

Deciphering the Science

GMO, GE, Biotech. What does it mean?

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THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL,
AND ENVIRONMENTAL SCIENCES

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What Questions Do You Have About GMO's, GE, etc.?

- Use the Q&A box to ask!

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What Are We Going to Talk About Today?

- SCIENCE!
- History of Crop Improvement
- Development of GMOs
- Pros and Cons of GMOs

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What We Are NOT Going to Talk About Today

- Business Practices
- Individual Companies
- Conspiracy Theories



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How Did We Get Here?

- Need to improve food for a variety of reasons
- Yield
- Taste
- Pest Resistance
- Harvesting Practices
- Nutrition
- Agronomic traits
- List goes on and on



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How Did We Get Here?



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Crop Selection and Breeding

- Saving seed from "elite" lines
 - Next generation will have higher % of elite genetics
- Backcrossing – breeding specific varieties/cultivars to introduce desirable traits
 - Example – Seed shattering
- Outcrossing – open pollination to increase genetic diversity

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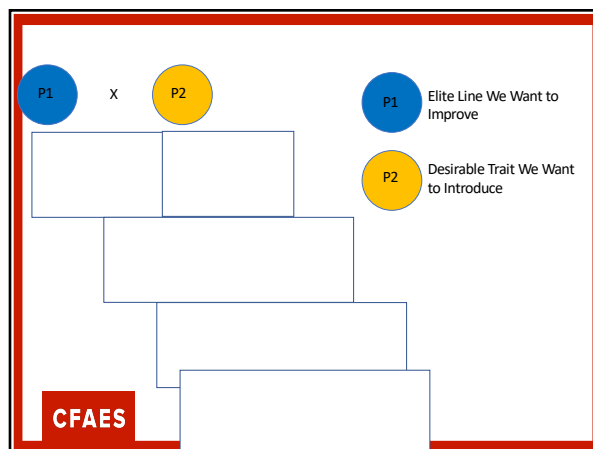
Modern Example

- Industrial Hemp
- Approximately 35% seed loss
- Harvest earlier to prevent seed loss results in immature seeds that are lower quality



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Crop Selection and Breeding

- Depending on species, each generation could take 1 year or more
 - Woody perennials could be 10 or more years between generations
- Typically 6-8 backcrosses needed for proper introgression of traits
- Traditional breeding is limited by the genes available within the species/genus

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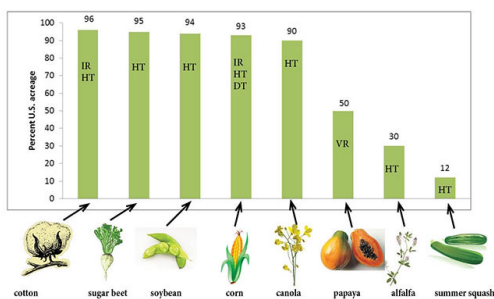
What Exactly is a GMO?

- **GMO** - **G**enetically **M**odified **O**rganism
- "Aren't all organisms genetically modified?"
 - Yes, but...
- GMO's typically refer to the transfer of foreign DNA that codes for specific genetic information from one species to another
- A scientific tool available to plant breeders to improve existing traits, or introduce new traits

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Current GMO Crops in US



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University of Colorado Extension

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GENETIC TRAITS EXPRESSED IN GMOs IN THE U.S.

