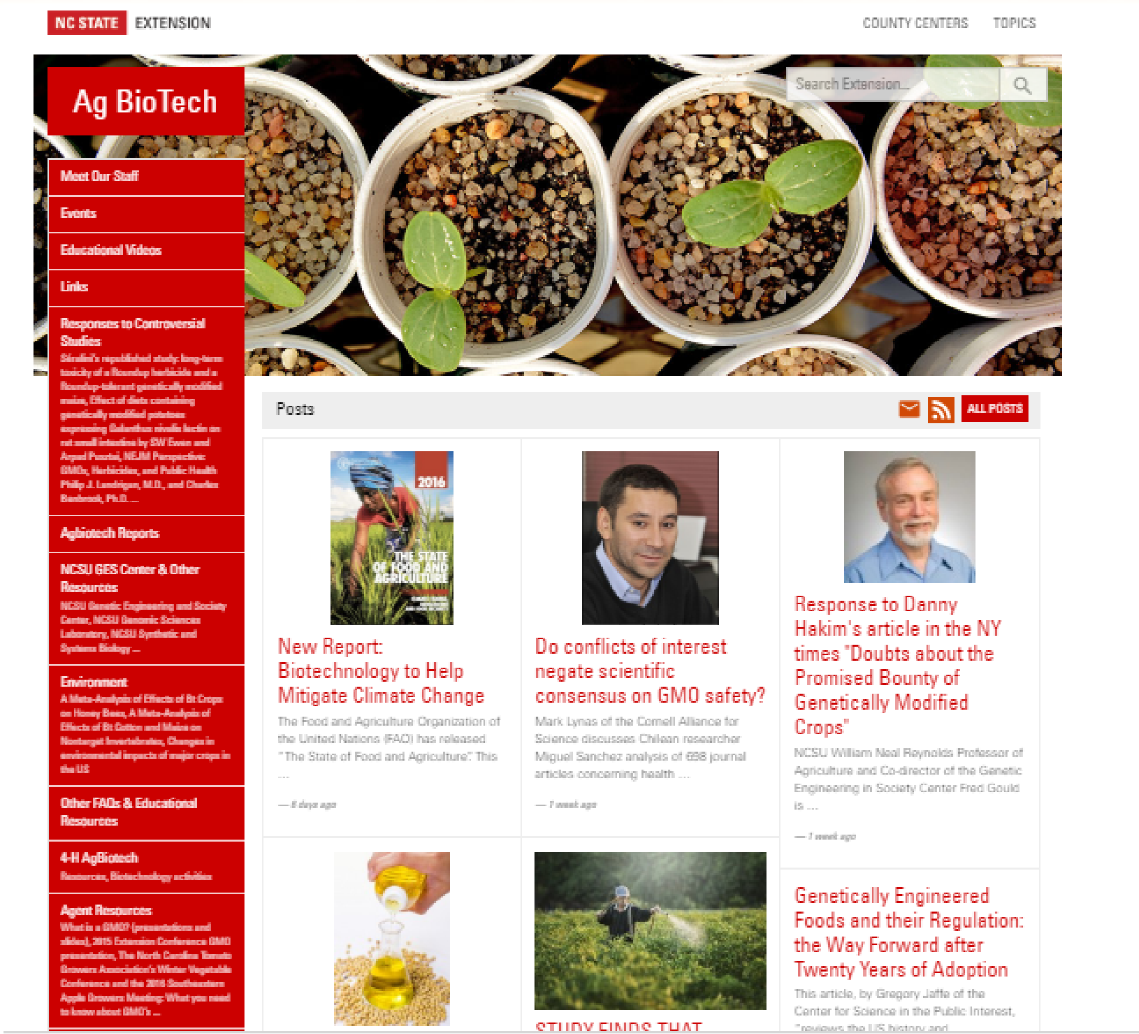
2017 NC Extension Master Gardener College
June 8-11, 2017
The Facts about GMOs



agbiotech.ces.ncsu.edu

What is a GMO? What is the difference between genetically modified organisms and genetically engineered organisms.



What is a GMO?

Man has been manipulating DNA in plants and animals for millennia

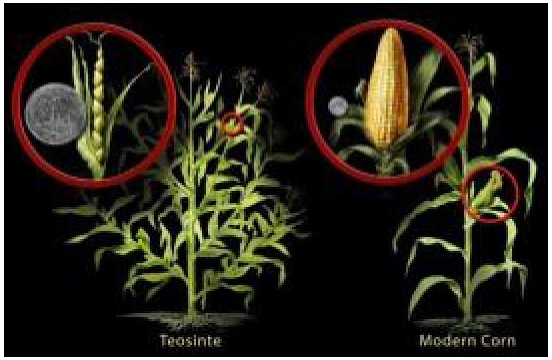


Figure 2 *Fruit of a wild species of tomato compared to a modern tomato variety bred for large fruit. From Frary et al (2000) Science 7 vol 289 no 5478: 85*

All due to mutations and genomic alterations. All required human intervention for breeding and/or selection

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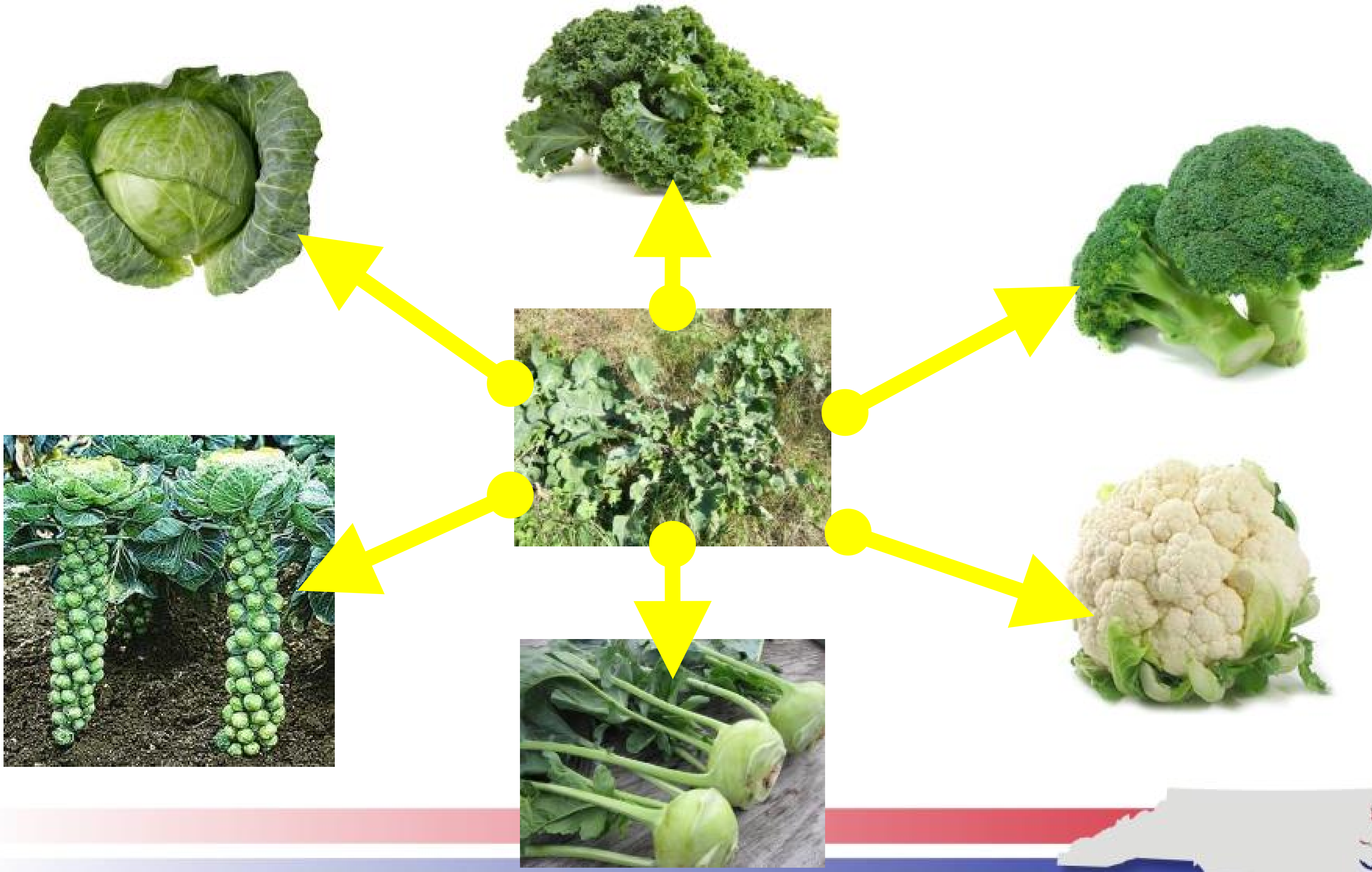


What is a GMO?

A committee of 14 scientific experts met to deliberate on the study objectives.

First, the committee defined **genetic engineering** as the **targeted manipulation of genetic material** used to alter the genetic composition of plants, animals and microorganisms.

Second, **GE foods** were defined as the product of recombinant DNA (rDNA) methods that allow a gene from any species to be inserted and subsequently expressed in a food or food product.

National Academies of Science http://nas-sites.org/ge-crops/category/events/pastevents/

What is a GMO?
Recombinant DNA

- **Transgenic -** **a gene is moved from one non-closely related species to another**

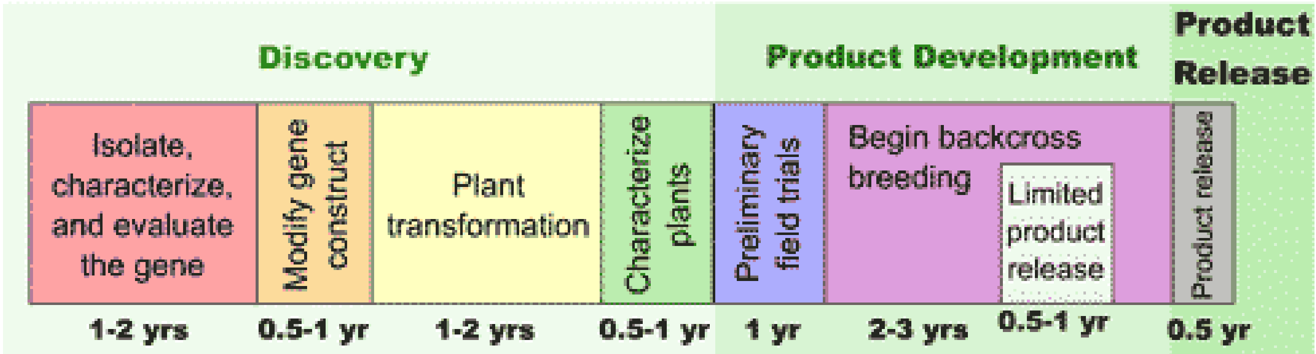
- **Cisgenic/intragenic -** **a gene is moved within the same species or a closely related species.**

- **Subgenic -** **a gene is edited to amplify, delete, insert, silence or repress the gene.**

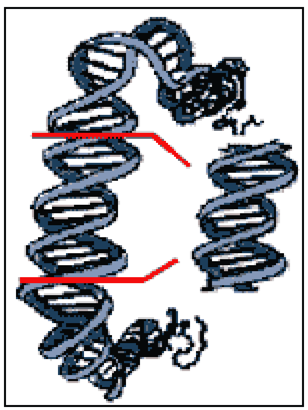
CRISPR - **https://www.youtube.com/watch?v=2pp17E4E-O8**

RNAi - is a biological process in which RNA molecules inhibit gene expression - https://www.youtube.com/watch?v=Vh3-NHdjnyQ

What is a GMO?



