



Introduction to Plant Biotechnology

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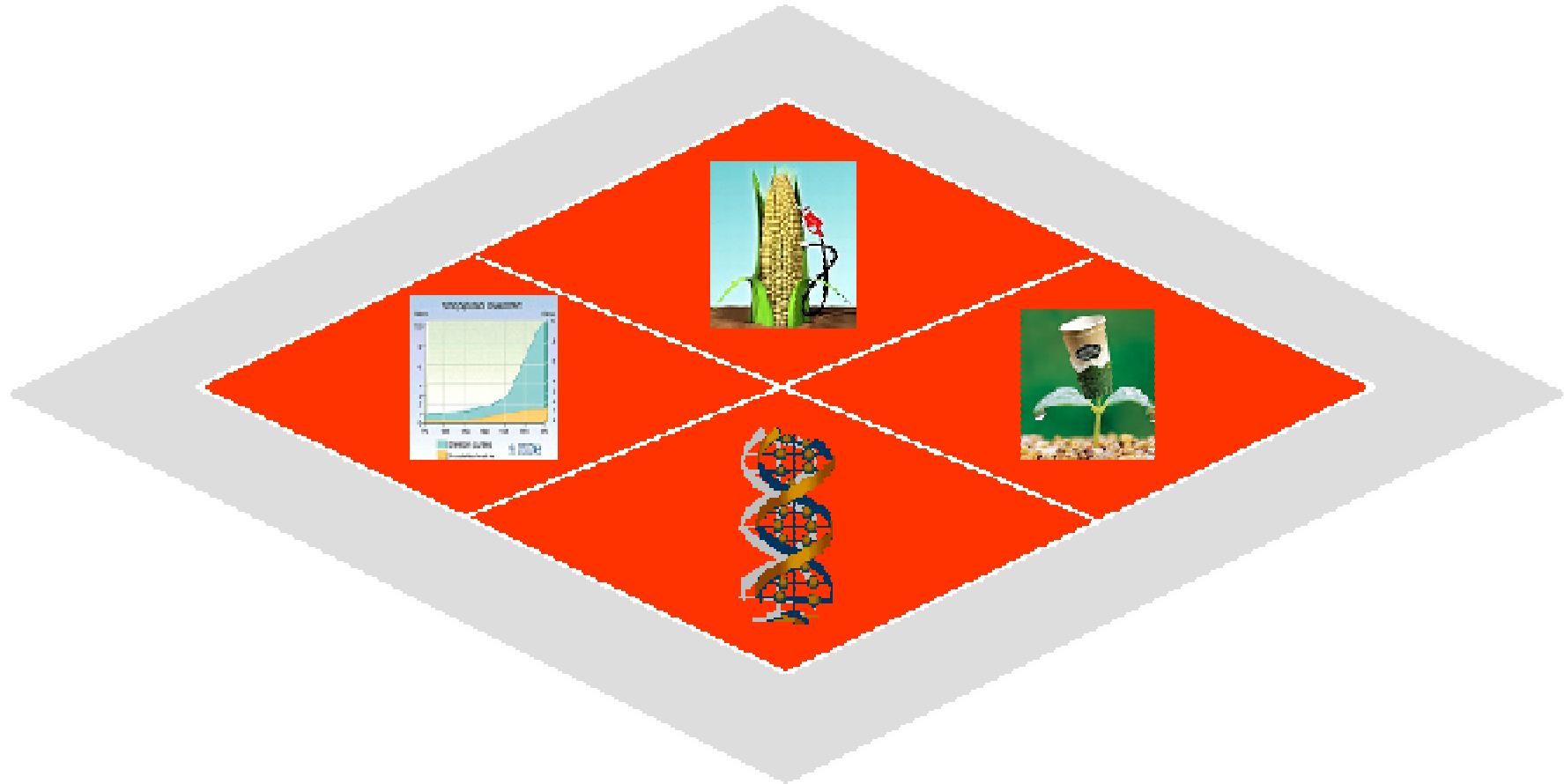
Citigroup: Chemicals for the Non-Chemist

December 3, 2007

Why Biotechnology in Agriculture?



It's a Great Time to be in the Biological Sciences



Introduction to Plant Biotechnology



What is Plant Biotechnology?

A precise process in which scientific techniques are used to develop useful and beneficial plants

Advantages over conventional
plant breeding methods

Ag Biotech product development

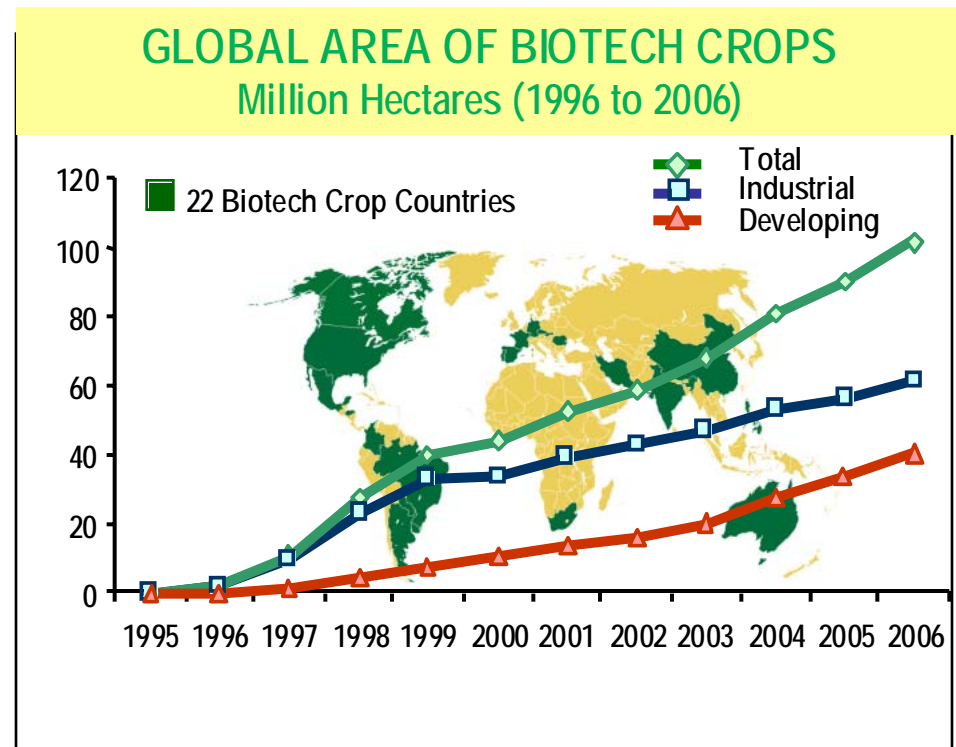
Future of Ag Biotech



Biotech Acceptance Growing



- Biotech displacing some traditional agricultural chemicals
- Markets are growing; planted areas expanding
- Regulatory environment is evolving
- Stewardship is key to public acceptance



