Genetic Engineering and the Seed Science

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Agenda

- Introductions
- Anticipatory Set
- Hands On Demo
- Presentation
- Helpful Resources

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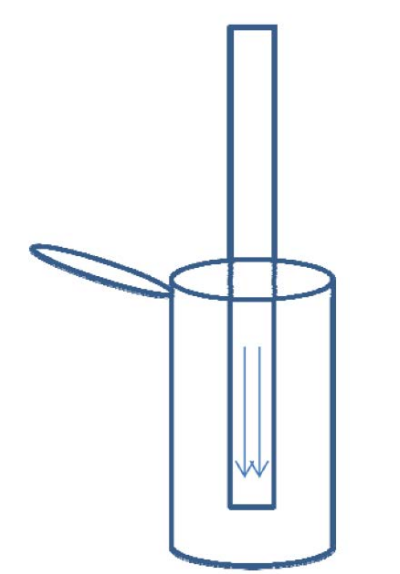
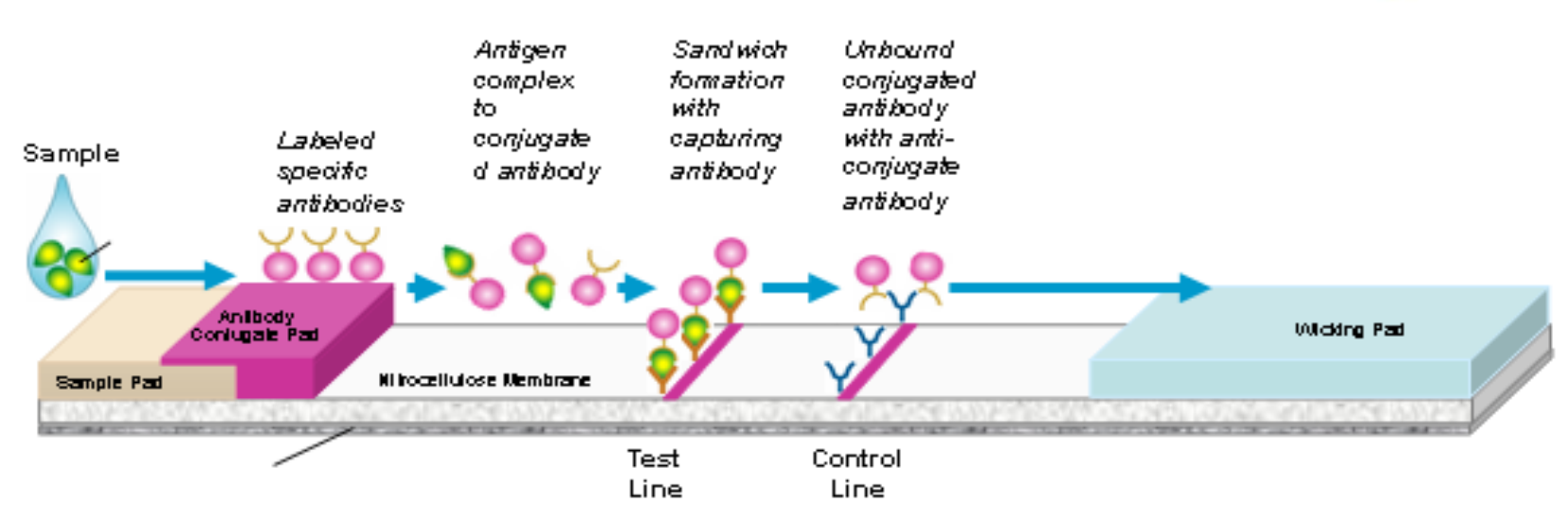
Anticipatory Set

Which is a "GMO"?

Let's find out…

Lateral Flow Strip Activity





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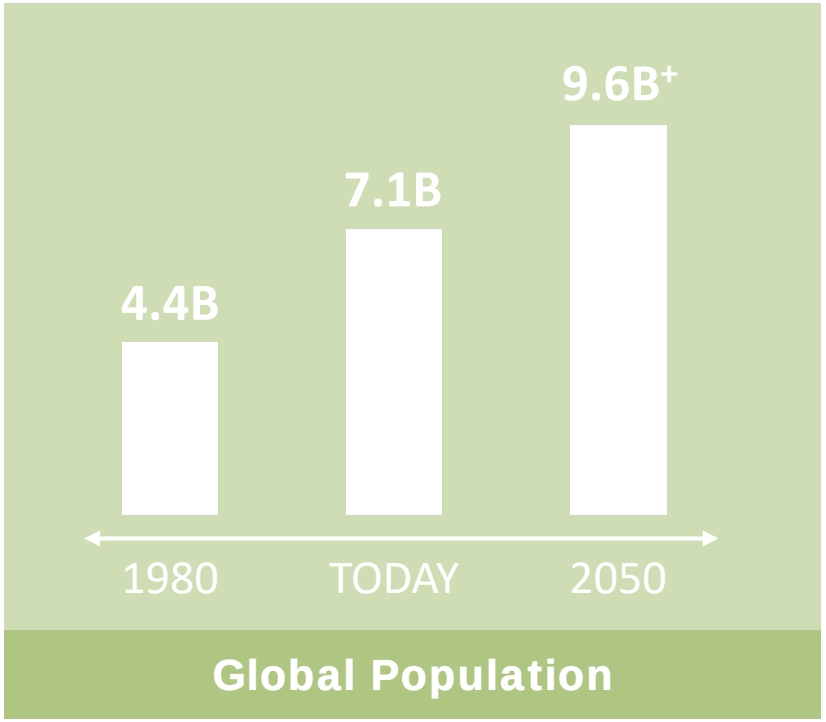
Rising Population

