

GMOs: Distinguishing Fact from Fiction

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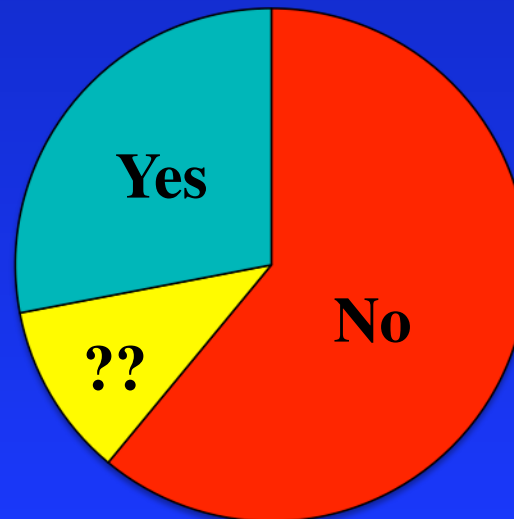
Topics

- Why the controversy?
- What is genetic engineering?
 - Context – previous crop genetic change
- What GE crops are out there?
(and not out there!)
- Questions and concerns...



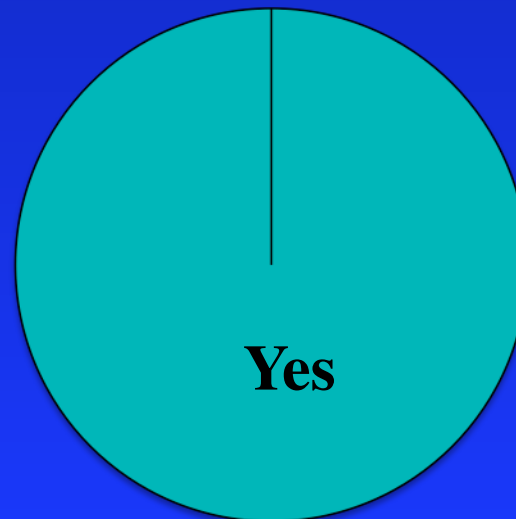
Why the Controversy?

- Genetic engineering - a logical extension of what plant breeders have always done
 - Little understanding of plant breeding
 - Have you ever eaten a fruit or vegetable that is a product of “traditional cross breeding”?



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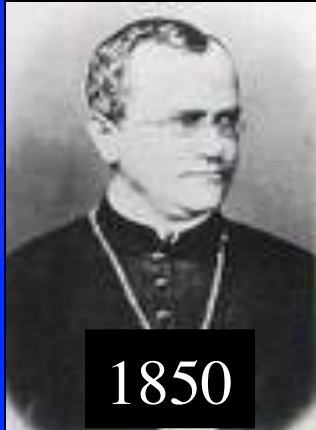
Why the Controversy?

- Genetic engineering - a logical extension of what plant breeders have always done
 - Little understanding of plant breeding
 - Have you ever eaten a fruit or vegetable that is a product of “traditional cross breeding”?
- Most GE crops - benefits to consumers unclear
- New technology always raises concerns...



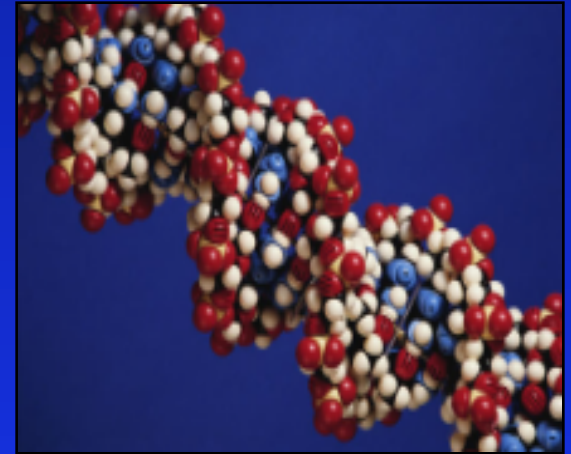
Genetic Engineering

- A new tool for breeding improved crops
- Alters the properties of organisms by:
 - Transferring individual genes between organisms
 - Modifying a gene within an organism
- No need for sexual cross-compatibility...



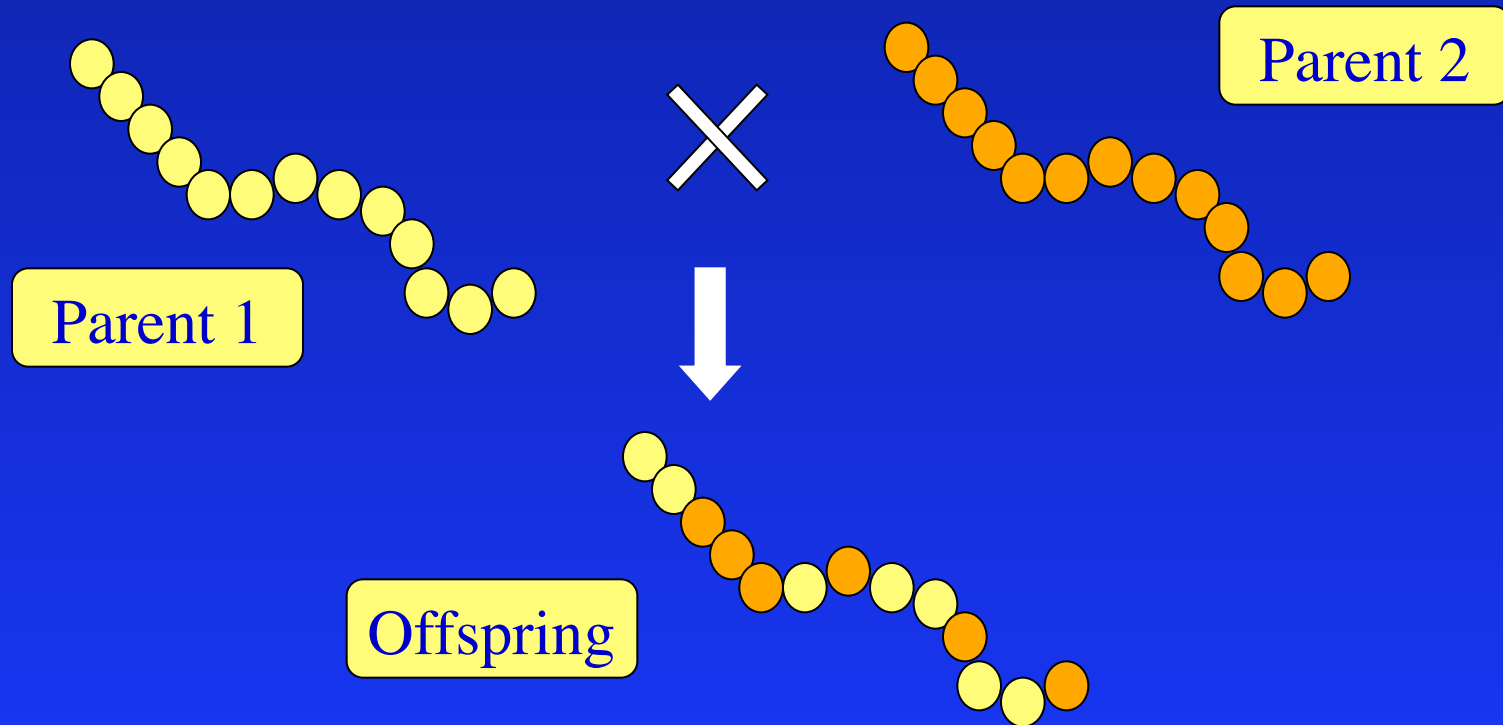
About Genetic Material...