Increase of 13%, 12 million hectares or 30 million acres, between 2005 and 2006

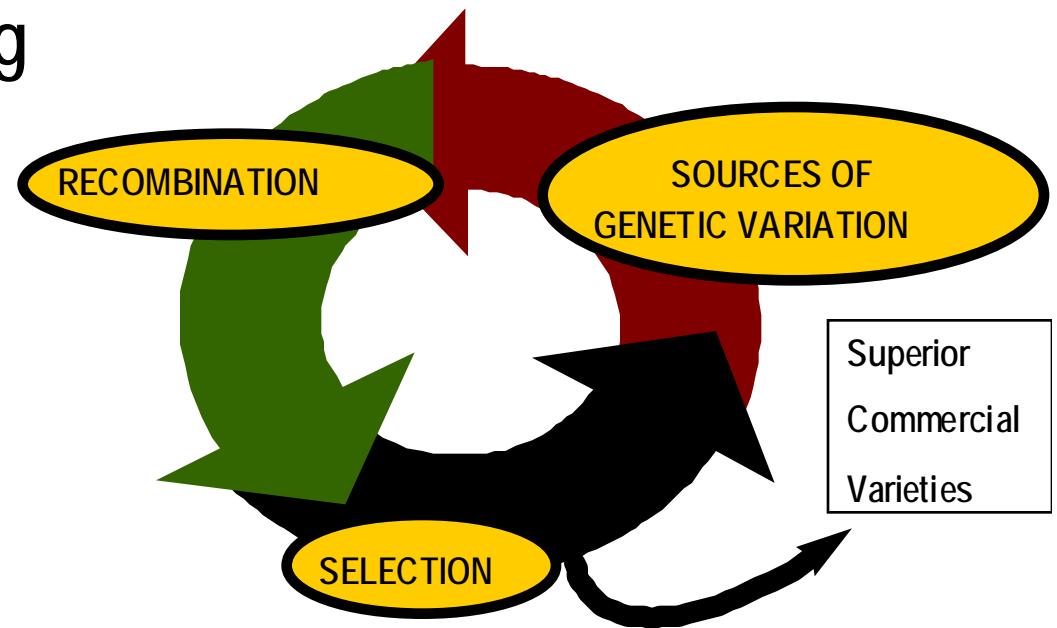
Source: Clive James, 2006

Advantages over Conventional Methods



Conventional Plant Breeding

- Identify/develop superior germplasm as source materials
- Identify and incorporate high-value characteristics into varieties & breeding stocks
- Develop new & competitive varieties



Germplasm = genetic base of a crop
Variety= subclass of species;
varieties within the same species can
be freely recombined (bred)

Advantages over Conventional Methods



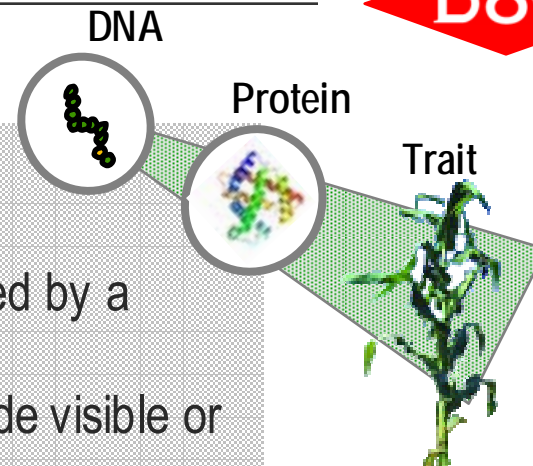
Basics of Molecular Biology

DNA= genetic instructions

Gene= unit of DNA sequence that is inherited

Protein= working molecule whose production is encoded by a gene(s)

Trait= distinctive inherited attribute of an organism, made visible or measurable by activity of proteins



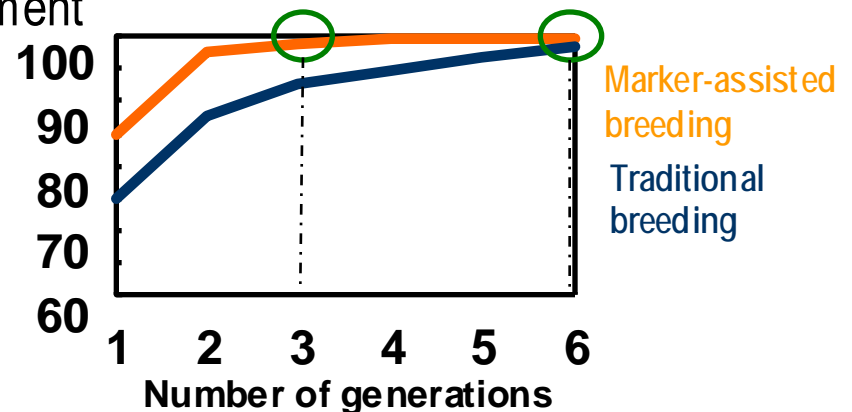
Molecular Breeding

Molecular markers= classes of DNA sequence used to distinguish between varieties, easily detectable with molecular tools

Genetic maps= illustrate the relative positions of markers and traits of interest

Advantages:

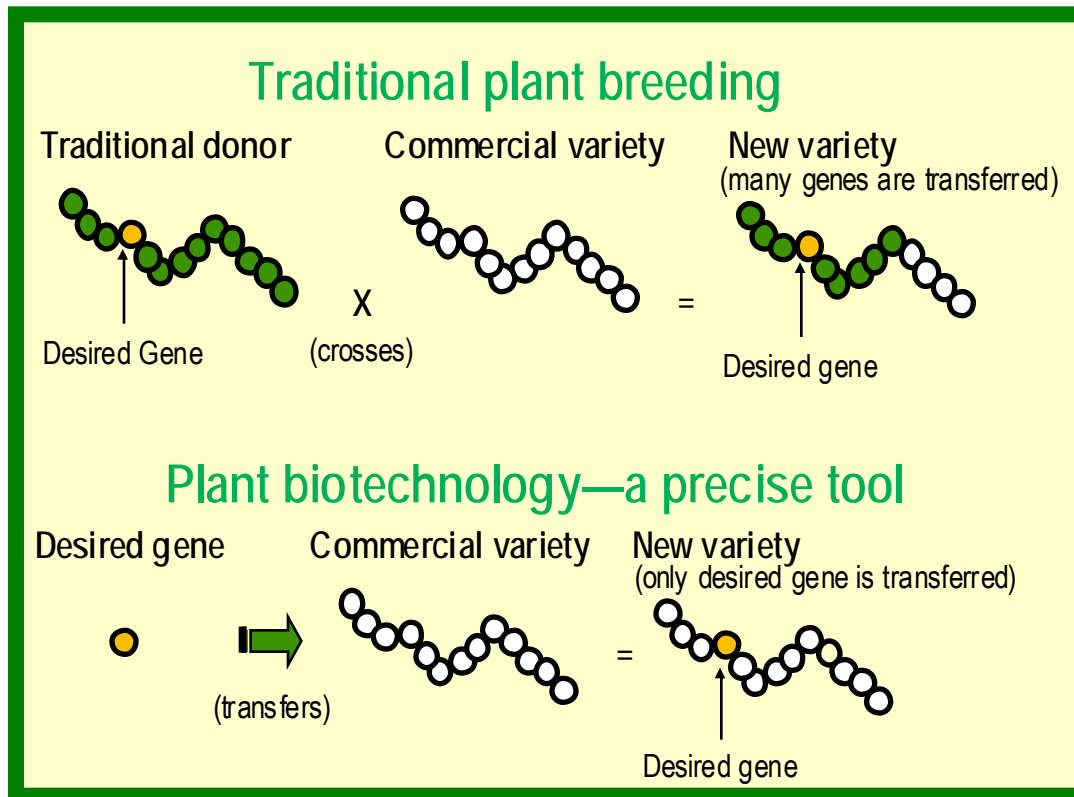
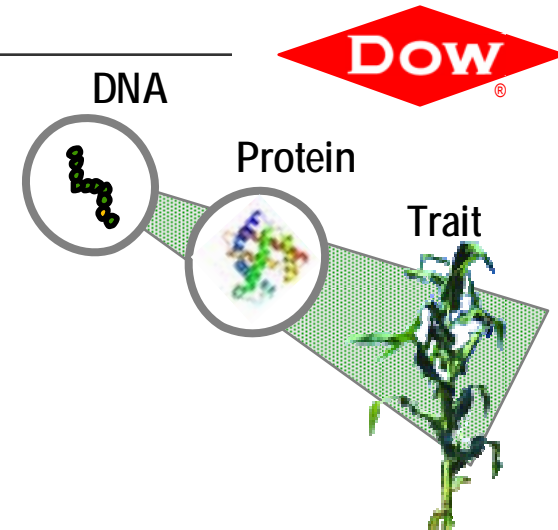
- Variety identification and protection (fingerprinting)
- Significantly reduced time required for product development



Advantages over Conventional Methods

Genetic Engineering

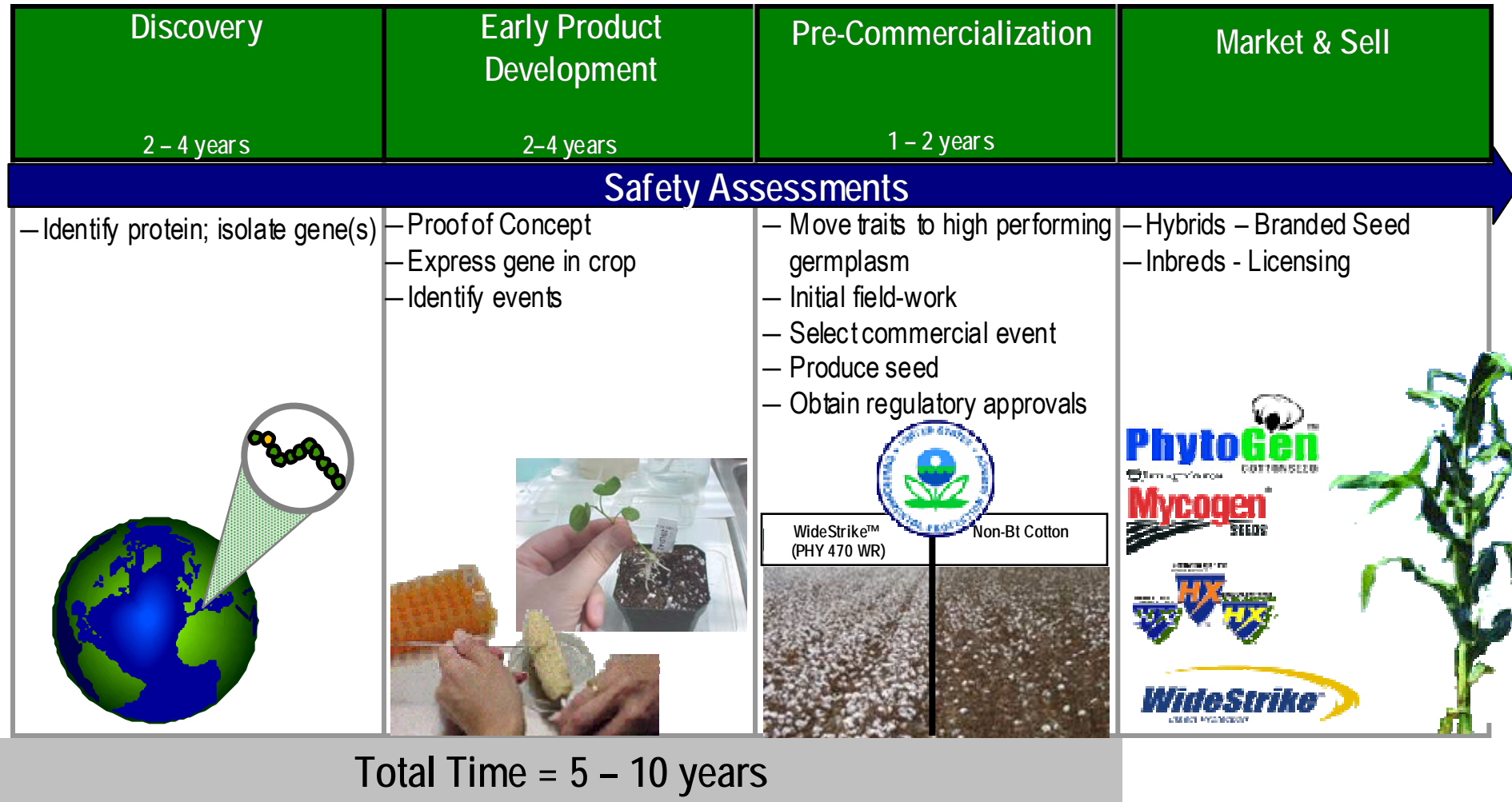
- Precisely selecting DNA encoding a desirable trait(s) and transferring it to another organism