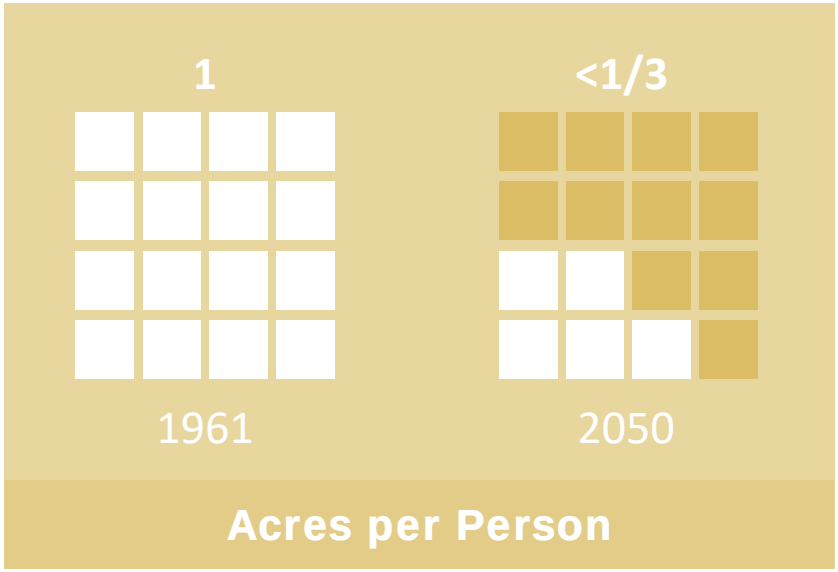
Growing enough for
a growing world



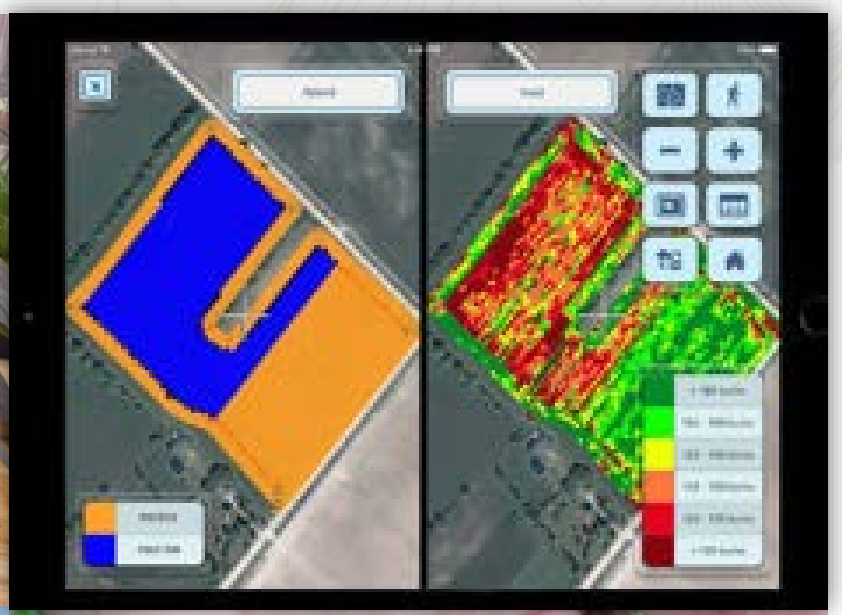
Source: http://www.fao.org/3/a-I6881e.pdf

Limited Farmland

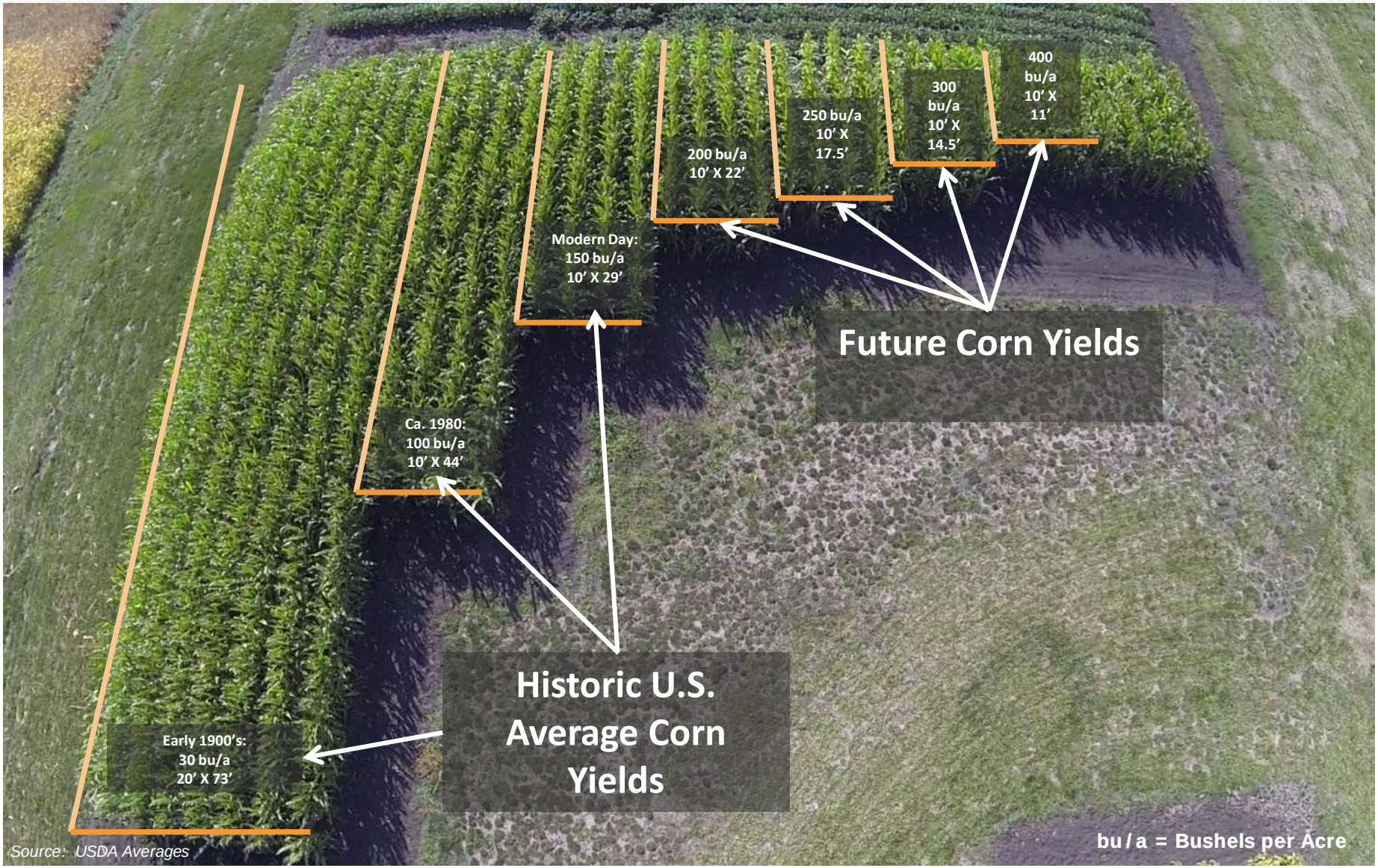
Farmers will need to produce enough food with fewer resources to support our world population



Source: The World Bank, Food and Agriculture Organization of the United Nations (FAO-STAT), Monsanto Internal Calculations