- Deoxyribonucleic acid (DNA)
 - The “code book” for an organism
 - Structural products
 - Regulation of their production
- An alphabet of four “letters” (A, T, G, C)
- Universal



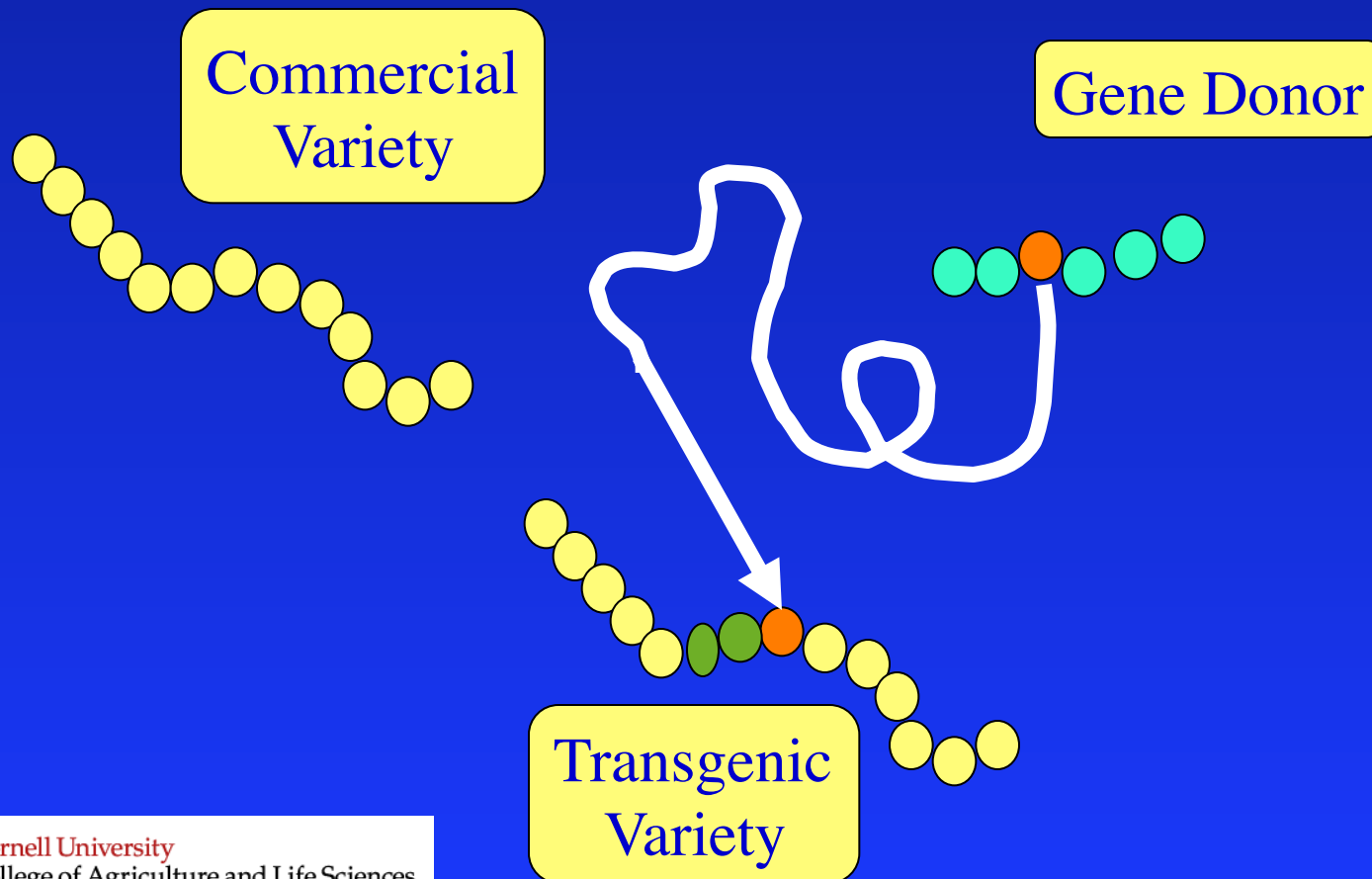
Traditional Cross Breeding

Combines many genes from both parents



Genetic Engineering

Adds one or a few genes to a particular parent



Genetic Modifications Humans Have Made...

- Domestication
- Farmer selection of new crops and varieties
- Cross breeding
- Genetic engineering



“GMO” suggests that our crops were not genetically altered prior to use of genetic engineering...

