

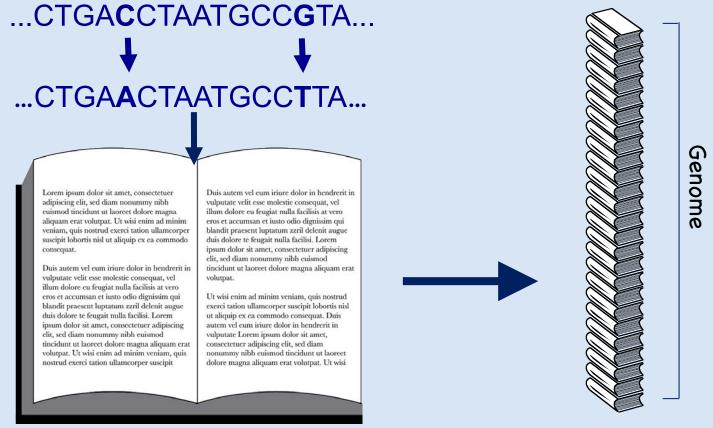
What I will cover

- 1. Background: genetic modification of crops
- 2. What GE crops are commercialized? In the pipeline?
- 3. What is the regulatory structure for GE crops?
- 4. What are some food safety issues with GE foods?
- 5. What are some environmental issues with GE crops?
- 6. Some food for thought...



Genetic information in cell is responsible for traits

Chemical units in DNA represented by alphabetic letters



1700 books 1000 pages each 1700 books (or 1.7 million pages)

Sometimes mistakes happen when copying information in books (genomes) \rightarrow creating changes, called <u>mutations</u>





Carrot

Mutations Happened to Make These Plants Go from Looking Like This...

To Looking Like They Do Today





Banana









Eggplant



Broccoli, Kale, Cabbage



Since 1950's intentional mutation breeding created >3200 crops—like 600 maize, rice, & wheat varieties. Although modified genetically, they are not regulated like genetically engineered (GMO) varieties.





Modern Example

Japanese Farmer Creates Mongee Banana With Softer, Digestible Skin



But genomes have also been modified by classical breeding to create new plant varieties



Triticum monococcum

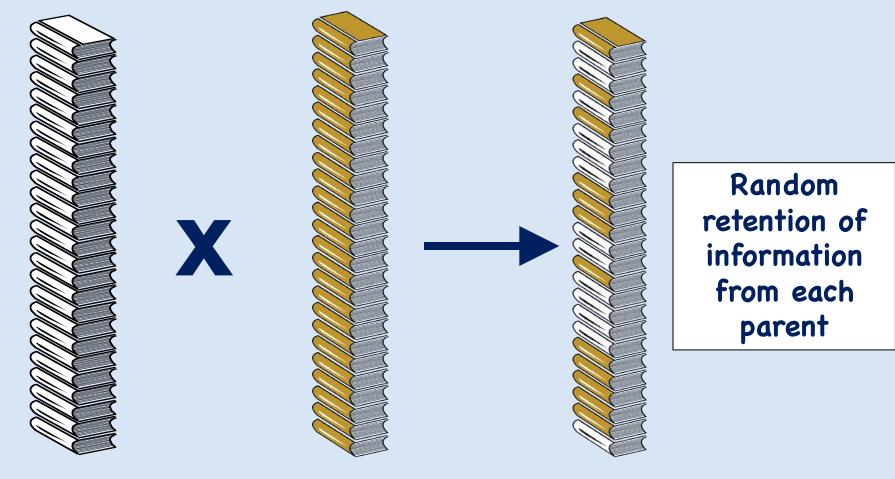


Triticum aestivum

Ancient variety Modern bread variety



Hybridization or Cross-breeding of Wheat



1700 books 1700 books 1700 books (or 1.7 million pages) (or 1.7 million pages)

