# Deciphering the Science

## GMO, GE, Biotech. What does it mean?

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CFAES

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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Forever Green, University of Minnesota

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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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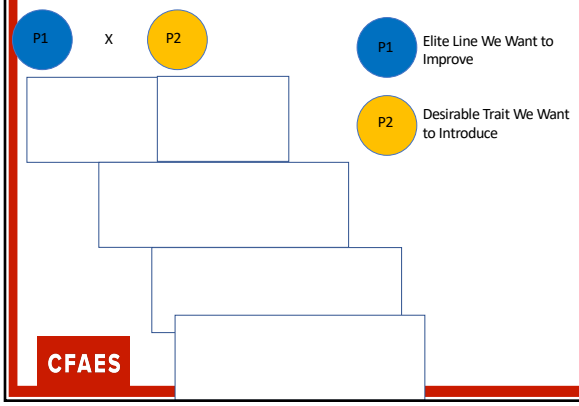


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## Crop Selection and Breeding

- 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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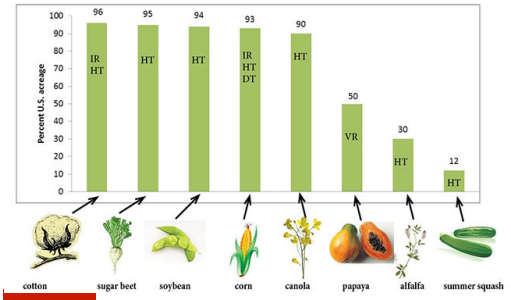
## Current GMO Crops in US

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University of Colorado Extension

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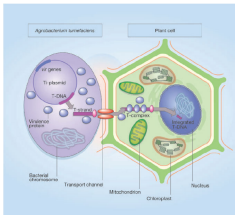
## Discovery and Development

- 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



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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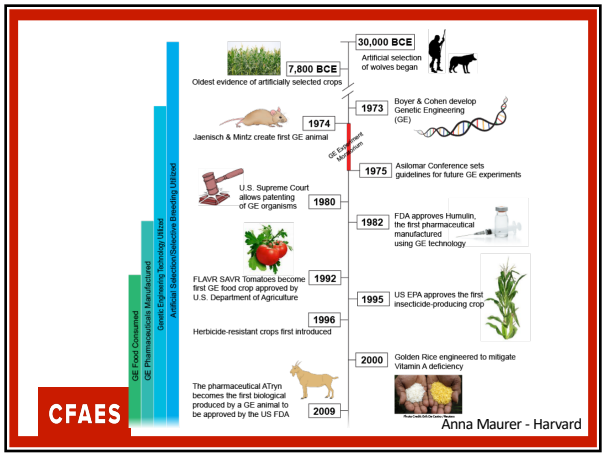


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Anna Maurer - Harvard

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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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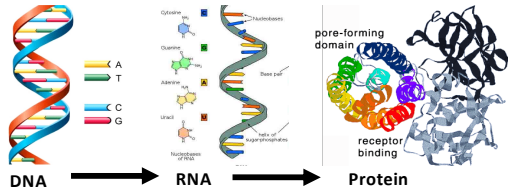
## The Central Dogma




**DNA** → **RNA** → **Protein**

| DNA | RNA | Protein |
|---|---|---|
| Genomic | Messenger | Primary |
| mitochondrial | Ribosomal | Secondary |
| chloroplast | Transfer | Tertiary |

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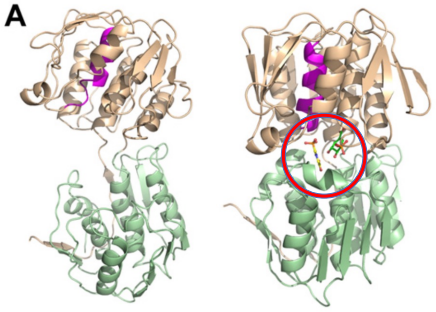


