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# *Translating Discovery Research into Commercial Products*

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DuPont's Agriculture and Nutrition Platform consists of three business units: Pioneer Hi-Bred International, DuPont Crop Protection Products, and Solae, an alliance between DuPont and Bunge Limited formed to develop and market nutritious soy-protein products. These businesses develop products for customers all along the agricultural value chain, from seed- and crop-protection chemical inputs for growers, to novel grain traits for food, feed and fuel processors, to more healthy and nutritious food products for consumers. The platform is supported by two R&D organizations. The focus here is on Crop Genetics R&D, aimed at the development of biotechnology traits.

## INCREASED DEMANDS ON AGRICULTURE

Growing needs for biobased, renewable fuels and materials will place a greater demand on agricultural productivity leading to the adoption of more intensive agricultural practices. To be successful under such conditions, farmers will require a suite of traits that protects crops from abiotic and biotic stresses, especially if economic conditions benefit monocropping practices. Trait combinations will be needed that protect crops from disease and help minimize risk to growers, that enhance crop productivity and genetic gain and that increase the end-use value of the harvested grain. Expression of such traits will be required at appropriate stages of plant growth and development to maximize effectiveness.

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*Our pipeline includes Optimum GAT, which provides new weed-control opportunities, the Herculex insect-control traits, increased nutrient-use efficiency, grain traits and drought tolerance.*

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	Trends	Traits
 <p>Stand Establishment</p>	<ul style="list-style-type: none"> <li>• No till</li> <li>• Monoculture</li> <li>• Earlier planting times</li> </ul>	<ul style="list-style-type: none"> <li>- Optimum™GAT™</li> <li>- Herculex® family of traits</li> <li>- Disease resistance</li> <li>- Nitrogen use efficiency</li> </ul>
 <p>Vegetative Growth</p>	<ul style="list-style-type: none"> <li>- Maximize genetic potential</li> <li>- Manage risk</li> </ul>	<ul style="list-style-type: none"> <li>- Anthracnose stalk rot resistance</li> <li>- Insect resistance II &amp; III</li> <li>- Water use efficiency</li> <li>- Yield enhancement</li> </ul>
 <p>Grain Fill &amp; Harvest</p>	<ul style="list-style-type: none"> <li>- Speed of harvest</li> <li>- Time and fuel efficiency</li> <li>- Grain end-use value</li> </ul>	<ul style="list-style-type: none"> <li>- Grain quality</li> <li>- Animal Feed II &amp; III</li> <li>- Ethanol yield II, III &amp; IV</li> <li>- Healthy oils</li> </ul>

Figure 1. Intensive agricultural production will demand traits for increased agricultural productivity.

Figure 1 shows traits that will provide growers with new and better options for weed and insect control. Our pipeline is robust and contains second- and third-generation traits that will follow in the marketplace after initial trait concepts are commercialized. Some specific examples include Optimum GAT, a trait that provides new weed-control opportunities and the Herculex insect-control family of traits. Other longer-term traits include disease resistance from transgenic and native sources, traits that increase nutrient-use efficiency, grain traits for food, feed and fuel uses and drought tolerance.

#### COMPLEMENTARY APPROACHES TO TRAIT DEVELOPMENT

Currently we employ two complementary technical paths to develop traits: a conventional transgenic plant approach and the use of marker-assisted breeding to identify and stack genetically complex, native-trait loci. We also use map-based cloning strategies to identify the genes and pathways involved in conditioning such complex traits. Often stacking both transgenic and native traits is required in order to achieve a product concept that meets customer needs. For example, to develop improved feed traits, we are exploiting natural variations for certain grain components—such as increased digestibility—and

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combining these loci with transgenic approaches that achieve a more balanced amino acid composition in the grain. Successful product development also demands that traits are bred into the most elite, high-yielding germplasm, and the use of molecular markers and other technologies like double haploids can be used in conjunction with contra-seasonal seed production to accelerate trait integration and breeding timelines.

**ROBUST PROJECT MANAGEMENT**

In addition to a strong discovery platform, product development requires a robust project-management system to ensure that resources are allocated optimally to advance traits rapidly through the product-development timeline. At Pioneer, we use a process called Stages and Gateways to provide a framework for project-advancement decisions. It is a gated discovery process that provides defined technical and commercial criteria that must be achieved for projects to move toward commercial development. Projects that have achieved proof-of-concept, have a clear intellectual property protection strategy, and have confirmed phenotypes in field and greenhouse trials advance to Phase 3 or Advanced Development where field and laboratory data are assembled and submitted for regulatory approval, and extensive field-efficacy and breeding trials are conducted. Advancement to Phase 3 signals an organizational commitment to commercialize a product and requires a significant increase in dedicated resources. New products with novel end-use applications require extensive product testing to confirm their value in-use and to quantify specific customer benefits. Such early application testing also provides data to support communications about consumer benefits.