Discovery
Product Development
Product Release
Isolate, characterize, and evaluate the gene
Modify gene construct
Plant transformation
Characterize plants
Preliminary field trials
Begin backcross breeding
Limited product release
Product release
1-2 yrs
0.5-1 yr
1-2 yrs
0.5-1 yr
1 yr
2-3 yrs
0.5-1 yr
0.5 yr



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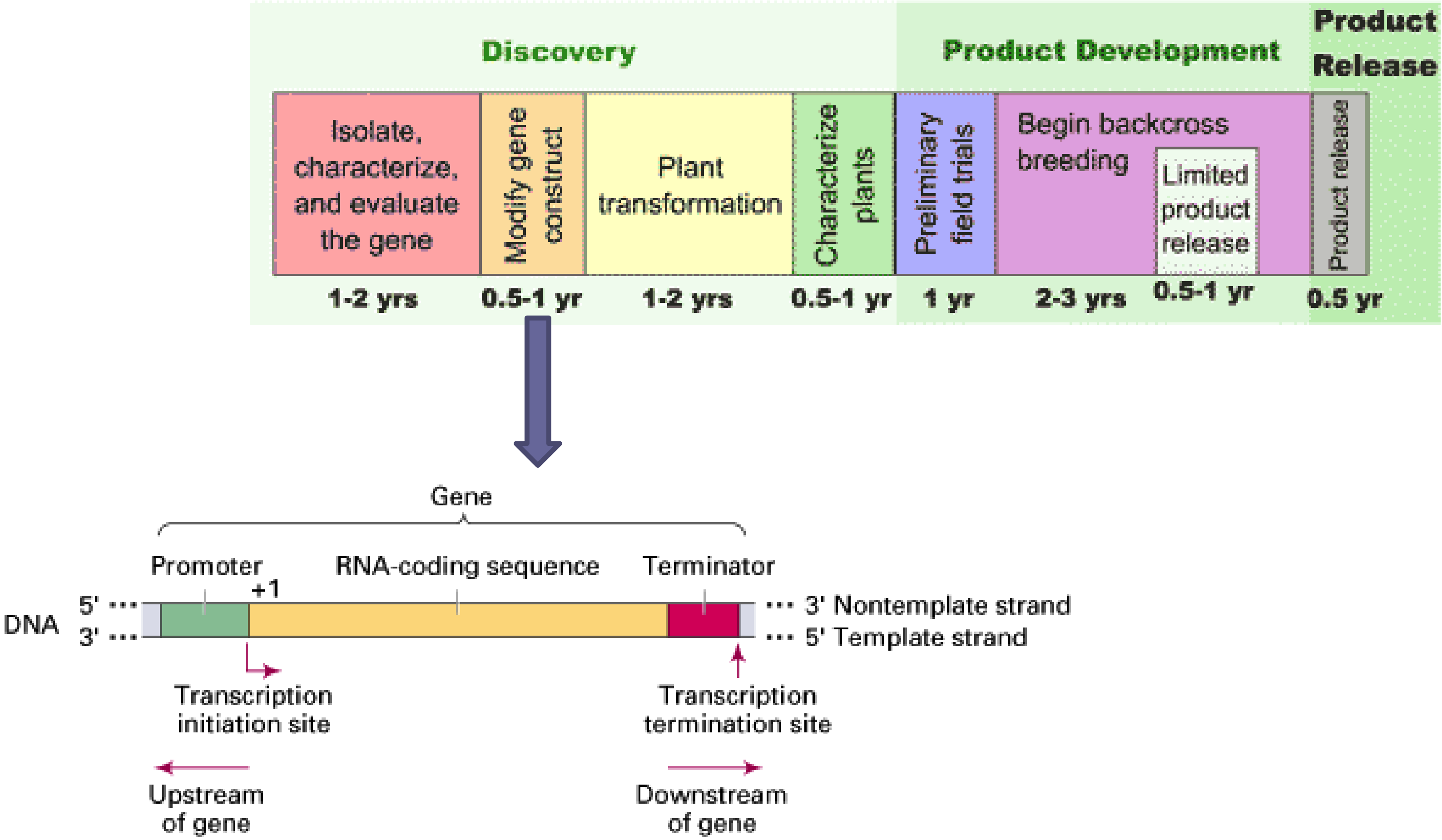
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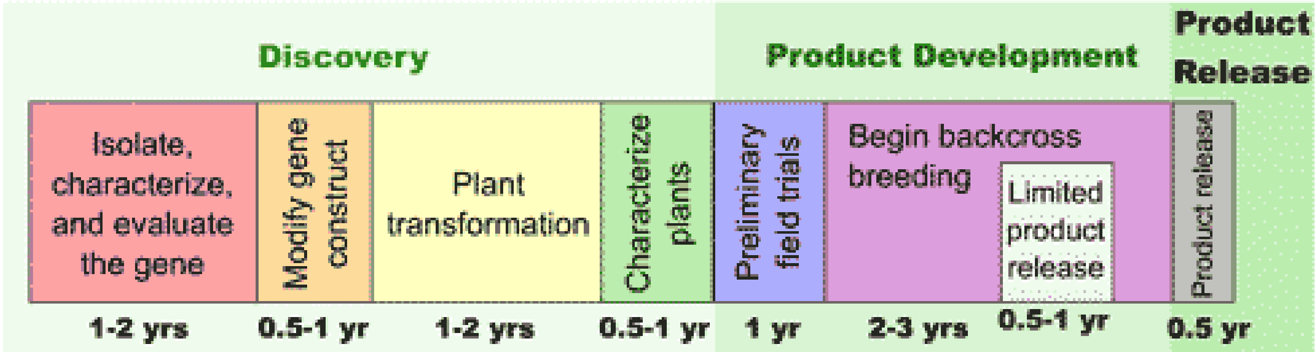
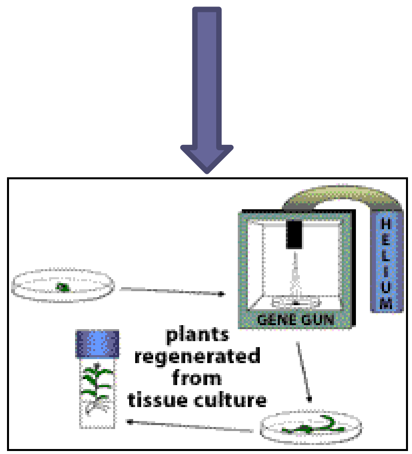
1 yr
2-3 yrs
0.5-1 yr
0.5 yr
Gene
Promoter
RNA-coding sequence
Terminator
+1
DNA
5' ...
3' ...
... 3' Nontemplate strand
... 5' Template strand
Transcription initiation site
Transcription termination site
Upstream of gene
Downstream of gene

What is a GMO?





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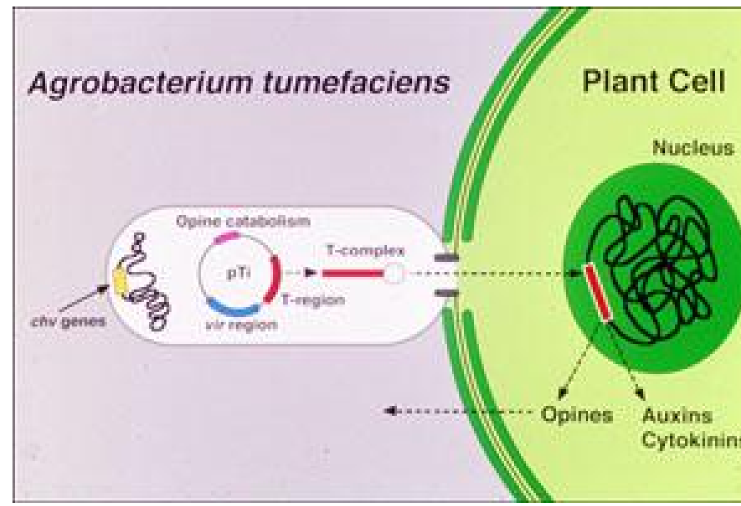

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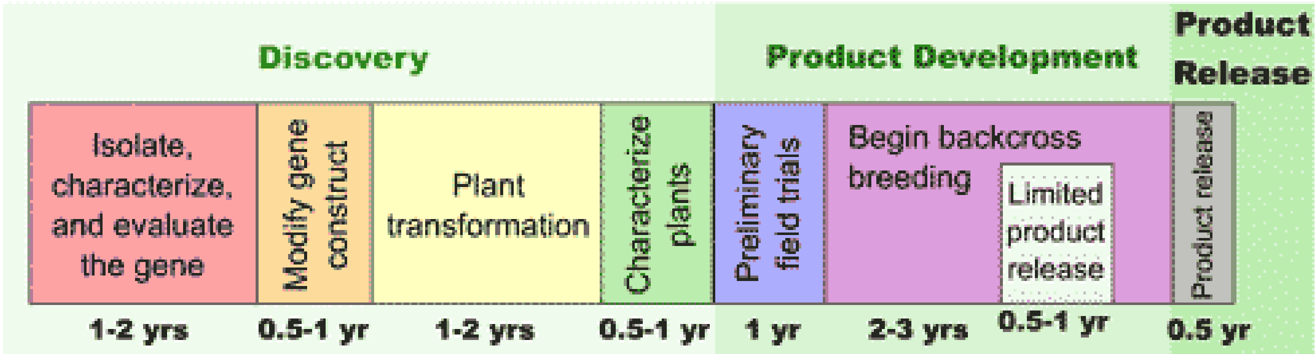
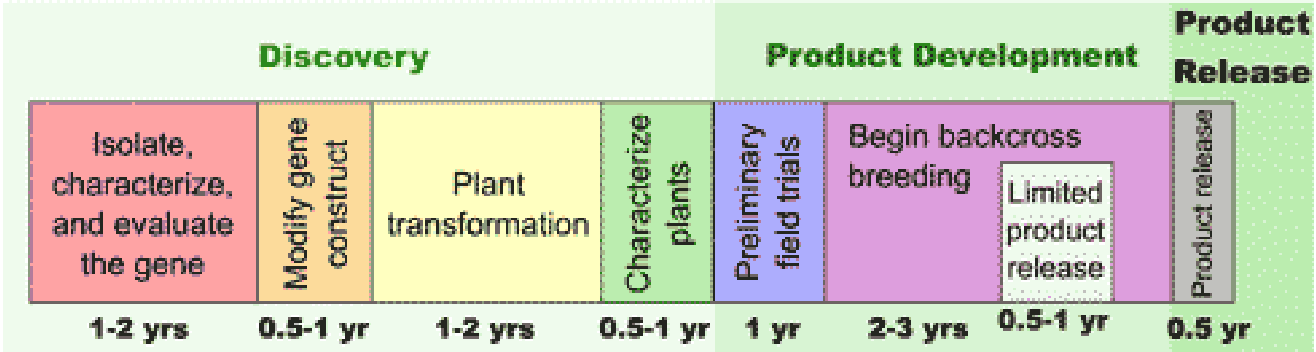


The sweet potato or yam was genetically modified not by Man, but by nature. Picture: Getty

http://www.scotsman.com/news/professor-anthony-trewavas-i-yam-convinced-gm-food-is-safe-1-3958842

What is a GMO?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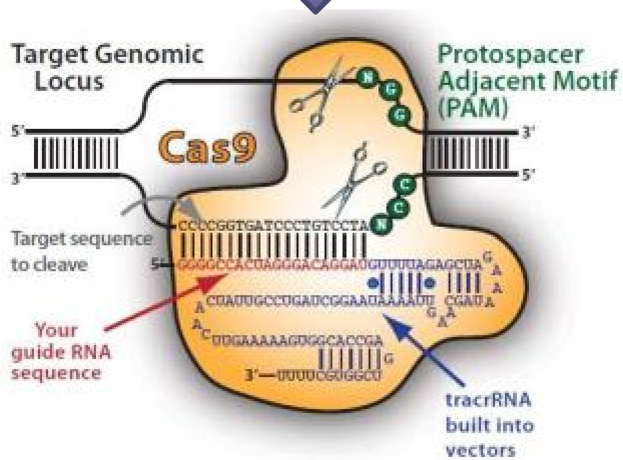
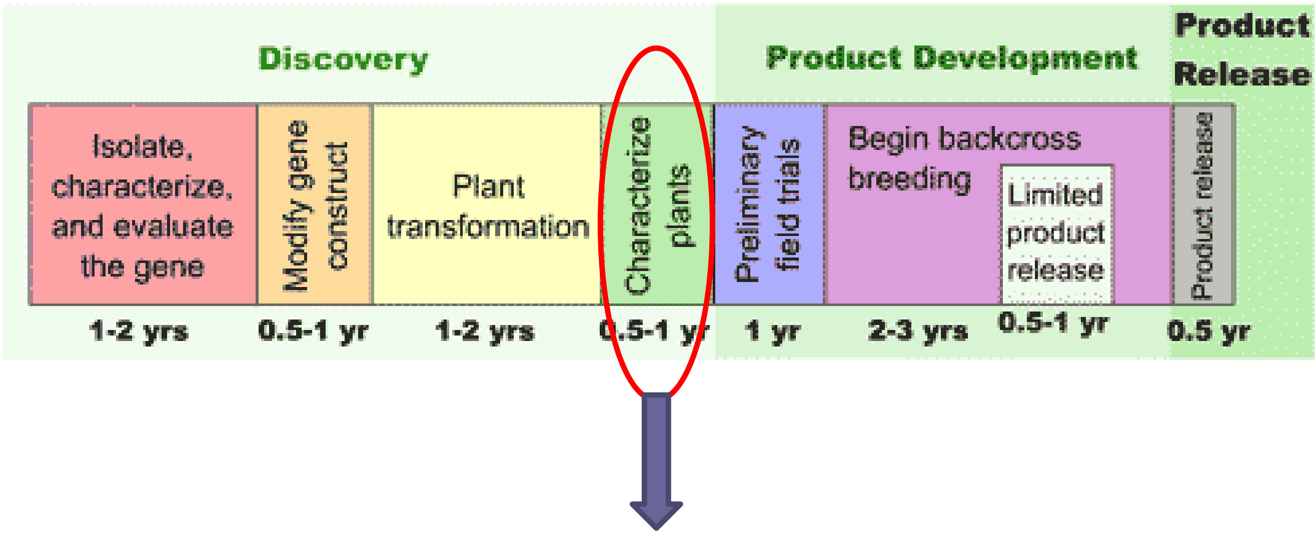