Sustainable Agriculture
Where We Have Been and Where We Are Going

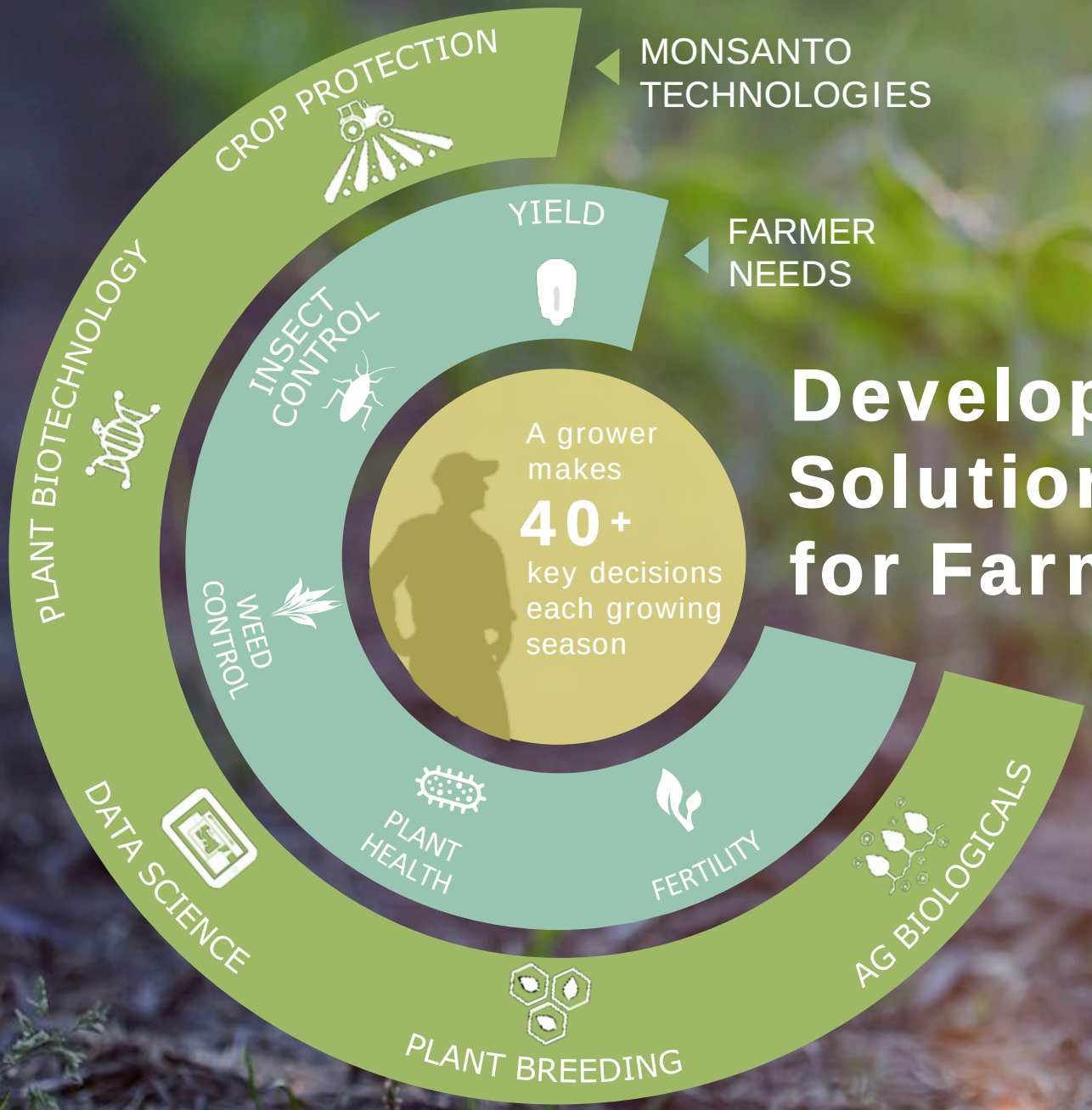


Source: USDA Averages

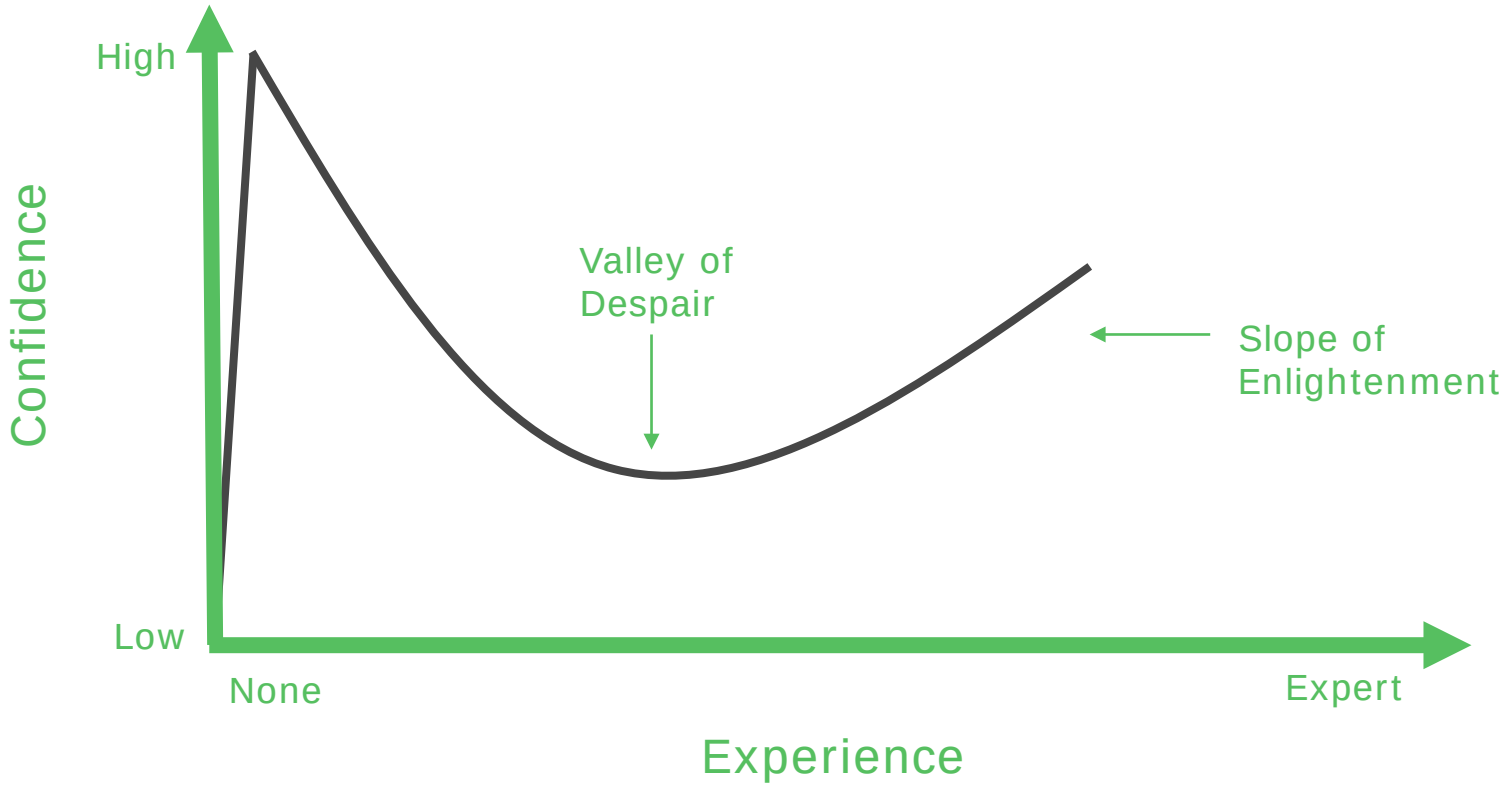
Monsanto is a Global Leader in Modern Agriculture

- **We produce seeds** for key crops and vegetables that help farmers have better harvests while using energy, water and land more efficiently
- **We provide solutions** that help farmers around the world maintain soil health, improve practices and minimize damage from pests and disease
- **We drive innovation** through collaborations and partnerships that tackle some of the world's biggest challenges