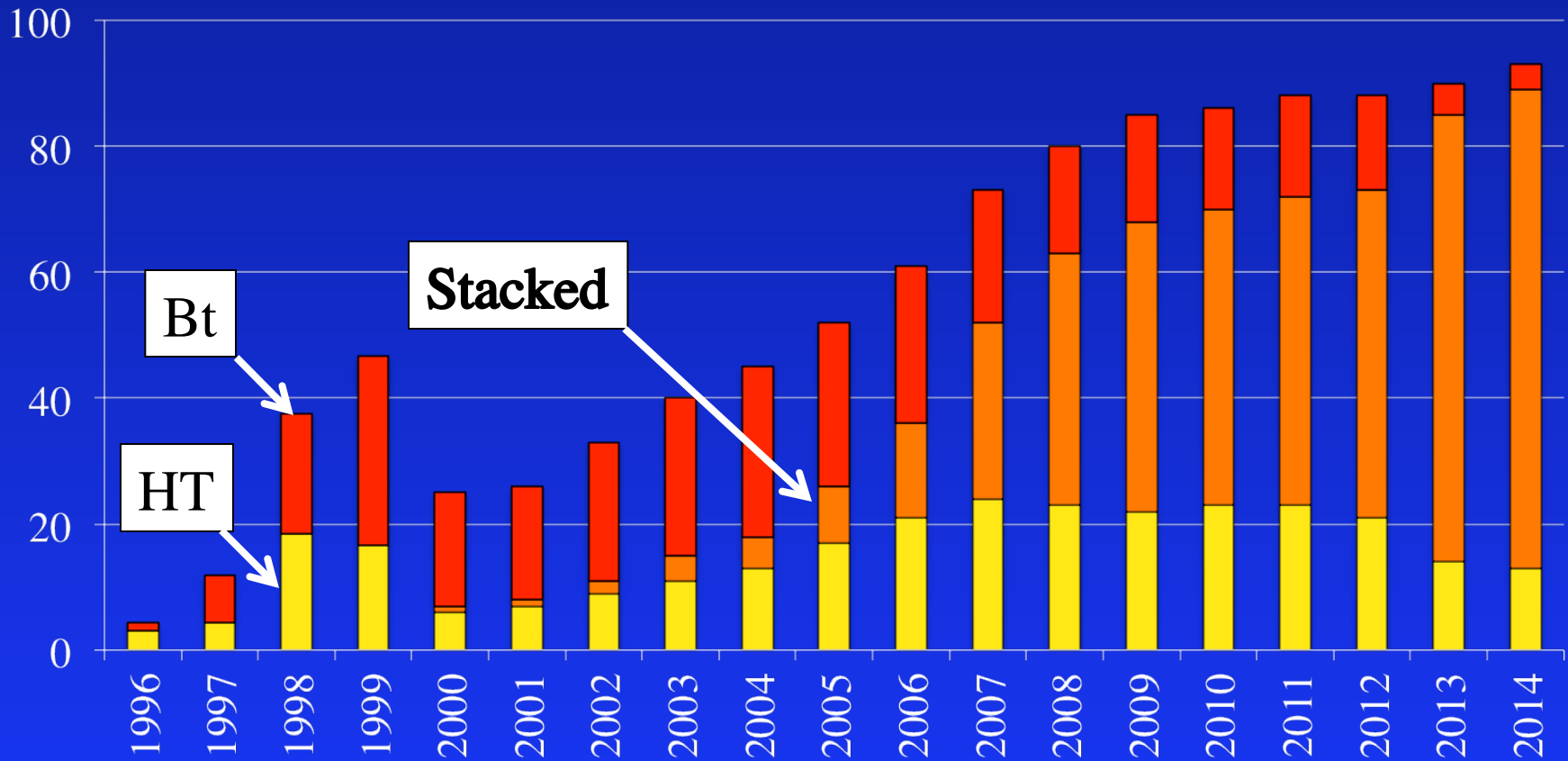


GE Crop Types Grown in the US

- Bt crops (corn, cotton, sweet corn)
- Herbicide resistant crops (soybean, corn, cotton, canola, sugar beet, alfalfa)
- Virus resistant crops (papaya, squash)



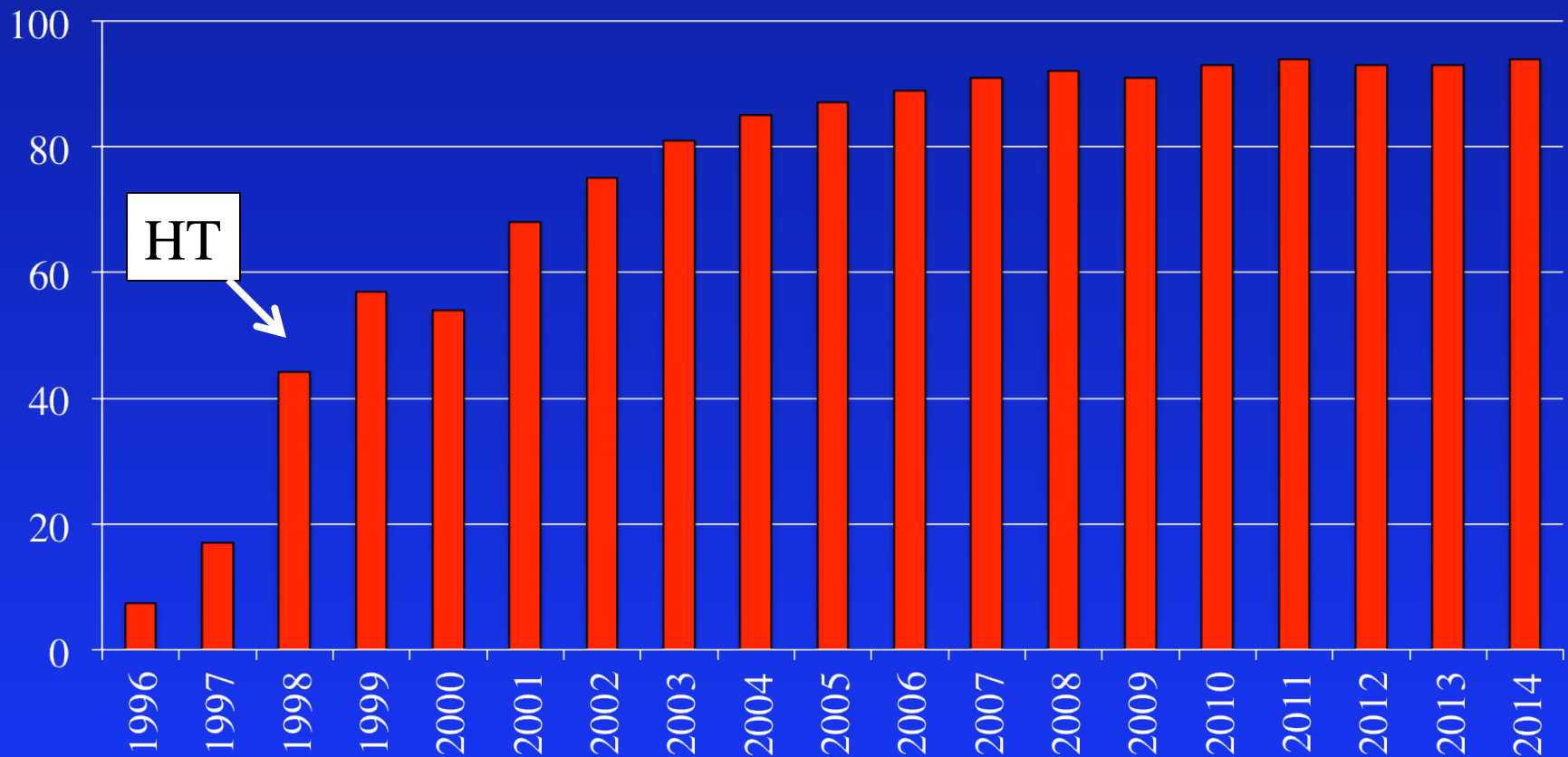
U.S. Corn Acreage Planted to GE Varieties, 1996 to 2014



