

Plant Biotechnology & Public Communication

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Environmental Horticulture Department
UF/IFAS Plant Innovation Center



So I Don't Have to Explain Later



Professional History



BA (2005) - Biology: MSUM



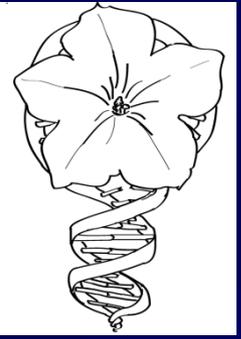
Ph.D. (2009) - Plant Molecular and Cellular Biology: UF



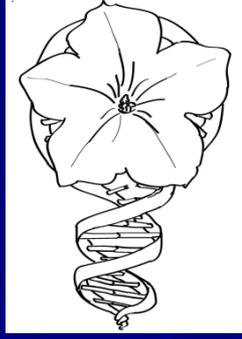
Assistant Instructor (2010) - Environ. Hort. Dept.,
UF/IFAS Floriculture Biotechnology & Genetics



Assistant Professor (2012) - Environ. Hort. Dept.,
UF/IFAS Plant Biotechnology Lab



UF/IFAS Plant Biotech Lab



Scientific Goal: Better people's lives!

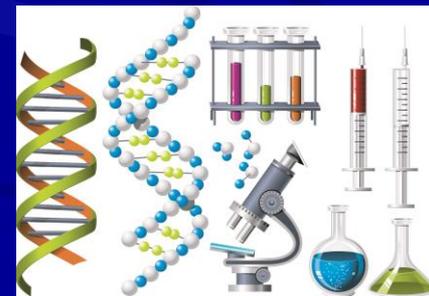
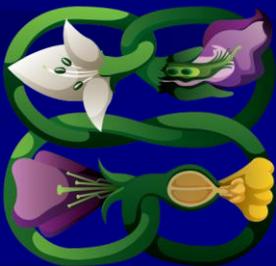
1. Enhance aesthetic appeal of plants
2. Increase flavor and nutrition of edible plant products
3. Deliver plant products consumers really want

Scientific Structure:

Psychophysics

Molecular Biology/Biochemistry

Plant Breeding/Genetics



Biological Scientists

My Team

Undergraduate Students



Joo Young

PhD Students



Ken

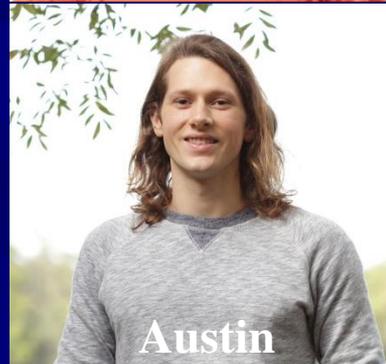


Tim

MS Students



Carolina



Austin



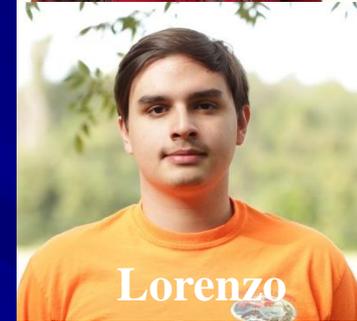
Shea



Terah



Brandon



Lorenzo



Maria



Engineer

Patrick



Cindy



Sadikshya



Brianna



Veronica



Kristen



Nathan

Crops/Products

Flowers

petunia, lily, rose, Arabidopsis

Foliage

coleus, spath, ornamental blueberry, moss, grass

Fruits

tomato, strawberry, blueberry, peach, orange, cherry,
grapefruit, apple

Herbs

basil, cilantro, microgreens, hops

Other

pine, corn, spaghetti sauce, jam, water, *SWEETENERS*

UF/IFAS-Plant Innovation Center

Sensory Analysis

Institutional & Corporate
Partnerships

Food Science

Business &
Marketing



Plant Genetics

New Product
Development

New Variety
Development

Plant Production

Postharvest
Shipping & Handling

BASIC Science
Inputs

Plant Supply Chain

APPLIED Science
Outputs

Example by Strawberry



Psychophysics:

Colquhoun, T.A., Levin, L.A., Moskowitz, H.R., Whitaker, V.M., Clark, D.G., and Folta, K.M. (2012). Framing the perfect strawberry: An exercise in consumer-assisted selection of fruit crops. *J. Berry Research*. 2(1): 45-61.

Molecular Biology/Biochemistry/Psychophysics:

Schwieterman, M.L., Colquhoun, T.A., Bartoshuk, L.M., Jaworski, E.A., Gilbert, J.L., Tieman, D.M., Odabasi, A.Z., Moskowitz, H.R., Folta, K.M., Klee, H.J., Sims, C.A., Whitaker, V.M., and Clark, D.G. (2014). Strawberry flavor and sweet volatiles. *PLoS ONE*. 9(2): e88446.

Breeding/Genetics:

The Grower (2013). New strawberry varieties create a sensation. Renee Stern



Florida Sensation™

Plant Biotechnology

Is a set of (genetic) techniques used to adapt plants for specific needs

Humans have genetically improved plants for ~16,000 years

Transgenic crop technology (familiar “GMO”) is a precise extension of conventional plant breeding.

“The techniques used pose no more risk (actually less risk) than conventional breeding.” (NAS, AAAS, AMA, EFSA many others)

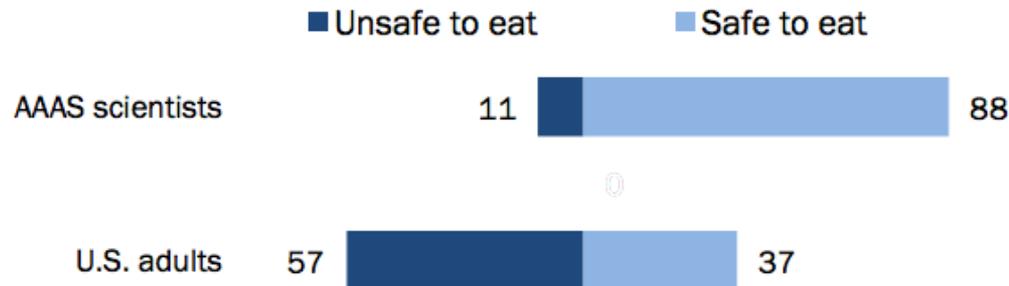
In 19+ years there has been no illness or death related to these products

In the USA there are several traits used in 10 main crops

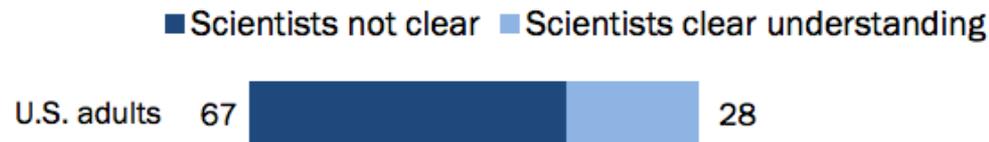
The Current State of Things

Wide Differences Between Scientists and Public on GM Foods, Public Skeptical of Scientific Understanding of Health Effects

% of AAAS scientists and U.S. adults who say it is generally safe or unsafe to eat genetically modified foods



% of U.S. adults saying that scientists have or do not have a clear understanding about the health effects of GM crops



Survey of U.S. adults August 15-25, 2014.Q38-39. AAAS scientists survey Sept. 11-Oct. 13, 2014. Other responses and those saying don't know or giving no answer are not shown.