Developing Solutions for Farmers



Dunning-Kruger Effect



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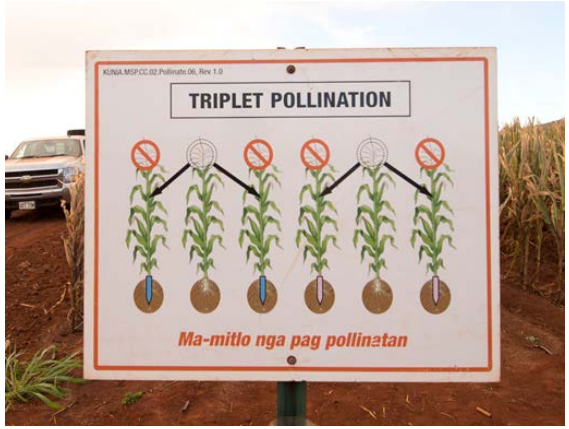
Methods of Crop Modification

- Cross-Breeding
- Mutagenesis
- Polyploidy
- Transgenics (GMO/ Biotech)
- Gene Editing



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Cross-Breeding

Crop Example

Norman Borlaug crossed two different types of wheat to produce a short statured variety which prevented tipping, increased yield and disease tolerance contributing to the "Green Revolution".

Technique

Breeding: Combining two sexually compatible sub-species to create a variety with the desired characteristics of the parents

Want the infographics? Visit Monsanto.com/STEM (resources tab)

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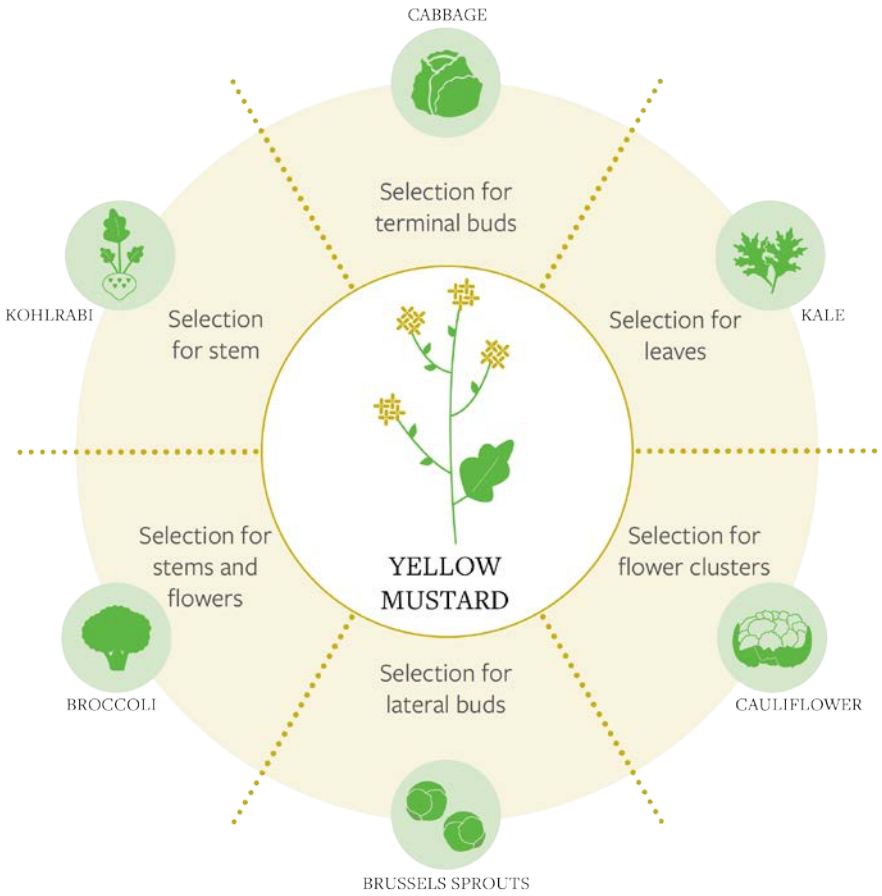
Dilemma in corn breeding: Finding new sources of useful genetic variation

Global Germplasm Diversity

Plant breeding is a powerful tool in improving crops and creating new varieties.



Mutagenesis

Ruby Sweet® grapefruits were created by exposing seeds to radiation causing a mutation resulting in a deep red fruit color.

Mutagenesis: Use of physical or chemical mutagens to induce random mutations, creating the desired characteristic.

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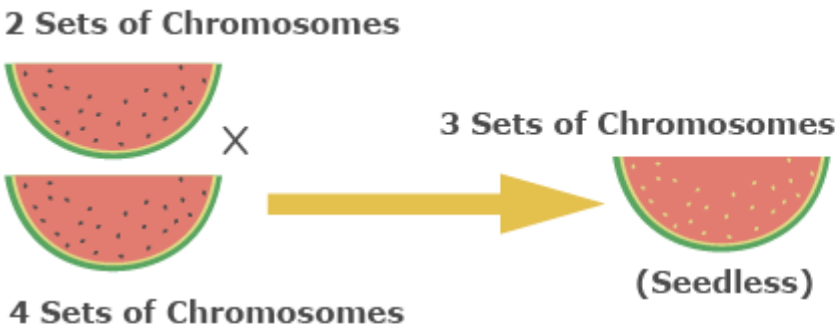
Polyploidy



Polyploidy: An uneven pairing of chromosomes sets occuring after cell division.

Seedless watermelons are a result of combining two varieties of watermelons with a different number of chromosomes.

Want the infographics? Visit Monsanto.com/STEM (resources tab)

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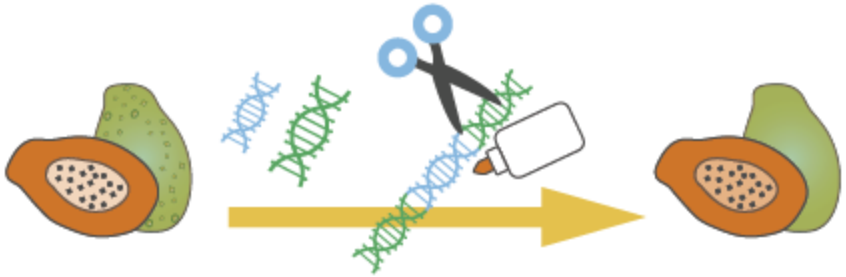
Transgenics



Rainbow Papaya is modified with an added gene that gives it resistance to the Papaya Ringspot Virus.

Transgenesis: Addition of genes from another species resulting in a plant with desired new characteristics.

Want the infographics? Visit Monsanto.com/STEM (resources tab)

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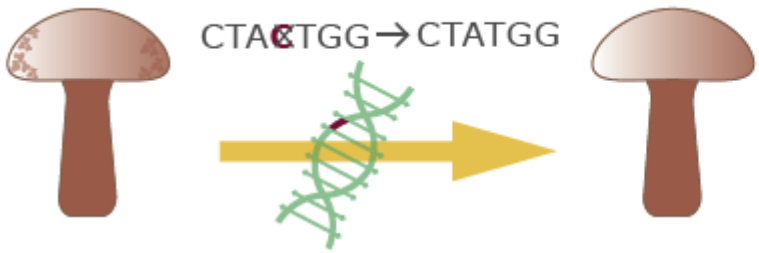
Gene Editing



A precise deletion in a specific gene prevents the mushroom from browning but all other characteristics remain the same.