Genetic modification by hybridization is not GE or GMO







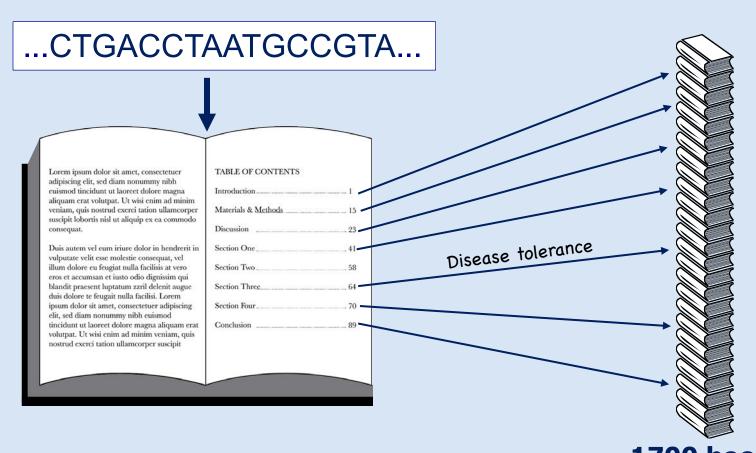
Breeding was critical to food production increases

Product	2014 US acreage	US Acreage needed at 1950's rate	Additional Resources needed
Soybeans	82,591,000 acres	180,971,889 acres	~98 million acres (= size CA)
Corn	83,136,000 acres	372,134,346 acres	~289 million acres (= 3X size CA)
Broiler Chickens	8,544,100,000 head	16,679,545,455 head	~8 billion head requiring 81.5 billion lbs feed



New Breeding Method

Uses table of contents of genes for marker assisted selection



1700 books (or 1.7 million pages)



Genetic modification that is not GE or GMO

Can't we just do all modifications this way?

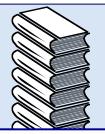


Marker-assisted selection used to protect rice against bacterial blight and blast disease

Protection limited to diversity in crop compatible relatives

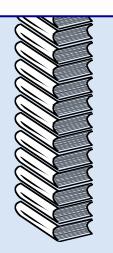


Also modify genomes with genetic engineering \rightarrow GMOs





What Kinds of GE Crops and Foods Are in the Commercial Market?

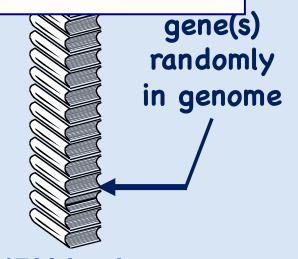


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One-half page equivalent to a gene

1700 books (or 1.7 million pages)



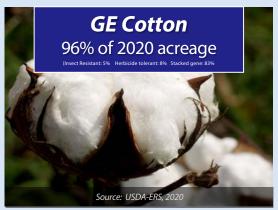
1700 books

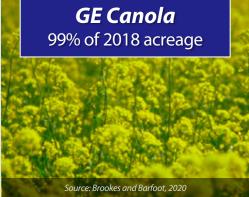
(or 1.7 million pages)

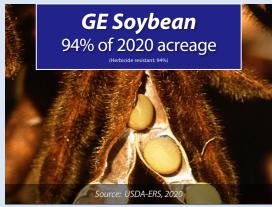


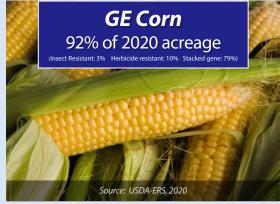
Genetic modification by genetic engineering is GE or GMO

Number of different commercially available, large acreage GE (GMO) crops is limited















Number of different traits available in large acreage GE crops is also limited



Insect-tolerant Bt crops engineered for resistance using gene from naturally occurring bacterium

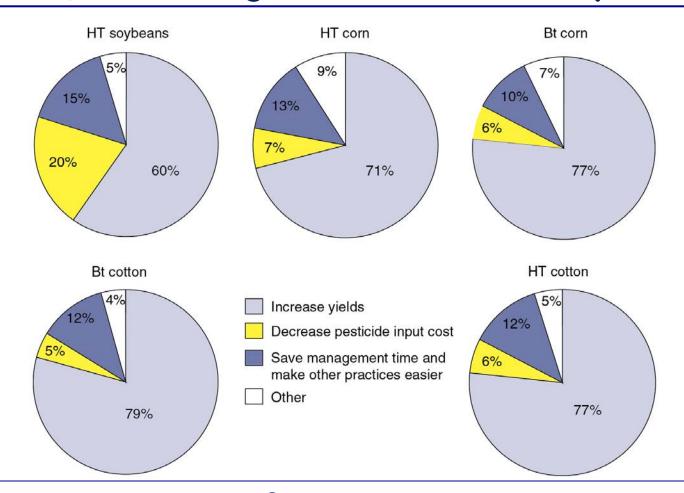


Herbicide-tolerant engineered with gene to
tolerate herbicide
application

Crops with stacked traits - Bt and HT - are available



Why do U.S. growers use GE crops?