APPLE Genetic Traits Non-browning Uses: Food	POTATO Genetic Traits Reduced bruising and black spot Non-browning Low Acrylamide Single Resistance Uses: Food	FIELD CORN Genetic Traits Insect Resistance Herbicide Tolerance Drought Tolerance Uses: - Livestock and poultry feed - Fuel ethanol - High-fructose corn syrup and other sweeteners - Corn oil - Cornstarch - Cornal and other food ingredients - Alcohol - Industrial uses	SOYBEAN Genetic Traits Insect Resistance Herbicide Tolerance Uses: - Livestock and poultry feed - Aquaculture - Soybean oil (vegetable oil) - High oleic acid (monounsaturated fatty acid) - Biodiesel fuel - Soy milk, soy sauce, tofu, other food uses - Lecithin - Pet food - Adhesives and building materials - Printing ink - Other industrial uses	COTTON Genetic Traits Insect Resistance Herbicide Tolerance Uses: Fiber, Animal feed, Cottonseed oil
CANOLA Genetic Traits Herbicide Tolerance Uses: Cooking oil, Animal feed	ALFALFA Genetic Traits Herbicide Tolerance Uses: Animal feed	RAINBOW PAPAYA Genetic Traits Disease Resistance Uses: Table fruit	SUGAR BEET Genetic Traits Herbicide Tolerance Uses: Sugar, Animal feed	SWEET CORN Genetic Traits Insect Resistance Herbicide Tolerance Uses: Food
			SUMMER SQUASH Genetic Traits Disease Resistance Uses: Food	

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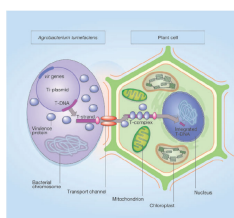
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Discovery and Development

- 1907 – *Agrobacterium tumefaciens* discovered
- Naturally occurring soil bacteria
- Induces tumor growth in plants (galls)



Figure 1. Crown galls on raspberry root.
OSU Factsheet HYG-3301-08



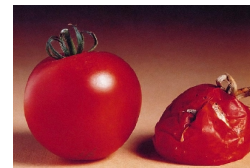
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Nature.com

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Discovery and Development

- 1930's to 1970's
 - Found transfer of DNA from bacteria to plant
- 1973 – First genetically engineered (GE) organism
- 1974 – First GE mouse
- 1992 – Flavr Savr tomatoes become 1st GMO crop



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From Theory to Crop

- Years, or even decades of research before taking the step to GMO
- Must have knowledge of target plant genome
- Knowledge of problem trying to be solved
 - Chemistry, biology, protein shape, etc.
- Identify the target gene, and then determine method of transformation
- Identify issues after transformation
- Regulatory issues

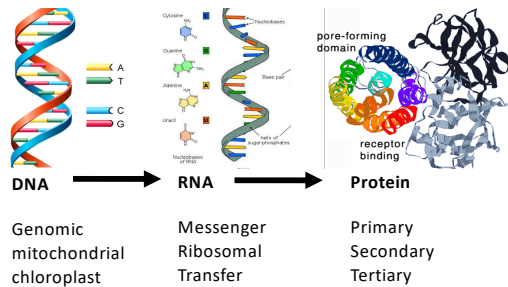
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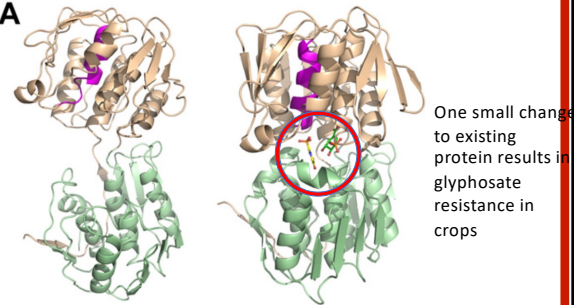
The Central Dogma



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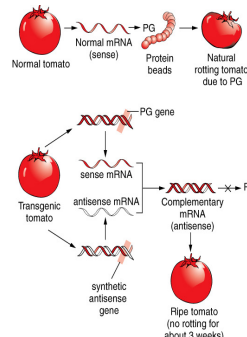
EPSP Synthase – Glyphosate Resistance

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From Theory to Crop

Targeted introgression of genes

- Flavr Savr tomatoes – gene will produce “anti-sense” copies of RNA
- Prevents the production of enzyme that breaks down cell walls



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How Do They Get Genes In There?

