, humidity, temperature, and other characteristics of the plant growth environment. Irrigation systems are an example of this technology with respect to field crop production; modern irrigation systems tied to weather stations and plant and

soil sensors automatically turn irrigation systems on when moisture becomes a constraint to plant growth, and automatically turn the systems off when moisture levels are adequate for optimum growth.

This technological transformation is significantly different from the mechanical and even biological transformations of the past. In essence implementation of the three components of process control technology in production agriculture as well as in the input supply manufacturing and product processing and retailing sectors eliminates the disconnect that has previously occurred at the farm gate in the assembly line from genetic material to the retail food store.

Biotechnology and the science that supports it opens up numerous options and opportunities for agriculture – it has the potential to profoundly change who we are and how we accomplish what we do.