Gene Editing: Use of a DNA editing tool such as CRISPR-Cas9 targeting a deletion or edit at a precise location within the cell's DNA.

Want the infographics? Visit Monsanto.com/STEM (resources tab)

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Little Cranberry Island, Maine

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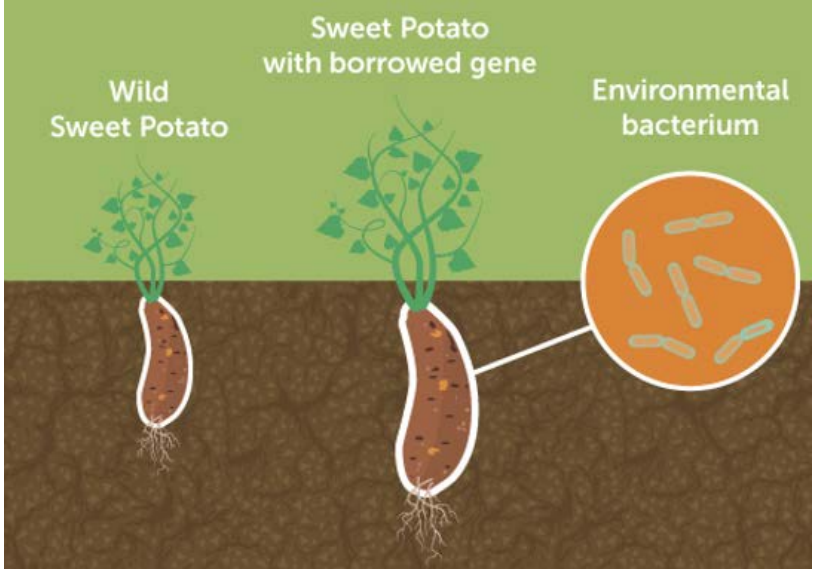
Genetic Modification Happens in Nature

RECENTLY, SCIENTISTS DISCOVERED WHAT MAY BE THE **WORLD'S FIRST GMO**...A SWEET POTATO THAT WAS NATURALLY IMPROVED BY BACTERIA IN THE SOIL.

Centuries ago, some wild sweet potato plants "borrowed" a natural bacterial gene in the environment. These plants ended up growing larger and stronger than other sweet potatoes.



Today, plant scientists are making similar efforts to adapt desirable traits to new plants. This process, known commonly as "genetic modification" or "GMO," helps plants thrive in their environment—which helps farmers have better harvests while using resources more efficiently.

For more information: http://bit.ly/washpost042915
For the full study: http://bit.ly/sciencedaily42815

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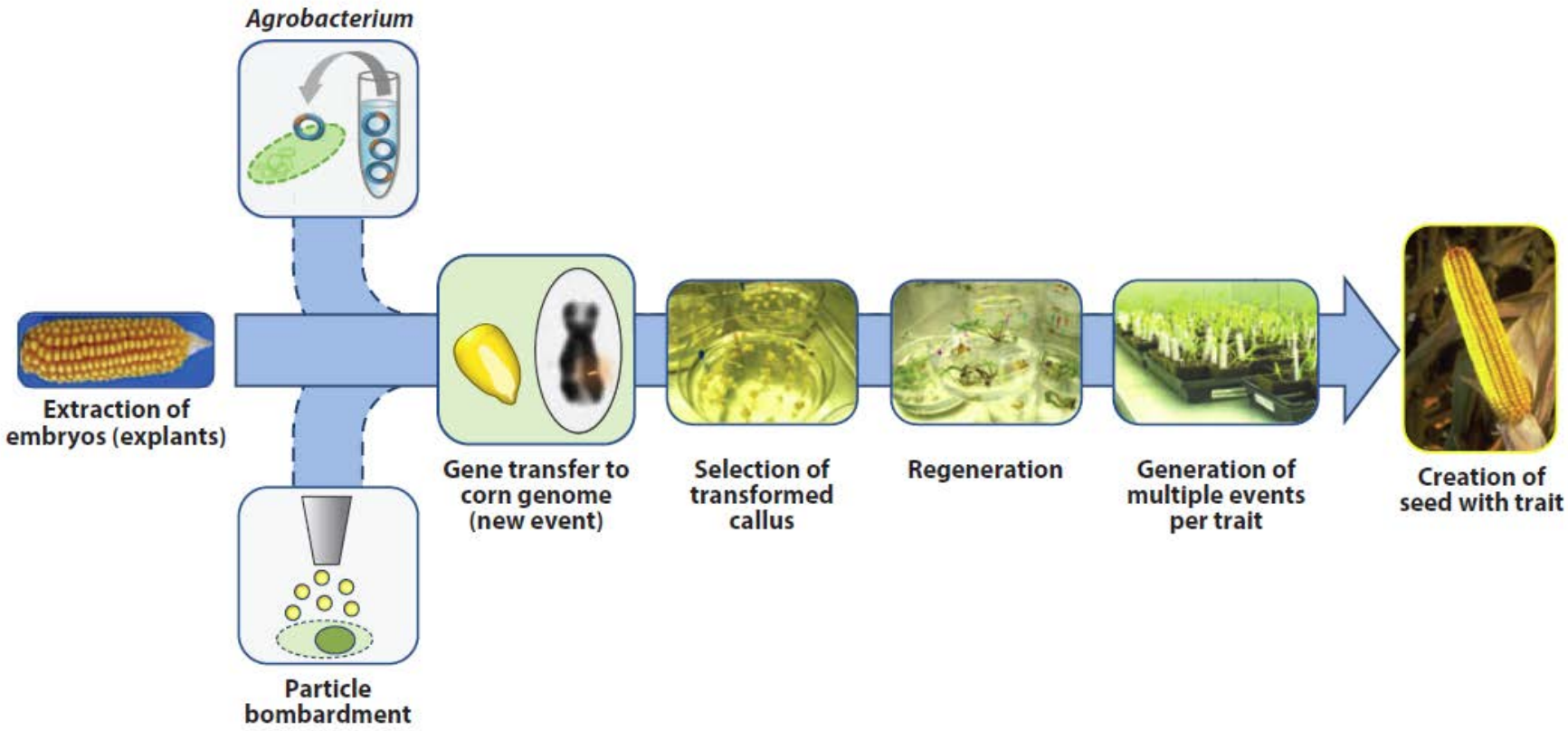
Methods for making a new GMO



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How many transgenic (“GMO”) crops are on the market today?