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(data source: USDA ERS, 2014)

U.S. Soybean Acreage Planted to GE Varieties, 1996 to 2014



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(data source: USDA ERS, 2014)

New Approved GE Crop Varieties

- Soybean – insect resistant (Apr. 2014)
- Alfalfa – reduced lignin (Nov. 2014)
- Potato – reduced black spot bruise and low acrylamide production (Nov. 2014)
- Soybean – 2, 4-D, dicamba, HPPD tolerance versions (Jul. 2014 – Jan. 2015)
- Cotton – dicamba tolerant (Jan. 2015)



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GE Crops Being Considered

- Apple – non-browning
- Potato – late blight resistant, reduced black spot bruise, low acrylamide potential, lowered reducing sugars
- Cotton – 2,4-D resistant



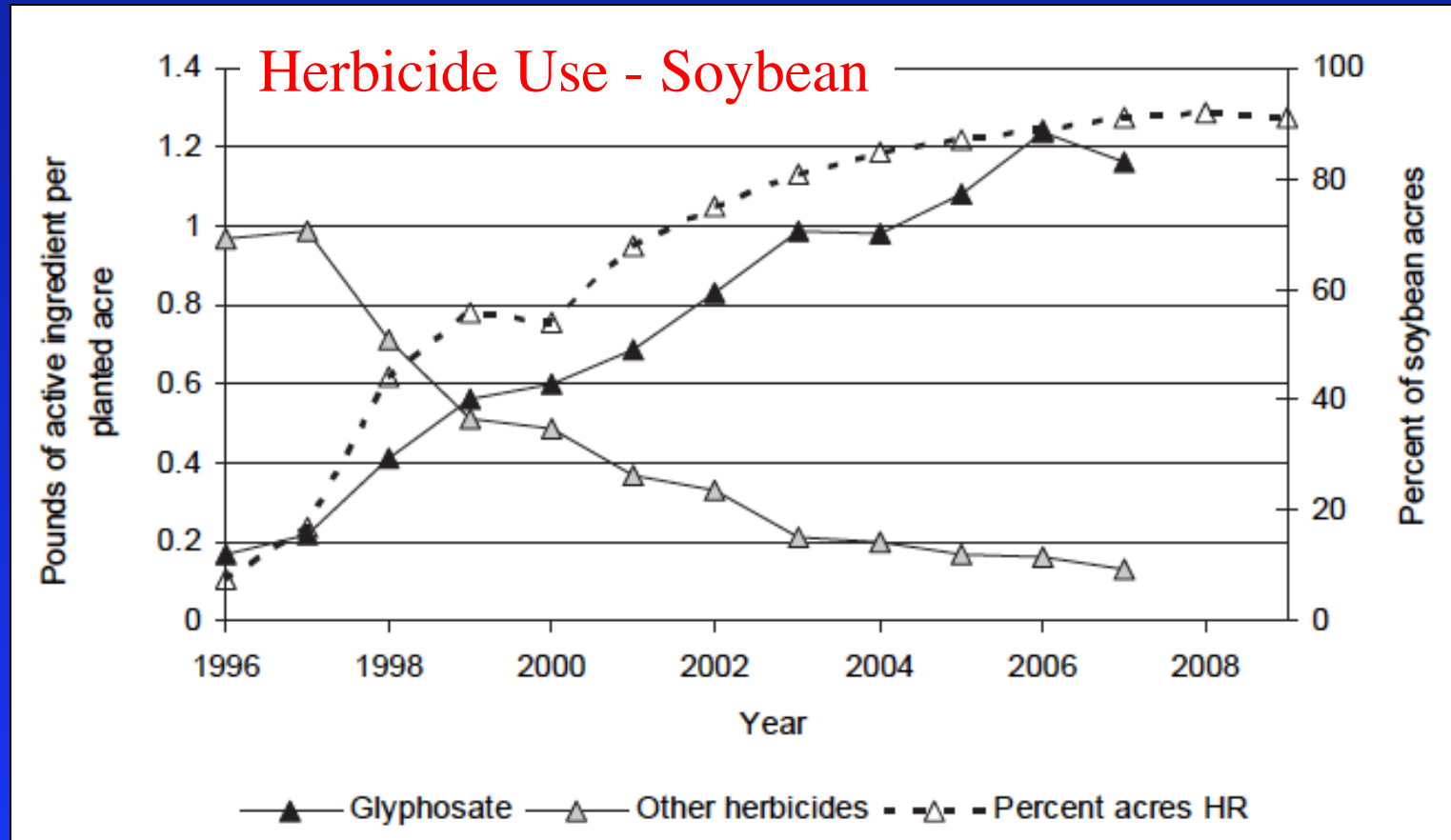
Impacts in U.S.

- National Research Council study released in 2010 from the National Academy of Sciences
- Evaluated peer reviewed literature on farm-level impacts



NAS – NRC Study Findings

- More herbicide used, but a less toxic one



Weed Resistance to Glyphosate

Areas not growing GE crops:



In U.S. since GE crops introduced:



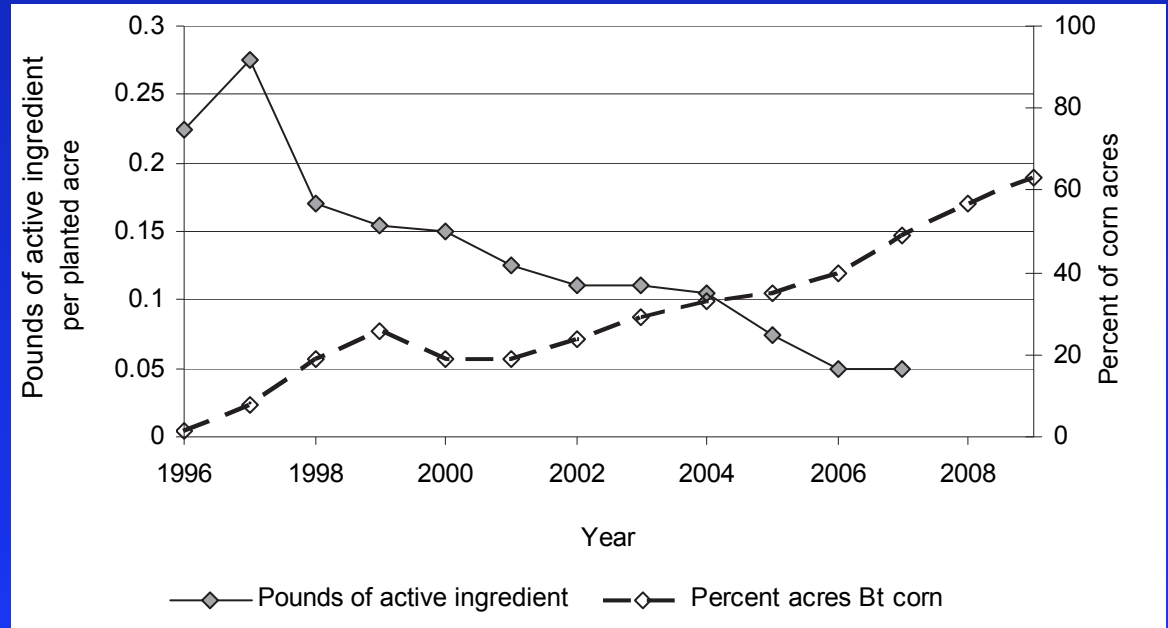
9 weeds evolved resistance



NAS – NRC Study Findings

- More herbicide used, but a less toxic one
 - Facilitated use of reduced tillage
- Less insecticide use

Corn Insecticide Use per Acre

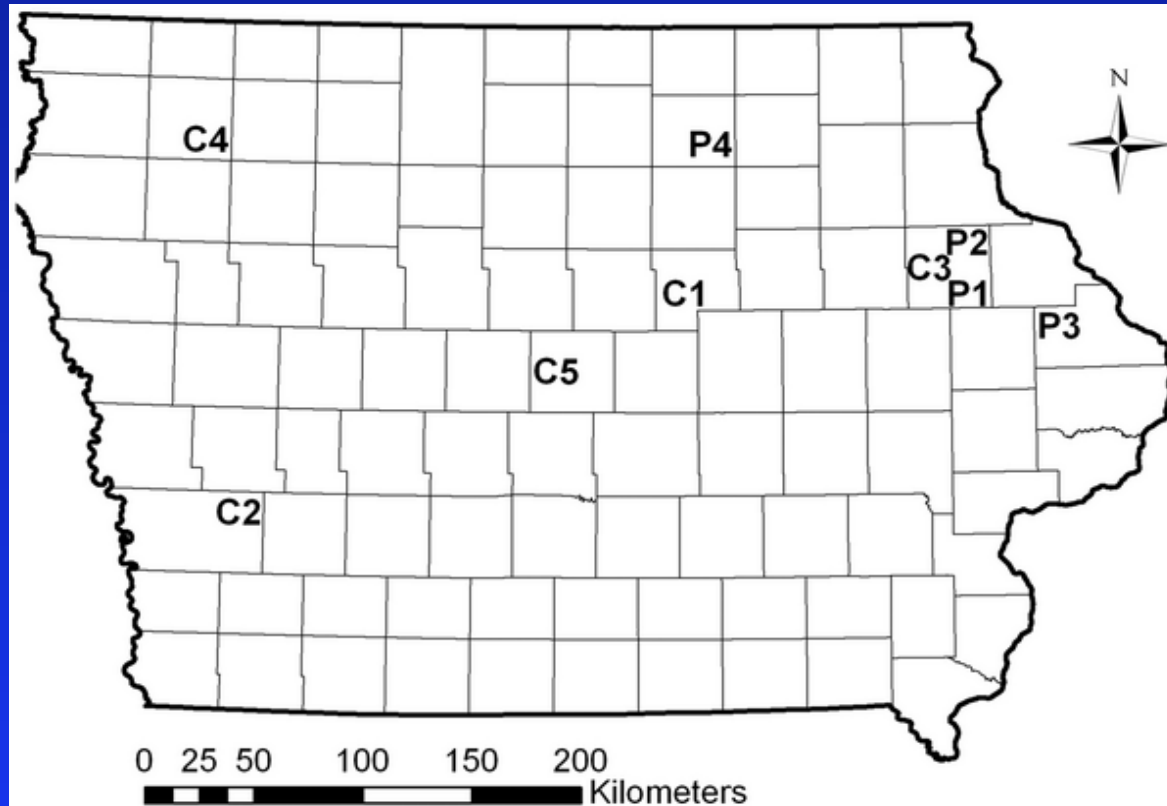


Bt Corn Rootworm Trait

- A very “plastic” insect species
- Has evolved resistance to:
 - Insecticides
 - Rotations



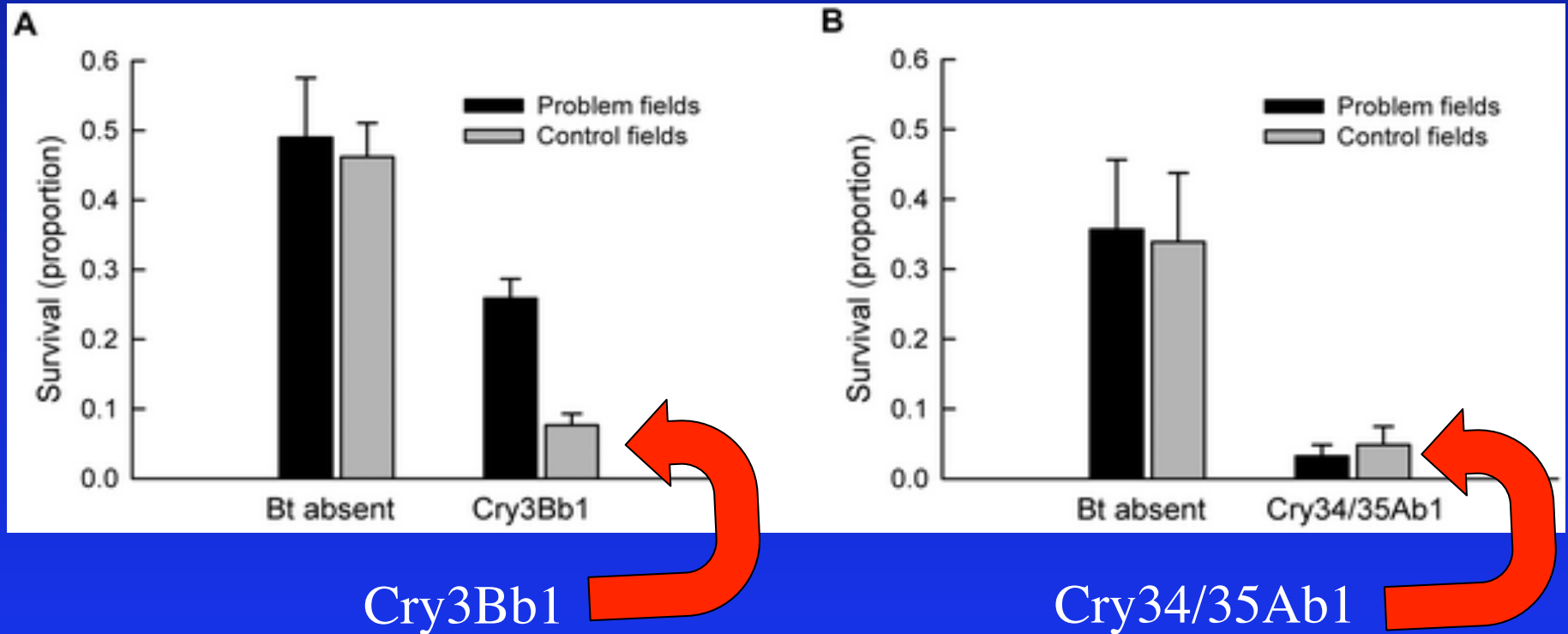
Distribution of sites sampled within Iowa during 2009