Advantages:

- Faster and more precise
- Can bring together beneficial genes from a wide range of living sources, not just from within the same crop species or from closely related plants

Ag Biotech Product Development

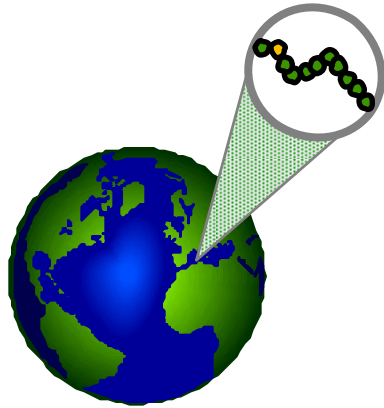


Trait Discovery

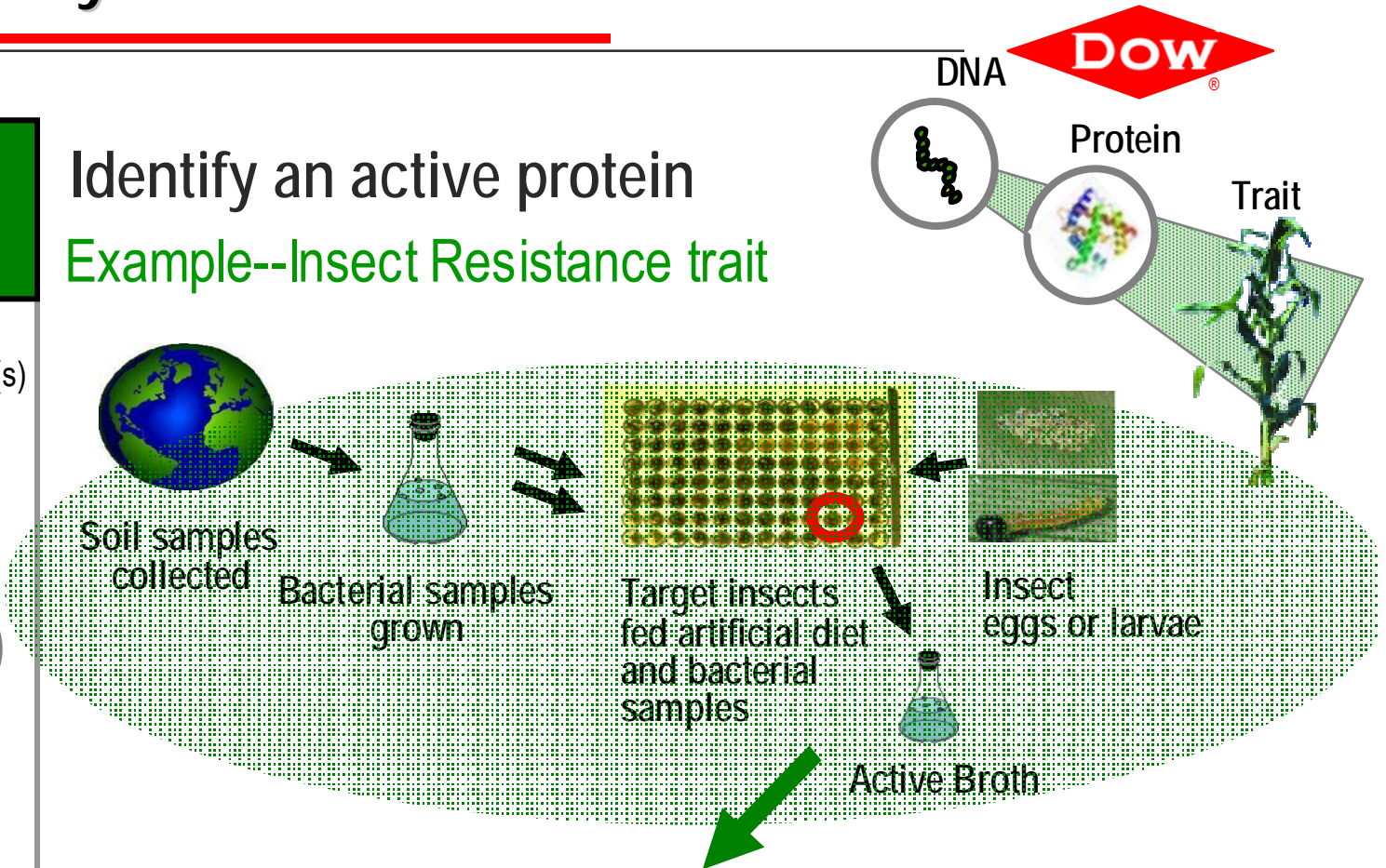


Discovery
2 - 4 years

— Identify protein; isolate gene(s)



Identify an active protein
Example--Insect Resistance trait



- Analysis of active broth results in the identification of a protein “lead”
- Determine gene responsible for protein
- Build gene for inserting into crop

Early Product Development



Validate Proof of Concept

Plant Transformation and Regeneration

- Insert gene of interest into the plant/plant cell

Plant transformation= heritable change brought about by the uptake and integration of foreign DNA into the host's DNA

- Validate insertion of gene

Genetically modified plant= plant containing a gene(s) selectively inserted rather than acquired through traditional breeding

Transgene= gene inserted into genetically modified plant, may be derived from various species

- Regenerate genetically modified plants
- Test for desired trait

Early Product Development

2-4 years

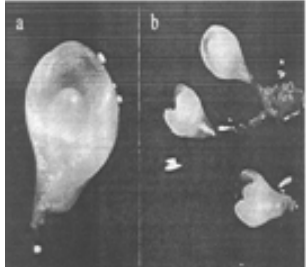
- Proof of Concept
- Express gene in crop
- Identify events