Reasons vary from crop-to-crop but primary reason is improved yields



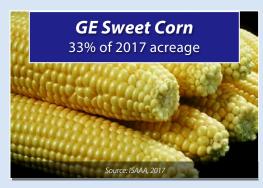


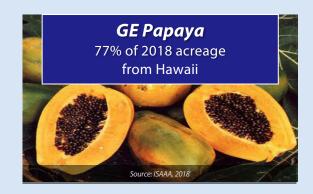
These large-acreage GE crops lead to estimates of 60-80% of U.S. processed foods have GE ingredients - often only minor



There are only a few whole, genetically engineered foods in the U.S market

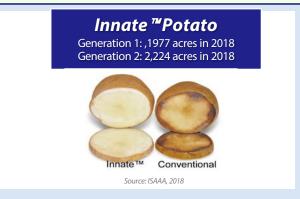






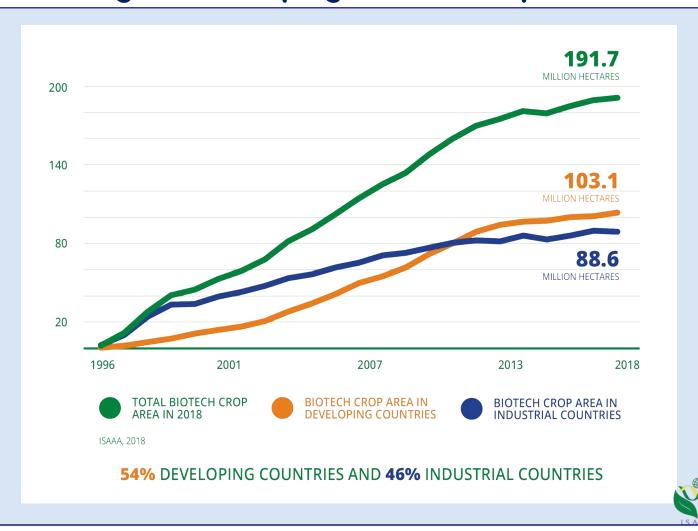
Two more are just being introduced







Despite limited U.S. crop and trait types, worldwide acreage is increasing in developing and developed countries



In 2018, 17M farmers in 26 countries planted 474M acres 191.7M hectares) ~4X size of CA



Salinity and Drought Tolerance - UC Davis





Conventional Engineered 200 mM NaCl (~1/2 sea water)





Conventional Engineered 15 days drought, 7 days re-watered

Salt-tolerance

Drought-tolerance



GE potato + pest management controls potato blight - reducing chemical fungicide use by up to 90%









By 1950, 4 B American chestnuts, the redwood of the east, were dead – 99.9% of the species



Chestnuts engineered with wheat gene prevents cankers
Can this be used to save endangered species?





"Increasing synthesis of protein critical to photosynthesis increases biomass and grain yields in rice under control and heat stress conditions."



Conventional

Engineered

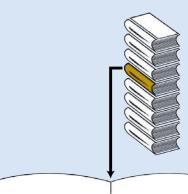




High anthocyanin purple GE tomatoes. Diets with 10% purple tomatoes increased lifespan of cancer-prone mice



New Genetic Method: Genome Editing - Mutation



Find target text, inserts gene edit at specific location in genome, using CRISPR system

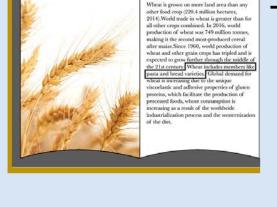
MUTATION

→ Wheat includes members like pasta and bread varieties.

Changing "includes" to "contains"



Wheat contains members like pasta and bread varieties.





EXAMPLES of edited products:



University

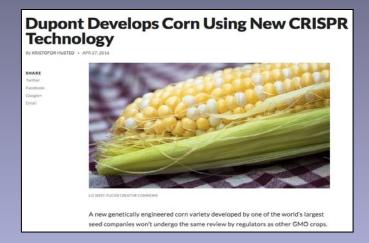


Company

Camelina is an oilseed that's been

The agency has determined the studied as an alternative crop in Eastern

tory process for biotech crops.