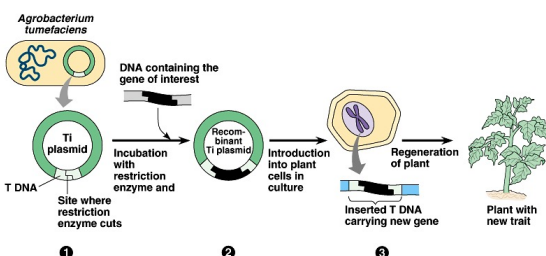


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How Do They Get Genes In There?

- Let nature do the the work
- Agrobacterium tumefaciens*



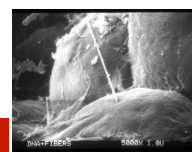
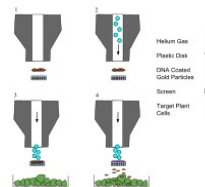
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How Do They Get Genes In There?

Less common techniques

- Less common
- “Gene Gun”
- “Whisker”
- Electroporation



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Koepler U. Wisc

Bio-Rad

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Genome Editing

- RNAi
- CRISPR
- Site-specific gene editing
- Fast, simple, cheap

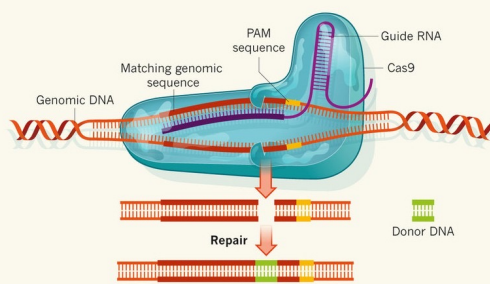


PPO - Polyphenol Oxidase

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CRISPR/Cas9



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CRISPR/Cas9

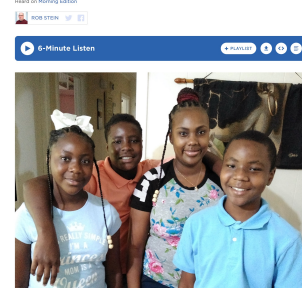
- This technology will increase the speed GMO crops are developed and released
- Genome sequencing of crops will enable rapid development of GMO's
- Polyphenyl oxidase (PPO) – gene that promotes the degradation of cell walls
 - Bruising/browning
 - Gene found in all plants

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CRISPR/Cas9

THE DESIRE DEVELOPMENT
A Year In, 1st Patient To Get Gene Editing For Sickle Cell Disease Is Thriving

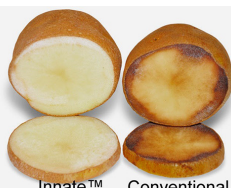


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CRISPR/Cas9

- Crops developed from these tools “escape regulation”
 - Not introducing anything novel
- There WILL be more public scrutiny as more varieties are developed



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Origin of GMO Genes

- Plants
 - Tomato – Flavr Savr
 - Apple – Arctic Apple
- Bacteria
 - *Agrobacterium tumefaciens* – glyphosate resistance (RoundUp)
 - *Bacillus thuringiensis* – Bt Corn, insect resistance
- Virus
 - Papaya Spotted Ring Virus (PRSV) – viral resistance

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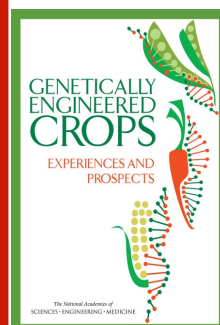
Advantages of GMO Crops

- Ability to quickly (relative) develop varieties with specific traits
- Introduce traits unavailable through traditional hybridization (PRSV, potato, etc.)
- Effective pest control
- Increase of nutritional value (golden rice)
- Biomedical opportunities (vaccines, etc.)

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Wait, what about increased yield?



"We can't feed billions without GMO's"

- Crop yield potential has not increased with GMO's
- More money, not more corn for the farmer

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Fast...