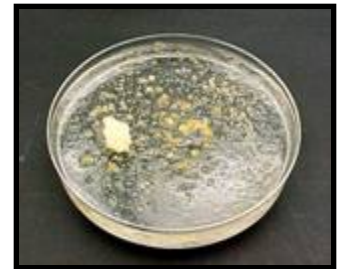
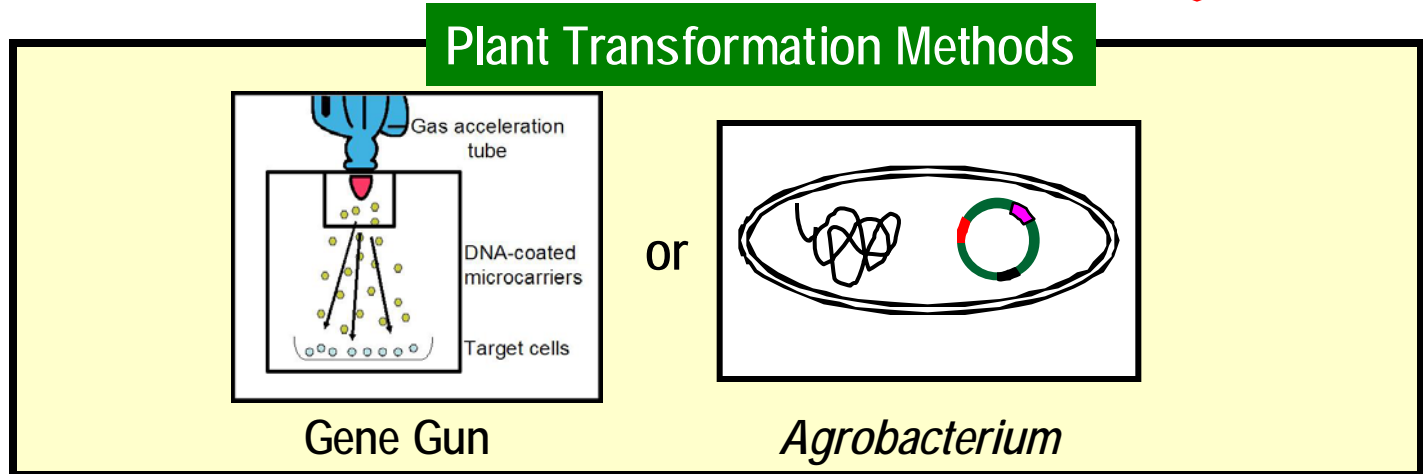
Early Product Development



Corn Example



Immature embryo



Transgenic Tissue



Plant Regeneration



Seed Production

Early Product Development



Express Gene in Crop and Identify Events

- Transformation results in
 - Random insertion of the transgene into the host plant's DNA
 - Variable number of copies of transgene inserted
- Event= genetically modified plant uniquely identified at the DNA level by characteristics of insertion site and number of copies of the transgene within the plant's native DNA
- Plants transformed with the same transgene, using the same transformation method, may demonstrate markedly variable attributes
 - Hundreds of events are generated from a single transformation
 - Events must be sorted to identify those with commercial potential

Early Product Development

2-4 years

- Proof of Concept
- Express gene in crop
- Identify events



Early Product Development



Event Sorting Criteria

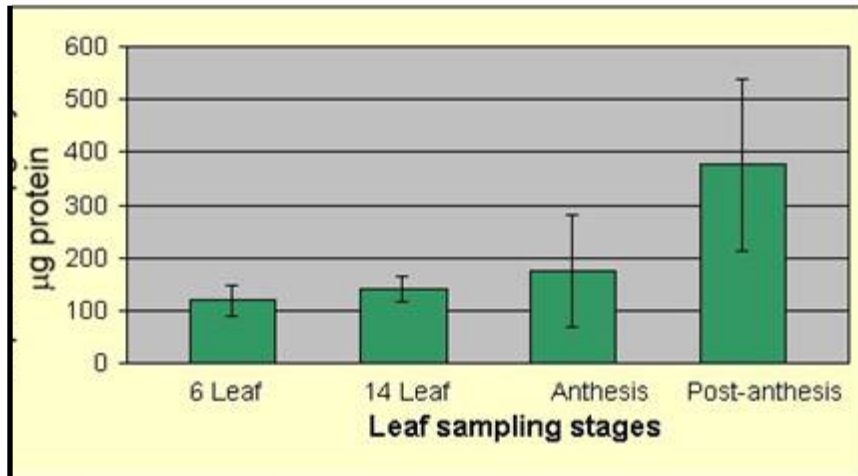
- *Physical characteristics at the DNA level*
 - How many copies of the gene were inserted?
 - Was a full-length gene inserted?
- *Genetic characteristics*
 - How is the gene passed to future generations during breeding?
- *Expression/Efficacy*
 - Does the event produce the required level of protein to confer the desired trait? When? Where?
 - Is protein expression stable over multiple generations?
- *Agronomics*
 - Are the native characteristics of the plant commercially acceptable?



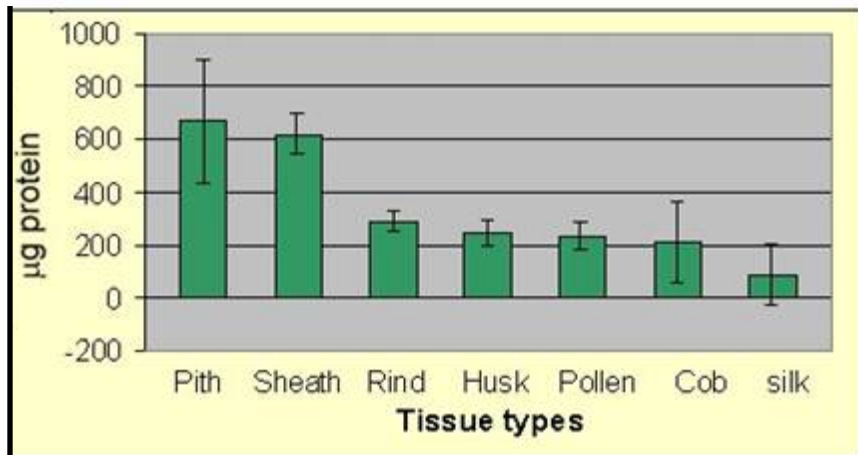
Event Sorting Example



Expression levels of active protein



When does expression occur?