Company



'knock out' mildewsusceptible gene By MATEUSZ PERKOWSKI

A wheat variety rendered mildere-resistant through the targeted
calified without Leeping USDA regilatory healed for biotech crops.
The agency's Animal and Pleat
Health Impection Service has found at
health Impection Service has found and anne mintee or
siterat wheat cuttiver downt has under
health projection. Service has found and anne mintee or
siterat wheat cuttiver downt has under
projections for regional projections.

must me cumrar soons taus used as paradection for regularing generically prediction for regularing generically prediction for regularing generically prossible plant perts and publicages. While the when was developed with generic elements from dis-ense-casualing bacteris, they aren't mental analysis and ophibic comments, APIES.

according to APHIS.

Most biotech crops commonly grown in the U.S. have undergone deregulation, and in some cases, lawsuits over the adequacy of this process have delayed their commercialization.

regulations are not been delegated in the control of the property of the control of the property of the proper

Company

In 2016/2017, USDA said they can't regulate these edited crops because no DNA from plant pests or pathogens is introduced

technology doesn't fall under the

Turn to CAMELINA, Page 12 USDA's regulatory purview.



Three Genes in Tomatoes Edited for Space and the Backyard

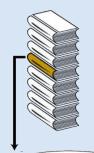


Small shape and size, sweet, and ripe in 40 days.

Perfect for backyard gardens and traveling into space!



Another Way of Genome Editing-Modification



Inserts edits specifically in genome



all other crops combined. In 2016, world production of when was 74 million tomes, making it the second most-produced cerval after makes. Since 1960, world production of wheat and other grain crops has tripled and is expected to grow further through the middle of the 21 tre cutury. Who at includes members like light and bread varieties! Global demand for wheat is necessaring due to the unique.

wheat is uncreasing the to the unique viscoclastic and affective properties of gluten proteins, which facilitate the production of processed foods, whose consumption is increasing as a result of the worldwide industrialization process and the westernization of the diet.

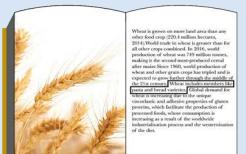
MODIFICATION

Wheat includes members like pasta and bread varieties.

Changing "includes" to "may contain"

INSERTION

Wheat may contain members like pasta and bread varieties.



Wheat includes members like pasta and bread varieties.

Changing "includes" to "has"

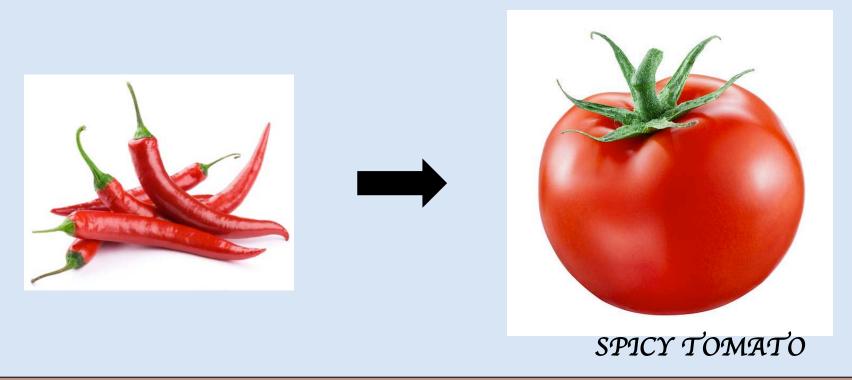
DELETION

Wheat has members like pasta and bread varieties.

This type of genome editing considered GE or GMO under federal regulations



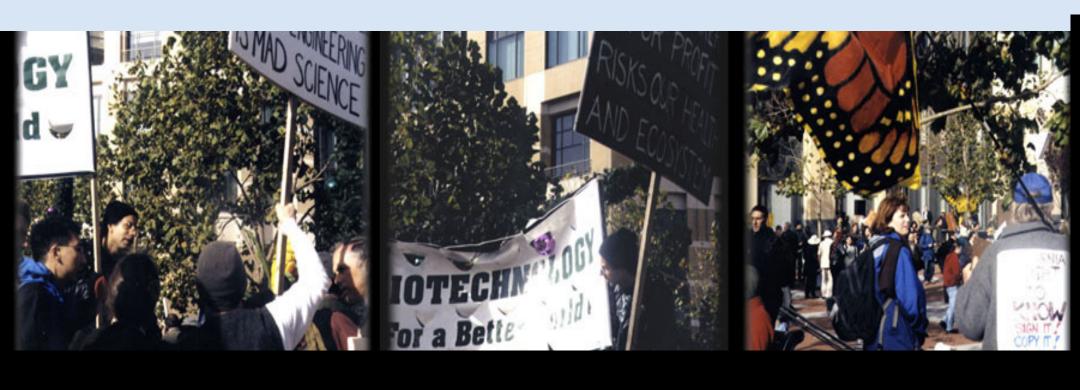
Example: Activating Capsaicin Production in Tomato to Yield Spicy Tomato



Researchers from Brazil and Ireland propose to activate genes present in tomato by editing to produce capsaicinoid – that gives peppers their heat.