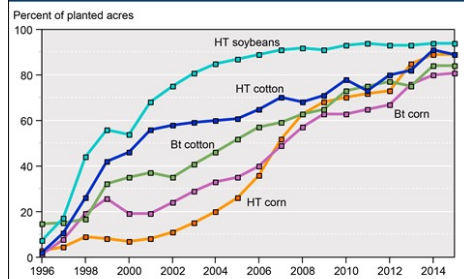
- American chestnut trees – an example
- Chestnut blight wiped out the trees in the mid 1900's
- ACF began backcross breeding in 1983
 - Close...maybe?
- SUNY ESF began genetic engineering in 2006
 - 10,000 trees in the next 5 years
 - Three planting sites in in 2021



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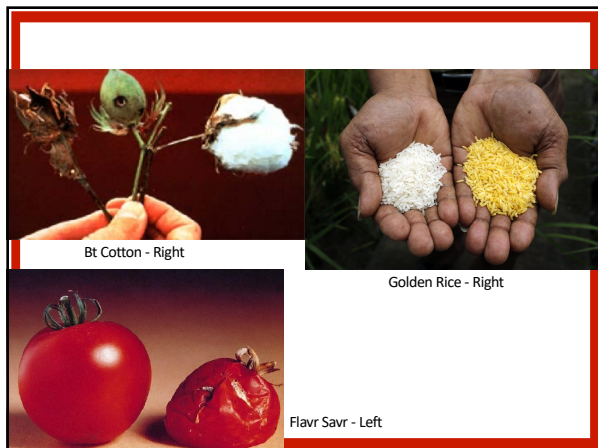
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Adoption of genetically engineered crops in the United States, 1996-2015



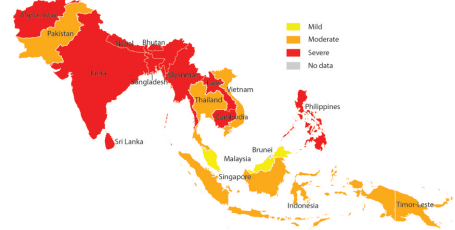
Data for each crop category include varieties with both HT and Bt (stacked) traits. Sources: USDA, Economic Research Service using data from Fernandez-Cornejo and McBride (2002) for the years 1996-99 and USDA, National Agricultural Statistics Service, June Agricultural Survey for the years 2000-15.

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Severity of Vitamin A Deficiency in South and South-East Asia



Source: Global Prevalence of Vitamin A Deficiency in Population at Risk 1995-2005: WHO Global Database on Vitamin A Deficiency (<http://www.who.int/vitamins>)

*Severity cutoffs based on serum or plasma retinol <0.70 µmol/l in preschool-age children (mild: ≥21% <10%; moderate: ≥10% <20%; severe: ≥20%)

Golden Rice has elevated levels of beta carotene that the body converts to vitamin A

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Environmental Advantages

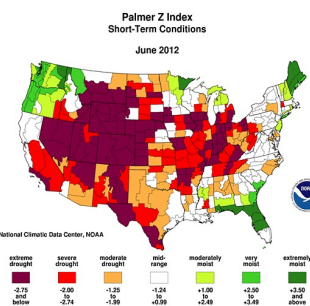


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Drought Resistant Technology - Right

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GMO Crops with drought resistance genes could reduce the water requirements needed for optimal yield



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Disadvantages of GMO Crops

- Expensive to develop
- High price to farmers
 - Some markets don't accept GMO's
- Public perceptions
- Herbicide resistant weeds – continued problem
- Seed saving

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The Great GMO Divide



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John Pritchett

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Societal Concerns

- Public perception on safety of GMO's in food supply
- **VALID** Concerns
 - NO documented evidence that GMO food is unsafe
 - Society of Toxicology – "The available scientific evidence indicates that the potential adverse health effects arising from biotechnology-derived foods are not different in nature from those created by conventional breeding practices for plant, animal, or microbial enhancement, and are already familiar to toxicologists." Toxicological Sciences 2003
 - Bt Corn – "EPA has determined that Bt corn and Bt cotton do not pose unreasonable risks to human health or to the environment" Nature Biotechnology 2003

