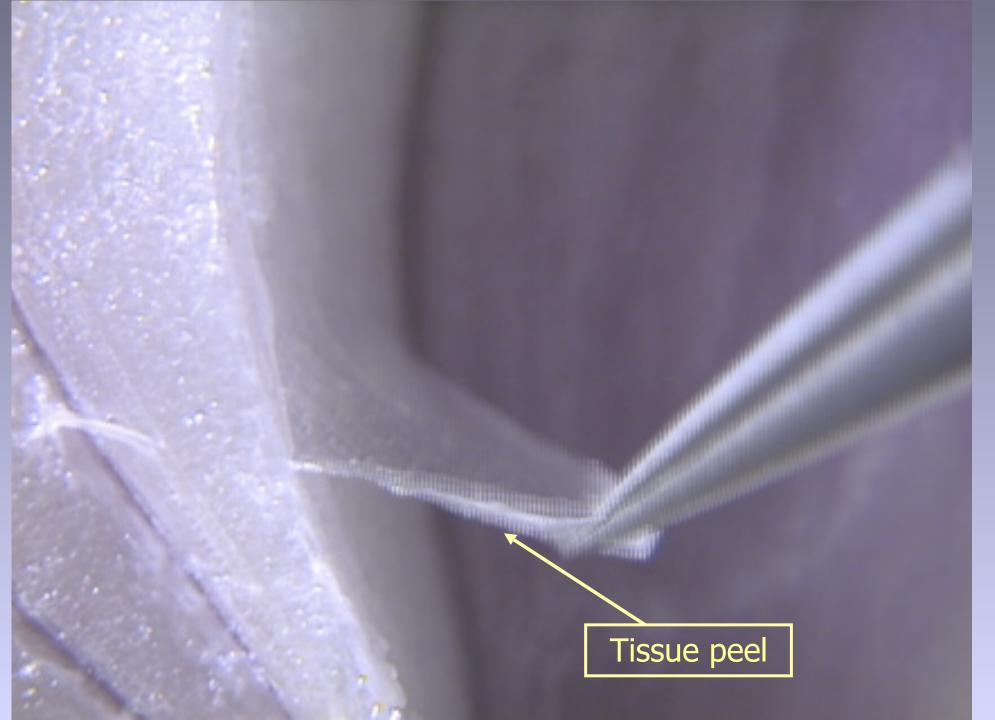


Tour d'Onion

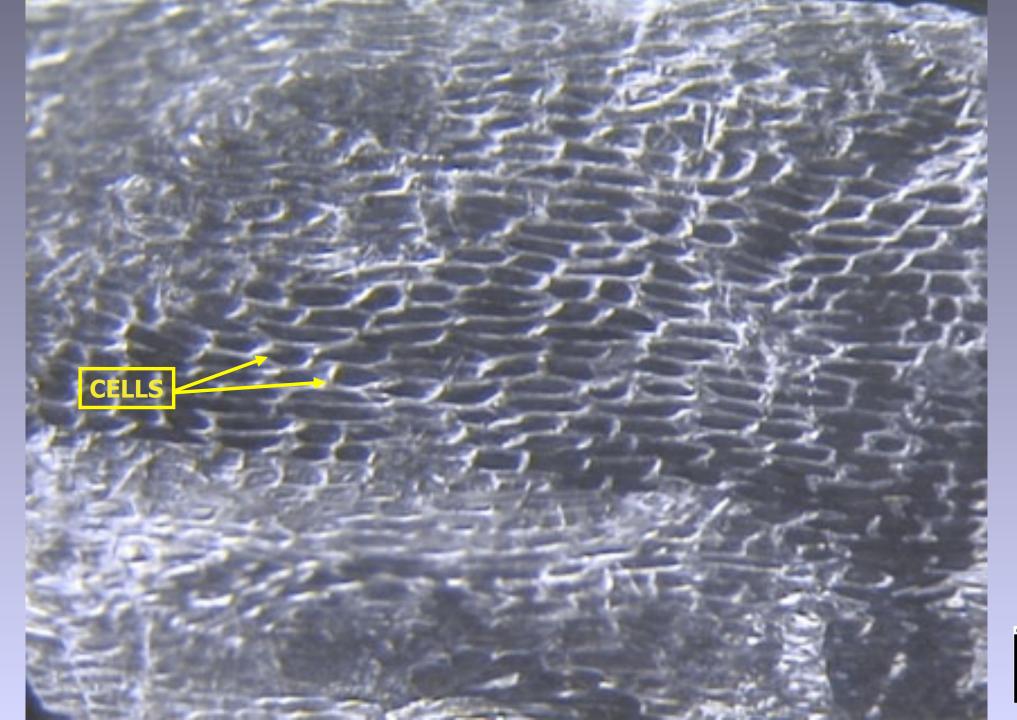


Or what makes an onion, an onion?