Why Are GE (GMO) Crops and Foods So Controversial?







Look what greeted residents in Tule Lake in late 80's during first field test of GE "ice minus bacterium" – men in moon suits spraying the organism on local fields.

They went elsewhere in CA; they weren't welcome there either!



But large-scale pushback started in the late 90's in Europe. Factors that fueled and continue to fuel controversy there:

- Food safety scares
- Involuntary nature of change
- Cultural differences
- Economic incentives





1999 Lord Melchett participating in GM protest

And there are issues in the U.S. too

2014
GM maize protest in Germany



What are some issues with GE crops & foods?

- Regulatory oversight
- Lack of peer-reviewed food safety tests
- Consumer attitudes and labeling
- Environmental issues
- Some additional food for thought...



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U.S. Regulatory Agencies

USDA

FDA

EPA

- Field testing
 - -Permits
 - -Notifications
- Determination of non-regulated status

- Food safety
- Feed safety

- Pesticidal plants

 tolerance
 exemption
 registrations
- Herbicide registration

Plant pest?

Danger to people?

Risk to environment?



Regulation based on 1986 regulatory system, creates problems:

- New products emerge with no rules to govern them
- · Old products not in market because no commercial pathway
- · New products created to step around regulatory system

Genetically engineered crops that fly under the US regulatory radar

To the Editor:

Recently, the US Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) has categorized as outside the scope of its regulations several genetically engineered (GE) crops that rely on either new approaches or new wrinkles on traditional recombinant DNA techniques in their provenance. Indeed, a survey of recent inquiries to APHIS suggests that the number of entities seeking nonregulated status for their products has been on the increase. Many of these inquiries originate from public institutions or small biotech companies, suggesting that the use of technologies, such as null segregants, novel delivery systems,

cisgenesis/intragenesis and site-directed nucleases, may be a deliberate strategy for smaller entities to navigate the US GE crop regulatory framework. The fact that the US Coordinated Framework is on the one hand failing to oversee these new product types and on the other overregulating GE crops and technologies with proven track records of safety should be a cause for concern. We conclude that it is time to reevaluate the US regulatory framework for GE crops and build a system that is based on science, with enough flexibility to evolve with accumulating scientific knowledge and technologies and, importantly, that allows the participation of small companies and public sector institutions. July 2, 2015: Obama announced plan to modernize biotech regulations - no progress until...



Executive Order on Agricultural Biotechnology June 11, 2019

- Agencies regulate end products, not methods used. So, edited pest resistant product not treated differently from one made with traditional breeding.
- Biotech products regulated proportional to risks.
- Applies only to edited, not transgenic, products or GMOs – still regulated on case-by-case basis.



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occasional widely
publicized
studies cast
doubt on safety
of GE foods one in Sept. 2012
by French
researcher

by European
Food Safety
Authority and
found to have no
merit

But you never hear that

French academies trash GM corn cancer study

By RFI

A controversial study that linked genetically modified maize to cancer in lab rats is a "scientific non-event", six French scientific academies said in a rare joint statement Friday.



Claim that Monsanto's RR corn causes tumors in rats



The report's author, Gilles-Eric Séralini, with his book All Guineapigs AFP /Jacques Demarthon

"This work does not enable any reliable conclusion to be drawn," they say, adding that the publicity surrounding the publication has "spread fear among the public."

The joint statement - an extremely rare event in French science - is unsigned and issued in the names of the national academies of agriculture, medicine, pharmacy, science, technology and veterinary studies.

What about other published studies?

2014 study

- 9B food-producing animals in U.S
- 95% consumed feed with GE ingredients
- Analysis of public data from 1983 to 1996, before GE crops, vs. 1996 to 2011

Conclusions:

- * No unfavorable or perturbed trends in livestock health and productivity.
- * No differences in nutritional profile of animal products from GE-fed animals.