One small change to existing protein results in glyphosate resistance in crops

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EPSP Synthase – Glyphosate Resistance

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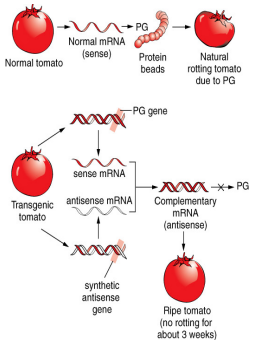
## From Theory to Crop

- 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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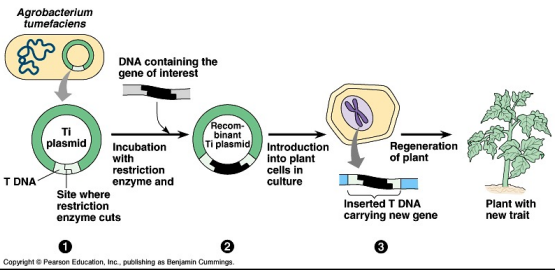
## How Do They Get Genes In There?

- Let nature do the the work
- *Agrobacterium tumefaciens*

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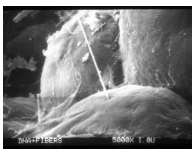
## How Do They Get Genes In There?

- Less common techniques
  - Less common
  - "Gene Gun"
  - "Whisker"
  - Electroporation



Kaeppler 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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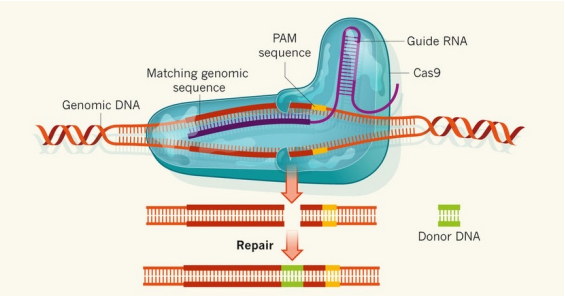
## CRISPR/Cas9

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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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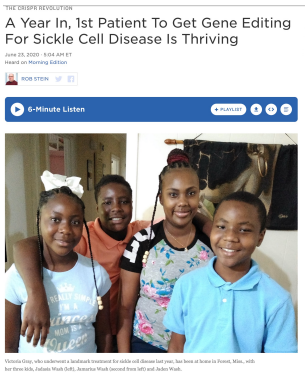
## CRISPR/Cas9

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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 thurigiensis* – 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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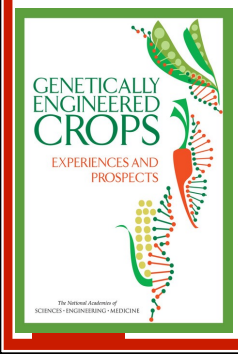
## Wait, what about increased yield?




***"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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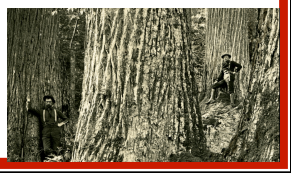
## Fast...

- 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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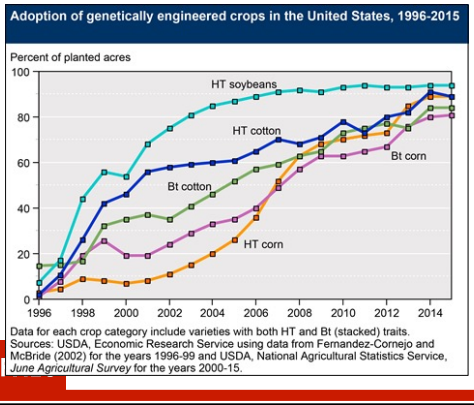


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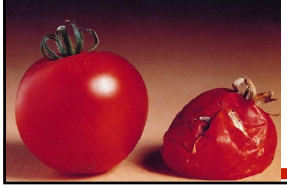
Bt Cotton - Right