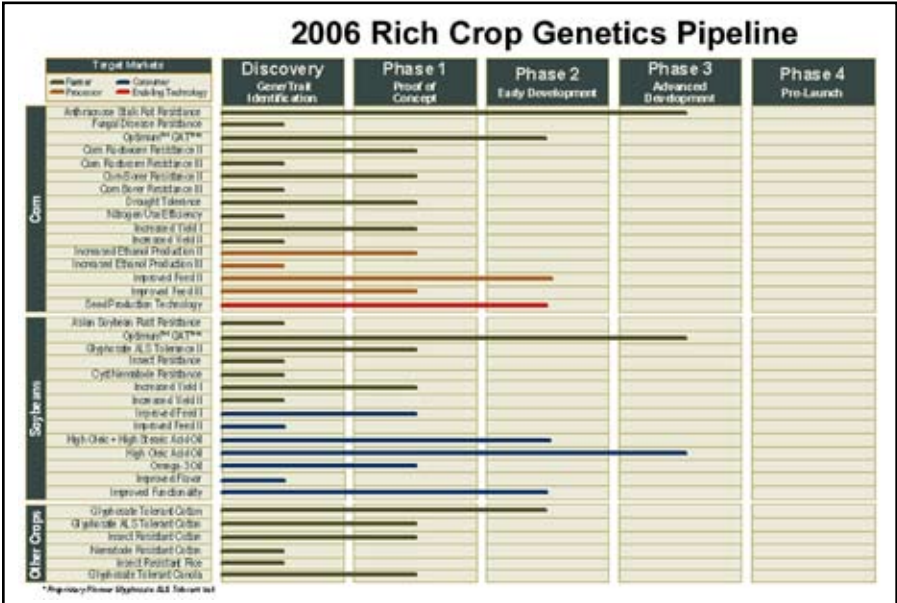


Figure 2. Pipeline of biotechnology traits.

## PRODUCT PIPELINE

As we look at our trait pipeline (Figure 2), we can see a shift from traits conditioned by single genes, such as insect or herbicide resistance, to traits where combinations of multiple genetic loci and/or several transgenes are required to achieve product specifications. In some cases, several genes are required to introduce new pathway branches to produce beneficial seed-oil compositions, such as in the production of long chain omega-3 fatty acids in soybeans. As more success is achieved in producing such products with clear consumer health benefits, more education will be required to achieve consumer acceptance of these products.

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*Production of health-promoting omega-3 fatty acids in soybeans represents a technical accomplishment achieved by introducing five to seven new biochemical steps.*

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Figure 3 shows our family of healthy oil products. On the market today is a non-transgenic, low-linolenic soybean oil product used in food-ingredient applications to reduce the amount of trans-fatty acids in the diet. This product will be followed in the market by a high oleic acid soybean product produced by reducing the amount of delta-12 de-

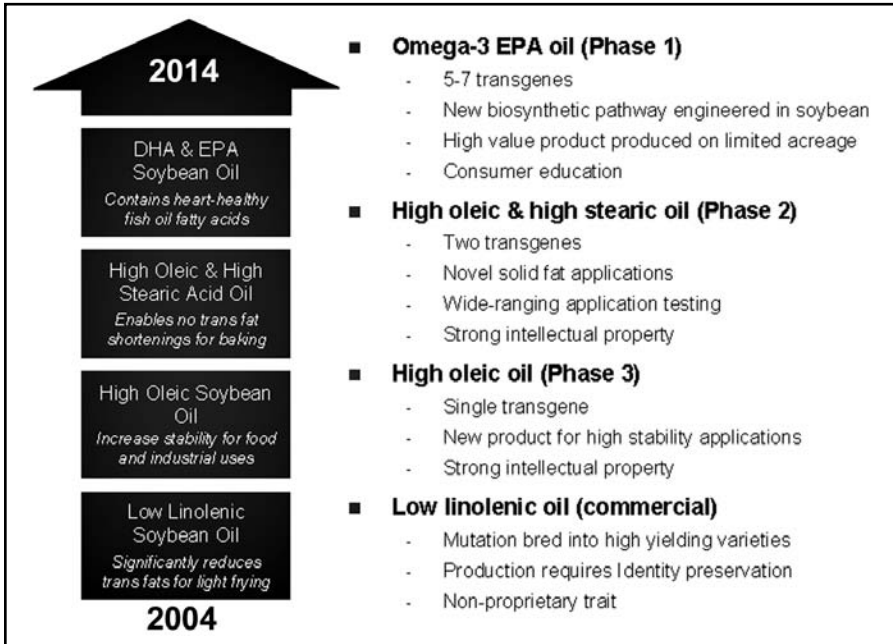


Figure 3. Soybean oil product pipeline.

saturase in the seed and preventing the conversion of oleic acid to linoleic acid. High oleic soybean oil is extremely stable, eliminating the need for hydrogenation. Combinations of high oleic acid and high stearic acid traits provide novel, healthy oils for solid-fat food applications. Production of health-promoting omega-3 fatty acids in soybeans represents a technical accomplishment achieved by introducing five to seven new biochemical steps required for the production of long-chain omega-3 fatty acids. This trait has achieved the proof-of-concept milestone in our pipeline. The commercialization of such a complex trait will require more investment of resources to ensure trait stability, agronomic performance and public acceptance than, for example, the introduction of second- and third-generation insect-resistance traits, where first-generation products already enjoy wide commercial acceptance.

## IN CONCLUSION

Several key components are required to translate discovery research into successful biotechnology-based products: a robust, technology-enhanced trait-discovery platform; a rigorous process for advancing products through the product-development process, increasing the probability of technical and commercial success at each step; a strong and experienced regulatory sciences program that provides high-quality data for agency approval; and a clear understanding of unmet customer needs.



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**RICHARD BROGLIE** is director for global R&D strategy for Crop Genetics Research and Development, which discovers and develops products primarily for DuPont's Pioneer Hi-Bred International seed-business unit. He received his PhD in microbiology from Rutgers University and served as both postdoctoral fellow and assistant professor in the Laboratory of Plant Molecular Biology at The Rockefeller

University before joining DuPont in 1985.

Dr. Broglie has held a number of research-leadership positions at DuPont, and has made significant contributions toward the discovery of traits for modified soybean and canola oils and disease resistance in corn, soybean, wheat and rice. He has served on the board of directors of InterMountain Canola, a limited partnership between DuPont and DNAP, and as business development manager linking internal research programs with strategic business partnerships.

In his present role, Broglie has responsibility for developing and implementing R&D strategies in India and China to access talent globally and to develop products for emerging markets in Southeast Asia.