GMO Foods

Only 10 GMO crops exist on the market today, offering consumer and farmer benefits

Insect Resistance **Herbicide Tolerance** **Virus Resistance** **Non-Browning**

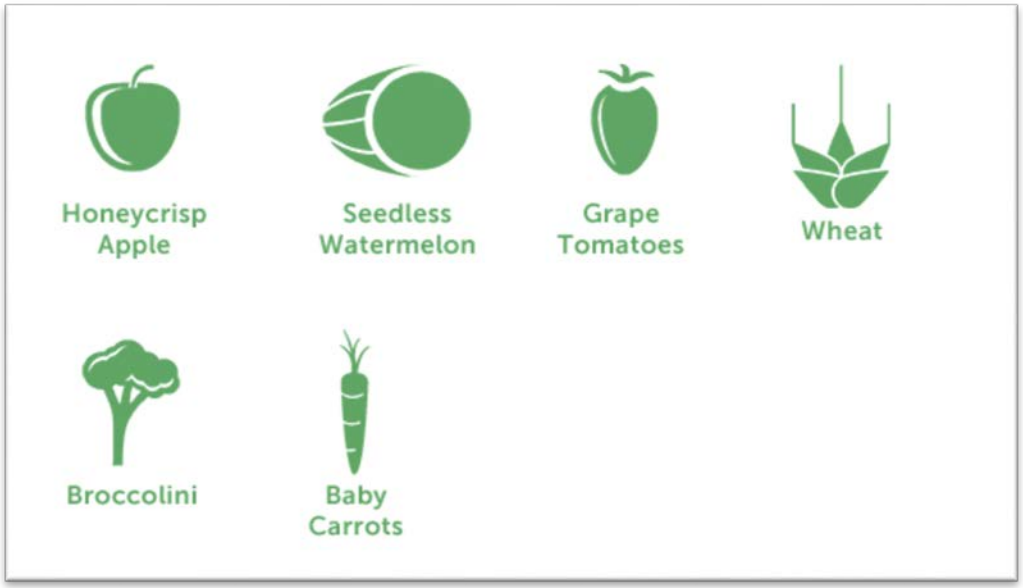
Drought Tolerance **Sustainable Production** **Disease Resistance**

Corn Soy Cotton Alfalfa Sugar Beets

Canola Papaya Apple Potato Squash

What is not a GMO?

- These crops (among many) are not the result of biotechnology



GMOs Used Outside of Ag/Crops

in Many Common Products

Enzymes

Nearly all cheese is made using rennin produced through biotechnology

Yeast

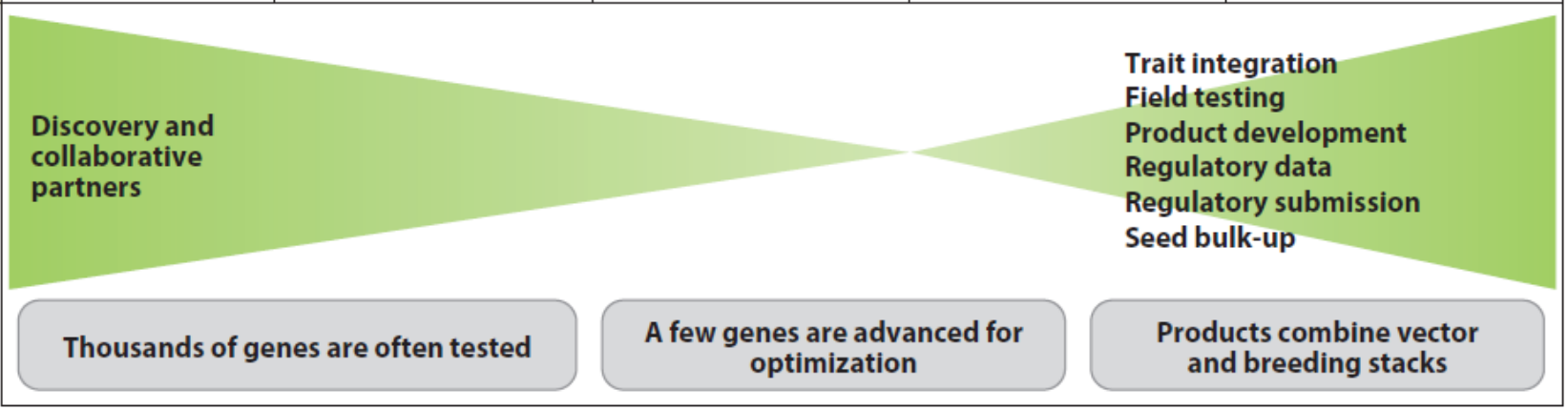
Scientists use biotechnology to create unique yeast strains for use in brewing beer and making bread

Medicine

Most insulin, supplements, and vitamins are produced through biotechnology

GMO testing and regulation is similar to clinical trials for medicine.

	Discovery Gene/trait identification	Phase 1 Proof of concept	Phase 2 Early development	Phase 3 Advanced development	Phase 4 Prelaunch
Average duration	54 months	27 months	30 months	37 months	49 months
Average cost	USD 31 million	USD 28.3 million	USD 13.6 million	USD 45.9 million	USD 17.2 million
Key activity	• High-throughput screening • Model crop testing	• Gene optimization • Crop transformation	• Trait development • Preregulatory data • Large-scale transformation	• Trait integration • Field testing • Regulatory data generation • Product development	• Regulatory submission • Seed bulk-up • Premarketing • Product development



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Biotechnology, from an idea to the field

Product concept → Gene discovery → Evaluation → Event selection → Variety development → Regulatory process → Field production → Market

Choice of genes/proteins	Agronomic assessment	Characterization of gene product and comparative analysis	Postmarket assessment
• Source • Initial molecular characterization • History of safe use • Mode of action	• Greenhouse to field • Agronomic performance • Phenotypic screening of events • Event selection (<1%)	• Toxicity • Allergenicity • Nutrition • Compositional analysis • Environment • Further molecular characterization	• Postmarket surveillance • Supplemental food/feed studies, as needed

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Monsanto GMO Traits

1. Bt Products
2. Roundup Ready® Crops
3. Disease resistant Squash
4. Drought Tolerant Corn
5. Soybeans – reducing Trans/Saturated fats
   - **SDA Omega-3** soybeans
   - **Vistive® Gold** soybeans

     Industrial/non toxic benefits of replacing petroleum-based products and synthetic oils