Target Genomic Locus
Cas9
Protospacer Adjacent Motif (PAM)
Target sequence to cleave
Your guide RNA sequence
tracrRNA built into vectors

What is a GMO?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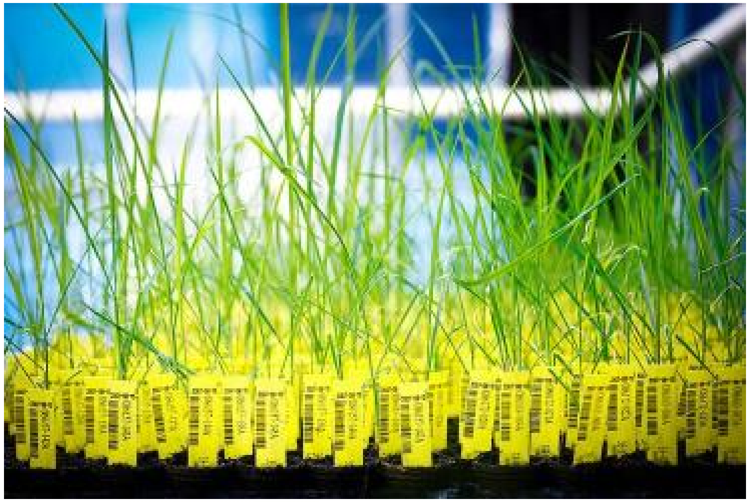

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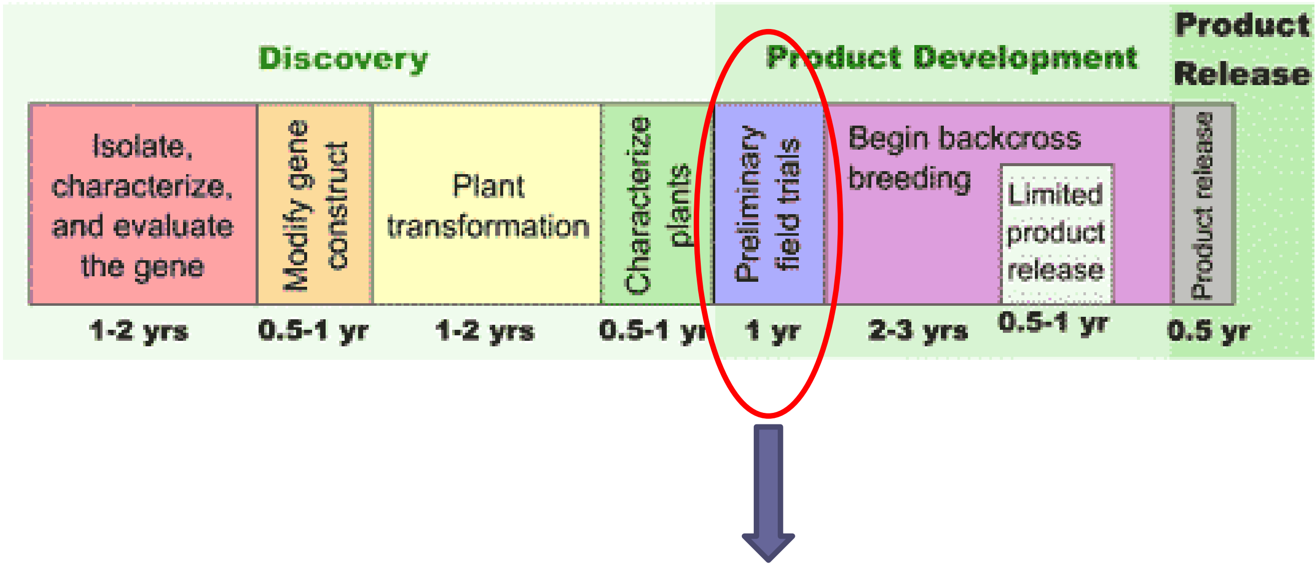
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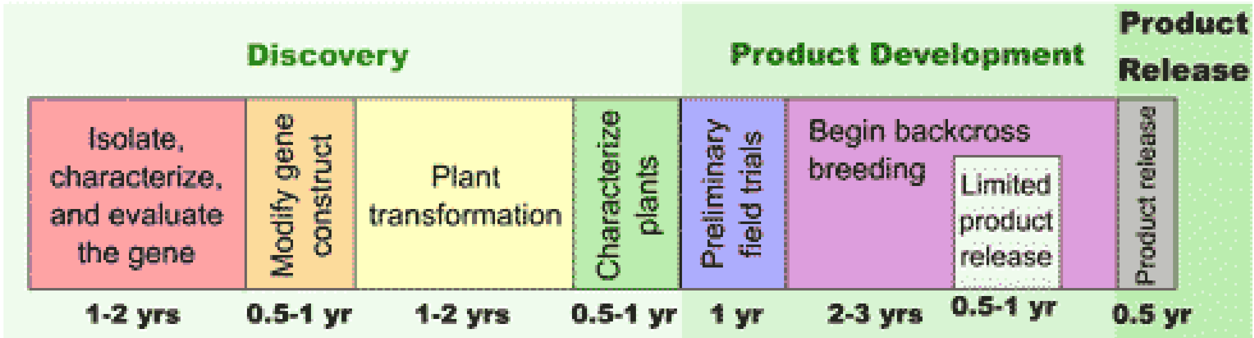
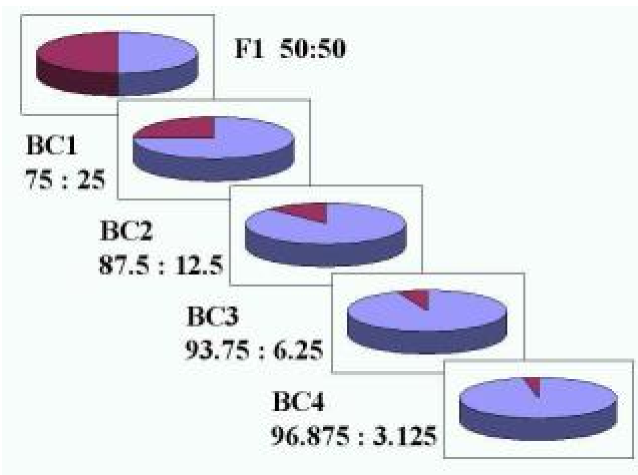
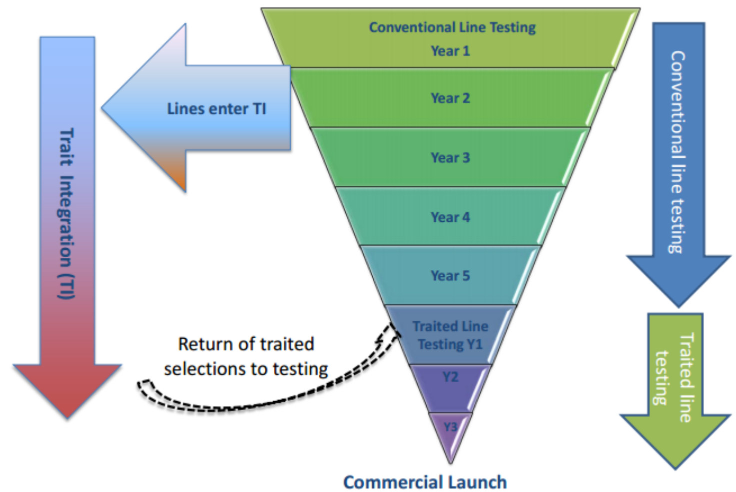




Cotton Breeding Testing Pipeline Workflow

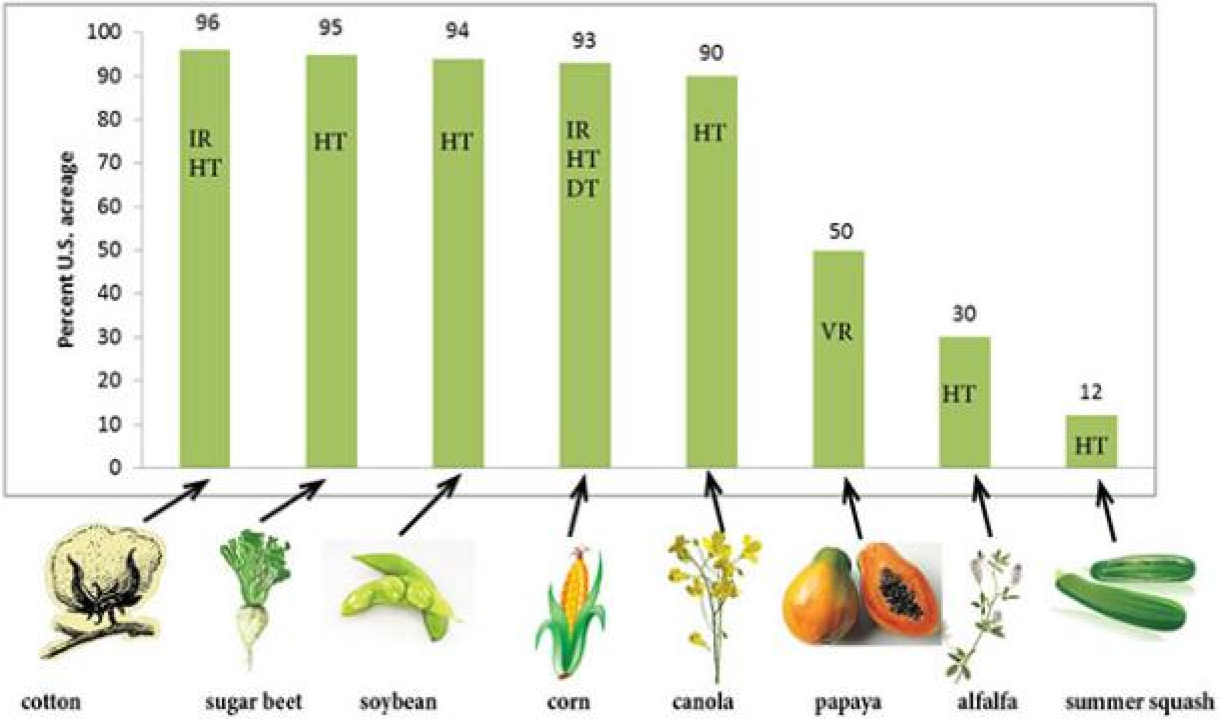


What is a GMO? What is the difference between genetically modified organisms and genetically engineered organisms?

	Conventional breeding/hybrids (crossbetween two non-clonal plants)	Mutation breeding	Transgenics	Cisgenics
Examples in common foods	Almost everything	Some bananas, pears, apples, rice, yams, mint, others	Much corn, cotton, soy, canola, papaya	Coming soon
Number of genes affected	10K 300k, depending on species	No way to assess	1-3, few more in stacked products	1-3, usually 1

What crops have a GMO trait? What do the traits do and what is the benefit of these traits?