Gassmann AJ, Petzold-Maxwell JL, Keweshan RS, Dunbar MW (2011) Field-Evolved Resistance to Bt Maize by Western Corn Rootworm. PLoS ONE 6(7): e22629. doi:10.1371/journal.pone.0022629

<http://www.plosone.org/article/info:doi/10.1371/journal.pone.0022629>

Survival of western corn rootworm on Bt and non-Bt maize



Gassmann AJ, Petzold-Maxwell JL, Keweshan RS, Dunbar MW (2011) Field-Evolved Resistance to Bt Maize by Western Corn Rootworm. *PLoS ONE* 6(7): e22629. doi:10.1371/journal.pone.0022629

<http://www.plosone.org/article/info:doi/10.1371/journal.pone.0022629>

NAS – NRC Study Findings

- More herbicide used, but a less toxic one
 - Facilitated use of reduced tillage
- Less insecticide use
- Gene flow not a concern to date
- Many farmers benefited economically, in worker safety, and in convenience
- Effects on prices, non-GE producers, social impacts not fully understood
- Need more study of market concentration





**Am I eating
foods from genetically
engineered crops?**

(and are they safe???)



What foods contain GE crops?

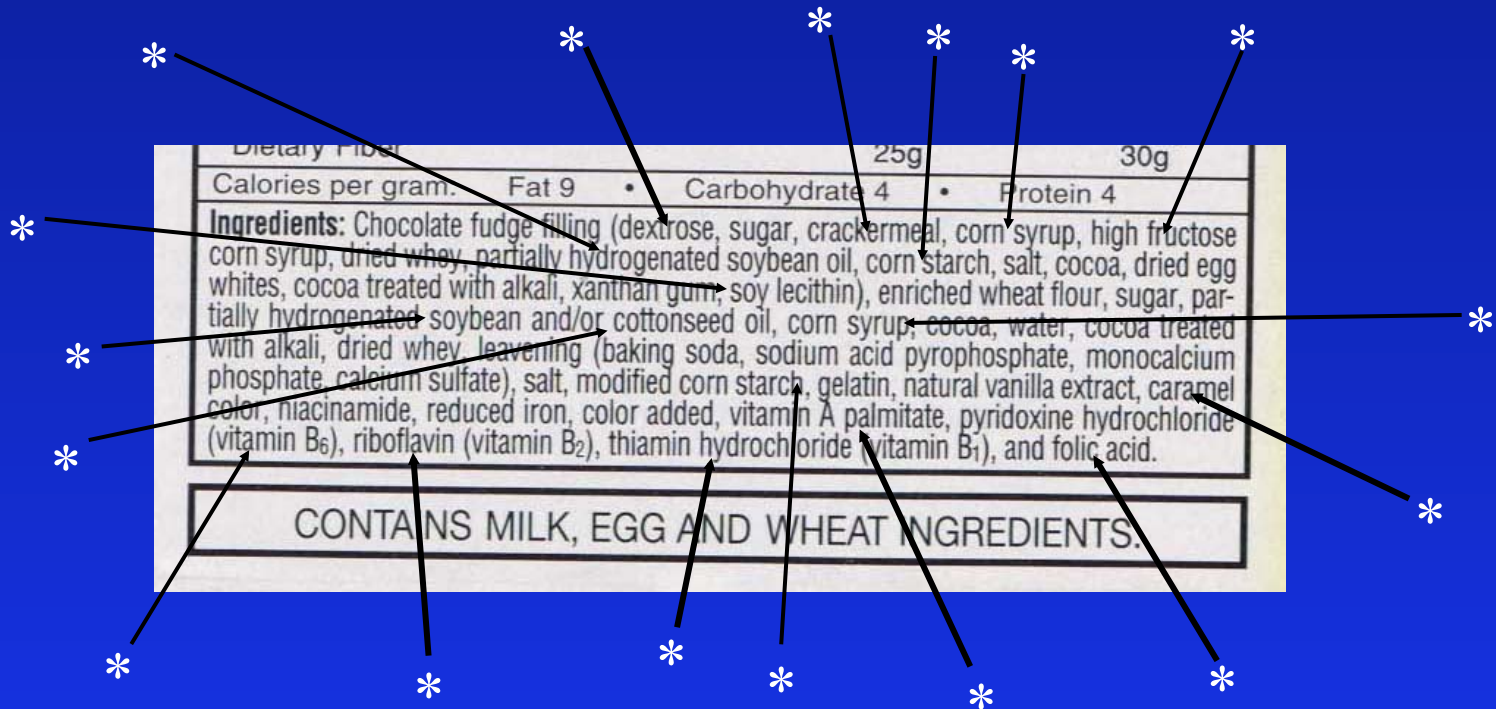
- 60-70% of supermarket foods have ingredients from a GE variety
- Products made with soy or corn most obvious
- Products with soy or corn derivatives
- Limited fresh produce



Common food ingredients derived from corn or soybeans:

Ascorbate (Vit. C)	Dextrin	Lysine	Soy Lecithin
Aspartame	Dextrose	Maltose	Soy Protein
Beta-carotene (Vit. A)	Fructose	Methionine	Soybean Oil
Caramel	Glucose	Methylcellulose	Textured Veg/. Protein
Carotenoids	Glutamate	Modified Starch	Threonine
Cellulose	Gluten	Mono- & Diglycerides	Tocopherol (Vit. E)
Cobalamin (Vit. B12)	Hemicellulose	MSG	Tryptophan
Corn Flour	HF Corn Syrup	Niacin	Vanilla Extract (corn syrup base)
Corn Masa	Inositol	Phenylalanine	Vegetable Fat
Corn Meal	Invert Sugars	Riboflavin (Vit. B2)	Vegetable Oil
Corn Oil	Lactose	Sorbitol	Xanthan Gum
Corn Starch	Lactoflavin	Soy Flour	Zein
Corn Syrup	Lecithin	Soy Isolate	
Cystein	Leucine	Soy Isoflavones	