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Societal Concerns

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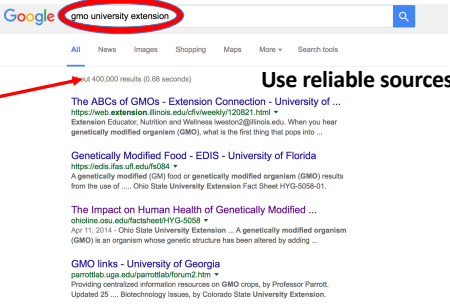
[The facts about GMOs - foodandwaterwatch.org](http://www.foodandwaterwatch.org/)
Quick answers to your GMO questions Learn more.
[Genetically Engineered Food: An Overview](#)

[What are GMOs? - smallplanet.org](http://www.smallplanet.org/)
Learn more about your food and collect some cool facts

Too much unreliable information!

A genetically modified organism (GMO) is any organism whose genetic material has been altered using genetic engineering techniques (i.e., a genetically engineered organism). GMOs are the source of medicines and genetically modified foods and are widely used in scientific research and to produce other goods.

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Google **gmo university extension**

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of 400,000 results (0.66 seconds)

Use reliable sources!

The ABCs of GMOs - Extension Connection - University of ...
<https://web.extension.illinois.edu/civ/weekly/120521.html>
 Extension Educator, Nutrition and Wellness Investor@illinois.edu. When you hear genetically modified organism (GMO), what is the first thing that pops into ...

Genetically Modified Food - EDIS - University of Florida
<https://edis.fas.ufl.edu/t004/>
 A genetically modified (GM) food or genetically modified organism (GMO) results from the use of ... Ohio State University Extension Fact Sheet HYG-5058-01.

The Impact on Human Health of Genetically Modified ...
ohio.osu.edu/factsheet/HYG-5058
 Apr 11, 2014 - Ohio State University Extension ... A genetically modified organism (GMO) is an organism whose genetic structure has been altered by adding ...

GMO links - University of Georgia
genlifefab.uga.edu/genlifefab/forum2.htm
 Providing centralized information resources on GMO crops, by Professor Parrott. Updated 25 ... Biotechnology issues, by Colorado State University Extension.

OREGON STATE UNIVERSITY Extension Service Food ...
extension.oregonstate.edu/_ip_50_888_foodb...
 Oregon State University - CROOK STATE UNIVERSITY Extension Service. SP 10-688. Reprinted ... from classical techniques. The results are sometimes called "genetically modified."


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Common GMO Myths

- "GMOs have higher levels of pesticide use"
 - Herbicide use may be equivalent to non-GMO varieties and insecticide use has dropped
- "GMOs produce Round-Up"
 - Plants do not produce herbicide
- "All research is biased toward Big Ag"
 - Example, in-season Dicamba use
- GMOs cause cancer
 - GMO crops are as healthy and nutritious as non-gmo crops

Of course they are!
There is no alternative!



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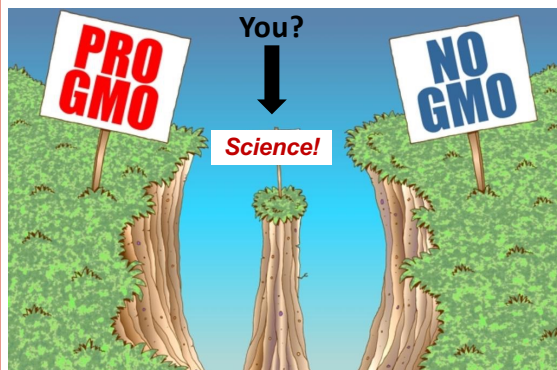
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Resistance to GMO's

- Genuine concern for food safety
 - Evidence does not support the concern
- Concern for environment
 - Again, science doesn't back this up (butterflies)
- "Natural"
 - Personal choice, but GMO's are as safe as "natural" or organic options
- Think globally, act locally
 - Doesn't always hold true for agriculture – Especially in USA

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PRO GMO

NO GMO

Science!

You?

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Questions?

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