Where does expression occur?

- Expression of desired protein increases in leaves as plant matures
- Desired protein expresses well in almost every tissue type except silks, throughout the growth and developmental stages

Pre-Commercialization



Move traits into high performing germplasm

Introgression= The process of incorporating a trait/gene into a variety while recovering the original characteristics of that variety

- Typically accomplished by a series of crosses in consecutive generations between the original and the new variety (*backcrossing*)
- Outcome is a new variety that performs like the original variety with the additional characteristics of the trait encoded by the inserted gene

Pre-Commercialization

1 – 2 years

- Move traits to high performing germplasm
- Initial field-work
- Select commercial event
- Produce seed
- Obtain regulatory approvals



WideStrike™
(PHY 470 WR)

Non-Bt Cotton



Pre-Commercialization



Field Development and Seed Production

Multiple year evaluation to select commercial event

- Trait function
- Yield, agronomic quality, adaptation, seed properties, etc.

Multiple year seed increase

- Use self-pollination and/or isolation
- Use domestic and winter nurseries
- Quality Control - trait purity and the lack of unintended events/traits

Pre-Commercialization

1 - 2 years

- Move traits to high performing germplasm
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WideStrike™
(PHY 470 WR)

Non-Bt Cotton

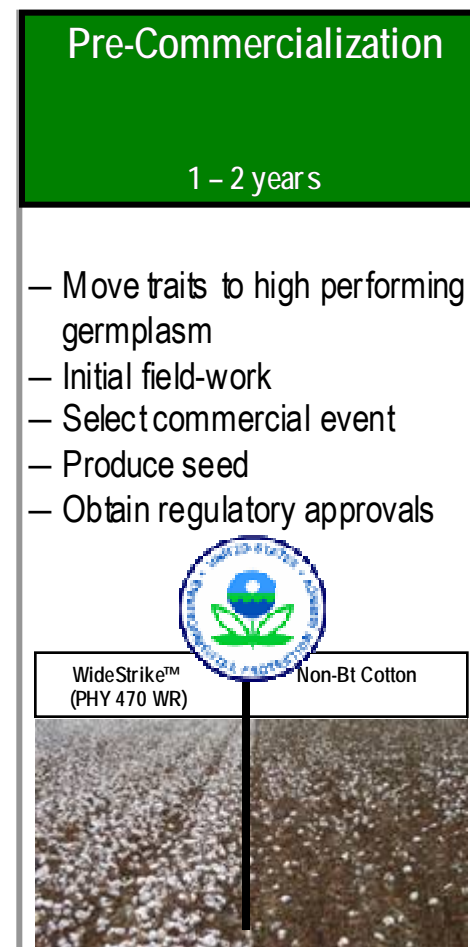


Pre-Commercialization



Obtain Regulatory Approvals

- Multiple agencies regulate biotech products around the world
 - US Environmental Protection Agency
 - US Department of Agriculture
 - US Food and Drug Administration
 - Appropriate OUS Agencies
- Global Regulatory environment is evolving; currently 0% tolerance in most geographies for sale of unapproved products
- Typical timeline for product registration = 2+ years from submission



Market & Sell



Channels to Market

Market & Sell

- Hybrids – Branded Seed
- Inbreds - Licensing



	<p>Mycogen® Seeds – North America</p> <ul style="list-style-type: none"> ▪ Market leader in sunflowers & Silage-Specific corn ▪ Corn enhanced with Herculex® I <i>Insect Protection</i>
	<p>Nexera® Canola</p> <ul style="list-style-type: none"> ▪ Exclusive source of Natreon™ canola oil ▪ DAS (Canada) & Mycogen (USA)
	<p>PhytoGen™ Seed Company</p> <ul style="list-style-type: none"> ▪ Global leader in Pima and Acala varieties ▪ Now enabled with WideStrike™ <i>Insect Protection</i>
	<p>Morgan™ Seeds – Argentina</p> <ul style="list-style-type: none"> ▪ Corn, sunflower, sorghum ▪ Platform for DAS IR traits in Argentina
	<p>Dow AgroSciences Sementes – Brazil</p> <ul style="list-style-type: none"> ▪ Corn, sunflower, sorghum ▪ Platform for Dow AgroSciences IR traits in Brazil

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The Opportunities Continue...