Food for Thought



* Ingredient may be made from a genetically-engineered organism



U.S. Approval of GE Crops

- USDA: Safety of environmental release
 - Gene flow concerns
 - Any other environmental impacts
- EPA: Safety of plant-incorporated protectants
 - e.g., the Bt toxin in Bt crops
 - Herbicide use on herbicide tolerant crops
- FDA: Safety as food and feed



Testing for Food Safety

- Focused on compounds that are novel or unique
 - Toxicology tests on normal food would reveal anti-nutritional effects
 - Paracelsus (~1500): “the dose makes the poison”
- No better tests for chronic health risks at low doses...



Food Safety Assessment

- Safety testing is mandatory only if:
 - Not substantially equivalent
 - New antibiotic resistance markers
 - Uncharacterized genetic elements
 - Higher toxin levels
 - Potentially allergenic proteins



Are GE Crop Products Safe?

- Genetic Engineering Risk Atlas
 - 400+ studies, half were independently-funded
 - <http://genera.biofortified.org/viewall.php>
- 2014 summary of 1,783 studies
 - Safety as food, feed (770 studies)
 - Environmental impacts (847 studies)
- No credible evidence of safety concerns



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GENERA

GENetic Engineering Risk Atlas

A project of
Biology Fortified, Inc.



What about labeling?

Do consumers want it??

- “Should GM food be required to be labeled?”
 - 73% say yes
- “What information would you like to see on food labels that is not already there?”
 - 7% bring up genetic engineering
- Not too many consumer questions at grocery stores, but inquiries at Wegman’s are up...



The Food Supply

GE Crops

Non-GE Crops

Harvesting
Equip. & Trucks

Whole Foods
& Grain

Refined
Ingredients

Derivatives

Fresh Market
Produce
(corn, tomatoes...)

Processed Foods
(syrops, flours, oils)

Nutrients &
Vitamins
(Vitamins C, E...)

Detection

DNA Protein



Case in point: Original Cheerios



Ingredients: Whole Grain Oats (includes the oat bran), Modified Corn Starch, Sugar, Salt, Tripotassium Phosphate, Wheat Starch. Vitamin E (mixed tocopherols) Added to Preserve Freshness.

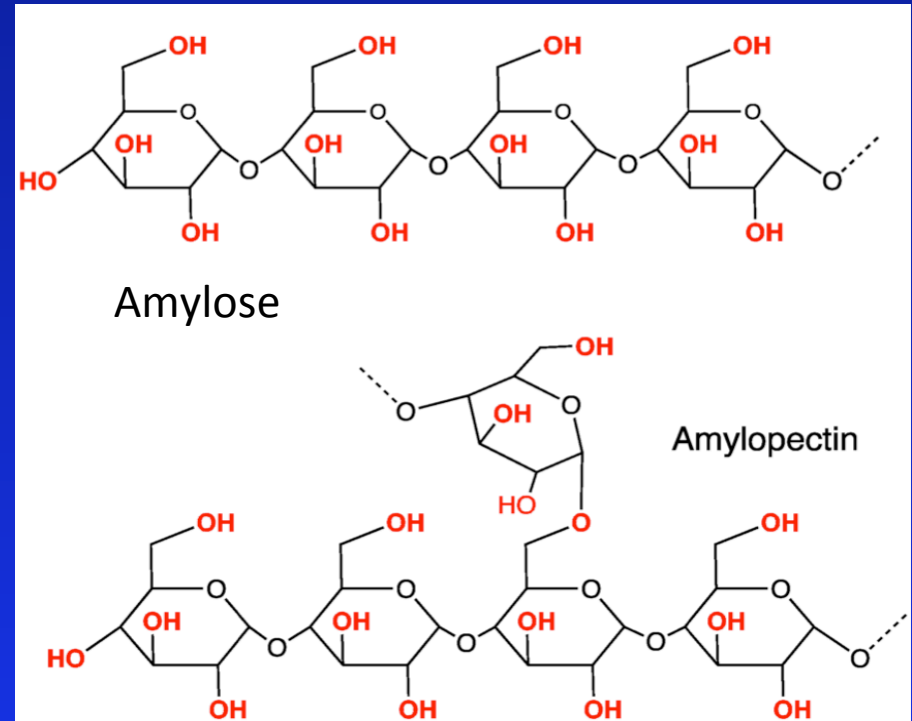
Vitamins and Minerals: Calcium Carbonate, Iron and Zinc (mineral nutrients), Vitamin C (sodium ascorbate), A B Vitamin (niacinamide), Vitamin B₆ (pyridoxine hydrochloride), Vitamin A (palmitate), Vitamin B₂ (riboflavin), Vitamin B₁ (thiamin mononitrate), A B Vitamin (folic acid), Vitamin B₁₂, Vitamin D₃.

Which ingredients could come from GE varieties?



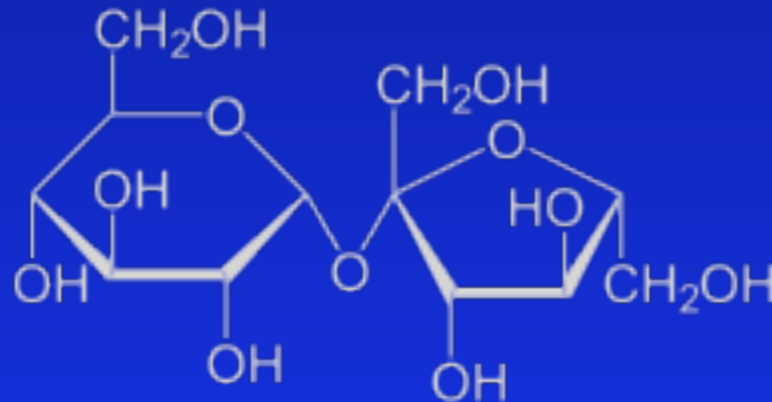
What is corn starch?

- Mixture of amylose and amylopectin
 - Chains of glucose molecules
- No DNA
- No protein



What is beet sugar? (or cane sugar...)

- Sucrose
- No DNA
- No protein



Are the new Cheerios different?