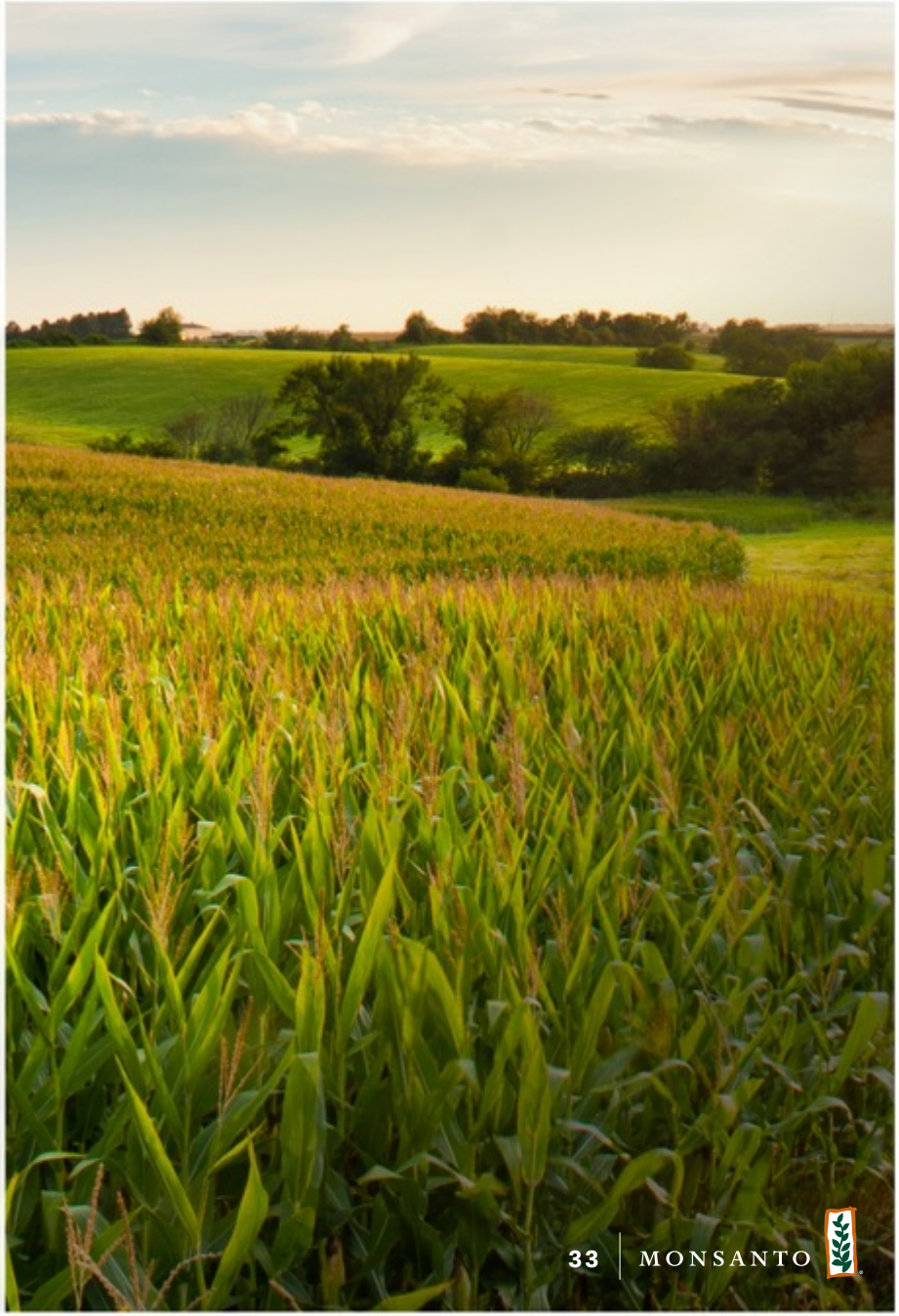
     http://www.monsanto.com/products/pages/vistive-gold-soybeans.aspx

Insect Protected Crops (Bt Crops)

- The bacterium, *Bacillus thuringiensis*, makes several proteins that are toxic to specific insects (*Coleoptera and Lepidoptera*). These protein toxins are activated in the insect gut and bind to specific receptors in the insect.

- Humans and other animals have acidic stomachs and thus the protein is digested.

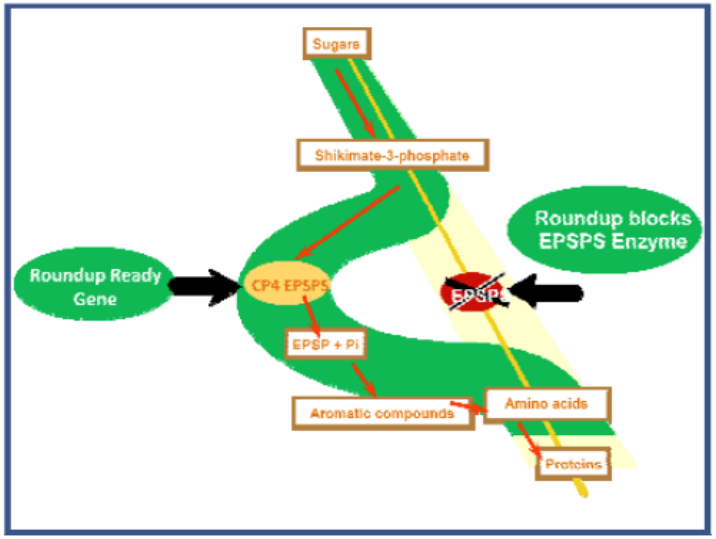
- Mammals lack the receptor to bind the protein making it completely non-toxic to humans and other animals.



Roundup Ready® Crops
(tolerant to the herbicide glyphosate)

5-EnolPyruvylShikimate-3-Phosphate Synthase

- Glyphosate binds to EPSPS and disrupts amino acid synthesis pathway
- Monsanto discovered an *epsps* gene from a bacterium that was not sensitive to glyphosate but still performed the same function.



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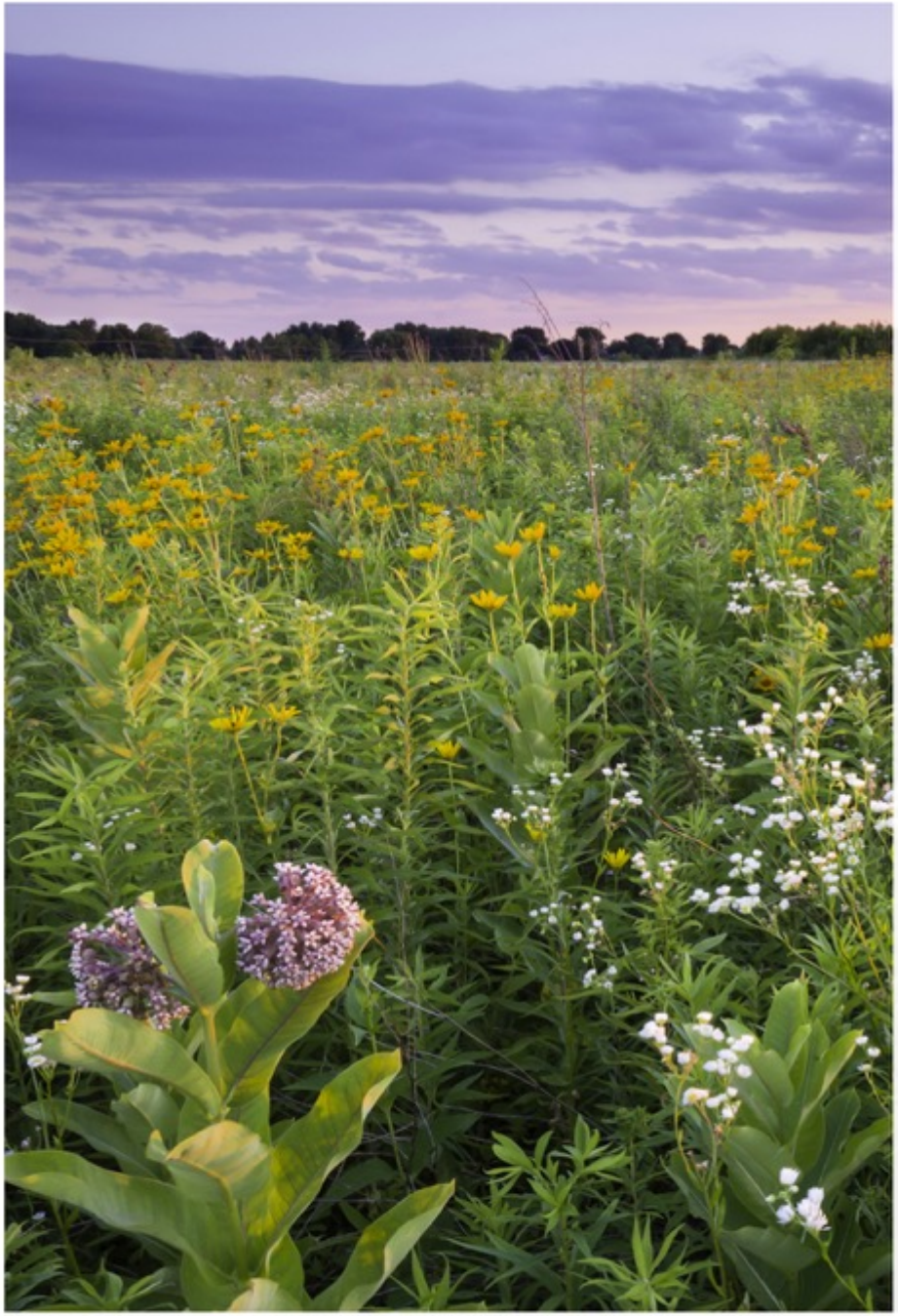