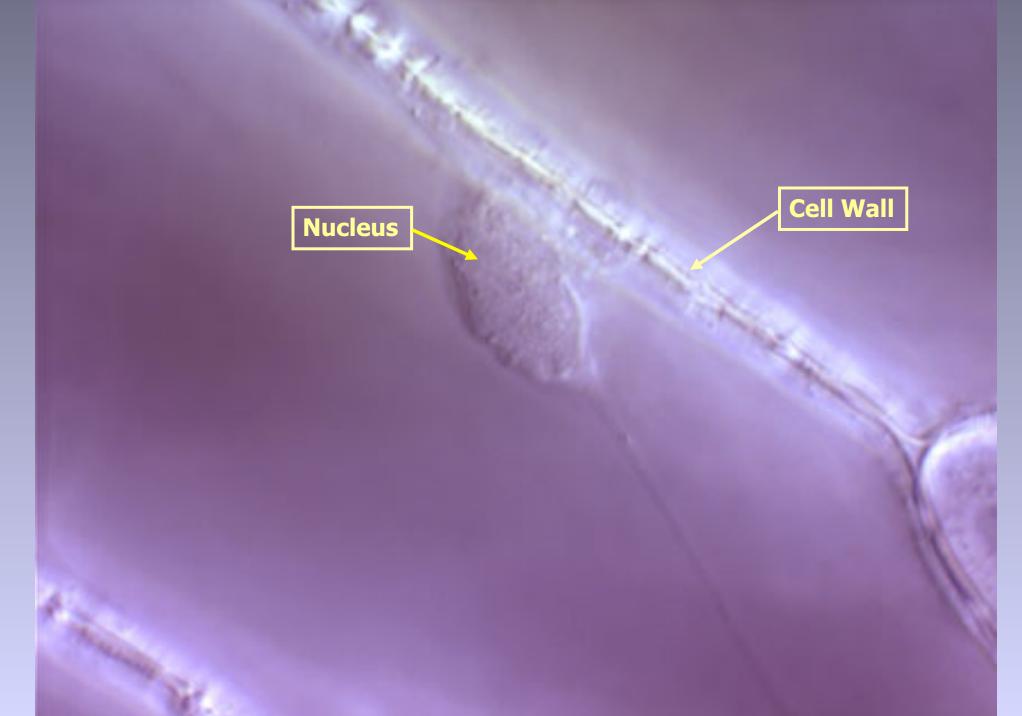




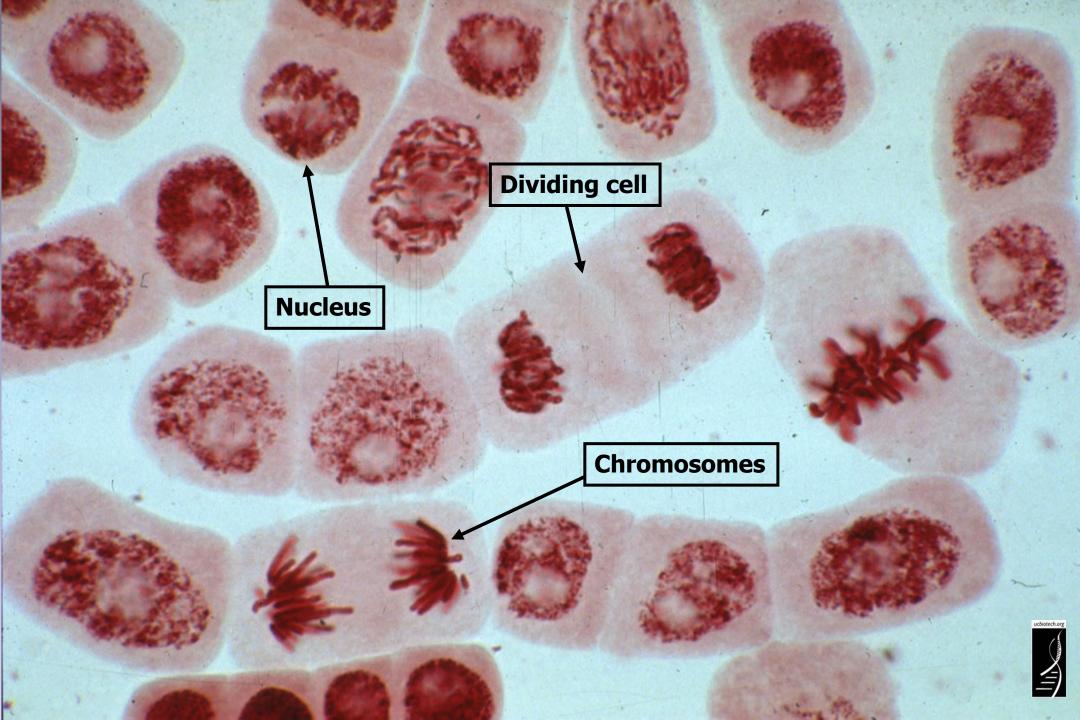


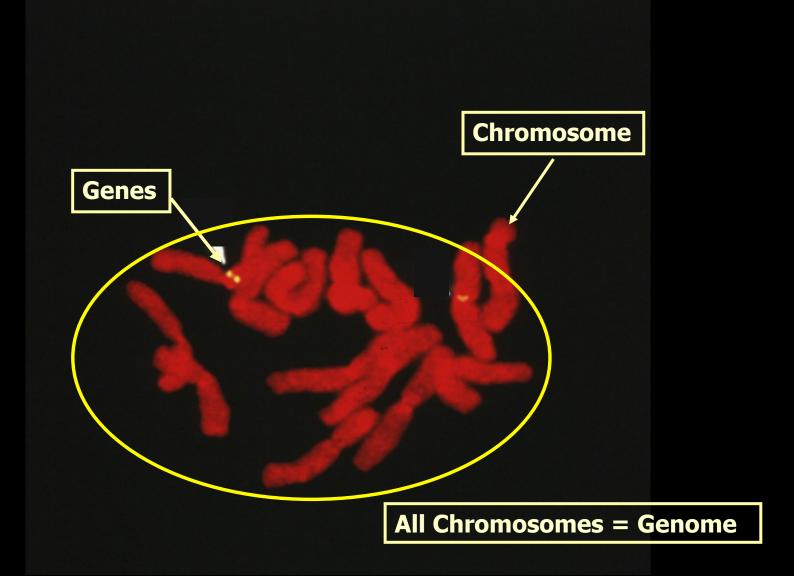








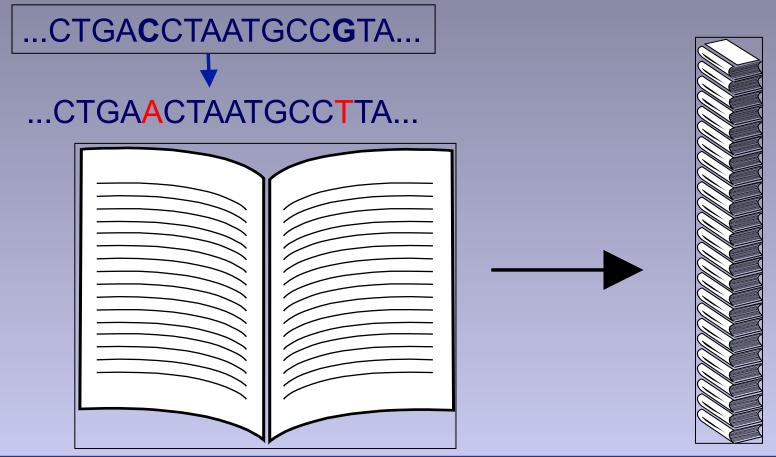






Genetic information in the genome is responsible for traits

Represent chemical units in genome by alphabetic letters



Sometimes mistakes happen when copying information in books → creating changes, called mutations





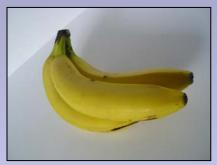
Mutations Have Gotten These Plants from Looking Like This...

To Looking Like They Are Now





Eggplant



Banana







Broccoli, Kale, Cabbage



Intentional mutation breeding has been used since the 1950s, creating >3200 officially released crops – like 600 maize, rice and wheat varieties. Although modified genetically, they are not under the regulations used for biotech varieties.



How are the genes and genomes changed to create new varieties using classical breeding?



Triticum monococcum



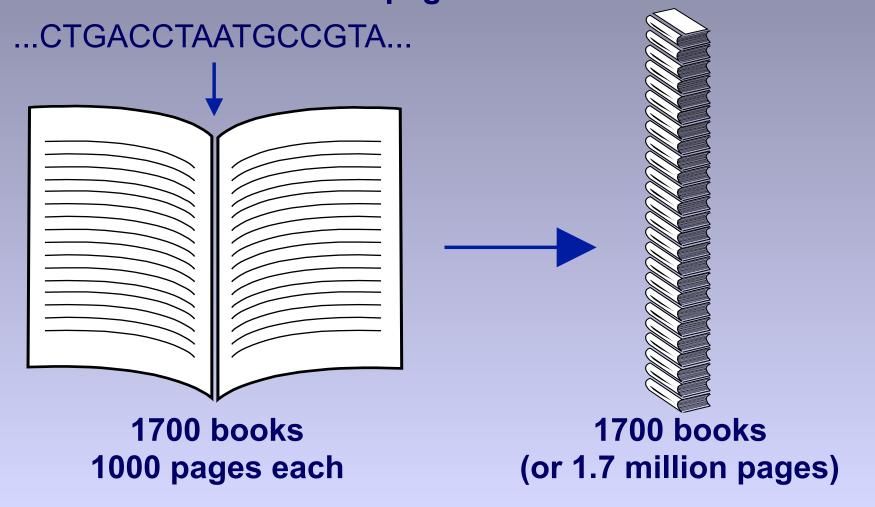
Triticum aestivum

Ancient variety Modern bread variety



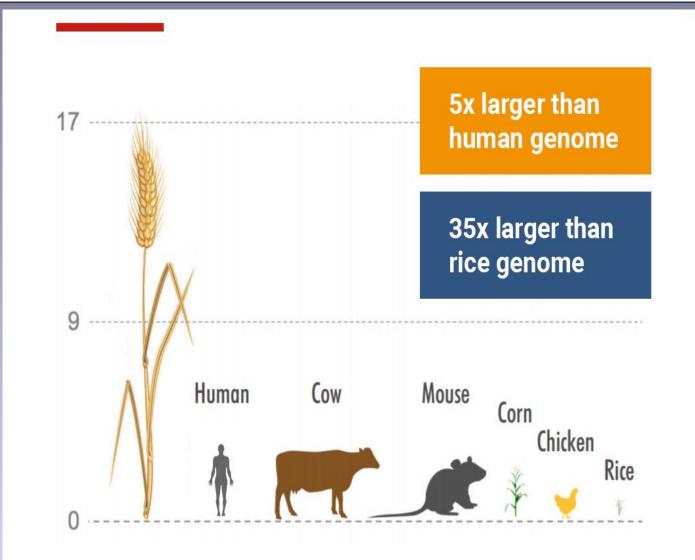
What does the information in the wheat genome look like?

Alphabetic letters representing chemical units result in 1.7 million pages of text!