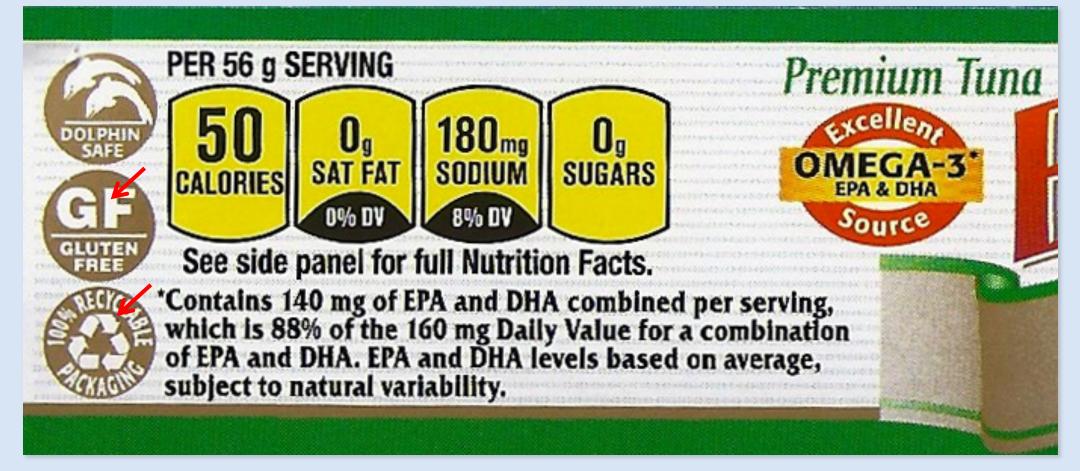
SOURCE: "Prevalence and impacts of genetically engineered feedstuffs on livestock populations"

A. L. Van Eenennaam and A. E. Young, J. Animal Science September 2014

What are some issues with GE crops & foods?

- Regulatory oversight
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- Labeling
- Environmental issues
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There are already many labels on foods- from gluten-free to dolphin-safe - none are mandated.





Proposed symbols for foods with GE ingredient – must use bioengineered, not genetically modified

What about labeling for GE foods?

July 8, 2016: Senate bill on mandatory national system for GM disclosures on food products. Obama signed on July 29.

Law requires USDA to decide what ingredients in food are from GE organisms; labels will use words, pictures or scannable bar code for smartphones. Started in 2020.



An example on a product



Burgers, tacos, lasagna...use like ground beef in your favorite recipes!

Make the Impossible Burger at home:

Pre-heat pan to MEDIUM-HIGH, or grill to HIGH heat. Cook a 1/4 lb. patty 5-6 min, flip halfway through. Cook to taste. Fully cooked when interior is 160°F.

For more recipes & tips visit ImpossibleFoods.com/recipes

Nutrition Facts

3 servings per container

Serving size 4oz. (113g)

Calories 240

Amount/serving	%DV	Amount/serving	%DV
Total Fat 14g	18%	Total Carb. 9g	3%
Saturated Fat 8g	40%	Dietary Fiber 3g	11%
Trans Fat 0g		Total Sugars <1g	
Cholesterol Omg	0%	Incl. <1g Added Sugars 1%	
Sodium 370mg	16%	Protein 19g	31%
		170 170 1 10	050

Vitamin D Omcg 0% • Calcium 170mg 15% • Iron 4.2mg 25%
Potassium 610mg 15% • Thiamin 2350% • Riboflavin 15%
Niacin 50% • Vitamin B6 20% • Folate 30%

Vitamin B12 130% • Phosphorus 15% • Zinc 50%

INGREDIENTS: WATER, SOY PROTEIN CONCENTRATE, COCONUT CIL, SUNFLOWER DIL, NATURAL FLAVORS, 2% OR LESS OF POTATO PROTEIN, METHYLCELIULOSE, YEAST EXTRACT, CULTURED DEXTROSE, FOOD STARCH MODIFIED. SOY LEGHEMOGLOBIN, SALT, SOY PROTEIN ISOLATE, MIXED TOCOPHEROLS (VITAMIN E), ZINC GLUCONATE, THIAMINE HYDROCHLORIDE (VITAMIN B1), SODIUM ASCORBATE (VITAMIN C), NIACIN, PYRIDOXINE HYDROCHLORIDE (VITAMIN B6), RIBOFLAVIN (VITAMIN B2), VITAMIN B12

CONTAINS: SOY GLUTEN FREE

Manufactured by: Impossible Foods Inc. 400 Seginew Dr Redwood City, CA 94063 Hello@ImpossibleFoods.com KEEP REFRIGERATED. IF PURCHASED FROZEN, THAW IN REFRIGERATOR AND USE SEALED WITHIN 10 DAYS.