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The Current State of Things

Scientist: Over 2,000 peer-reviewed publications focusing on GEs – e.g. over 10 years 100 Billion animals fed with no detrimental effects

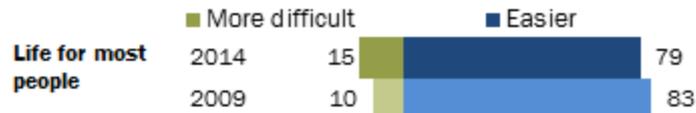
Consumer: Regulation of GE foods by three Govt. Agencies – is the most rigorous and extensive in human history for food

Farmer: GEs are the fastest adopted crop technology of the last decades

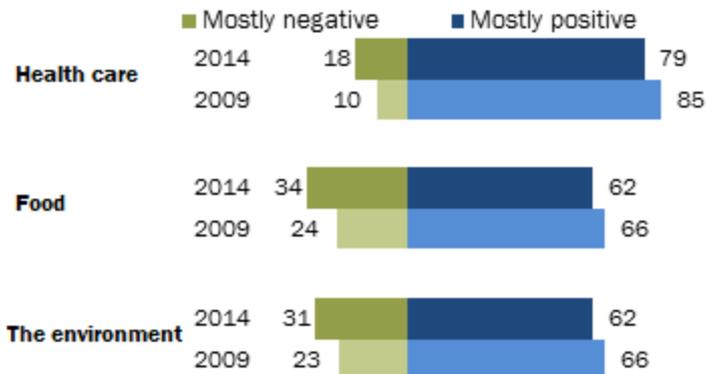
The Current State of Things

Public Still Largely Positive About the Contribution of Science to Society, But Uptick in Negative Views

% of U.S. adults saying science has made life easier or more difficult for most people



% of U.S. adults saying effect of science on the quality of each area in the U.S. has been mostly positive or negative

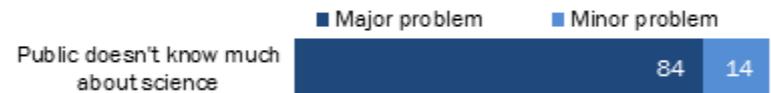


Survey of U.S. adults August 15-25, 2014. Q4, 5a-c. Comparison with survey conducted April 28-May 12, 2009. Those saying don't know or volunteering no effect are not shown.

PEW RESEARCH CENTER

Scientists' Perspective: Limited Public Knowledge About Science Is a Major Problem

% of AAAS scientists saying... is a major or minor problem for science in general



AAAS scientists survey Sept 11-Oct 13, 2014. Q5d. Those saying this is not a problem or giving no answer are not shown.

PEW RESEARCH CENTER

The Effect of Scientific Information

McFadden, B.R., J.L. Lusk, “Cognitive Biases in the Assimilation of Scientific Information on Global Warming and Genetically Modified Food.” *Food Policy*, Volume 54, July 2015, Pages 35–43 doi:10.1016/j.foodpol.2015.04.010

‘...people who previously believed GM foods were safe to eat were most likely to respond that the scientific information made them believe GM foods were more safe; while the beliefs of people who previously believed GM foods were not safe to eat were most likely unchanged after receiving scientific information.’

The Salad Study

Colquhoun, T.A., Turbyfill, V., and Folta, K.M. (201X). The root of the GMO debate. *In Prep.*

Welcome! In this survey we will ask you to imagine different experiences involving purchasing plant products to make a salad. You are making a salad for dinner with a long time friend. S/he has requested that the following plant products to be in the salad:

Carrots, Tomatoes, Lettuce, Apples, Corn, Grapes, Almonds, Strawberries, Soybeans

Imagine yourself in a produce section shopping for the plant products for the salad. You come across one of the needed plant products with the following characteristics (as an example):

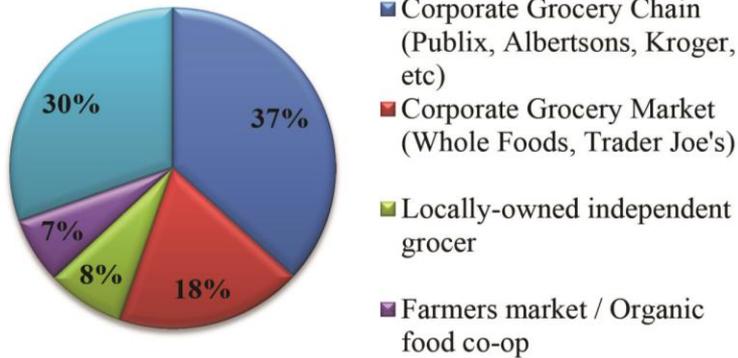
Trait: Plant requires less water
Developed by: Beijing Genomics Institute
Genetic Method: Adding an insect gene
Ingredient: Grapes

1) How acceptable is this plant product?

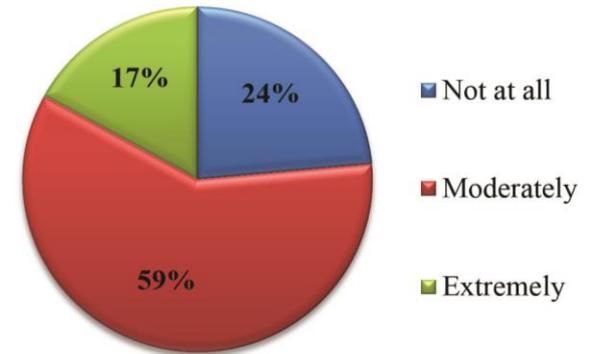
Not at all... 1 2 3 4 5 6 7 8 9... Very Much