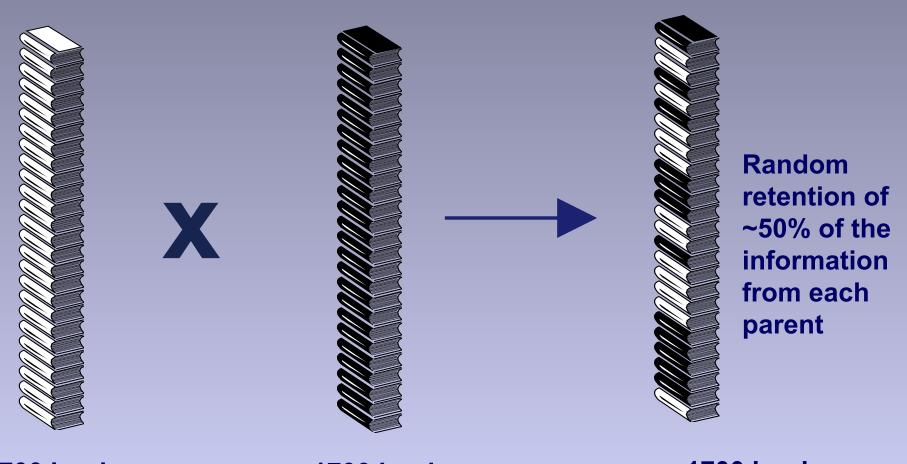


How does the wheat genome compare to the human genome?



Source: Earlham Institute communications team, Chris Bennett4

What happens when you breed wheat to create new varieties?



1700 books

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

1700 books (or 1.7 million pages)





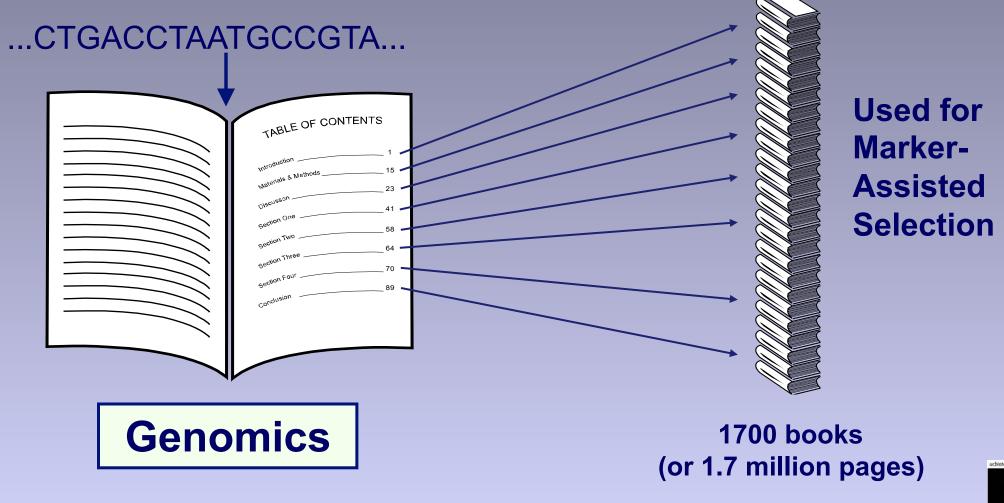


Putting this in context, these breeding efforts were critical to increasing crop production...

Product	2014 total production	2014 acreage	Acreage needed at 1950's rate	Additional needed
Soybeans	3.927.090,000 bu 235,562,540,000 lb	82,591,000 acres	180,971,889 acres	~98 million acres (= size CA)
Corn	14,215,532,000 bu	83,136,000 acres	372,134,346 acres	~289 million acres (= 3X size CA)
Broiler Chickens	51,373,100,000 lbs	8,544,100,000 head	16,679,545,455 head	~8 billion head requiring 81.5 billion lbs feed



Another means to modify the genome uses a table of contents for gene locations





Can't we just do all modifications this way?

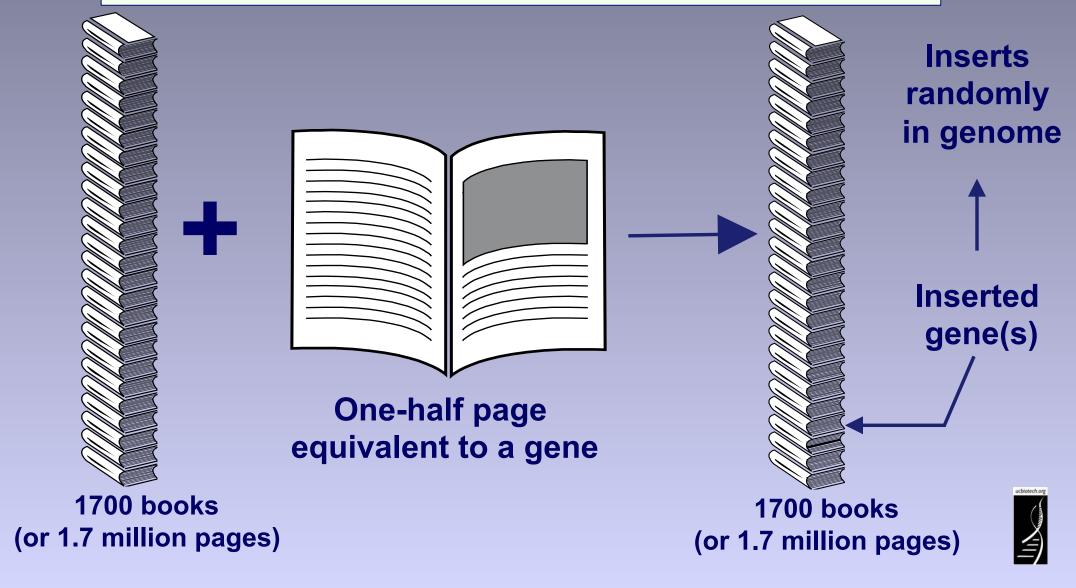


Marker-assisted selection used to protect rice against bacterial blight and blast disease

Protection limited to diversity in crop and compatible relatives



Another means to modify the genome uses genetic engineering



Classical Breeding

compared to

Genetic Engineering

Uses plant machinery in plant

Gene exchange is random involving whole genome

When/where gene expressed not controlled by breeder

Source of gene primarily within genera – not between kingdoms like plants & bacteria

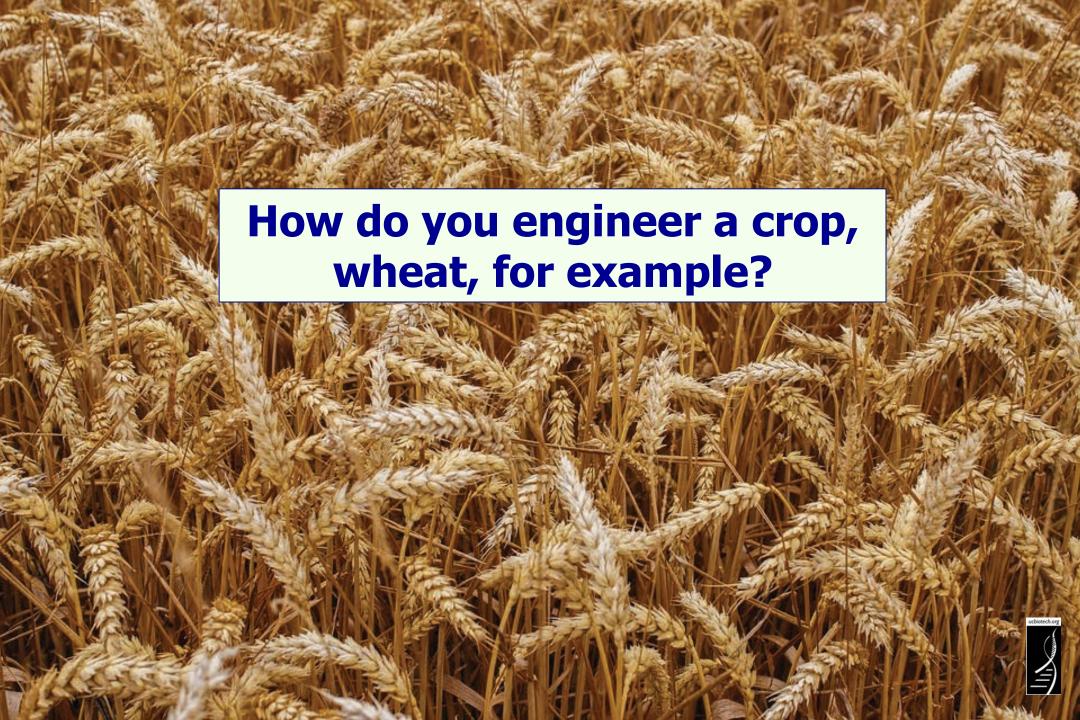
Uses plant machinery in laboratory

Gene exchange is specific involving single or few genes

When/where gene expressed controlled precisely

Source of gene from any organism





What Is Engineered into the Plant? Construct with Gene of Interest & Marker Gene + On/Off Switches