Golden Rice - Right



Flavr Savr - Left

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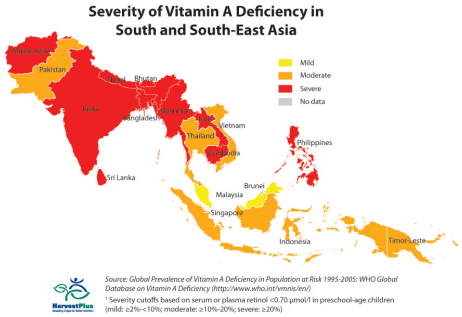


Golden Rice has elevated levels of beta carotene that the body converts to vitamin A

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## Environmental Advantages

Drought Resistant Technology - Right

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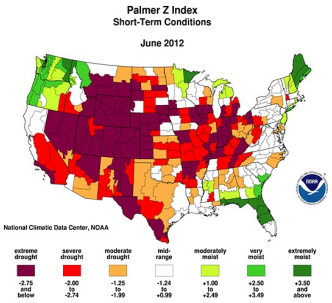
GMO Crops with drought resistance genes could reduce the water requirements needed for optimal yield

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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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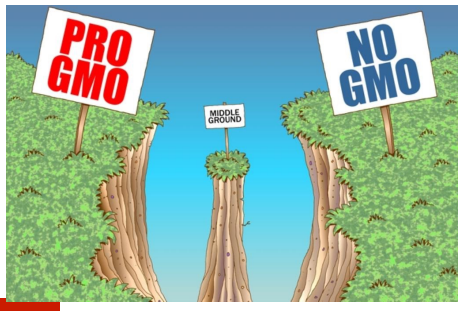
## The Great GMO Divide

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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." Toxilogical 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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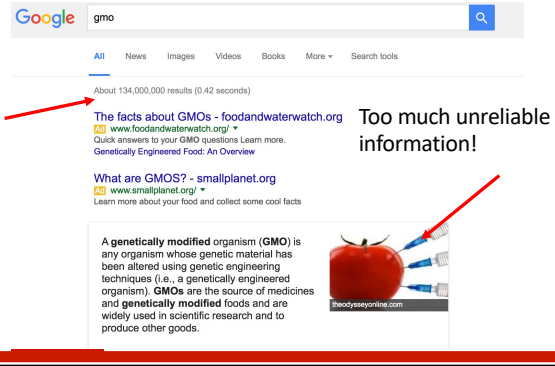
## Societal Concerns




Too much unreliable information!