Demographic Background

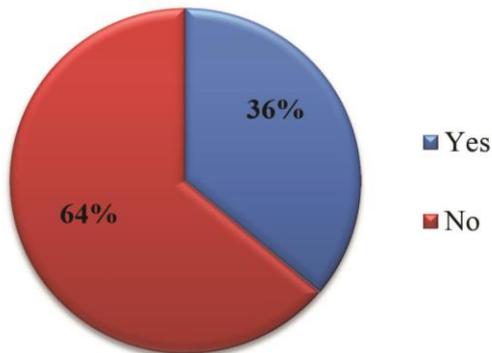
Food Purchase Location



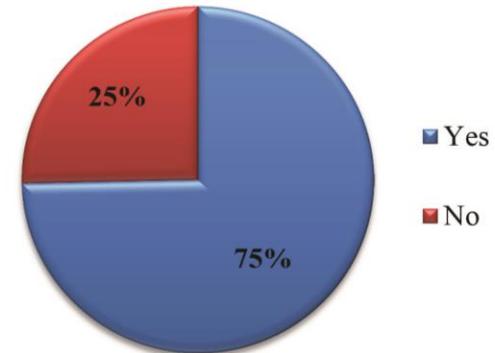
Biotech Comfort



Pesticide Used in Organic



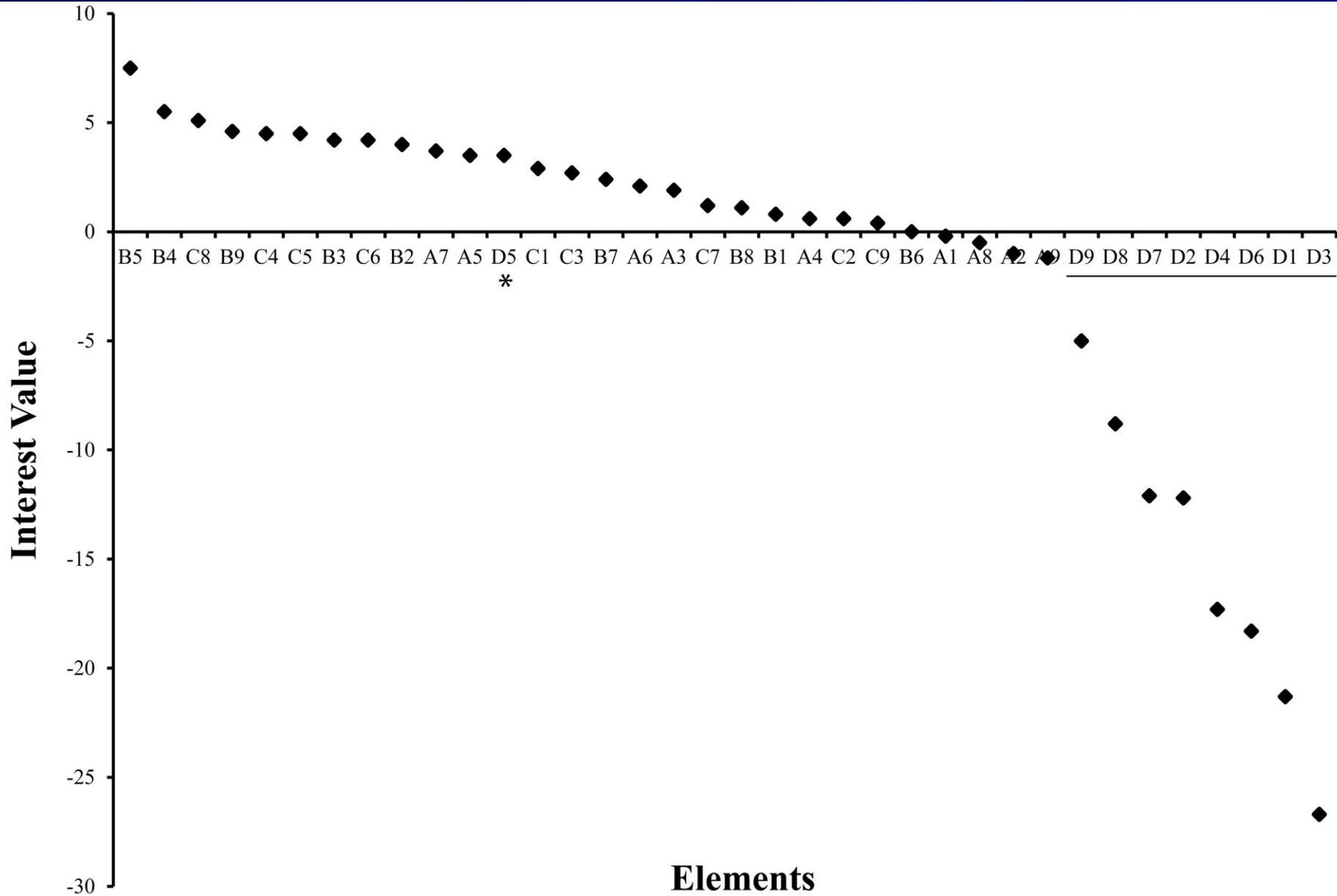
Better 100 Years Ago



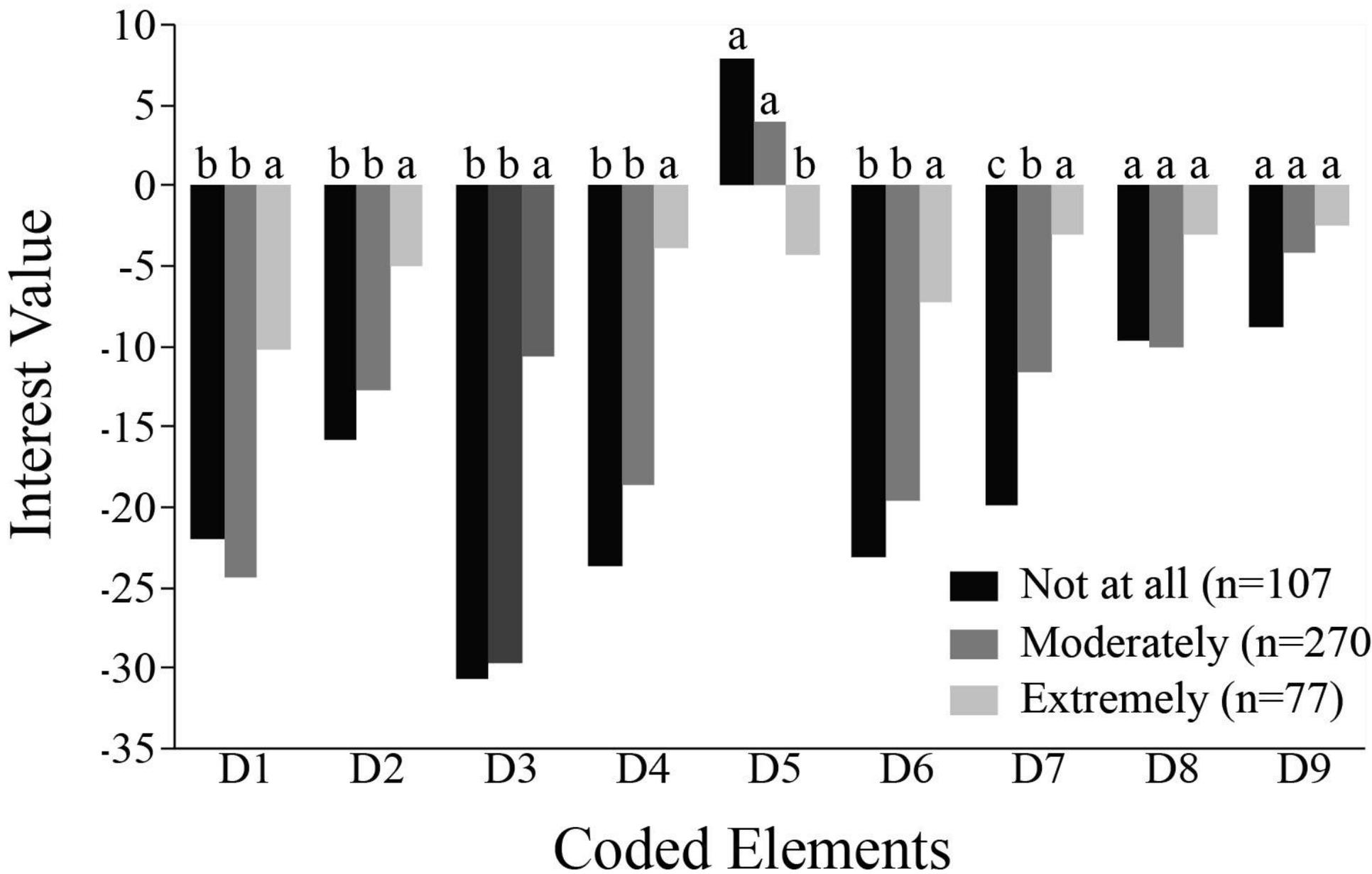
Concepts Tested

Who Does It	
A1	Developed by: Monsanto Corporation
A2	Developed by: Manitoba Specialty Crops (4 full time employees)
A3	Developed by: USDA Laboratory, Beltsville MD
A4	Developed by: Harvard University
A5	Developed by: University of California - Davis
A6	Developed by: Bayer Corporation
A7	Developed by: Scientist sponsored by The Bill and Melinda Gates Foundation
A8	Developed by: European Commission Funded Laboratory
A9	Developed by: State University of Campinas, Brazil
Plant Trait	
B1	Trait: plant is resistant to herbicides
B2	Trait: plant is resistant to all pests, bacteria, insects, and fungi
B3	Trait: plant requires less water and fertilizer
B4	Trait: plant has a higher amount of vitamin A, folate, and other nutrients
B5	Trait: plant produces anti-cancer compounds
B6	Trait: plant consumes greater amounts of CO ₂ (carbon dioxide) from the air
B7	Trait: plant produces antibodies against flu virus
B8	Trait: plant removes toxic compounds from soil
B9	Trait: plant requires less pesticide
Plant Type	
C1	Ingredient: corn
C2	Ingredient: tomatoes
C3	Ingredient: carrots