GE Crops that have been commercialized in US

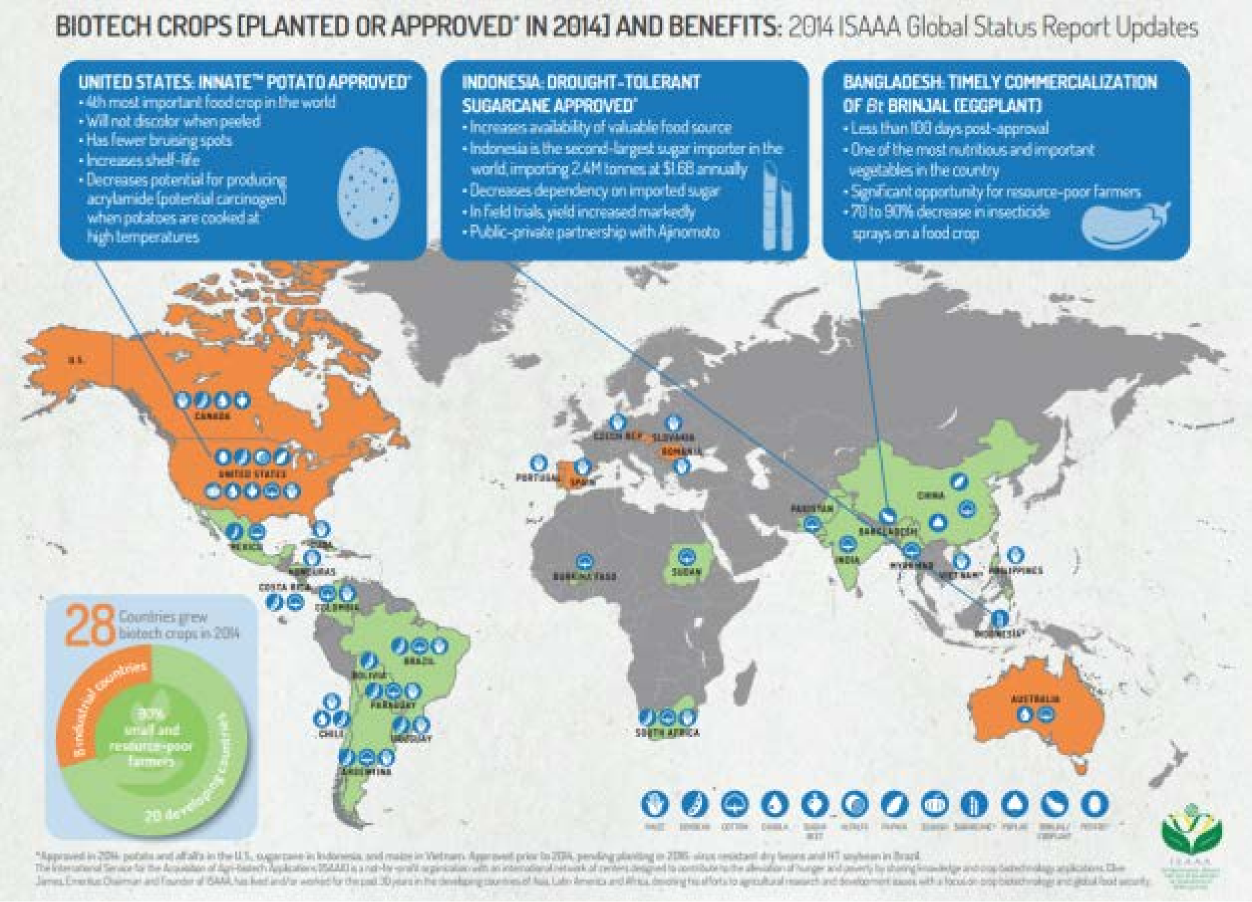


GE Crops that have been approved but not commercialized in US

Innate Potato

Arctic Apple

What is a GMO?
Where are they grown?



Rennet is a complex of enzymes produced in stomachs of ruminant mammals which is used in the production of most cheeses. Chymosin, its key component, is a protease enzyme that curdles the casein in milk, helping young mammals digest their mothers' milk.

Increased anti-oxidant resveratrol
Decreased wine spoilage
Decreased biogenic amines

tart-tasting malic acid, naturally present in grape must, is converted to softer-tasting lactic acid.

wA
wineanorak.com

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Controversies
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UK buying guide
Wine links
What's new?
Jamie's blog

GM yeasts: the next battleground

I'm going to make a prediction. I reckon the next battleground in the wine world will be the controversial use of genetically modified (GM) yeasts in winemaking. Plenty of these genetically modified strains already exist in laboratories around the globe, but they haven't previously been commercialized because of the negative reactions of consumers to GM food products. The scientists are busy engineering beneficial traits into wine yeasts even though they know they won't be useful for commercial winemaking for the forseeable future, for two reasons. First, they reckon the public oppisition to GM technology will one day recede, at which point they'll be in a good position to move. Second, they can learn a lot of useful information from using these introduced genes, which will then inform conventional breeding and selection programs.

http://www.wineanorak.com/GM_yeasts.htm

TECHNOLOGY

Genetically Modified Yeast Could Boost Health Benefits Of Wine And Reduce Hangovers

March 22, 2015 | by Justine Alford

photo credit: Marcos Mesa Sam Wordley/ Shutterstock

15K ?

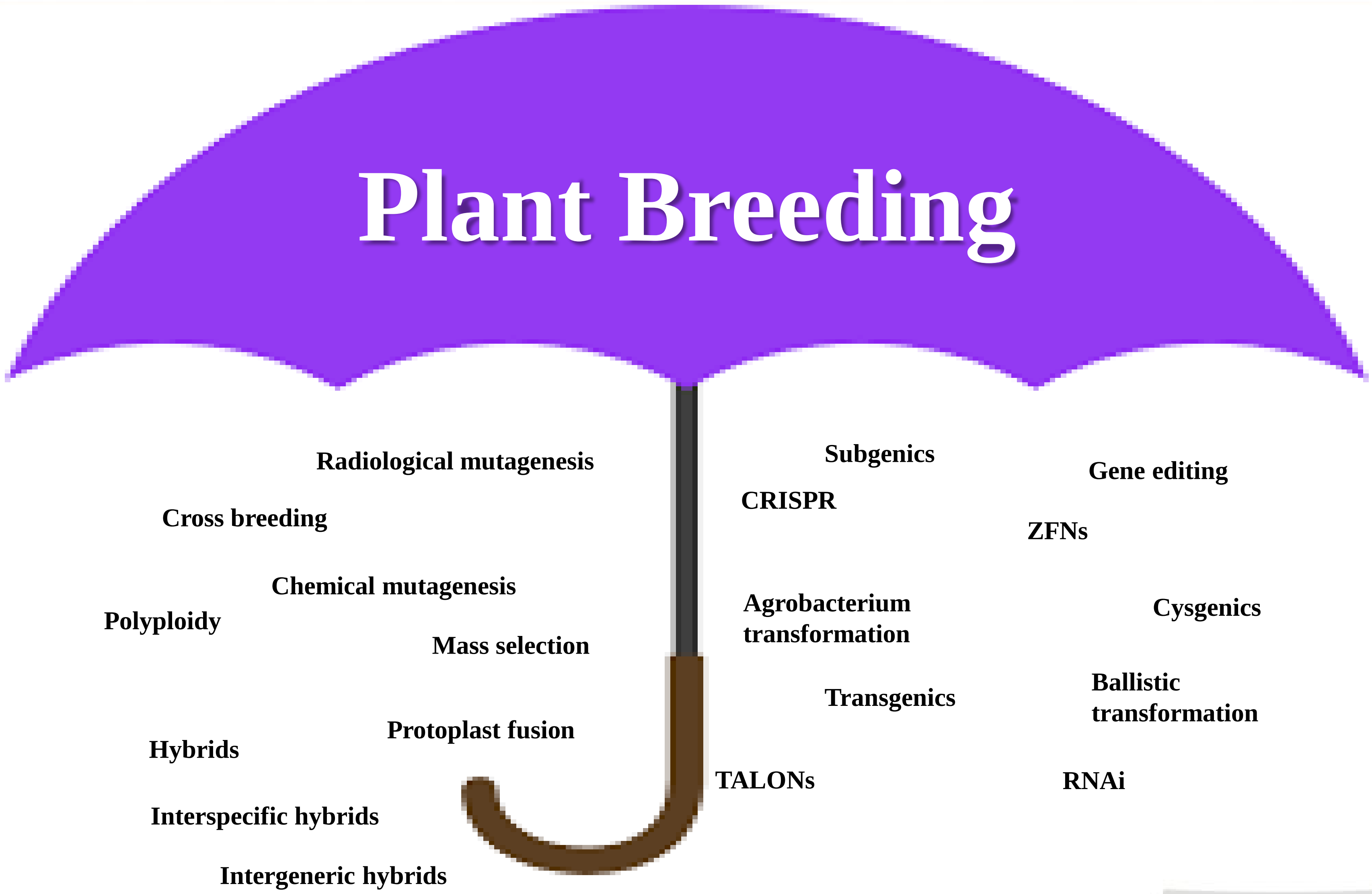
As if the human population needed an excuse to drink more booze: Scientists have demonstrated that it is possible to genetically engineer yeast in such a way that it could improve the content of the health-boosting substances of wine and beer. And the icing on the cake? It could potentially reduce the amount of toxic byproducts that can contribute to that dreaded hangover. Praise science!

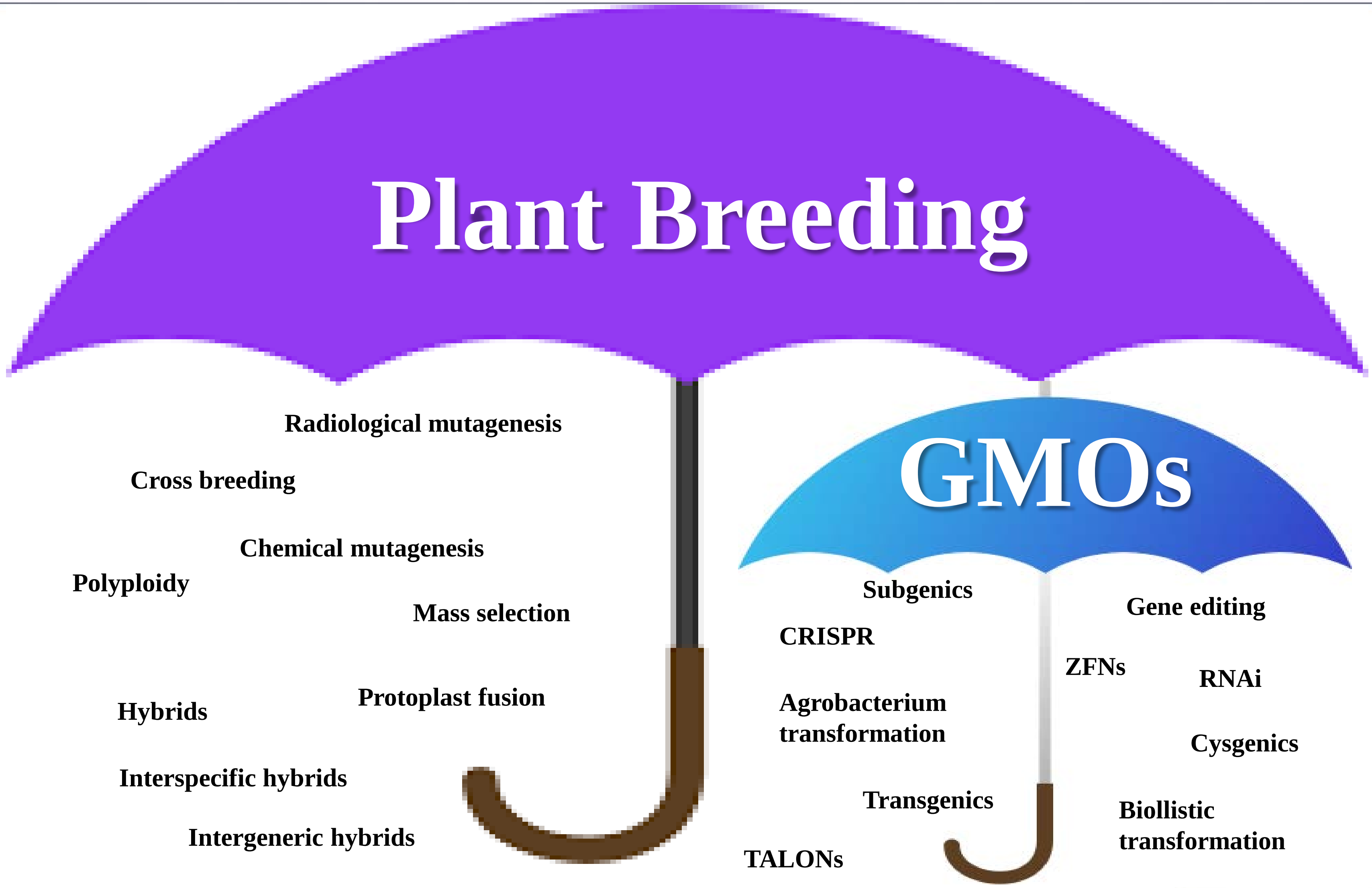
http://www.iflscience.com/technology/gm-yeast-could-boost-health-benefits-wine-and-reduce-hangovers