Promoter Gene of interest Off switch Promoter Marker Off switch (on switch) (transgene) (on switch)

Promoter: controls when and where gene is made

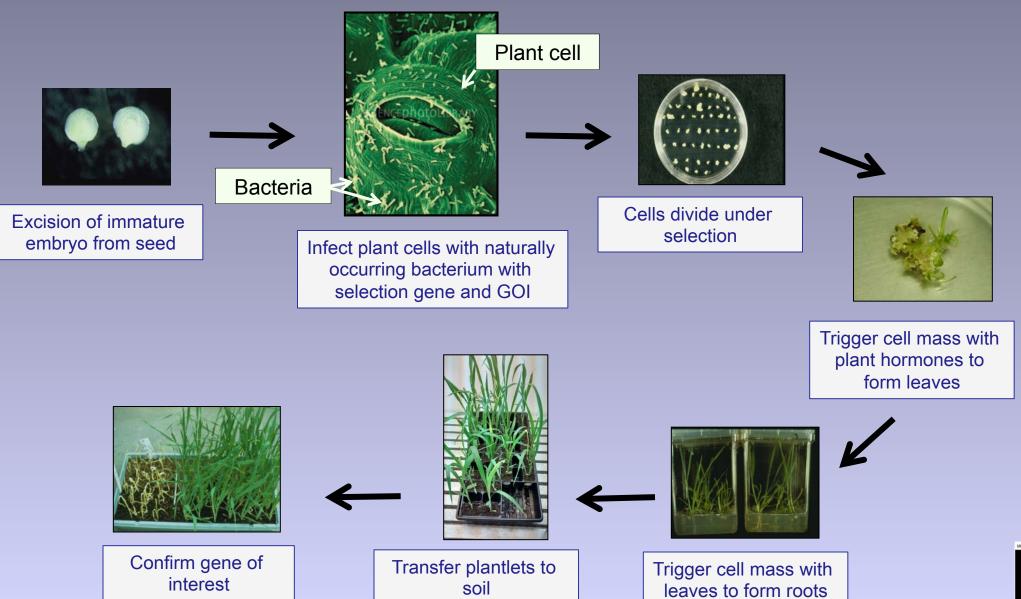
Off switch: stops expression of gene

Gene of interest: gene you want to introduce into plant

Marker: used to identify which cells have gene of interest

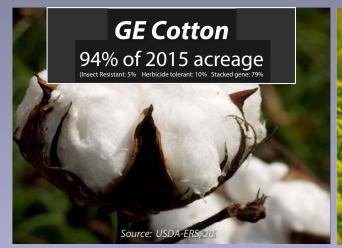


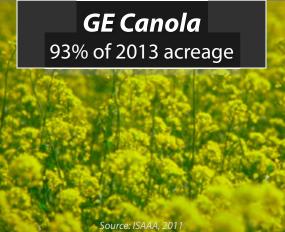
Genetic Engineering of Wheat

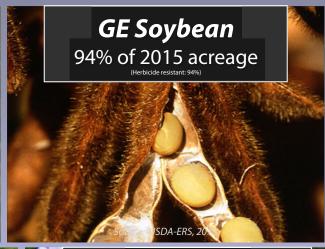


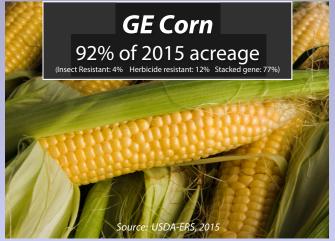


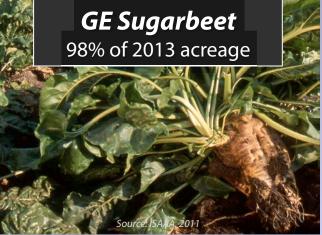
Number of different commercially available large acreage GE crops is limited











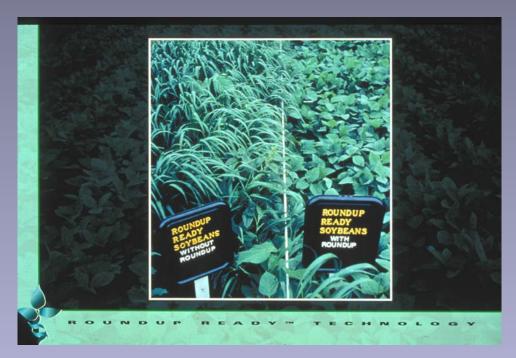




Number of different traits available in GE crops is also limited



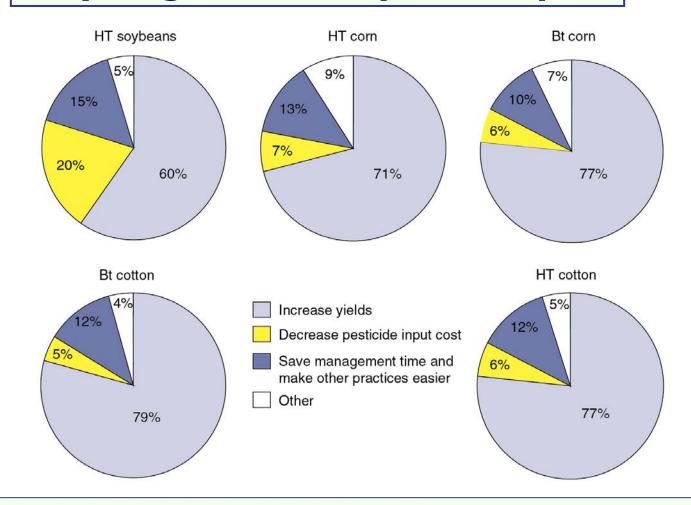
Bt Crops - engineered for insect resistance using gene from naturally occurring bacterium



Herbicide-tolerant engineered with genes to
tolerate herbicide
application

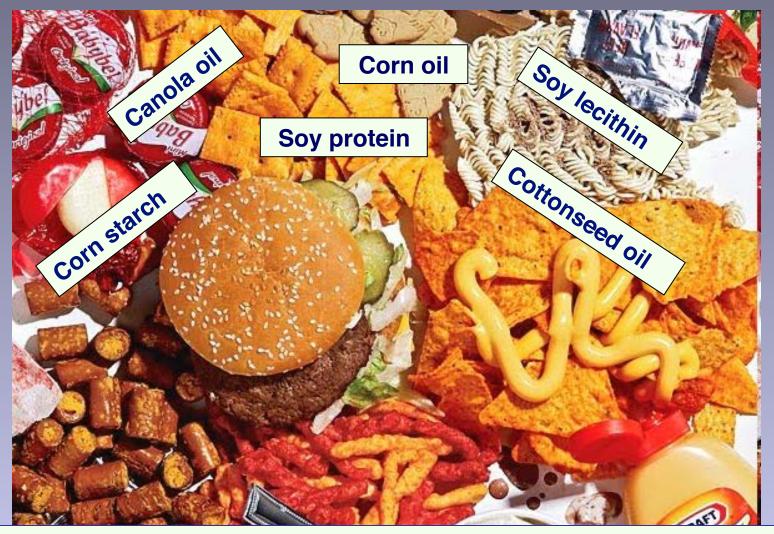


Why do growers adopt GE crops?