C4	Ingredient: lettuce
C5	Ingredient: grapes
C6	Ingredient: apples
C7	Ingredient: almonds
C8	Ingredient: strawberries
C9	Ingredient: soybeans
Genetic Method	
D1	Genetic method: adding an insect gene using genetic engineering
D2	Genetic method: splicing in a gene from a plant, but not the same species
D3	Genetic method: lab-induced mutations in the plant's DNA with radiation
D4	Genetic method: adding a gene by crossing to a wild plant species never used in agriculture
D5	Genetic method: traditional breeding and selection
D6	Genetic method: addition of a bacterial gene using genetic engineering
D7	Genetic method: taking out a gene with genetic engineering
D8	Genetic method: changes of a plant's DNA due to naturally-occurring random mutations
D9	Genetic method: splicing in a gene from the same species

TopLine (n=454)



How comfortable are you with plant biotechnology?



Irony at the Apple Store



New improved products!



New improved products!

We loves new Apple products!



I demand new technology!

Don't want new apple products!

If nature didn't make it, I don't want it!!

The best company on earth!

Down with corporations!



What Plant Genetic Improvement Is



More varieties



Improved yields



Grow better under given conditions



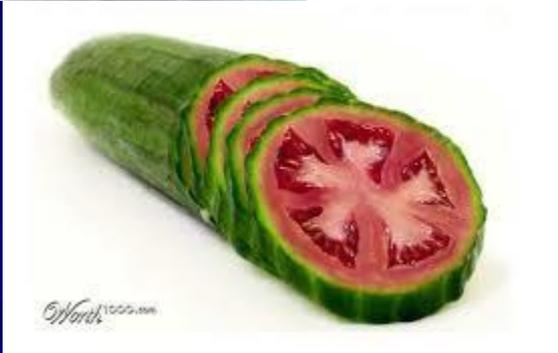
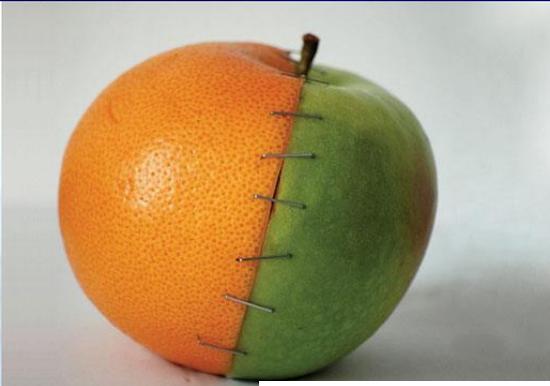
Improved nutrition