What is a GMO? GE Crop Traits

All genetically engineered crops are not created equal - Raoul Adamchak

- **Herbicide tolerance -** crop can withstand herbicide applications
- **Insect tolerance -** plant produces toxin to kill pest
- **Improved nutrition –** plant produces a substance of nutritive value or is changed to not produce an antinutrient
- **Disease resistant –** crop is resistant to certain disease
- **Stress Tolerance –** crop is tolerant of stress, low nutrient levels or excess nutrients
- **Increased Storage –** crop can be stored longer to avoid spoilage losses
- **Medicinal uses –** crops that produce medicines or vaccines
- **Industrial uses –** crops to make more efficient industries
- **Toxin removal -** removal or silencing of genes responsible for toxins in plants
- **Improved Metabolism –** change in metabolism to improve efficiency
- **Improved breeding** – speeds up traditional breeding efforts
- **Ornamental purposes**


Plant Breeding
Radiological mutagenesis
Cross breeding
Chemical mutagenesis
Polyploidy
Mass selection
Protoplast fusion
Hybrids
Interspecific hybrids
Intergeneric hybrids
Subgenics
Gene editing
CRISPR
ZFNs
Agrobacterium transformation
Cysgenics
Ballistic transformation
Transgenics
TALONs
RNAi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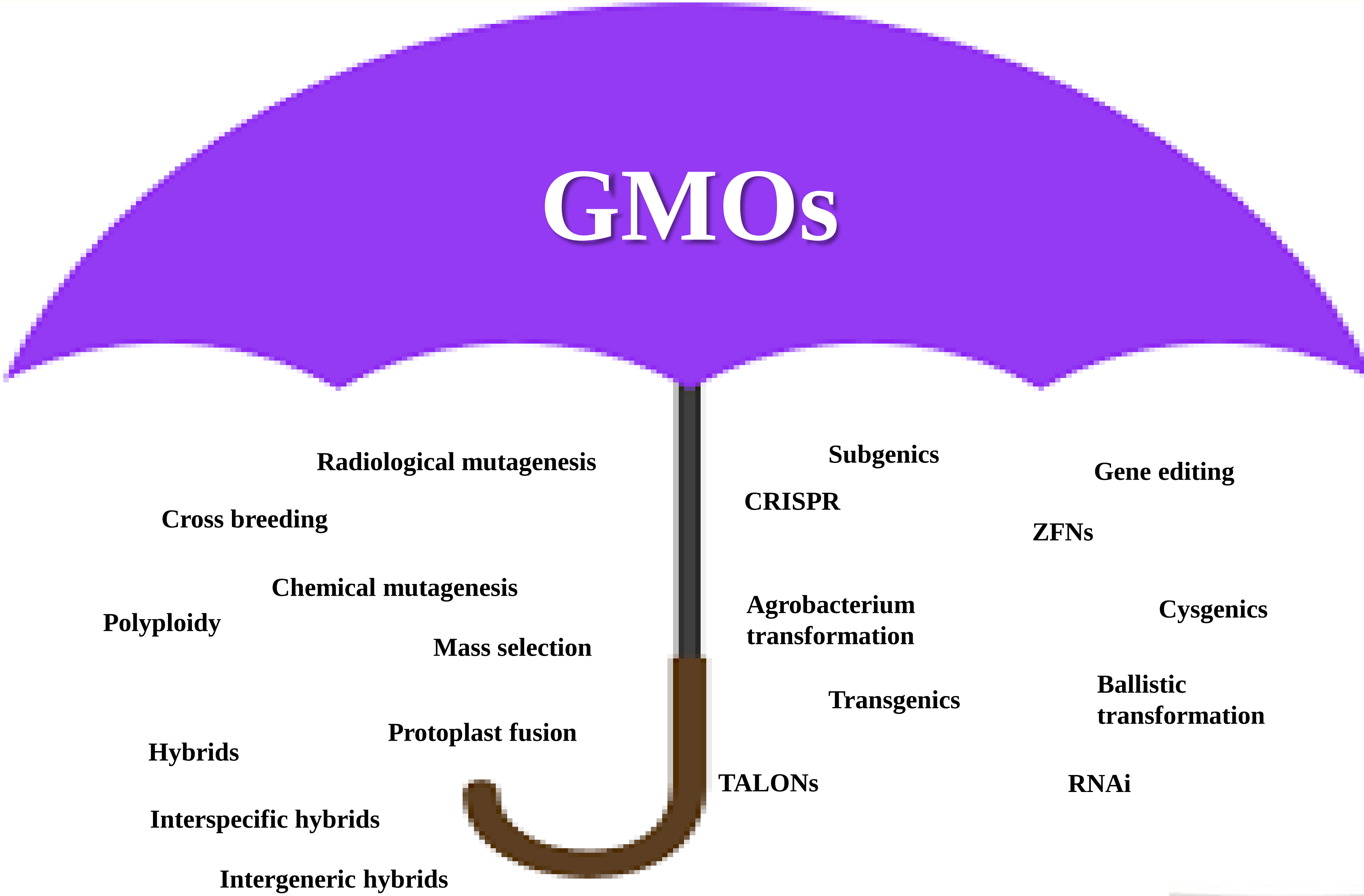
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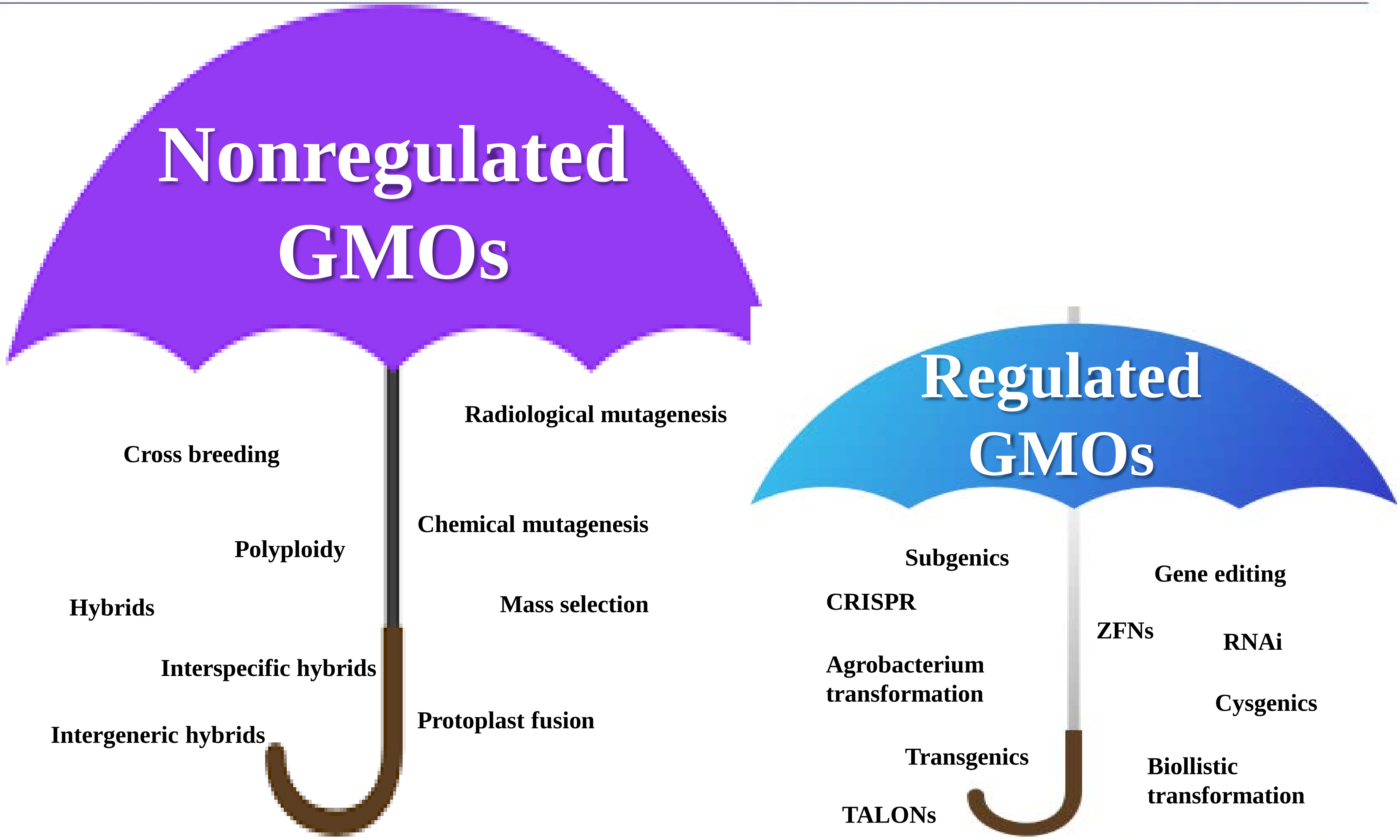
Nonregulated GMOs
Radiological mutagenesis
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Nonregulated GMOs

Regulated GMOs

Roundup Ready
TECHNOLOGY

What is a GMO?

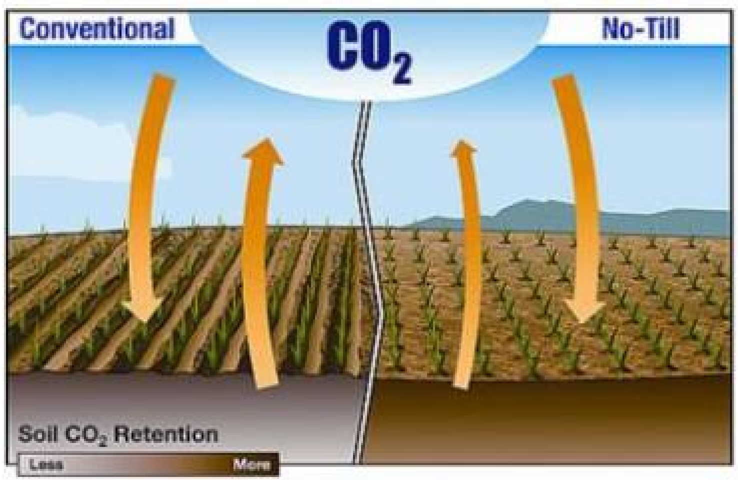
What crops have a GMO trait? What do the traits do and what is the benefit of these traits?

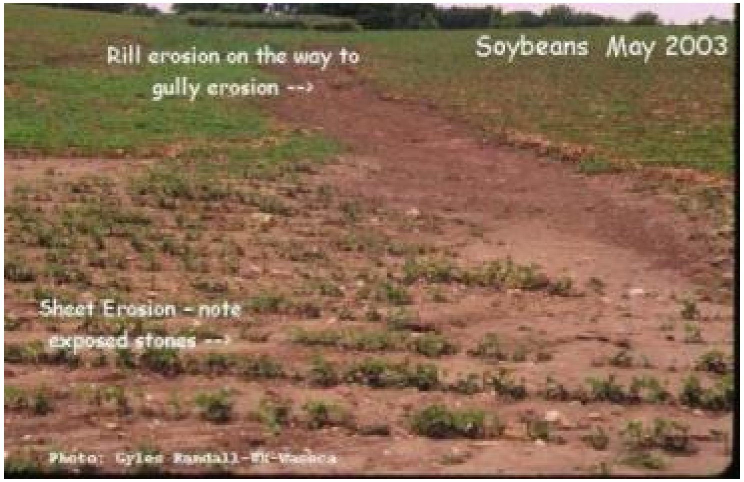
GE Crop Traits

Herbicide Resistance

Decreased tillage

- Less soil erosion
- CO2 sequestration
- Increase soil organic matter
- Reduced trips through the field
- Less fuel use



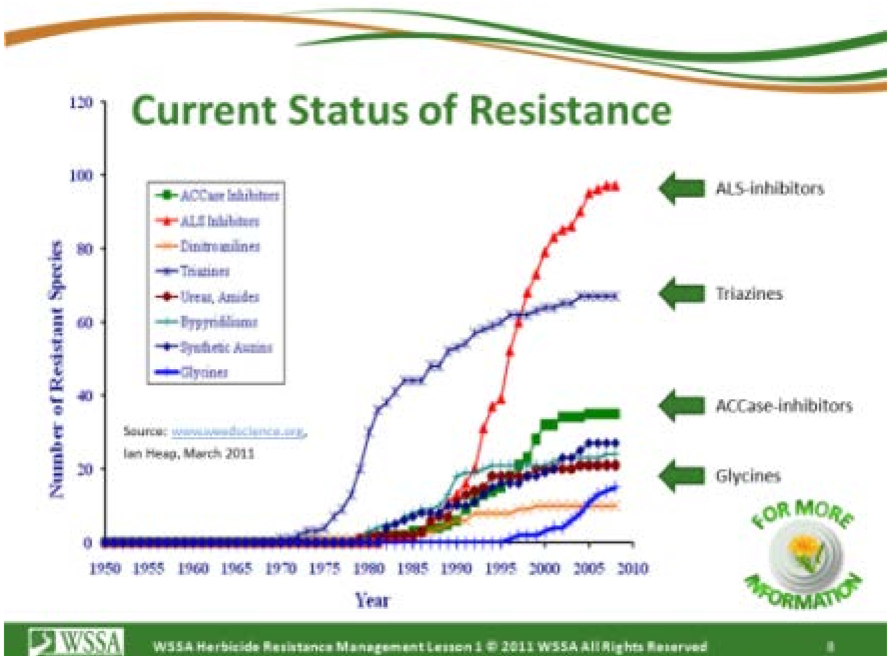


X	Farmers
	Consumers
X	Environment
	Needy

GE Crop Traits
Herbicide Resistance

Concerns

- **Weed resistance**
- **Gene flow to closely related species**
- **Increased herbicide usage**



GE Crop Traits

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Centers of origin of selected crops

Note: The pointer locations indicate general regions where crops are believed to have first been domesticated. In some cases, the center of origin is uncertain. Other geographic regions also harbor important genetic diversity for these crops.