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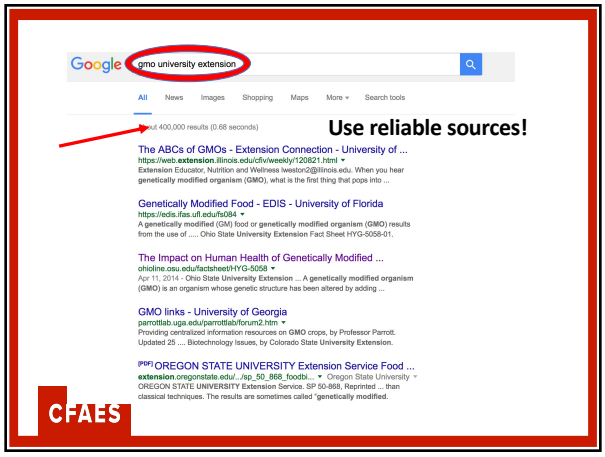
Google
gmo university extension
All
News
Images
Shopping
Maps
More
Search tools
Use reliable sources!
The ABCs of GMOs - Extension Connection - University of ...
https://web.extension.illinois.edu/cfiv/weekly/120821.html
Genetically Modified Food - EDIS - University of Florida
https://edis.ifas.ufl.edu/fs084
The Impact on Human Health of Genetically Modified ...
ohioline.osu.edu/factsheet/HYG-5058
GMO links - University of Georgia
parrottlab.uga.edu/parrottlab/forum2.htm
[PDF] OREGON STATE UNIVERSITY Extension Service Food ...
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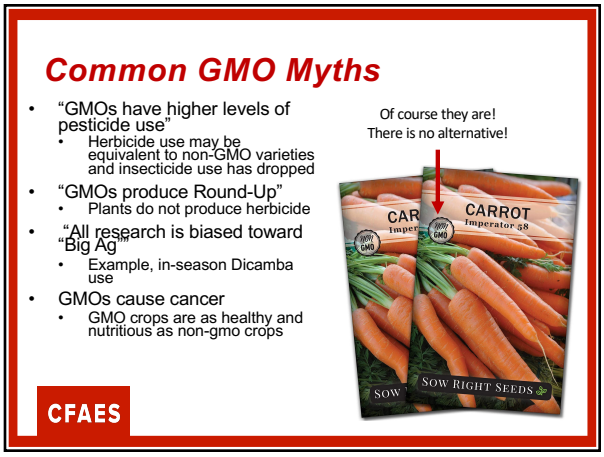
Common GMO Myths
"GMOs have higher levels of pesticide use"
Herbicide use may be equivalent to non-GMO varieties and insecticide use has dropped
"GMOs produce Round-Up"
Plants do not produce herbicide
"All research is biased toward "Big Ag""
Example, in-season Dicamba use
GMOs cause cancer
GMO crops are as healthy and nutritious as non-gmo crops
Of course they are!
There is no alternative!
CARROT
Imperator 58
SOW RIGHT SEEDS
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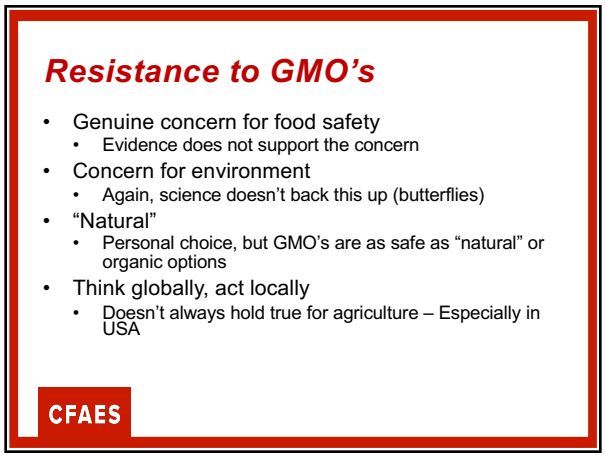
Resistance to GMO's
Genuine concern for food safety
Evidence does not support the concern
Concern for environment
Again, science doesn't back this up (butterflies)
"Natural"
Personal choice, but GMO's are as safe as "natural" or organic options
Think globally, act locally
Doesn't always hold true for agriculture – Especially in USA
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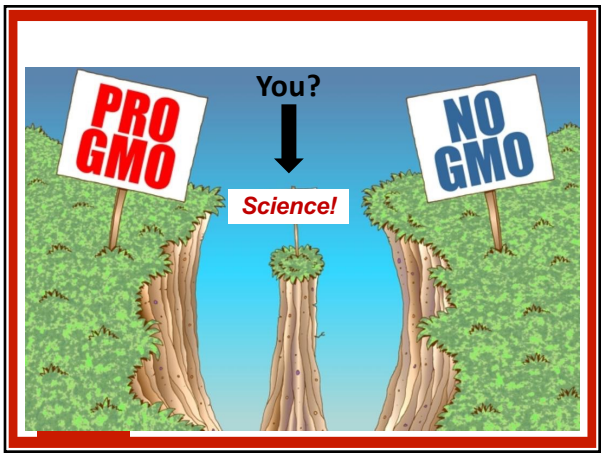
You?
PRO GMO
NO GMO
Science!

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Questions?
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