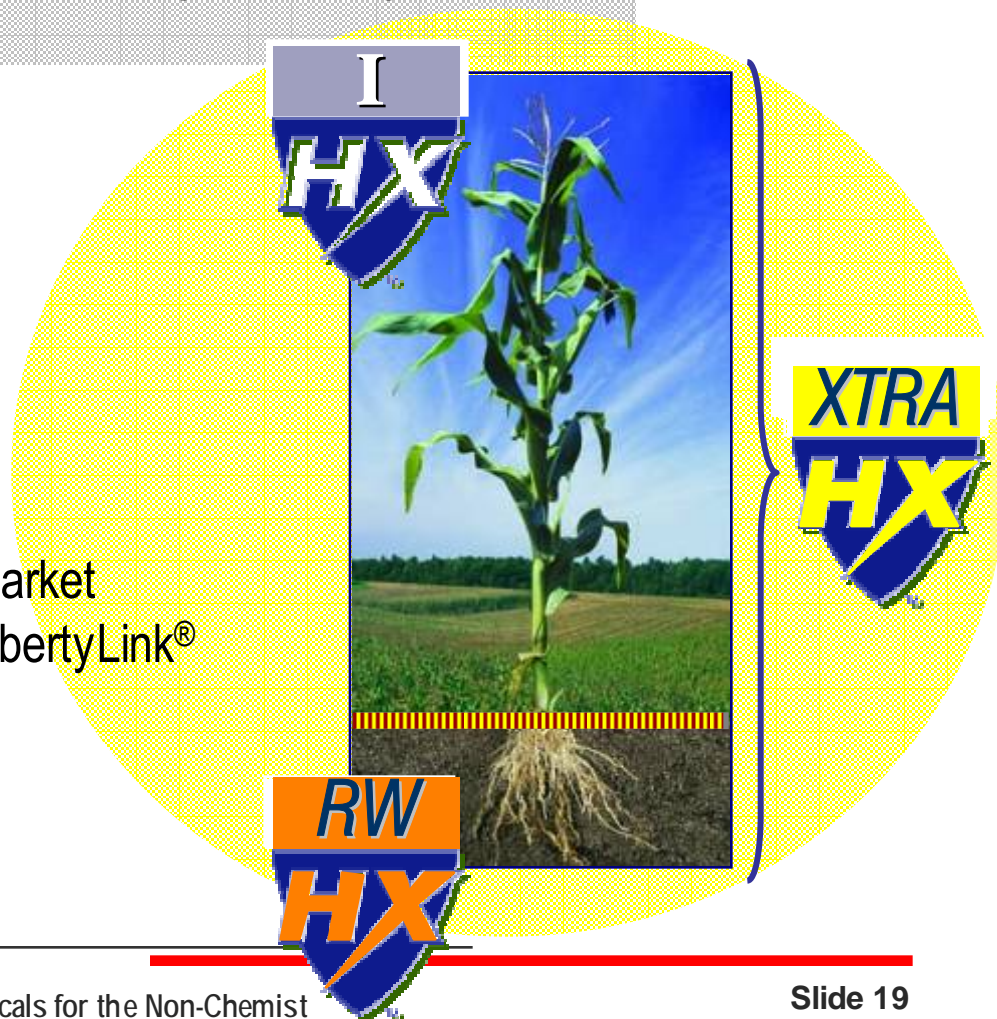


Stacking= The process of combining two or more traits/genes into one plant or variety. Most commonly done by cross pollinating plants containing the two genes (breeding). Can also be done by insertion of two or more genes during plant transformation (molecular stacking).

**Example: Herculex™ XTRA
Protects Corn Top to Bottom**



- Broadest spectrum insect control on the market
- Also stacked with Roundup Ready® and LibertyLink® genes for herbicide tolerance



™Trademark of Dow AgroSciences LLC

LibertyLink® Trademark of Bayer CropScience

Roundup Ready® Trademark of Monsanto Co.

Coming Soon...



Revolutionizing Traits through Stacking

SmartStax™ creates platform with superior performance in one package

SmartStax

Anatomy of first-ever eight-way gene stack

ABOVE-GROUND INSECT PROTECTION



BELOW-GROUND INSECT PROTECTION



WEED CONTROL SYSTEM



New value and opportunity for farmers:

Durability

- Combined modes of action for insect protection guard against the development of insect resistance
- Combined herbicide tolerant traits that offer multiple modes of action for weed control

Performance

- Enhanced control of a broader spectrum of above- and below-ground insects
- Most comprehensive protection against established and emerging secondary pests
- The industry's best weed control system

™SmartStax is a trademark of Monsanto Technology LLC

Broadest Control Available



The broadest control of primary and secondary pests available to farmers

	Primary Pests					Secondary Pests		
	European Corn Borer	S'thw eastern Corn Borer	Northern Corn Rootw om	Western Corn Rootw om	Fall Armyw om	Western Bean Cutw om	Black Cutw om	Corn Earw om
	Red	Red	White	White	Red	Red	Red	White
	White	White	Red	Red	White	White	White	White
	Red	Red	White	White	Red	White	White	Red
	White	White	Red	Red	White	White	White	White
	Red	Red	Red	Red	Red	Red	Red	Red

For information on current commercial GMO products, see <http://www.agbios.com/dbase.php>



- :: Recent Updates**
1. **LLRICE601**- Glufosinate Rice
 2. **IMINTA-1, IMINTA-4** Herbicide tolerance Rice
 3. **BW255-2, BW238-3** Herbicide tolerance Wheat
 4. **MON88017**- Herbicide tolerance + insect resistance Maize
 5. **LY038**- Plant quality Maize
 6. **DAS-06275-8**- Insect resistance Maize
 7. **LLRICE06, LLRICE62**- Glufosinate Rice

:: Synopsis

[Overview of all products in database](#)



- :: Essential Information**
- :: Biotech Crop Database
 - :: Principles and Practice of Environmental Safety Assessment of Transgenic Plants
 - :: The Safety of GM Livestock Feeds
 - :: Bibliography Database

:: Search the GM Crop Database

Our database of safety information includes not only plants produced using recombinant DNA technologies (e.g., genetically engineered or transgenic plants), but also plants with novel traits that may have been produced using more traditional methods, such as accelerated mutagenesis or plant breeding. These latter plants are only regulated in Canada.

Also, please note that regulatory approval should not be interpreted as an indication that the product is in commercial production. There are many examples of products that were granted regulatory approval but were never commercialized, or if they were, have been subsequently discontinued.

By setting conditions for more than one criterion from the options below, you can construct boolean queries. For example, selecting "maize" as the crop plant and "herbicide tolerance" as the trait will display a listing of herbicide tolerant maize products.

The values in the Event Name selection box, below, correspond to the identifiers commonly used by regulatory authorities and international organizations, such as the Organization for Economic Cooperation and Development (OECD).

:: Select values, then click the Submit button

Event Name	--Any--	
Crop Plant	--Any--	
Trait	--Any--	
Inserted Gene	--Any--	
Type of Approval	--Any--	
Country	--Any--	
Original Developer	--Any--	

Future Products



New traits = improved spectrum, better efficacy, new crops

The image shows two vertical ovals. The left oval contains a close-up of a corn cob with yellow and red kernels. The right oval contains a cotton plant with white bolls and a glass bottle of yellow oil.