Source: This map was developed by the General Accounting Office using data provided by the National Plant Germplasm System's Plant Exchange Office.

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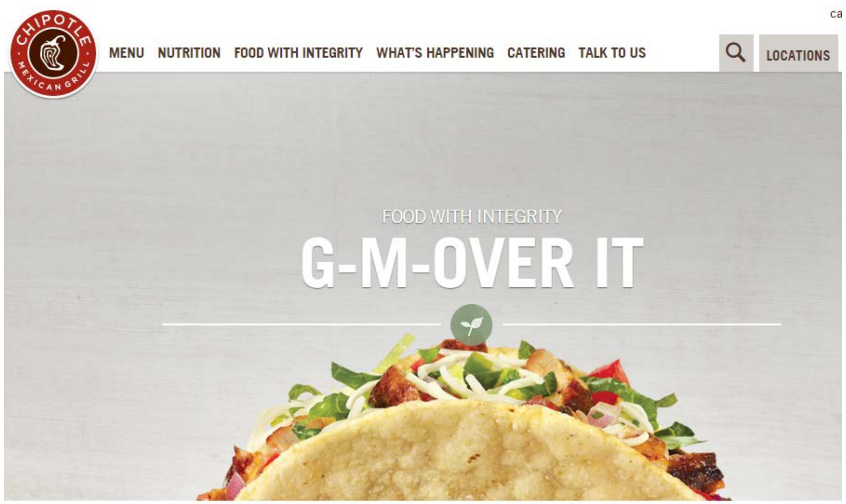

WHEN IT COMES TO OUR FOOD, GENETICALLY MODIFIED INGREDIENTS DON'T MAKE THE CUT.

For Sunflower Weed Control Use DuPont™ ExpressSun® Herbicide

Weed control in sunflowers, especially broadleaf weed control, has always been difficult. In all other crops, sunflowers are considered a weed and are easily controlled by a wide range of herbicides. That means new technology was needed to help sunflower growers maximize yield potential through clean fields.

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Does resistance confer competitive advantage in the wild?

Pollen-mediated gene flow between glyphosate-resistant *Brassica napus* canola and *B. juncea* and *B. carinata* mustard crops under large-scale field conditions in Saskatchewan

Ginette Séguin-Swartz[1], Hugh J. Beckie[1,4], Suzanne I. Warwick[2], Vicky Roslinsky[1], Jacqueline A. Nettleton[1], Eric N. Johnson[3], and Kevin C. Falk[1]

[1]Agriculture and Agri-Food Canada (AAFC), Saskatoon Research Centre, 107 Science Place, Saskatoon, Saskatchewan, Canada S7N 0X2; [2]AAFC, Eastern Cereal and Oilseeds Research Centre, K. W. Neatby building, Central Experimental Farm, Ottawa, Ontario, Canada K1A 0C6; and [3]AAFC, Scott Research Farm, P.O. Box 10, Scott, Saskatchewan, Canada S0K 4A0.
Received 25 April 2013, accepted 17 July 2013. Published on the web 8 August 2013.

Séguin-Swartz, G., Beckie, H. J., Warwick, S. I., Roslinsky, V., Nettleton, J. A., Johnson, E. N. and Falk, K. C. 2013. **Pollen-mediated gene flow between glyphosate-resistant *Brassica napus* canola and *B. juncea* and *B. carinata* mustard crops under large-scale field conditions in Saskatchewan**. Can. J. Plant Sci. **93**: 1083–1087. A Saskatchewan study examined hybridization between two mustard (*Brassica juncea* and *B. carinata*) crops that were either adjacent to a glyphosate-resistant canola (*B. napus*) crop or separated by a 5-m strip. Overall, field hybridization levels, detected with glyphosate resistance and species-specific AFLP markers, were low: 0.024% and up to 400 m in the adjacent *B. juncea* field and 0.013% (up to 350 m) in the separated field, and 0.005% (up to 150 m) in the adjacent *B. carinata* field and 0.002% (up to 65 m) in the separated field. Based on fitness information under controlled conditions, the fertility of hybrid plants is expected to be low.

http://pubs.aic.ca/doi/pdf/10.4141/cjps2013-129

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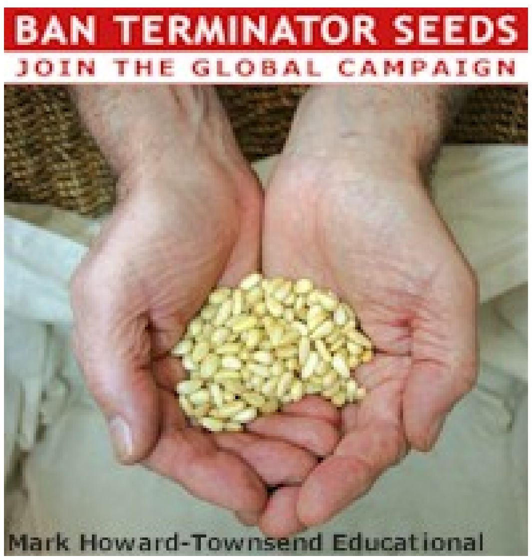

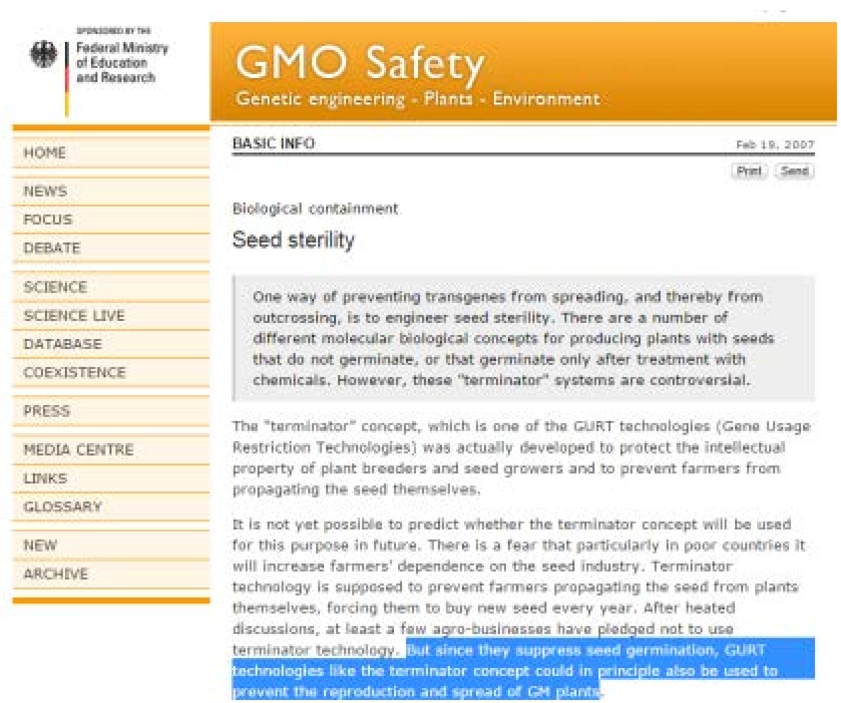

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GMO Safety
Genetic engineering - Plants - Environment

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BASIC INFO — Feb 19, 2007

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Biological containment

Seed sterility

One way of preventing transgenes from spreading, and thereby from outcrossing, is to engineer seed sterility. There are a number of different molecular biological concepts for producing plants with seeds that do not germinate, or that germinate only after treatment with chemicals. However, these "terminator" systems are controversial.

The "terminator" concept, which is one of the GURT technologies (Gene Usage Restriction Technologies) was actually developed to protect the intellectual property of plant breeders and seed growers and to prevent farmers from propagating the seed themselves.

It is not yet possible to predict whether the terminator concept will be used for this purpose in future. There is a fear that particularly in poor countries it will increase farmers' dependence on the seed industry. Terminator technology is supposed to prevent farmers propagating the seed from plants themselves, forcing them to buy new seed every year. After heated discussions, at least a few agro-businesses have pledged not to use terminator technology. But since they suppress seed germination, GURT technologies like the terminator concept could in principle also be used to prevent the reproduction and spread of GM plants.

http://www.gmo-safety.eu/basic-info/359.seed-sterility.html

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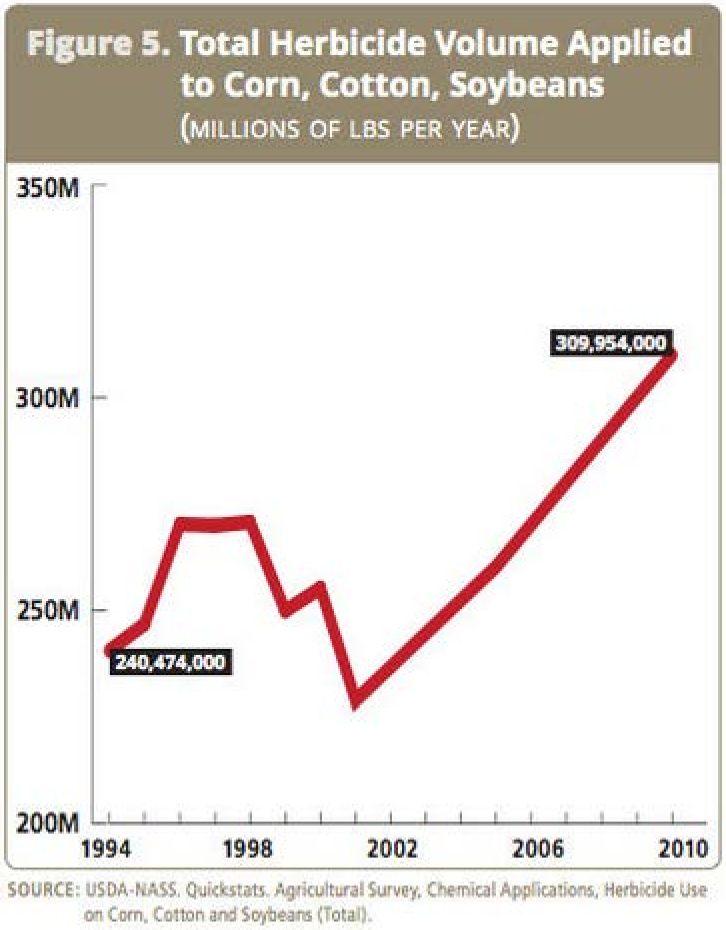

1. Skyrocketing herbicide use

Despite assurances to Congress and regulators over the last two decades that crops modified to be herbicide resistant would lead to less chemical usage, a peer-reviewed paper published last summer showed that the three major GMO crops in the U.S. – corn, soybeans, and cotton – have increased overall herbicide use by more than 527 million pounds between 1996 – 2011, compared to what it likely would have been in the absence of GMO crops. http://www.justlabelit.org/right-to-know-center/why-labeling-makes-sense/

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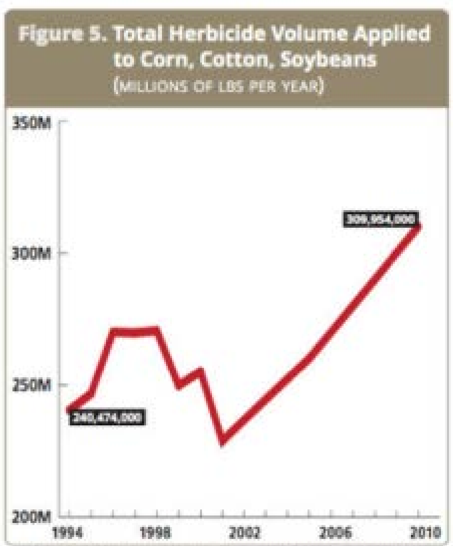