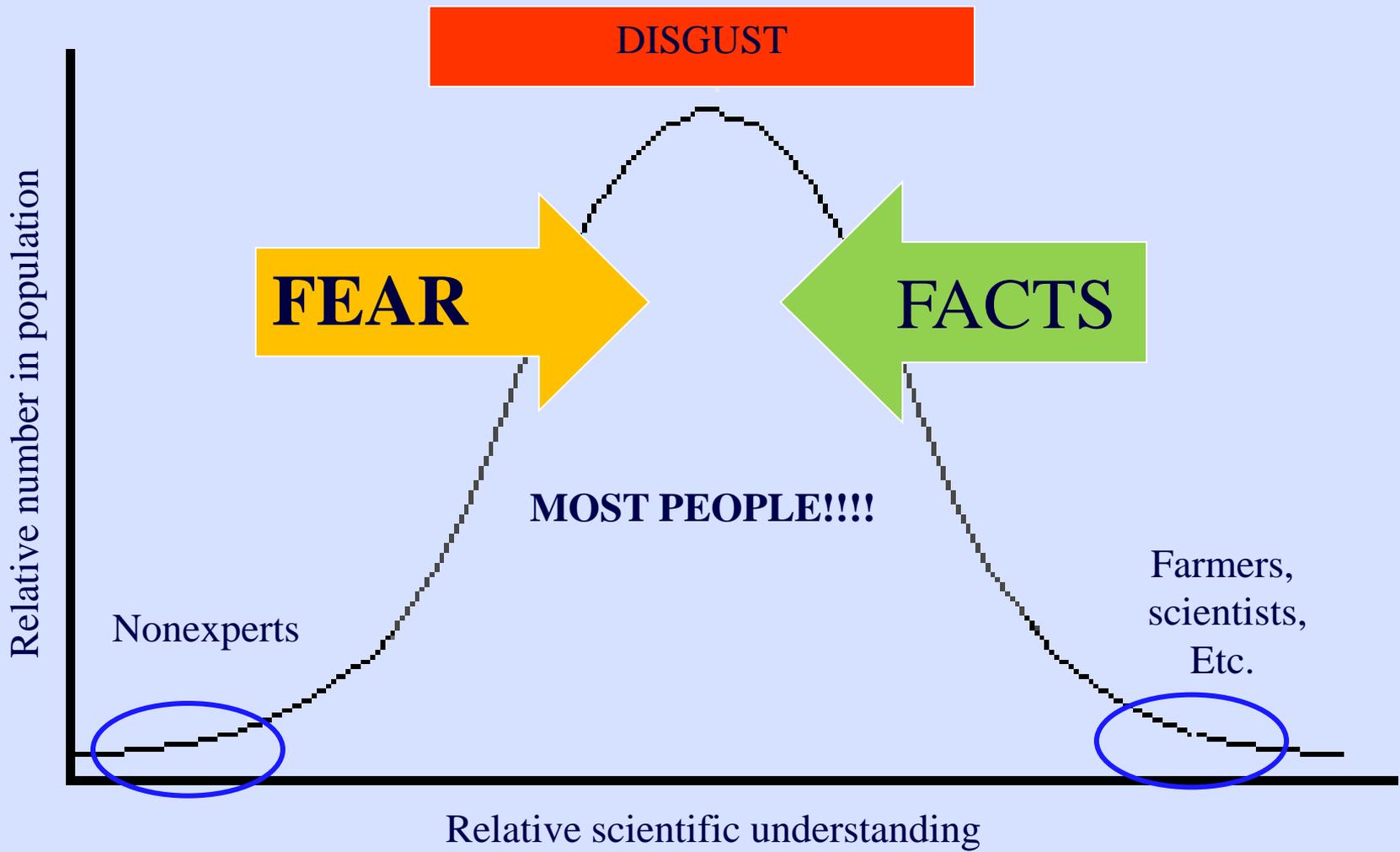


Safer products

What Plant Genetic Improvement Is

↑
some people think





The Start of Plant Biotechnology

Plant Biotech = a set of techniques used to adapt plants for specific needs; throughout the history of agriculture, farmers have altered the genetics of crops via introduction to new environments and selective breeding



fig

wheat

chickpea

gourd

rice

potato

corn

Domestication of wild plants ~ 16,000 years ago

What are these plant products?













Anybody get them all correct?



watermelon



corn



banana



aubergine / eggplant

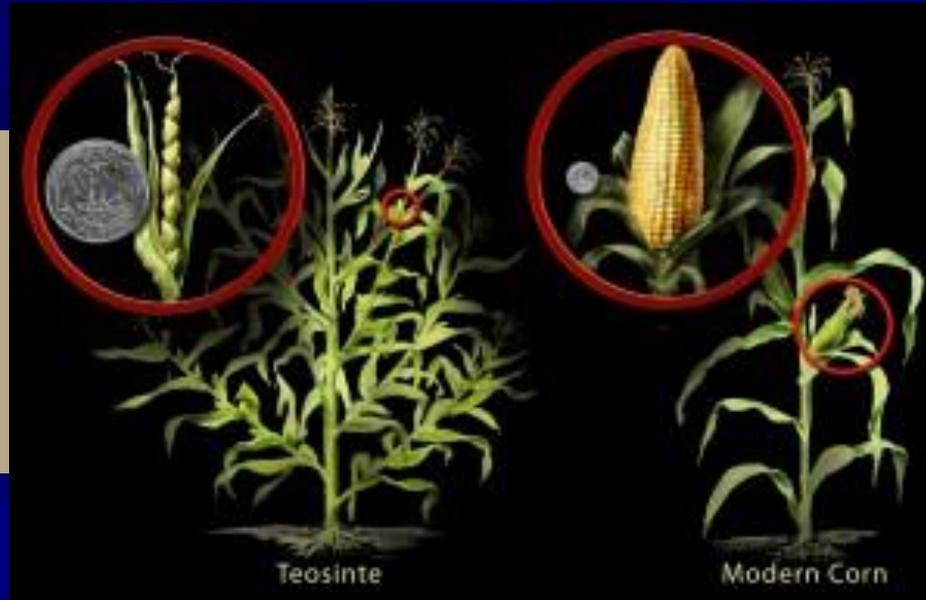
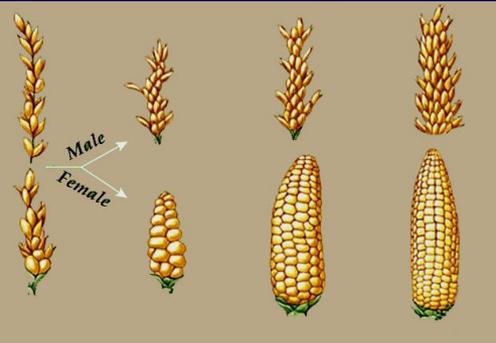


carrot



cabbage, kale, broccoli, etc.