Environmental Benefits

The reduction in pesticides from 1996 to 2014 was estimated at **1.3 billion lbs.** or **8.2% reduction**

In 2014 alone, biotech helped prevent an estimated **49.4 billion lbs. of CO_2 emissions**, equivalent to removing **10 million cars** from the road for a year.

Without biotech, it would take an additional **44.7 million acres** (1 acre roughly size of football field) to produce the same amount of food produced during 1996 to 2014.

Other Industry Products

Golden Rice / Super Banana – Vitamin A (2020)

- to cure Vitamin A deficiency in developing countries which kills 670,000 children each year.

Citrus Greening Resistant Oranges

- gene from spinach for resistance to the bacterium, Liberibacter.

Aphid Resistant Wheat

- Natural defense to Aphids which require repeat pesticide usage to combat pests.

Potato – resist bruising (gene taken from wild variety)

- Lowers Acrylamide in high temperature cooking
- Lowers bruises

- **Mosquitoes** (Eliminates transmission of Malaria)
  - GMO mosquito blocks malaria parasite infection
  - Could be used for Zika vírus?

- **Arctic Apples** (Apples that don't brown)
  - Reduction in production of one protein- Polyphenol oxidase (PPO)

Lesson Plans & Kit

agclassroomstore.com

https://agclassroomstore.com/gm-soybean-seed/

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Documentary Highlight

Food Evolution

- See where the film will be showing in your community: http://www.foodevolutionmovie.com/screenings/
- Watch the trailer and share it: https://www.foodevolutionmovie.com/#trailer
- Follow the producers on Twitter: https://twitter.com/foodevomovie
- Rent and see the film, through Hulu and these services:
  - Amazon Video
  - iTunes
  - YouTube
  - Google Play Movies & TV

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Check it out!

Podcast	Teacher PD	Interactive Activity	Videos	Websites	Social Media Groups
Talking Biotech	BioBuilder	Journey of a Gene	League of Nerds- Interview with Fred Perlak Bt Cotton Launch	Food and Farm Discussion Lab	"Ag Education Discussion Lab"
Science Vs	CASE	Univ. of NE-Lincoln "Plant and Soil Science" Animations	Skeptics in the Pub- Idea to Market GMO Crops	Monsanto.com/STEM	"Biotech & Your Brain: A Global Forum for Educators"
Owl Pellets	PLTTW-Environmental Sustainability		Food Evolution		Reddit AMA with Fred Perlak
	Grow Next Gen				

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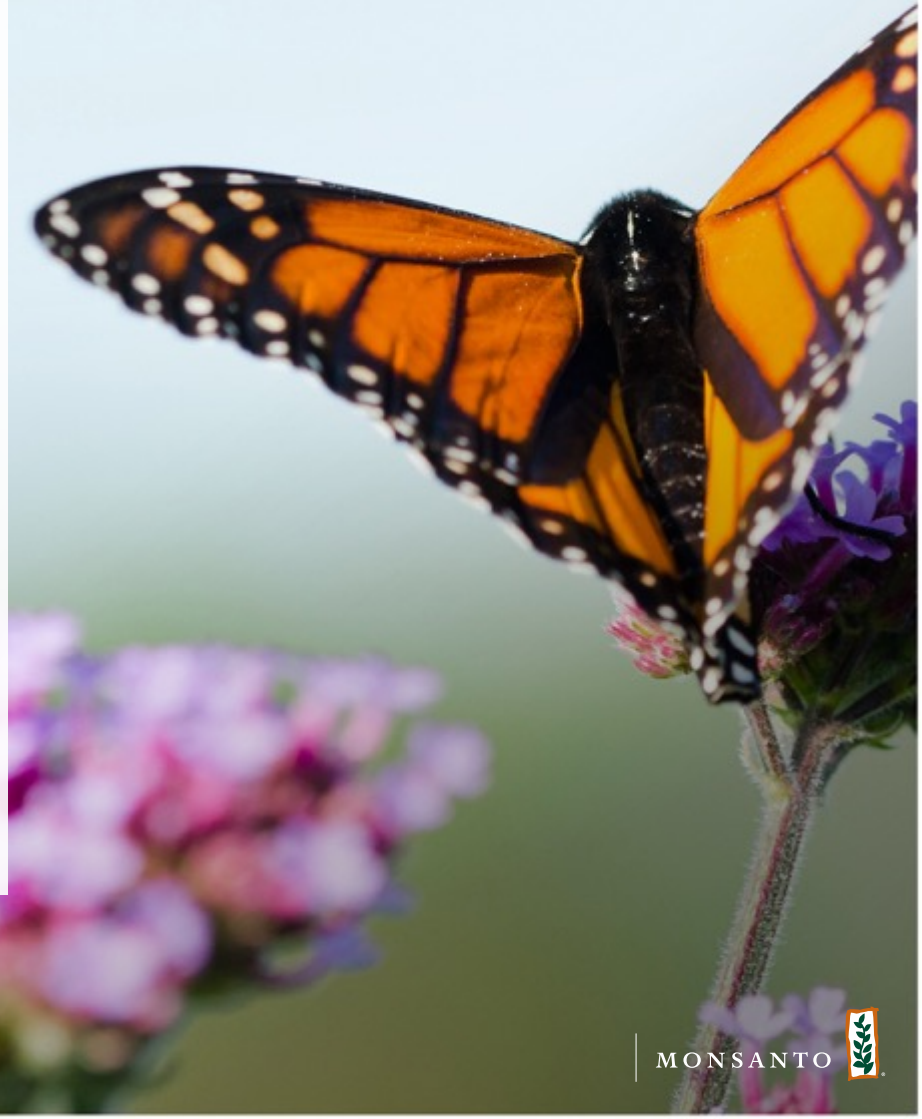
Website

Monsanto.com/STEM

Email

stemeducation.outreach@monsanto.com



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