20-00041R3





What are some issues with GE crops & foods?

- Regulatory oversight
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- Environmental issues
- Some additional food for thought...

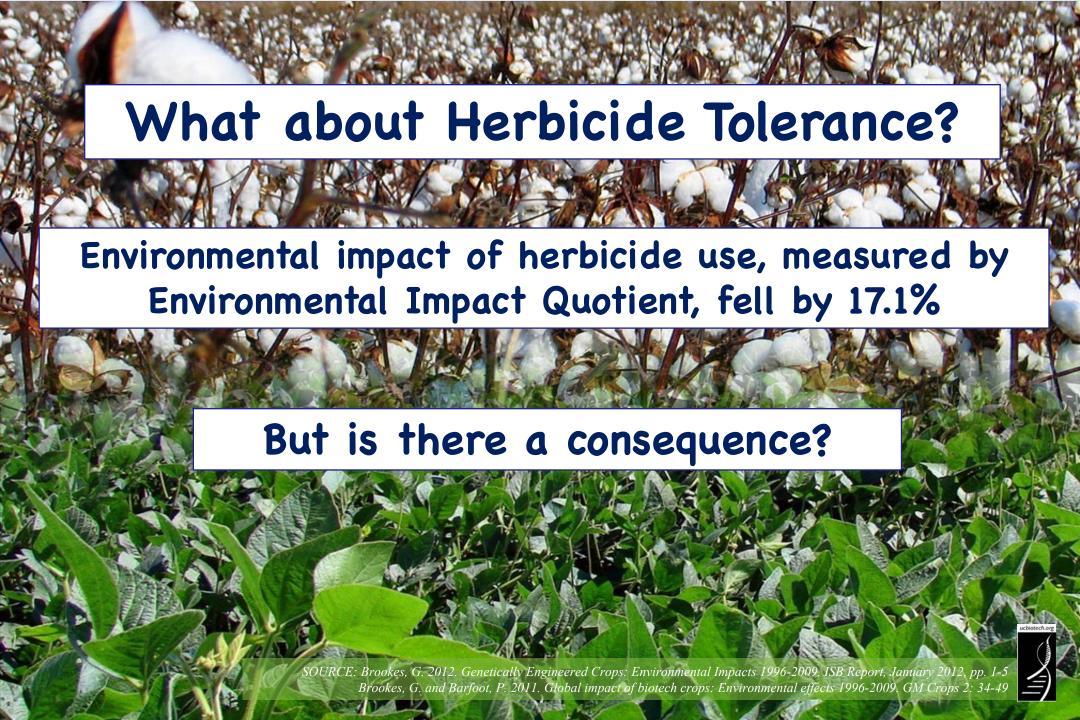
Insect Resistance

B.t. cotton and corn engineered for insect resistance with gene(s) from naturally occurring bacterium.

Development of resistant insects or herbicide-tolerant weeds

To date minimal insect resistance has occurred



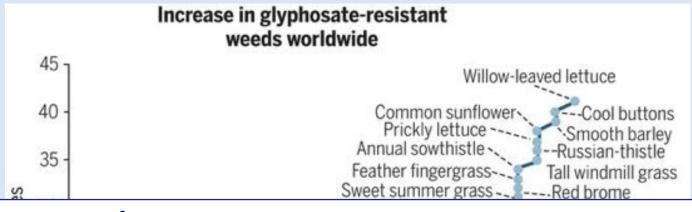


Herbicide-resistant Weeds Threaten Soil Conservation Gains: Finding a Balance for Soil and Farm Sustainability

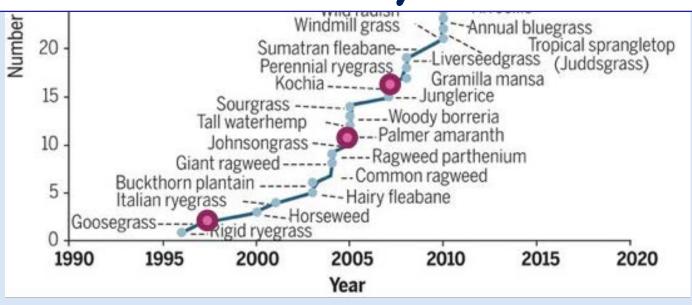
"When any single herbicide mechanism of action is used repeatedly without alternative management tactics, selection pressure becomes intense for plants tolerant or resistant to that herbicide."