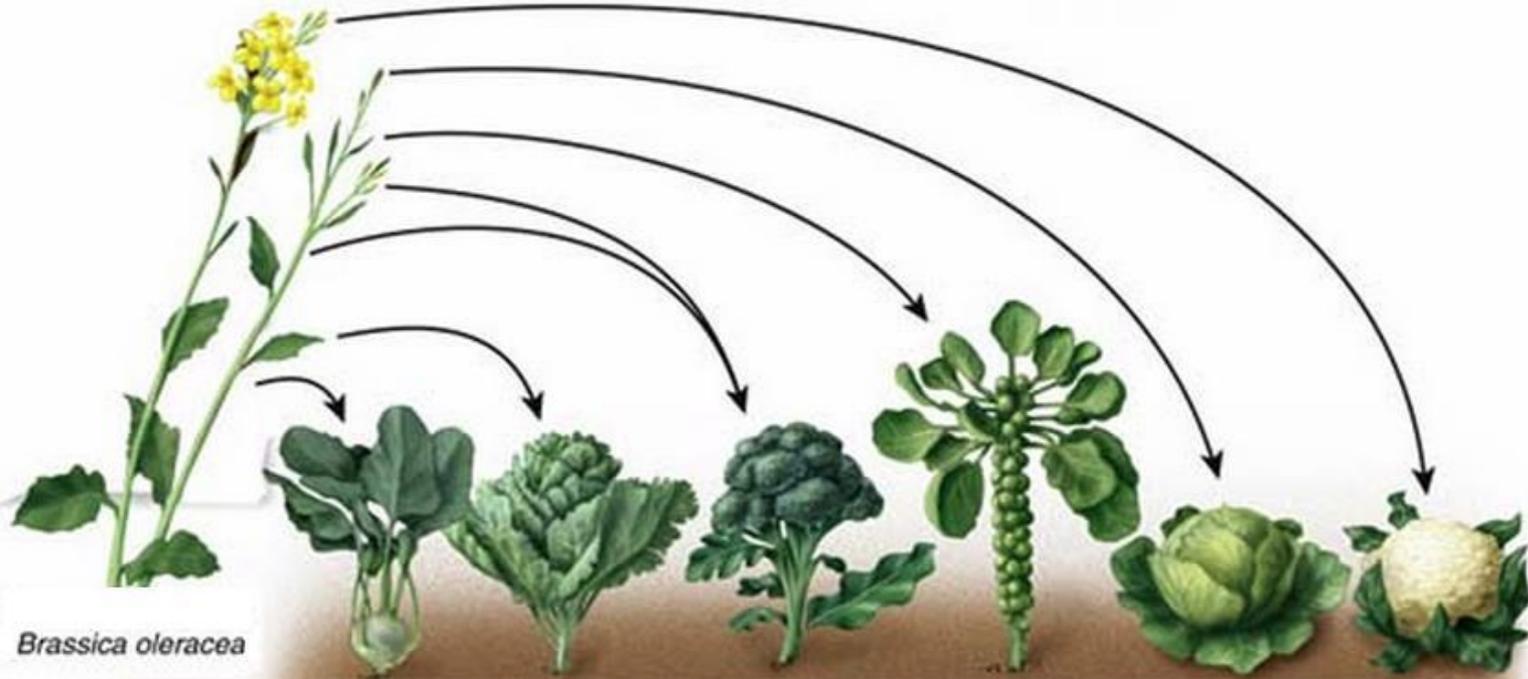
Selective Breeding



Organisms with 'desirable' characteristics are mated to produce offspring with equal or better characteristics of one or both parents

e.g. this technique was used with maize to produce the largest and sweetest crops (took about 7,000 years)

Selective Breeding



Brassica oleracea

Strain	Kohlrabi	Kale	Broccoli	Brussels sprouts	Cabbage	Cauliflower
Modified trait	Stem	Leaves	Flower buds and stem	Lateral leaf buds	Terminal leaf bud	Flower buds

Mutation Breeding (~1945)

Changes make a difference!

Mutations are permanent changes in the DNA sequence. Mutations to the order of the A, T, G, C bases can result in different versions of a particular gene. The different versions of a gene are called **alleles**. One reason individuals of the same

species do not have exactly the same traits is because they have different alleles.

The color of fruits and vegetables is usually controlled by more than one gene, and there may be several alleles for each gene. The first cultivated carrots came from the area of Afghanistan and were purple or yellow.

Traders carried them to Europe and the Mediterranean, where mutations occurred or they were crossed with wild varieties. This resulted in the orange carrots we are familiar with. Carrots may be white, yellow, orange, red, or purple, depending on the combination of alleles that they inherit.



Exposing seeds and/or tissue to chemicals or radiation in order to generate mutants with desirable traits to be bred with other cultivars

Advanced Breeding (~2010)



Using contemporary technology like DNA-seq, RNA-seq, ChIP-seq, and Bis-seq

Genetic Engineering (~1995)

Transgenic = being or used to produce an organism or cell of one species into which one or more genes of another species have been incorporated

Transformation = genetic alteration of a cell resulting from the direct uptake, incorporation and expression of exogenous genetic material (viruses and bacteria)

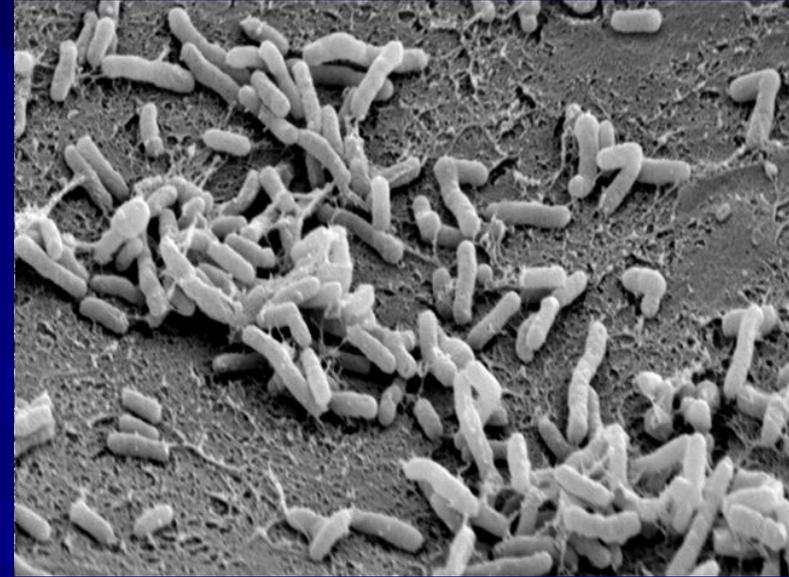
Unlike traditional breeding approaches, transgenic systems alter very specific segments, genes, or parts of the genome.

Agrobacterium tumefaciens

Family - *Rhizobiaceae*

Rod shaped, gram- negative
thin peptidoglycan layer
thick cell wall

Cause of the economically
impactful disease, crown gall
infects 60 families of plants



1st Commercialized GEs

People's Republic of China - first country to allow commercialized GE plants (a virus-resistant tobacco) in 1992

US - first GE crop approved for sale in 1994 (FlavrSavr tomato, which had a longer shelf life)

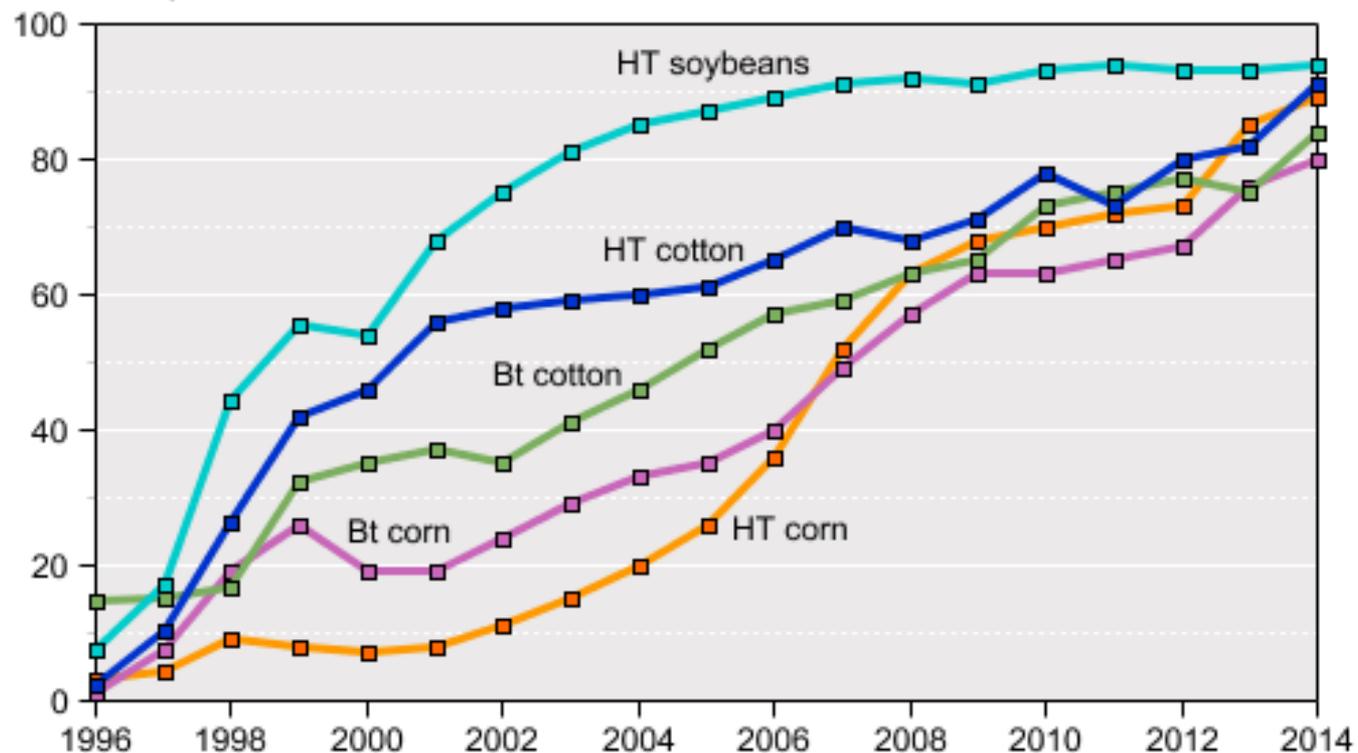
European Union - first GE approved in 1994 (tobacco, resistant to bromoxynil)