WHY THEY'RE SO GOOD

- 12 Vitamins & Minerals
- Low Fat
- Good source of calcium
- Good source of fiber
- Made with whole grain*
- May reduce the risk of heart disease
- Can help lower cholesterol**
- 1g sugar
- Excellent source of iron
- Not made with genetically modified ingredients***



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What will GE labeling cost?

- Assumptions are complex
 - Two versions of all products?
 - How many will buy GE products anyway?
 - How many will buy organic / non-GE?
- Estimates vary (yearly, for a family of four):
 - CA: \$348 - \$401
 - WA: \$360 - \$490
 - NY: about \$500



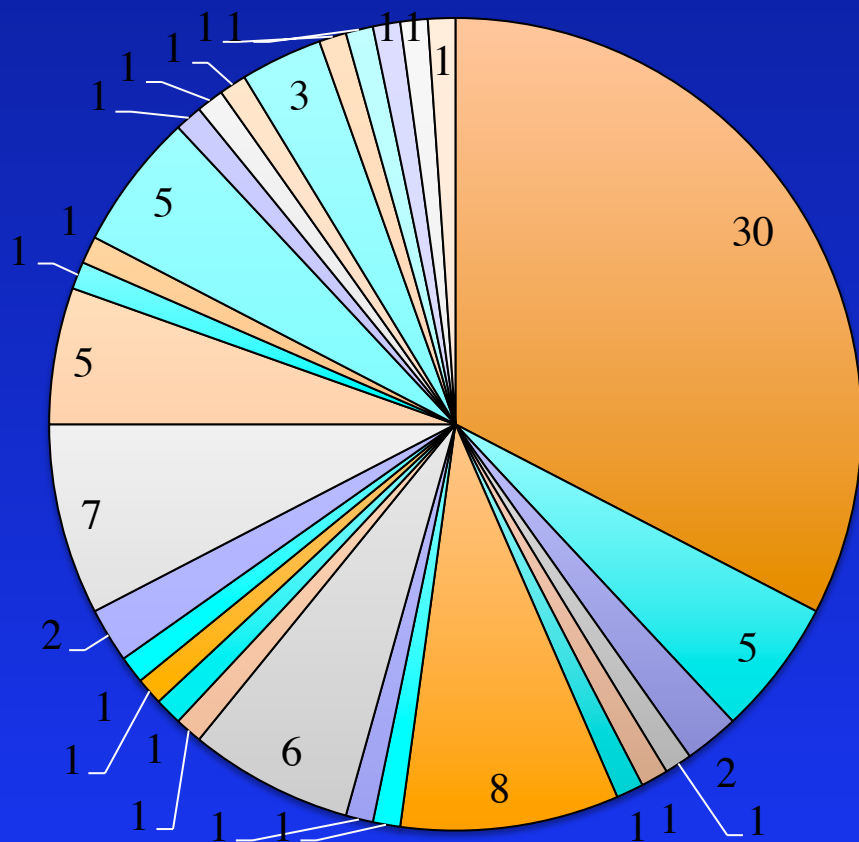
What choices exist already?

- Certified organic
- Non-GMO verified
- Voluntary labels
 - “We do not use ingredients that were produced using biotechnology”
 - “This oil is made from soybeans that were not genetically engineered”
 - “Our tomato growers do not plant seeds developed using biotechnology”



Who Owns GE Traits? - originally

Total = 92

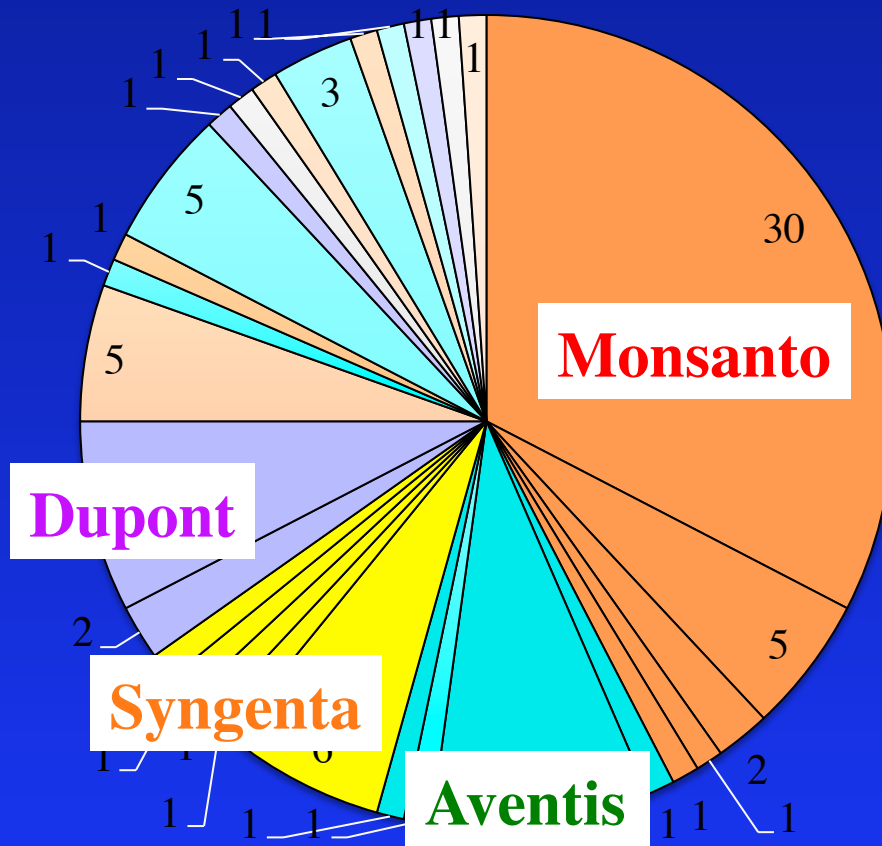


- Monsanto
- DeKalb
- Upjohn
- AgrEvo
- Plant Genetic Systems
- Novartis Seeds
- Northrup King
- Du Pont
- Dow AgroSciences
- Bejo
- Cornell University
- Florigene
- Simplot
- University of Florida
- Vector Tobacco
- Calgene
- Asgrow
- Aventis
- AgriTope
- Syngenta
- Ciba-Geigy
- Zeneca & Petoseed
- Pioneer
- BASF
- Bayer
- DNA Plant Tech
- Mycogen
- U of Saskatchewan
- USDA/ARS



Who Owns GE Traits? – now...

Total = 92



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Summary

- Am I eating foods with GE crop ingredients?
 - Very likely yes
 - Most are refined ingredients with none of the novel DNA or protein in them
- What about fresh produce?
 - Sweet corn, papaya, summer squash
- Are they safe?
 - All credible evidence to date shows no risk
 - Future products need to be evaluated...





Thank you!