Glyphosate-resistant weeds due to mutation, gene flow, weed shift - exacerbated when same herbicide is used repeatedly



Didn't we already learn this?







And there are/were ways to avoid this

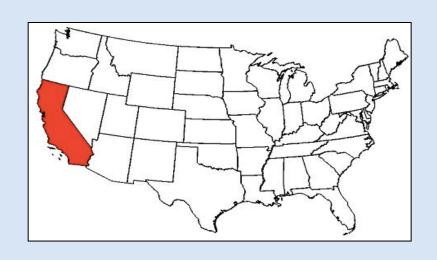
Example: "Sugar beet engineered for resistance to three herbicides gives growers more options"



What are some issues with GE crops & foods?

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Consider This...





- > Nigeria: little over twice the size of California
- >75% more arable land than U.S.
- > But 5 times less land per capita than in U.S.
- In 2050, expected to be third most populous country in the world overtaking the U.S.



And this...

If food waste were a country, it would rank behind only the US and China for greenhouse gas emissions.



And...production of wasted food uses 28% of the world's agricultural area.



And this...

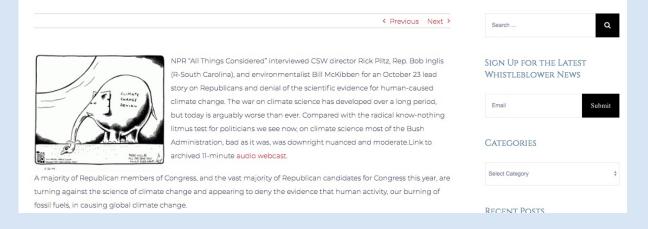


Loss of diversity

In the past 250 years, 571 plant species have gone extinct; four times more than the number of plant extinctions on record

National Public Radio leads with story on Republicans' anti-science position on climate Change

And this...



Climate Change?



Capital Public Radio News

Wildfires In California Will 'Continue To Get Worse,' Climate Change Experts Explore Why

Flames from the LNU Lightning Complex fires burn in unincorporated Napa County, Calif., on Tuesday, Aug. 18, 2020. AP Photo/Noah Berger.





Where to get more information on issues and copies of my talks?

http://ucbiotech.org



ABOUT US NEWS

ISSUES & RESPONSES

GMO LABELING RESOURCES LINKS GLOSSARY

SEARCH

Select Language V

This website provides educational resources focused broadly on issues

THANKS!

FEATURED LECTURE VIDEO

Famine and

ire of Food"

Oregon State University January 25, 2012

BIOTECHNOLOGY INFORMATION

technologi

tion relate

tools and informed



Informational resources available.

ANNUAL REVIEWS

Review articles:

Focused on food, environmental and socioeconomic issues of GE crops and

Part 1 | Part 2

RESOURCES FOR OUTREACH & EXTENSION, RESEARCHERS & TEACHERS

DNA for Dinner 4-H curriculum: For grades 5-8, covers topics from plant diversity to genetic engineering. Each of the five lessons has 3 to 5 activities.





New Game: Who's In Your Family?

A free educational game to teach participants about the diversity of fruits and vegetables, and how they are related.

Slide Archive:

Extensive collection of PP slides on agriculture & biotechnology.

Available on loan:

Teaching Aids: Handouts and cards available, in both English and



Educational displays: "Genetics and Foods" and "Genetic Diversity and Genomics" available with companion educational cards and teacher worksheet in English and Spanish.

Gene-IE Juice Bar: Interactive activity to isolate DNA from common fruits and vegetables.

HELPFUL SITES

Academics Review

Academics Review website Testing popular claims against peer-reviewed science.



Biofortified website Provides factual information to foster discussion

about agriculture, especially plant genetics and genetic engineering.

Animal Genomics 8 Biotechnology

Cooperative Extension

Program, UC Davis

Provides education on use of animal genomics & biotechnology in livestock production.