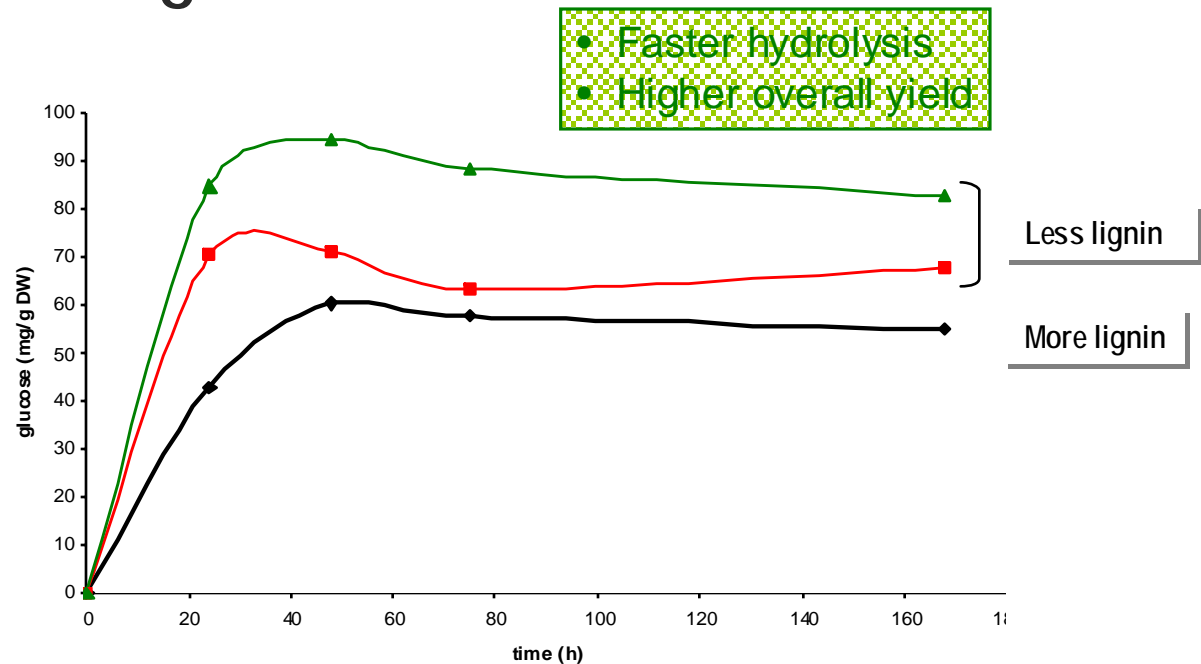
<p>Corn</p> <p><i>Yield enhancement</i></p> <ul style="list-style-type: none">-- Insect resistance-- Herbicide resistance-- Stress management <p><i>Animal Nutrition</i></p> <ul style="list-style-type: none">-- High energy-- Low phytate-- Improved digestibility-- Essential amino acids	<p>Cotton</p> <ul style="list-style-type: none">-- Insect resistance-- Fiber quality <p>Healthy Oils</p> <ul style="list-style-type: none">-- No-sat Omega-9 Oil-- High oil content-- Novel oil seed processing-- Yield enhancement-- Pod-shatter resistance-- High energy meal
--	---

Future Products



Corn Potentially Advantaged for Ethanol

- Corn products with 50% less lignin result in more readily-available energy release
- Collaborative research between Dow AgroSciences and Purdue University demonstrated utility of low lignin corn as improved cellulosic feedstock*



Less lignin



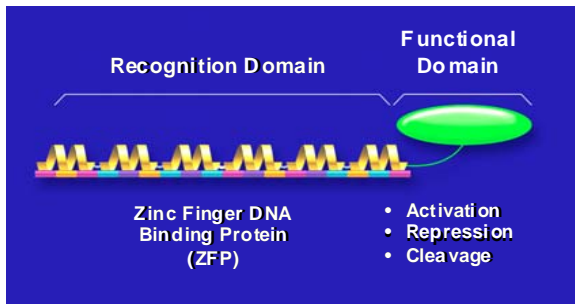
Conventional:
More lignin

*Acknowledgment: Michael Ladisch, Wilfred Vermerris, Nate Mossier; Purdue University

Future Technologies



Precise targeting of DNA integration for more rapid product development



Zinc fingers

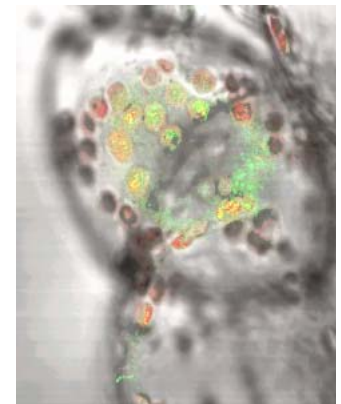
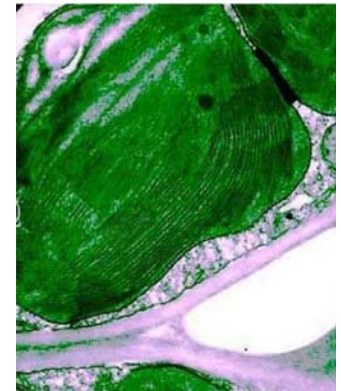
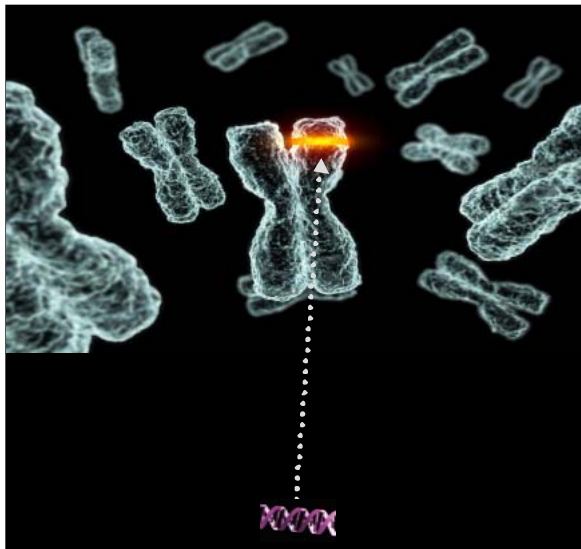
- ZFP™ DNA-binding domains can be used to integrate transgenes into precise locations

Chloroplast transformation

- Substantial increases in expression when genes targeted to chloroplasts rather than nucleus
- No potential for transgene spread through pollen

Artificial Chromosomes

- “Extra” chromosomes engineered with potential to add multiple genes conferring multiple traits or an entire metabolic pathway (*molecular stacking*)



™Trademark of Sangamo BioSciences

Always Working With an Eye to Stewardship



Product stewardship= the responsible and ethical management of a biotechnology product from its discovery or development through to its ultimate use

<http://excellencethroughstewardship.org>

SEC Disclosure Rules



- Some of our comments today may include statements about our expectations for the future. Those expectations involve risks and uncertainties. Dow cannot guarantee the accuracy of any forecasts or estimates, and we do not plan to update any forward-looking statements if our expectations change. If you would like more information on the risks involved in forward-looking statements, please see our annual report and our SEC filings.
- In addition, some of our comments may reference non-GAAP financial measures. Where available, a reconciliation to the most directly comparable GAAP financial measures and other associated disclosures are provided on the internet at www.dow.com in the Financial Reports page of the Investor Relations section.