Reasons vary from crop-to-crop but the predominant reason is to improve yield





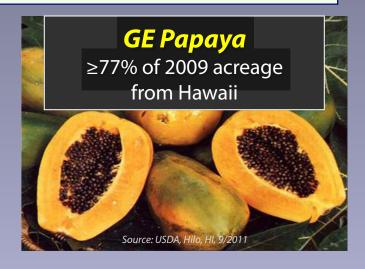
These types of large-acreage GE crops lead to estimates that 60-80% of processed foods in U.S. have GE ingredients – often only a minor ingredient



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

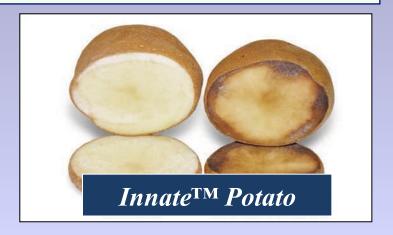






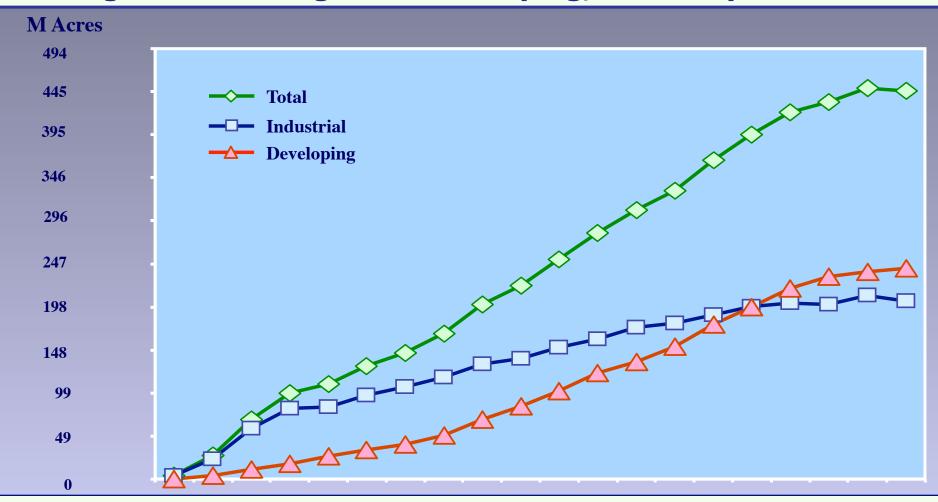
Two more are just being introduced



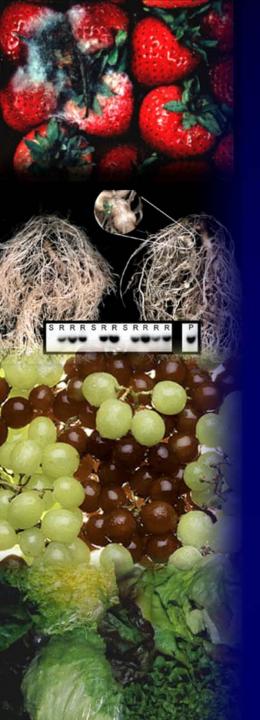




Despite the same limited U.S. crop and trait types, worldwide acreage is increasing in 20 developing, 8 developed countries

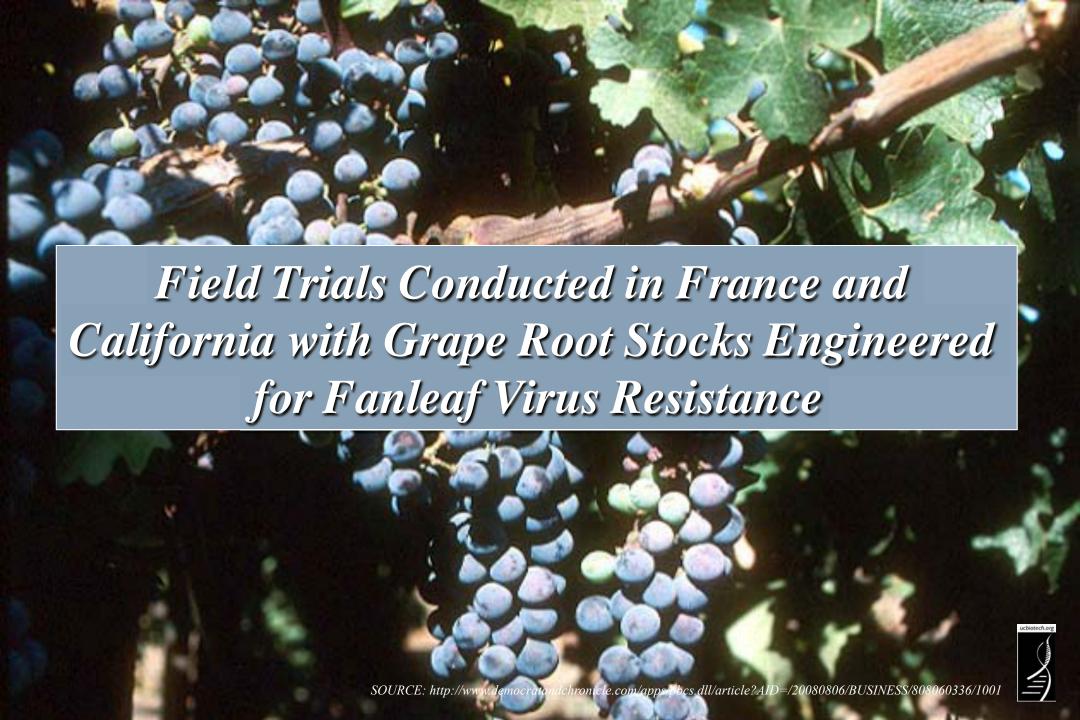


2015 figures indicate 18 million farmers in 28 countries planted 444M acres (>3X size of California) — over 90% were resource-poor farmers



WHAT'S IN THE PIPELINE?





Greening disease tolerance could involve genetic engineering of citrus or psyllid insect?



The New York Times

July 27, 2013

A Race to Save the Orange by Altering Its DNA

By AMY HARMON

CLEWISTON, Fla. - The call Ricke Kress and every other citrus grower in Florida dreaded came while he was driving.

"It's here" was all his grove manager needed to say to force him over to the side of the road.

The disease that sours oranges and leaves them half green, already ravaging citrus crops across the world, had reached the state's storied groves. Mr. Kress, the president of Southern Gardens Citrus, in charge of two and a half million orange trees and a factory that squeezes juice for Tropicana and Florida's Natural, sat in silence for several long moments.

"O.K.," he said finally on that fall day in 2005, "let's make a plan."

In the years that followed, he and the 8,000 other Florida growers who supply most of the nation's orange juice poured everything they had into fighting the disease they call citrus greening.

To slow the spread of the bacterium that causes the scourge, they chopped down hundreds of thousands of infected trees and sprayed an expanding array of pesticides on the winged insect that carries it. But the contagion could not be contained.



2013 GE potato field study – Ireland Desiree potato variety, highly susceptible to late blight, engineered with gene from wild potato variety



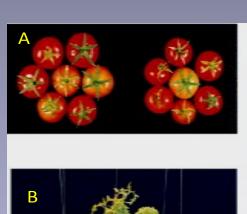








Salinity and Drought Tolerance - UC Davis









Wild type AtNHX1 200 mM NaCl (~1/2 sea water)

Wild type IPT gene 15 days drought, 7 days re-watered

Salt-tolerance

Drought-tolerance





High anthocyanin purple GE tomatoes protect against cardiovascular disease and certain cancers. Diets with 10% purple tomatoes increased lifespan of cancer-prone mice