US - 1995: potato, canola, corn, cotton, soybeans, squash

US Major Crops

Adoption of genetically engineered crops in the United States, 1996-2014

Percent of planted acres



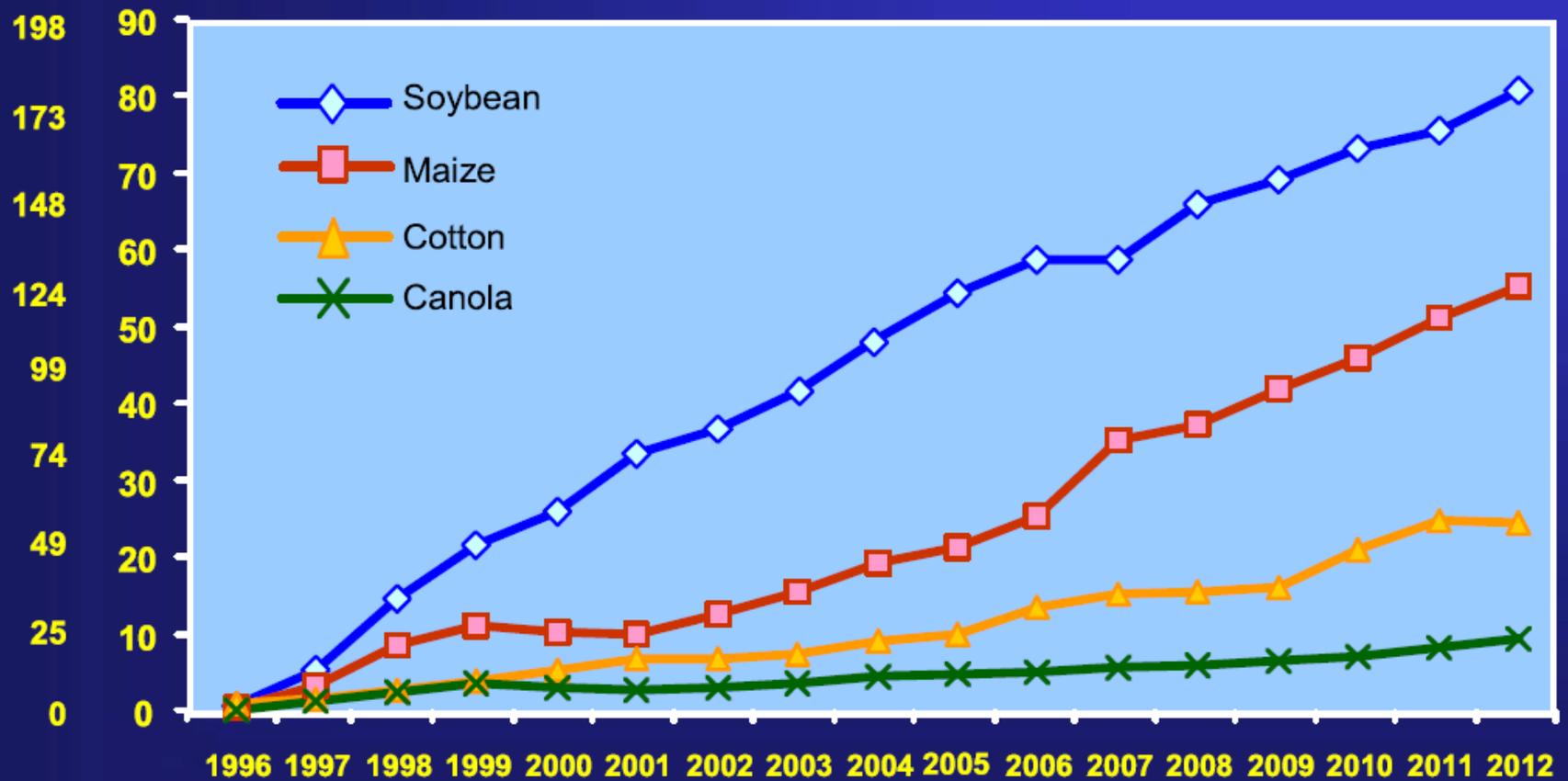
Data for each crop category include varieties with both HT and Bt (stacked) traits.

Sources: USDA, Economic Research Service using data from Fernandez-Cornejo and McBride (2002) for the years 1996-99 and USDA, National Agricultural Statistics Service, June Agricultural Survey for the years 2000-14.