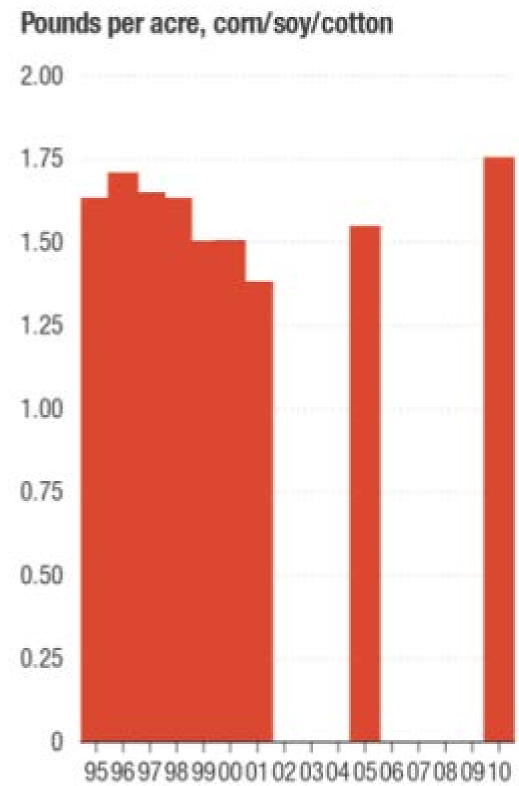

Herbicide use on corn, soybeans and cotton — break it down per acre and it's not so dramatic. *NPR using USDA data - http://www.npr.org/sections/thesalt/2014/01/24/265687251/soil-weedkillers-and-gmos-when-numbers-don-t-tell-the-whole-story*

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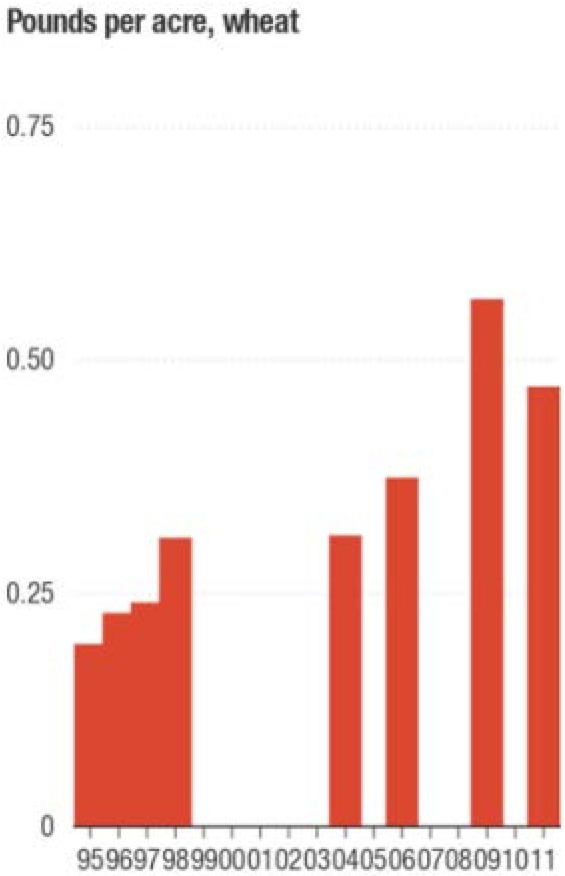
- Increased herbicide usage



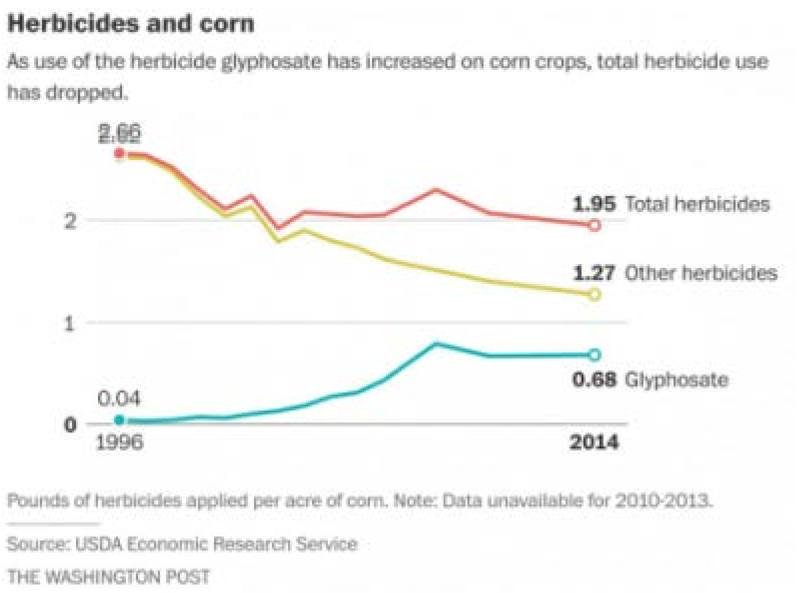
Herbicide use on corn, soybeans and cotton. *NPR using USDA data* - http://www.npr.org/sections/thesalt/2014/01/24/265687251/soil-weedkillers-and-gmos-when-numbers-don-t-tell-the-whole-story

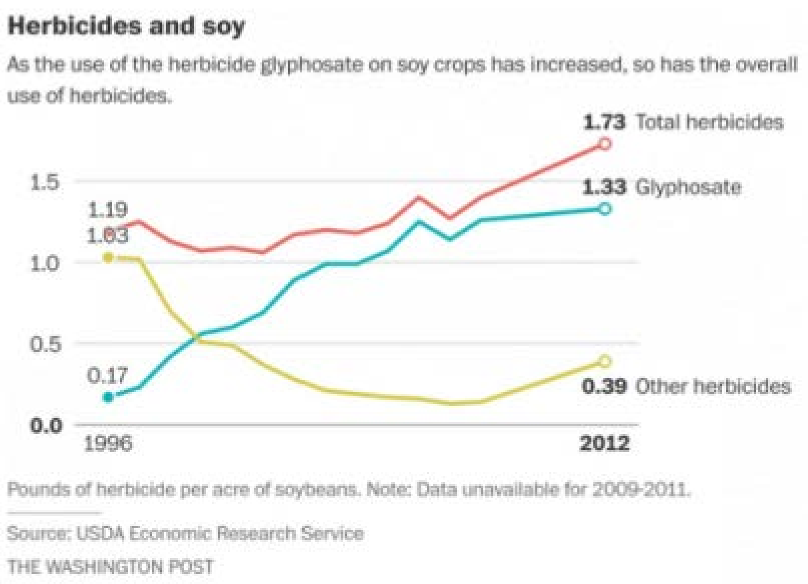
GE Crop Traits

Herbicide Resistance

Concerns

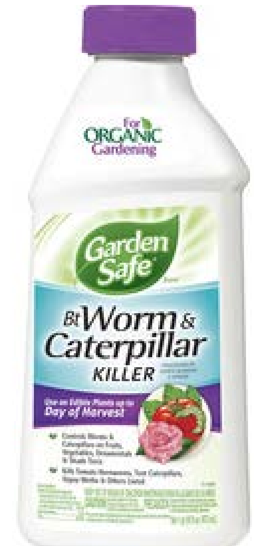
- Weed resistance
- Gene flow to closely related species
- Increased herbicide usage





GE Crop Traits

Insect Resistance
Decreased Insecticide Applications



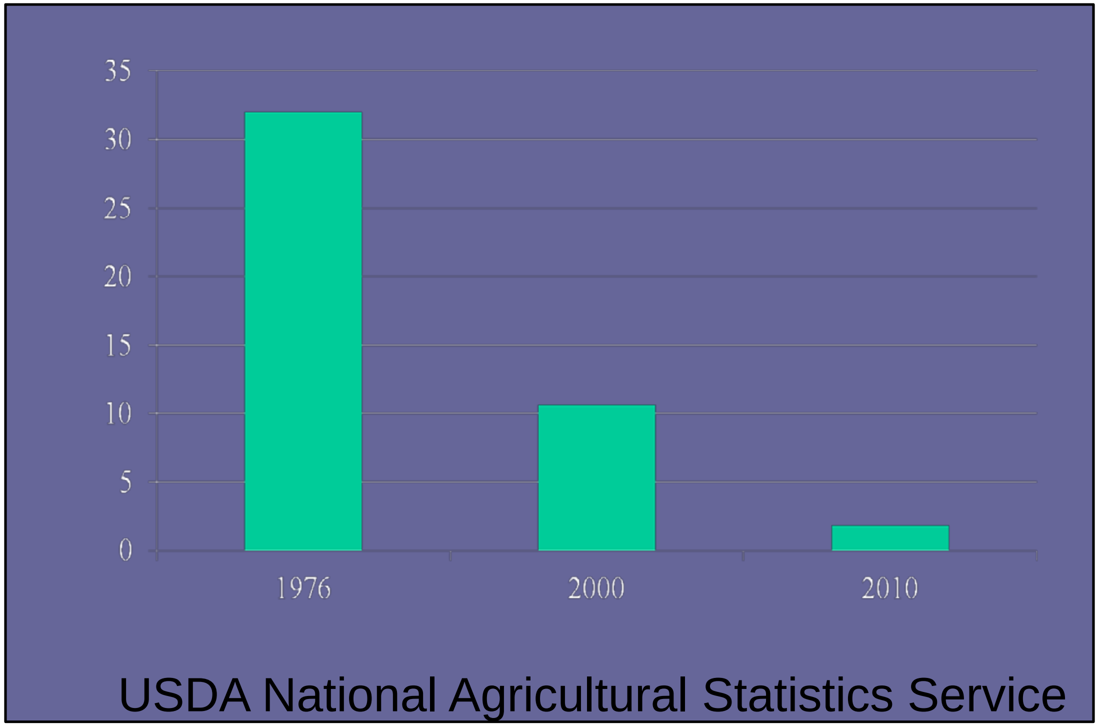
X	Farmers
	Consumers
X	Environment
X	Needy

GE Crop Traits

Insect Resistance

Decreased Insecticide Applications

U.S. Insecticide use in Corn (M lbs) of active ingredient)



X	Farmers
	Consumers
X	Environment
X	Needy

GE Crop Traits

Insect Resistance

Decreased Insecticide Applications

Non Bt brinjal (left), Bt brinjal (right)

X	Farmers
	Consumers
X	Environment
X	Needy

GE Crop Traits

Insect Resistance

Advantages

Decrease in broad-spectrum insecticide use on corn and cotton

Lower fuel and labor costs for farmers

Solid dividends in the developing world

No effect on beneficials

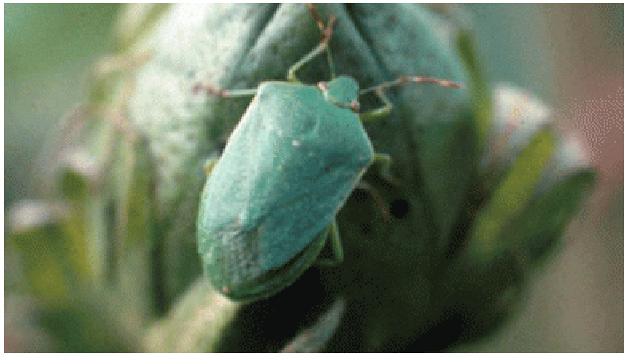
Limitations

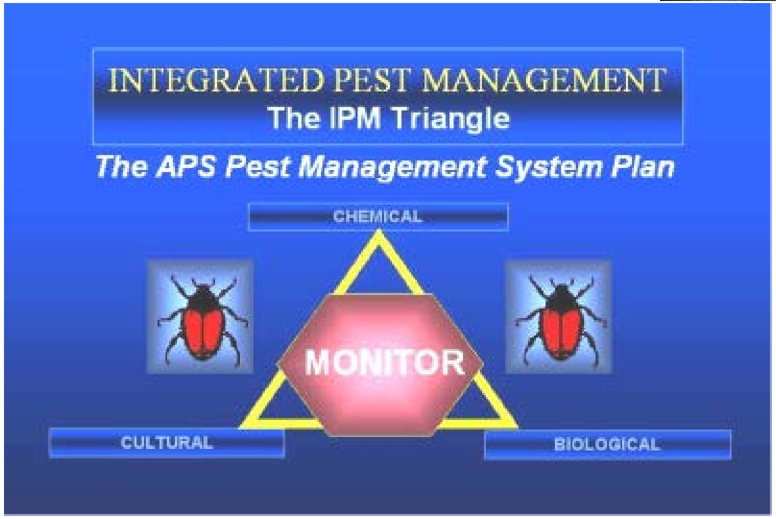
Need to plant refugia to slow resistance

Pockets of resistance are seen and require use of insecticides

Still requires careful scouting for secondary insects

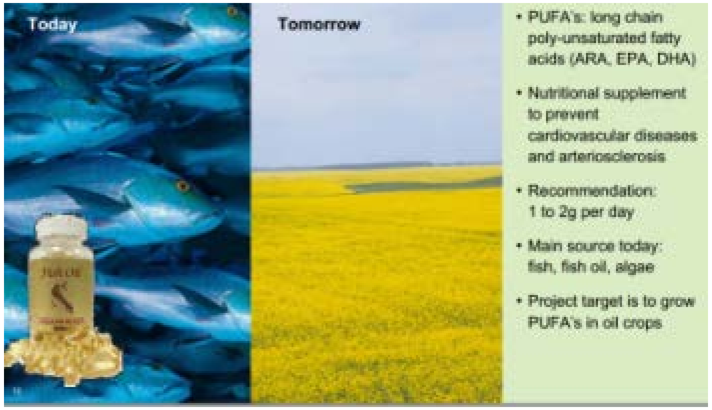
GE Crop Traits
Insect Resistance
Secondary pests





GE Crop Traits

Improved Nutrition



One acre of omega-3 producing soybeans yields as much oil as 10,000 fish!