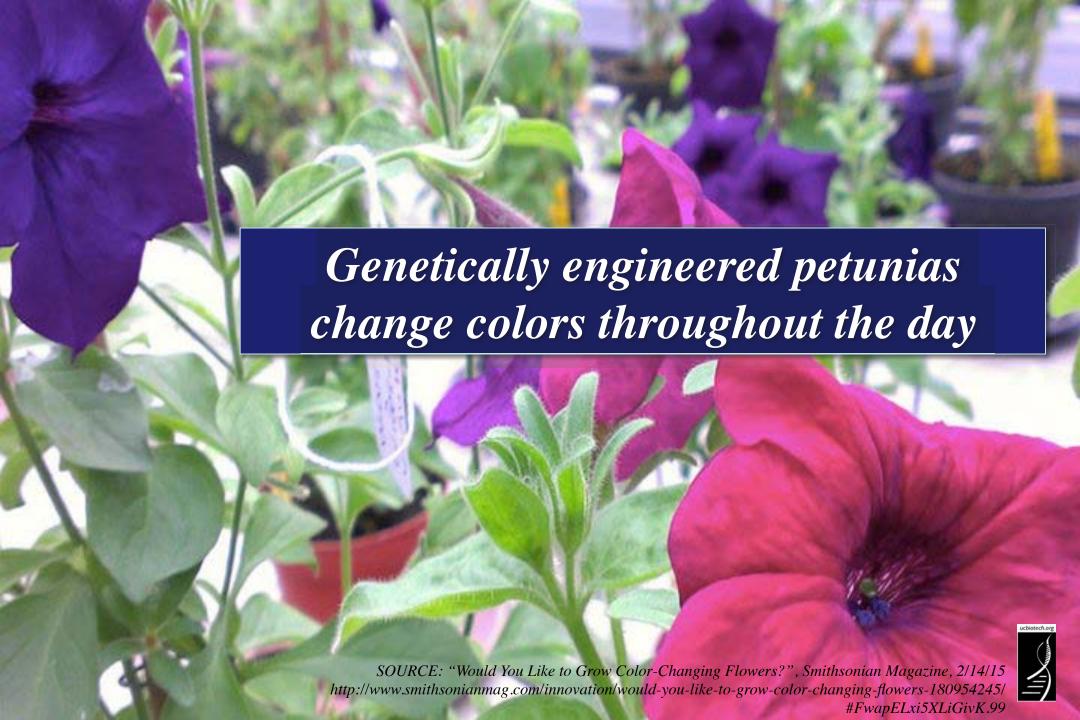


Golden Rice engineered to contain bioavailable pro-Vitamin A



Normal portion of Golden Rice 2 provides half of a child's Vitamin A needs



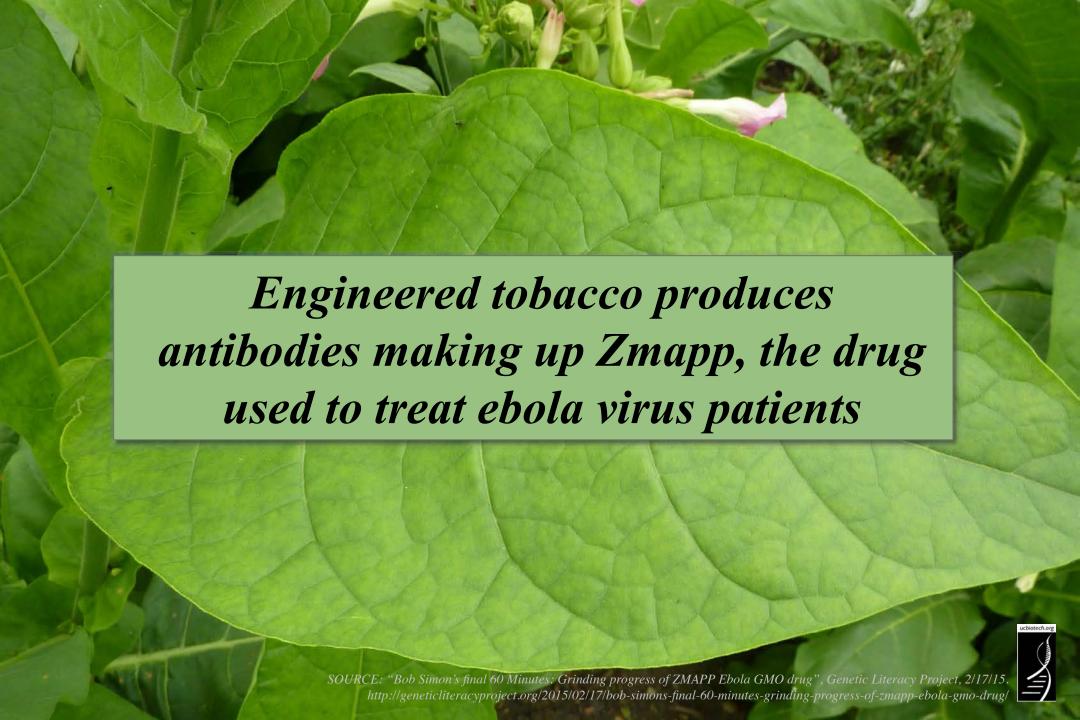






American chestnut engineered with wheat gene prevents cankers from forming; replanted with \$104K raised through crowd funding





MIT Technology Review

Chinese Researchers Stop Wheat Disease with Gene Editing

Researchers have created wheat that is resistant to a common disease, using advanced gene editing methods.

By David Talbot on July 21, 2014

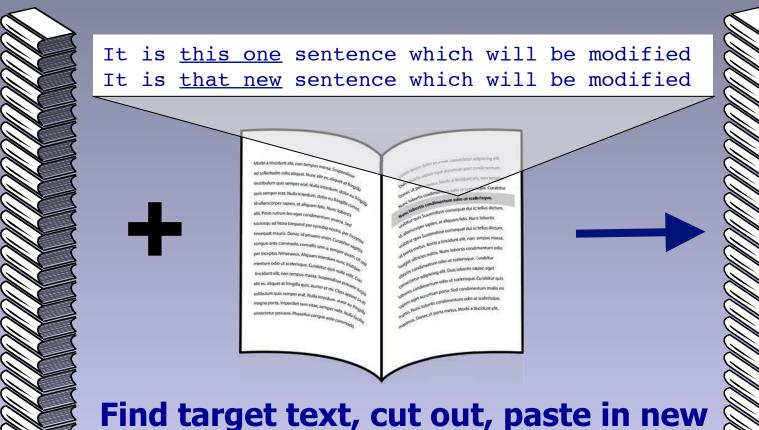
Advanced genome-editing techniques have been used to create a strain of wheat resistant to a destructive fungal pathogen – called powdery mildew – that is a major bane to the world's top food source, according to scientists at one of China's leading centers for agricultural research.



Wheat resistant to powdery mildew created using new genome-editing techniques



What is Genome Editing?



Inserts specifically in genome

modified text

1700 books (or 1.7 million pages)

This type of genome editing is not being regulated as GE (or 1.7 million pages) or GMO

1700 books



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.

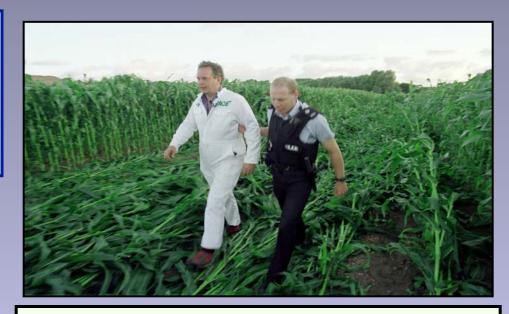
Then on to Monterey – where they were also not welcomed!



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



What are some issues with GE crops & foods?

- Regulatory oversight
- Lack of peer-reviewed food safety tests
- Labeling
- Environmental issues





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?

Are they as safe as conventional foods?

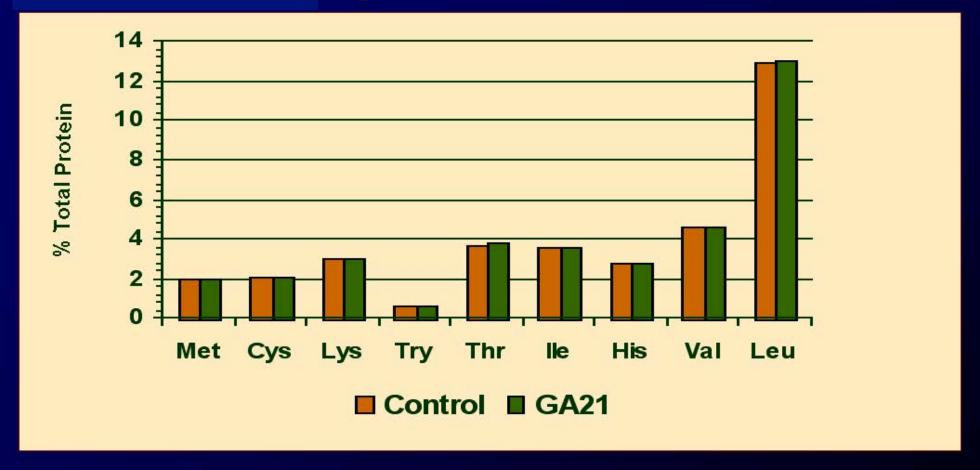
This is based on the concept of substantial equivalence

Modified food has essentially all characteristics of nonmodified food with respect to food and feed value except for introduced trait

The product of the introduced genetic information is tested for safety separately?



