Deciphering the Science
GMO, GE, Biotech. What does it mean?

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What Questions Do You Have About GMO’s, GE, etc.?
- Use the Q&A box to ask!

What Are We Going to Talk About Today?
- SCIENCE!
- History of Crop Improvement
- Development of GMOs
- Pros and Cons of GMOs

What We Are NOT Going to Talk About Today
- Business Practices
- Individual Companies
- Conspiracy Theories

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
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

Modern Example

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

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

What Exactly is a GMO?

- GMO - Genetically Modified Organism
- "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
**Current GMO Crops in US**

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

**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

**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
The Central Dogma

DNA ➔ RNA ➔ Protein

- Genomic
- Mitochondrial
- Chloroplast

Messenger Ribosomal Transfer
Primary Secondary Tertiary

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

How Do They Get Genes In There?

- Let nature do the work
- *Agrobacterium tumefaciens*

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

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

EPSP Synthase – Glyphosate Resistance

How Do They Get Genes In There?

How Do They Get Genes In There?
**Genome Editing**
- RNAi
- CRISPR
- Site-specific gene editing
- Fast, simple, cheap

**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
- Polyphenol oxidase (PPO) – gene that promotes the degradation of cell walls
  - Bruising/browning
  - Gene found in all plants

**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
**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.)

**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

**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 2021

**Severity of Vitamin A Deficiency in South and Southeast Asia**

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

Drought Resistant Technology

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

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

The Great GMO Divide

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
  - Too much unreliable information!
Use reliable sources!

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!

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

Questions?
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