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”?

Yes

No

??
Why the Controversy?

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Why the Controversy?

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• 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

Parent 1

Parent 2

Offspring
Genetic Engineering

 Adds one or a few genes to a particular parent

 Commercial Variety

 Gene Donor

 Transgenic Variety
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

(data source: USDA ERS, 2014)
U.S. Soybean Acreage Planted to GE Varieties, 1996 to 2014

(data source: USDA ERS, 2014)
What About GE Vegetables and Fruits?
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)
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

Herbicide Use - Soybean
Weed Resistance to Glyphosate

Areas not growing GE crops:

7 weeds evolved resistance

1974 - 2009

In U.S. since GE crops introduced:

9 weeds evolved resistance

1996 - 2009
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

- Pounds of active ingredient per planted acre
- Percent acres Bt corn
Bt Corn Rootworm Trait

- A very “plastic” insect species
- Has evolved resistance to:
  - Insecticides
  - Rotations
Distribution of sites sampled within Iowa during 2009


http://www.plosone.org/article/info:doi/10.1371/journal.pone.0022629
Survival of western corn rootworm on Bt and non-Bt maize


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:

<table>
<thead>
<tr>
<th>Corn &amp; Soybean Ingredients</th>
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<tbody>
<tr>
<td>Ascorbate (Vit. C)</td>
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<tr>
<td>Aspartame</td>
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<tr>
<td>Beta-carotine (Vit. A)</td>
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<tr>
<td>Caramel</td>
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<tr>
<td>Carotenoids</td>
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<tr>
<td>Cellulose</td>
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<tr>
<td>Cobalamin (Vit. B12)</td>
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<td>Corn Flour</td>
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<td>Corn Masa</td>
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<td>Corn Meal</td>
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<td>Corn Oil</td>
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<td>Corn Starch</td>
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<td>Corn Syrup</td>
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<td>Glucose</td>
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<td>Glutamate</td>
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<td>Hemicellulose</td>
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<td>HF Corn Syrup</td>
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<td>Inositol</td>
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<td>Invert Sugars</td>
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<tr>
<td>Lactose</td>
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<td>Lactoflavin</td>
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<td>Lecithin</td>
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<td>Leucine</td>
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<td>Lysine</td>
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<tr>
<td>Maltose</td>
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<tr>
<td>Methionine</td>
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<tr>
<td>Methylcellulose</td>
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<tr>
<td>Modified Starch</td>
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<tr>
<td>Mono- &amp; Diglycerides</td>
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<tr>
<td>MSG</td>
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<tr>
<td>Niacin</td>
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<tr>
<td>Phenylalanine</td>
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<tr>
<td>Riboflavin (Vit. B2)</td>
</tr>
<tr>
<td>Sorbitol</td>
</tr>
<tr>
<td>Soy Flour</td>
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<tr>
<td>Soy Isolate</td>
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<tr>
<td>Soy Isoflavones</td>
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<tr>
<td>Soy Lecithin</td>
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<tr>
<td>Soy Protein</td>
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<tr>
<td>Soybean Oil</td>
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<tr>
<td>Textured Veg/. Protein</td>
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<tr>
<td>Threonine</td>
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<tr>
<td>Tocopherol (Vit. E)</td>
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<tr>
<td>Tryptophan</td>
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<tr>
<td>Vanilla Extract (corn syrup base)</td>
</tr>
<tr>
<td>Vegetable Fat</td>
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<tr>
<td>Vegetable Oil</td>
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<tr>
<td>Xanthan Gum</td>
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<td>Zein</td>
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Food for Thought

Ingredients: Chocolate fudge filling (dextrose, sugar, cracker meal, corn syrup, high fructose corn syrup, dried whey, partially hydrogenated soybean oil, corn starch, salt, cocoa, dried egg whites, cocoa treated with alkali, xanthan gum, soy lecithin), enriched wheat flour, sugar, partially hydrogenated soybean and/or cottonseed oil, corn syrup, cocoa, water, cocoa treated with alkali, dried whey leavening (baking soda, sodium acid pyrophosphate, monocalcium phosphate, calcium sulfate), salt, modified corn starch, gelatin, natural vanilla extract, caramel color, niacinamide, reduced iron, color added, vitamin A palmitate, pyridoxine hydrochloride (vitamin B6), riboflavin (vitamin B2), thiamin hydrochloride (vitamin B1), and folic acid.

* Ingredient may be made from a genetically engineered organism

CONTAINS MILK, EGG AND WHEAT INGREDIENTS
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
  – Parcelsus (~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/viewwall.php

• 2014 summary of 1,783 studies
  – Safety as food, feed (770 studies)
  – Environmental impacts (847 studies)

• No credible evidence of safety concerns
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…

(data source: Hallman et al., 2013)
The Food Supply

GE Crops
- Harvesting Equip. & Trucks
  - Whole Foods & Grain
    - Refined Ingredients
      - Derivatives
  - Non-GE Crops
    - Detection
      - DNA
      - Protein

Fresh Market Produce (corn, tomatoes...)
Processed Foods (syrups, flours, oils)
Nutrients & Vitamins (Vitamins C, E...)

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College of Agriculture and Life Sciences
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***
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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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

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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!