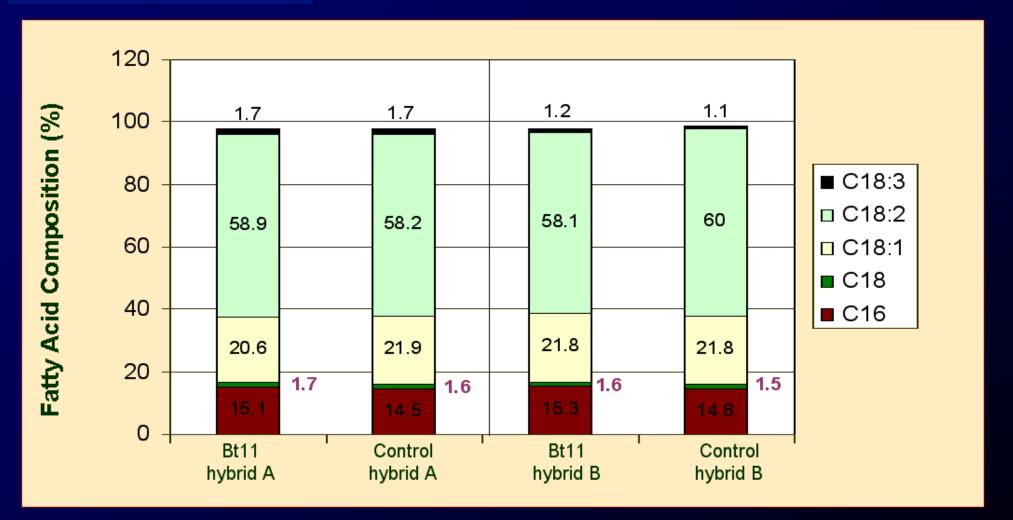
Substantial Equivalence: Amino Acids



These results have been generated on event GA21. Data showing similar amino acid composition have been generated on the other corn events.



Substantial Equivalence: Fatty Acids

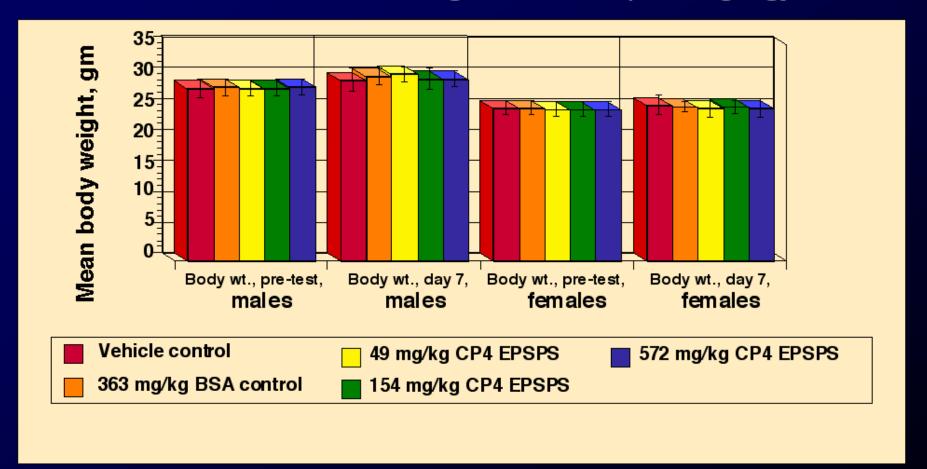


These results have been generated on Event Bt 11. Data showing similar fatty acid composition have been generated on the other corn events.



Toxicity Assessment: Roundup Ready/CP4 EPSPS protein

No deleterious effects at highest dose (572mg/kg)



Regulation is based on an outdated regulatory system, created in 1986, which has caused problems:

- New products emerge with no rules to govern them
- Old products are not on the market because there are no clear pathways for commercialization
- New products created to step around regulatory system

EXAMPLES:





In April 2016: USDA APHIS decided not to regulate a mushroom and corn genetically modified with genome editing.

Reason: no DNA from plant pest or other species introduced.



These examples resulted in calls for revamping U.S. regulatory oversight

Genetically engineered crops that fly under the US regulatory radar

First step taken on July 2, 2015 by a White House Initiative to modernize biotech regulation

the scope of its regulations several genetically

Coordinated Framework is on the one hand

Charge: Update 1986 Coordinated Framework to clarify roles of agencies; determine what products fall under which authority

inquiries to APHIS suggests that the number of entities seeking nonregulated status for conclude that it is time to reevaluate the US regulatory framework for GE crops and

Also decide regulation for products created with genome editing

institutions or small biotech companies, suggesting that the use of technologies, such as null segregants, novel delivery systems, scientific knowledge and technologies and, importantly, that allows the participation of small companies and public sector institutions.





Release of Final Version of 2017 Update to the Coordinated Framework for the Regulation of Biotechnology

01/06/2017

Update to Coordinated Framework presents information about agency roles and responsibilities through:

- Agency-specific overviews of regulatory roles.
- Case studies demonstrating how product developers might navigate regulatory framework.
- Comprehensive table summarizing current responsibilities and relevant coordination across EPA, FDA, and USDA for regulatory oversight of various biotechnology product areas.

What are some issues with GE crops & foods?

- Regulatory oversight
- Lack of peer-reviewed food safety tests
- Labeling
- Environmental issues



Occasionally
there are widely
publicized
studies casting
doubt on GE
food safety one published
by French
researcher in
Sept. 2012

by European
Food Safety
Authority and
found to have
no merit

But did you ever hear that on Dr. Oz?

French academies trash GM corn cancer study

By RFI

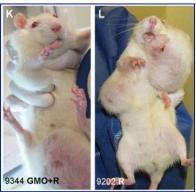
in a

A controversial study that linked genetically modified maize to cancer



in la Foati

Featured on Dr. Oz Show



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 have other published studies shown?

Meta-analysis from France in 2012 showed GE foods:

- Are nutritionally equivalent to non GE foods
 - Can be safely consumed in food and feed

Based on 12 long-term (>90d to 2yr) and 12 multigenerational (2 to 5 generation) feeding trials of GE feed in animals



maize





SOY

rice







triticale



2014 study

- 9 B food-producing animals in U.S
- 95% consumed feed with GE ingredients
- Analyzed public data from 1983 to 1996, before GE crops, vs. 1996 to 2011, after GE
- Included >100 B animals



Conclusion:

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





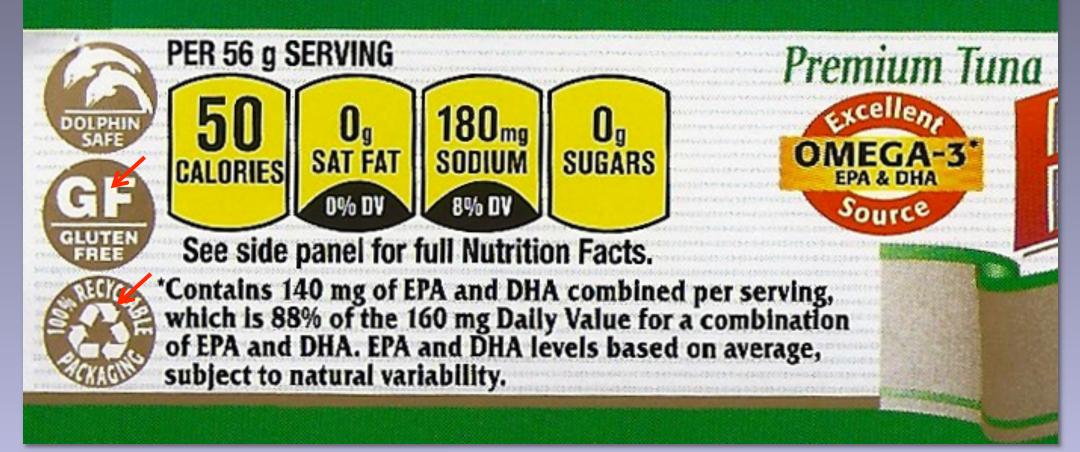




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There are many labels on foods—from gluten-free to dolphin-safe — none are mandated. And, up to recently, there were no federally mandated labels on foods with GE ingredients.