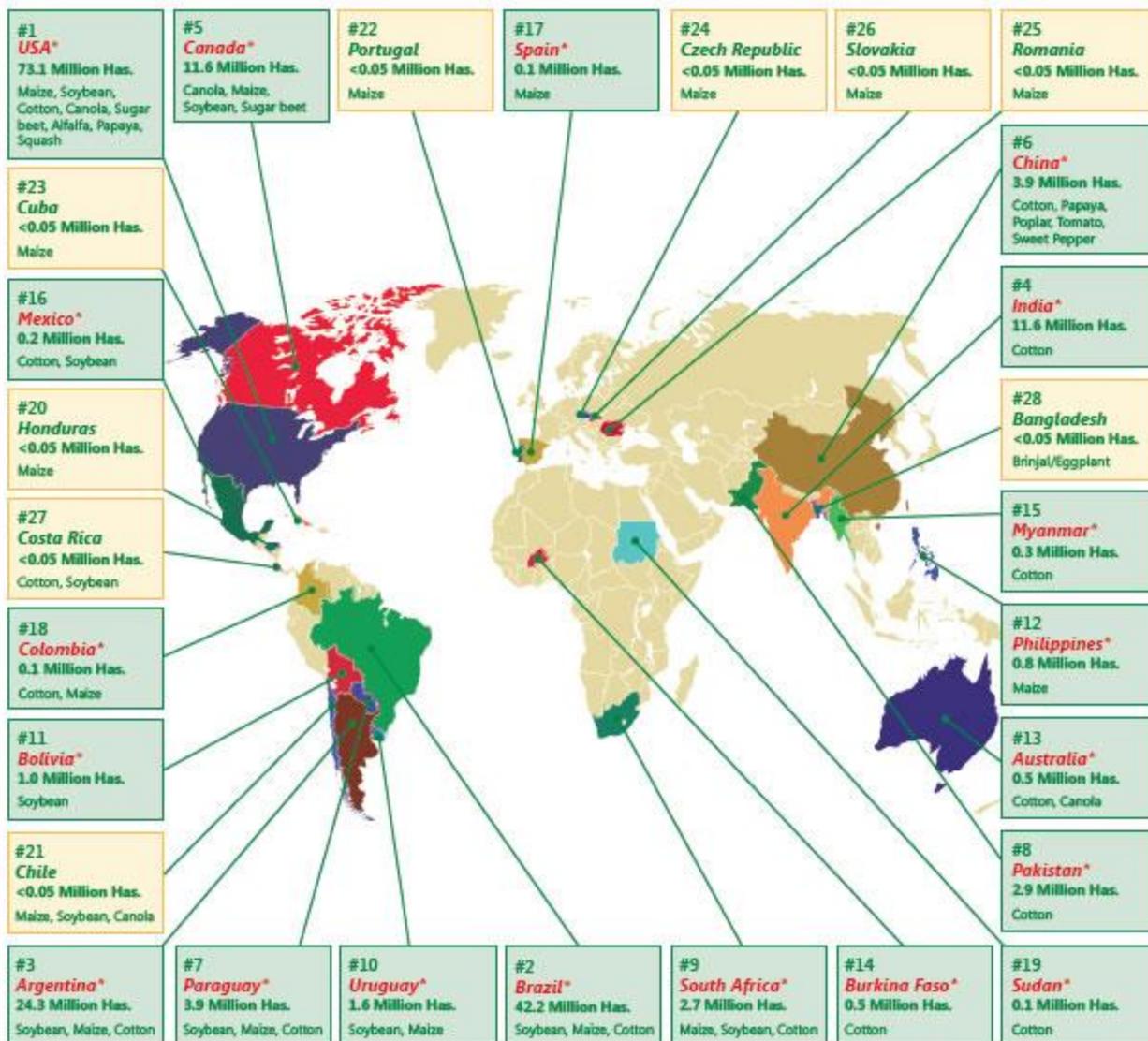
Global Area of Biotech Crops, 1996 to 2012: By Crop (Million Hectares, Million Acres)



M Acres



Biotech Crop Countries and Mega-Countries*, 2014



■ *19 biotech mega-countries growing 50,000 hectares, or more, of biotech crops.

Source: Clive James, 2014.

Figure 1. Global Map of Biotech Crop Countries and Mega-Countries in 2014

How To Reach that Middle?

1. FACTS DON'T MATTER

Start from SHARED VALUES

What are some common themes shared by those that embrace the technology and those that deplore it?

WHO IS YOUR AUDIENCE?

These are usually people that don't know about science and are concerned about food

Share science with them

State Larger Priorities Up Front

Developing World



Environment



Farmers



Food Safety



The Needy



Consumers



How To Reach that Middle?

2. Plant Genetic Improvement Is Not “NATURAL”

Remind people that genetic improvement of food is a necessity

Very few of the plants we regularly consume originated in North America. Almost all were brought here by humans

None of the food you eat is like its “NATURAL” form

GM technology is simply the most precise version of an age-old practice of breeding and selection

Human Manipulation of Genetics

Centers of origin of selected crops



Note: The pointer locations indicate general regions where crops are believed to have first been domesticated. In some cases, the center of origin is uncertain. Other geographic regions also harbor important genetic diversity for these crops.

Source: This map was developed by the General Accounting Office using data provided by the National Plant Germplasm System's Plant Exchange Office.

How To Reach that Middle?

3. Plant Biotechnology Is an Extension of Traditional Breeding, Just Much More Precise

The end goal is always to incorporate genetic traits that were not present before

How To Reach that Middle?

4. Know a Few Central Core Concepts

Humans have genetically improved plants for ~16,000 years

Transgenic crop technology (familiar “GMO”) is a precise extension of conventional plant breeding.

“The techniques used pose no more risk (actually less risk) than conventional breeding.” (NAS, AAAS, AMA, EFSA many others)

In 18 years there has been no illness or death related to these products

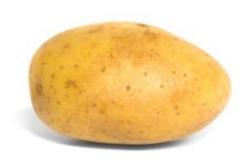
In the USA there are several traits used in only 10 main crops

How To Reach that Middle?

5. 10 Biotech Crops Available

BIOTECH

- 1  corn
- 2  soy
- 3  alfalfa
- 4  cotton
- 5  squash
- 6  papaya
- 7  sugar beets
- 8  canola



10 Common Crops Commercially Available Use Biotech Seeds, reducing crop loss to insect and plant diseases as well as drought and other environmental conditions.

SOURCE: www.isaaa.org

Talking to the Public, Get Involved!

Plant genetic improvement techniques are safe

All methods involve some small risk – but all are about the same risk as traditional breeding

Techniques that breed in traits can take a long time

Directed changes are more precise and more rapidly available, but frequently require regulatory hurdles

Solutions

1. Get involved, **NOW!**
2. Stand up for science
3. Teach the evidence
4. Win the middle
5. Do it with kindness and sincerity

Finding the right market

Conventional

Non-GMO certification

Organic certification

Finding the right market

- <http://www.sfchronicle.com/food/article/Non-GMO-milk-label-angers-some-farmers-9240037.php>
- <https://extension.udel.edu/animalscienceblog/2016/05/16/gmo-milk/>
- <https://extension.udel.edu/animalscienceblog/2016/05/16/gmo-milk/>
- <http://modernfarmer.com/2015/12/organic-feed/>

Online Resources

<http://www.geneticliteracyproject.org>

<http://kfolta.blogspot.com>

<http://www.scibabe.com>

<https://www.facebook.com/pages/GMOLOL/675652282498007>

<https://gmoanswers.com>

<http://www.aaas.org>

“Man seems to insist on ignoring the lessons available from history.”

-- Dr. Norman Borlaug



"The good thing about science is that it's true whether or not you believe in it."

-- Dr. Neil deGrasse Tyson

‘It is our mission to stand up for the truth that science gives us.’

-- Dr. Jack Payne



"There is a path to truth and sincerity that you must guard and defend."

-- Teruyuki Okazaki