Food Safety News

Breaking news for everyone's consumption

GE Labeling Resurrected in California, Petition For Ballot Measure Circulating in Colorado

BY DAN FLYNN | MARCH 25, 2014

California's 2012 food-labeling ballot measure, rejected by state voters, makes a return from the grave tomorrow with a public hearing in Sacramento. And another state initiative is in the offing in Colorado.

Since the narrow loss for the Golden State's Proposition 37, which called for labeling foods made with genetically modified organisms (GMOs), almost half the states have seen bills introduced containing similar



This led to state labeling laws for GE foods that would have resulted in a patchwork of regulation – causing commerce and enforcement problems



While waiting for federal laws, non-legislative labeling efforts, like the popular Non-GMO Project label, arose



Senators Reach Deal On National **GMO Labeling Bill** June 23, 2016 · 6:39 PM ET **PEGGY LOWE** COCOA BUTTER, SKIIVI IVIILA, LAUTUSE, IVIILATAT, PEA - CORN SYRUP, DEXTRIN, COLORING (INCLUDES BLU BLUE 2 LAKE, BLUE 2), GUM ACACIA. INS PEANUTS, MILK AND SOY. MAY CONTAIN TREE NUT PARTIALLY PRODUCED WITH GENETIC ENGINEERING. statement on a package of peanut M&Ms candy notes they are "partially produced with genetic

And then...

July 8, 2016: Senate passes bill by Senators Roberts (R, KN) and Stabenow (D, MI) for a mandatory national system for GM disclosures on food products, **nullifying Vermont's** labeling law, which took effect July 1. Obama signed on July 29.

Legislation requires USDA to decide what ingredients are from genetically modified organisms and then labels will be added on foods using words, pictures or bar codes that can be scanned by smartphones.



What are some issues with GE crops & foods?

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- Lack of peer-reviewed food safety tests
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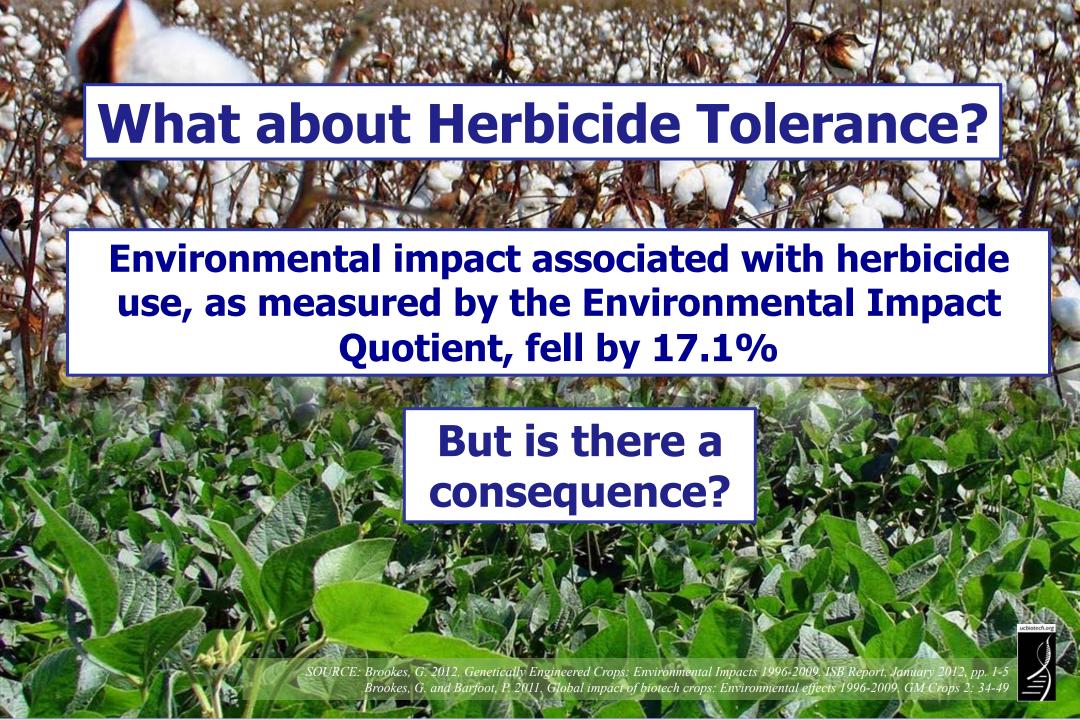
Insect Resistance

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

Development of herbicide-tolerant weeds or resistant insects

To date minimal insect resistance has occurred





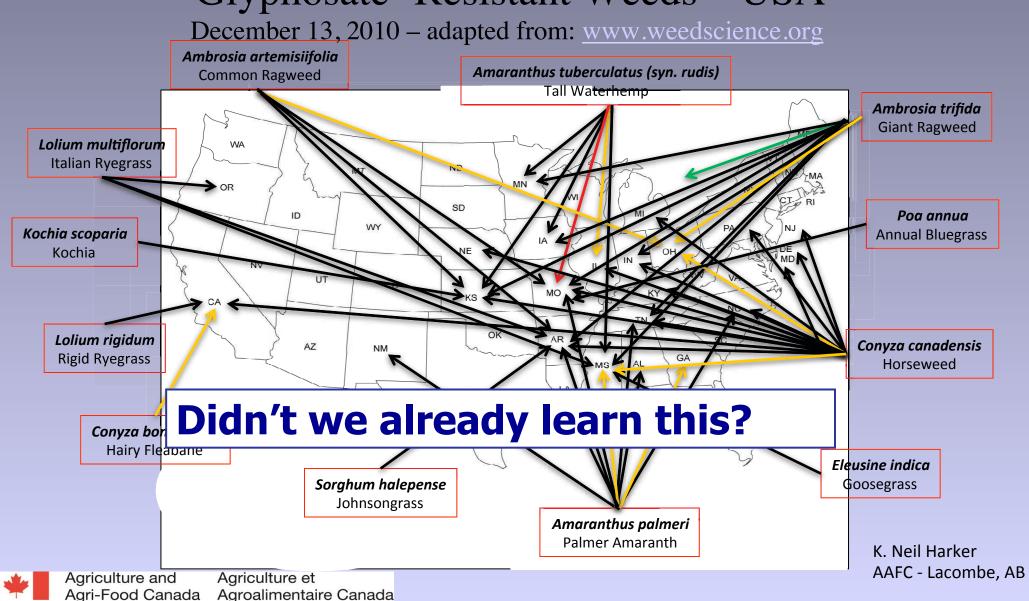
Herbicide-resistant Weeds Threaten Soil Conservation Gains: Finding a Balance for Soil and Farm Sustainability

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



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

Glyphosate- Resistant Weeds – USA



Where to get more information on the issues?





ABOUT US NEWS

ISSUES & RESPONSES GMO LABELING RESOURCES LINKS GLOSSARY

Select Language | V



This website provides educational resources focused broadly on issues related to agriculture, crops, animals, foods and the technologies used to improve them. Science-based information related to these issues is available, as well as educational tools and information, which can be used to promote informed participation in discussions about these topics.



BIOTECHNOLOGY **INFORMATION**



Informational resources available.



Review articles:

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

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.

ADDAIDAID

DNA FO

DINNER?

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 & Biotechnology Cooperative Extension Program, UC Davis



Provides education on use of animal genomics & biotechnology in livestock