X	Farmers
X	Consumers
	Environment
X	Needy

GE Crop Traits

Improved Nutrition

Fewer Wild Fish Needed: Genetically Modified Plants Produce Omega-3 Fish Oil

By News Staff | January 31st 2015 10:34 AM | 3 comments | Print | E-mail | Track Comments

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News Staff

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Researchers have revealed that genetically modified Camelina plants produce omega-3 fish oils suitable for feeding Atlantic salmon. The new GMO plants can produce up to 20% of eicosapentaenoic acid (EPA), one of the two omega-3 LC PUFA conferring health benefits.

Consumption of omega-3 fish oils, specifically long-chain polyunsaturated fatty acids (omega-3 LC-PUFA), through eating oily fish like salmon and mackerel, has been linked with improved cardiovascular health and cognitive development. The primary dietary sources of these fatty acids are wild or farmed fish.

Fish accumulate the omega-3 fish oils through eating other organisms in the marine food chain or, in farmed fish, through fishmeal and fish oil in feeds. Currently there is a gap between supply and demand for these fish oils and new sources are required for the aquaculture industry and for direct human consumption.

X	Farmers
X	Consumers
X	Environment
X	Needy

http://www.science20.com/news_articles/fewer_wild_fish_needed_genetically_modified_plants_produce_omega3_fish_oil-152784

GE Crop Traits

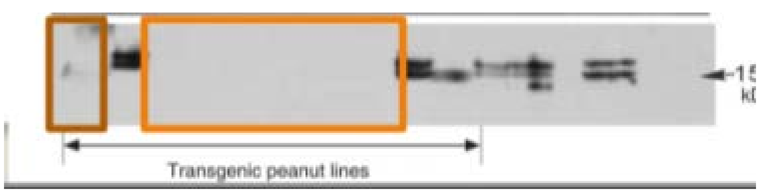
Improved Nutrition

Allergy-Free Peanuts

Characteristics of Peanut Allergens

Allergen	Molecular Mass	Characteristics
Ara h 1	63 k-Da	Member of vicilin family of seed storage proteins, a 7S globulin
Ara h 2	17–19 k-Da	Member of conglutin family of seed storage proteins, a 2S albumin
Ara h 3	14–45 k-Da, processed from 64 k-Da protein	Member of glycinin family of seed storage proteins; heteromultimeric protein formed from differently proteoltically processed products of the same gene, an 11S globulin
Ara h 4	37 k-Da	Isoform of Ara h 3
Ara h 5	15 k-Da	Member of profilin family of G-actin-binding proteins
Ara h 6	15 k-Da	Member of conglutin family of seed storage proteins, a 2S albumin
Ara h 7	17 k-Da	Member of conglutin family of seed storage proteins, a 2S albumin
Ara h 8	16 k-Da	Homologous to major birch pollen allergen, Bet v 1 and other pathogenesis-related proteins
Ara h 9	9.8 k-Da	Lipid transfer protein
Ara h 10	16 k-Da	Oleosin seed storage protein
Ara h 11	14 k-Da	Oleosin seed storage protein

Plant tested	Two letter code	Ara h 2 protein concentration
Wild Type	WT	27.73%
12.1.1	S1	4.24%
32.1.1	S2	3.08%
45.6	S3	4.04%



- [ ] Farmers
- [X] Consumers
- [ ] Environment
- [ ] Needy

GE Livestock Traits

Improved Nutrition

BRIEF COMMUNICATIONS

nature biotechnology

Nature Biotechnology 24:435-436. 2006

Generation of cloned transgenic pigs rich in omega-3 fatty acids

Liangxue Lai[1,2,8], Jing X Kang[5,8], Rongfeng Li[1], Jingdong Wang[5], William T Witt[6], Hwan Yul Yong[1], Yanhong Hao[1], David M Wax[1], Clifton N Murphy[1], August Rieke[1], Melissa Samuel[1], Michael L Linville[3], Scott W Korte[4], Rhobert W Evans[7], Thomas E Starzl[6], Randall S Prather[1,2] & Yifan Dai[6]

Meat products are generally low in omega-3 (n-3) fatty acids, which are beneficial to human health. We describe the generation of cloned pigs that express a humanized *Caenorhabditis elegans* gene, fat-1, encoding an n-3 fatty acid desaturase. The hfat-1 transgenic pigs produce high levels of n-3 fatty acids from n-6 analogs, and their tissues have a significantly reduced ratio of n-6/n-3 fatty acids ($P < 0.001$).

The health benefits of long chain n-3 fatty acids, found mainly in fish oils, are well recognized. Meat products normally contain small amounts of n-3 fatty acids and large amounts of n-6 fatty acids[1] such as the *fat-1* gene found in the roundworm *C. elegans*[3]. Earlier work in transgenic mice carrying the *fat-1* gene has suggested the feasibility of creating *fat-1* transgenic livestock capable of producing n-3 fatty acids from the corresponding n-6 fatty acids[4]. Here we report the cloning of *fat-1* transgenic pigs that produce high levels of n-3 fatty acids in their tissues and organs.

An h*fat-1* expression vector, pCAGGS-h*fat-1*, which contains a humanized *fat-1* cDNA (with modification of codon usage) driven by the cytomegalovirus enhancer and chicken β-actin promoter, has been described previously[4]. A pgk-neo expression cassette as a selection marker was inserted into pCAGGS-h*fat-1* to generate pST103, which was transfected into early-passage male primary porcine fetal fibroblast cells, pCFF4-3[5], by electroporation; the transfected cells were selected with 250 μg/ml G418. The G418-resistant colonies were pooled. Gas chromatographic analysis showed that pCFF4-3/pST103 cells contained higher amounts of n-3 fatty acids and lower amounts of n-6 fatty acids compared with the nontransfected pCFF4-3 cells, indicating that the hfat-1 protein was functional in the primary porcine cells. The PCFF4-3/pST103 cells were used to clone h*fat-1* transgenic pigs by nuclear transfer as described previously[6]. A total of 1,633 reconstructed embryos were transferred into 14 gilts that exhibited a natural estrus. Twelve early pregnancies were established, and five of them went to term. Twelve (ten alive and two dead) male piglets were born by either caesarean section or natural delivery. PCR analysis of DNA samples from the tails of ten live piglets showed that six piglets (nos. 1, 3–5, 8 and 9) were positive for the

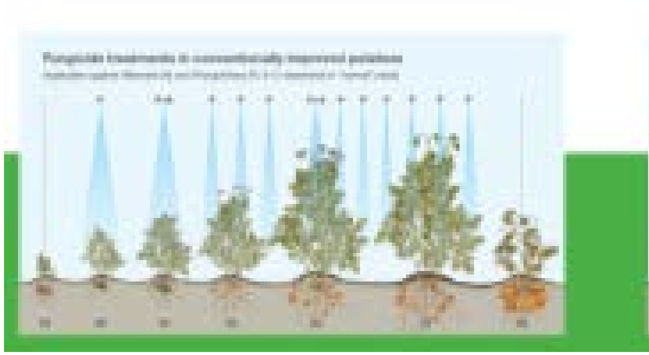
	Farmers
X	Consumers
	Environment
	Needy

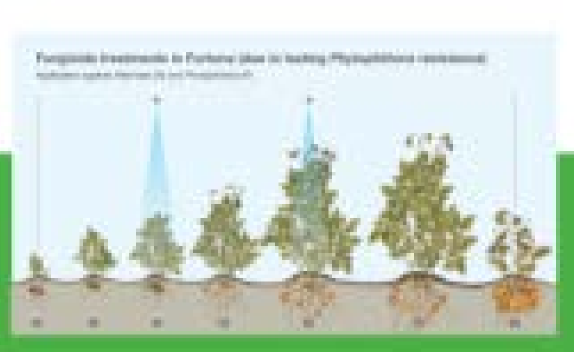
University of Missouri/Massachusetts General Hospital and Harvard Medical School

GE Crop Traits

Disease Resistance

Decreased Fungicide and Insecticide Applications





X	Farmers
	Consumers
X	Environment
X	Needy

GE Crop Traits
Disease Resistance
Decreased Insecticide Applications

Stopping Citrus Greening

Spinach defensin,

NPR1, Lytic peptides

Many show promise

Earliest deregulation is 2019

X	Farmers
?	Consumers
X	Environment
X	Needy

GE Crop Traits
Disease Resistance
Decreased Insecticide Applications

Clonally propagated crops

X	Farmers
?	Consumers
X	Environment
X	Needy

GE Livestock Traits

Disease Resistance

GE Chickens That Don't Transmit Bird Flu

Breakthrough could prevent future bird flu epidemics

Suppression of Avian Influenza Transmission in Genetically Modified Chickens

Jon Lyall,[1] Richard M. Irvine,[2] Adrian Sherman,[3] Trevelyan J. McKinley,[1] Alejandro Núñez,[2] Auriol Purdie,[3*] Linzy Outtrim,[2] Ian H. Brown,[2] Genevieve Rolleston-Smith,[3] Helen Sang,[3]† Laurence Tiley[1]†‡

Infection of chickens with avian influenza virus poses a global threat to both poultry production and human health that is not adequately controlled by vaccination or by biosecurity measures. A novel alternative strategy is to develop chickens that are genetically resistant to infection. We generated transgenic chickens expressing a short-hairpin RNA designed to function as a decoy that inhibits and blocks influenza virus polymerase and hence interferes with virus propagation. Susceptibility to primary challenge with highly pathogenic avian influenza virus and onward transmission dynamics were determined. Although the transgenic birds succumbed to the initial experimental challenge, onward transmission to both transgenic and nontransgenic birds was prevented.

The diversity of avian influenza viruses (AIVs) and their propensity for inter-species transmission make them a global threat to animal and public health communities. Cross-species transmission of influenza viruses may occur directly or be facilitated by inter-mediate host species that amplify and diversify virus populations, notably domestic chickens, ducks, and pigs (*1*). Although control of AIV infection in its wild aquatic bird reservoir is impractical, control of AIV in domesticated hosts is possible (*2*). The diversity of viral antigenic subtypes and their potential for evolutionary shift and drift are a challenge, particularly because current vaccines do not generally achieve sterile immunity even against antigenically well-matched viruses (*3*). One potential route to control AIVs in commercial poultry is to use genetic modification to introduce novel genes that confer resistance to infection (*4*, *5*). Here we evaluate transgenic expression of an RNA hairpin molecule capable of inhibiting influenza viral polymerase activity (*6*).

An RNA expression cassette (Fig. 1A) was designed to use a chicken U6 promoter (*7*) to express the short hairpin RNA molecule, decoy 5 (D5, Fig. 1B) (*8*). This decoy contains the conserved 3′- and 5′-terminal sequences of influenza virus genome segments that encompass the complementary RNA (cRNA) binding site for

[1]Department of Veterinary Medicine, University of Cambridge, Madingley Road, Cambridge CB3 0ES, UK. [2]Veterinary Laboratories Agency, Weybridge, Addlestone, Surrey KT15 3NB, UK. [3]The Roslin Institute and Royal (Dick) School of Veterinary Studies, University of Edinburgh, Edinburgh EH25 9PS, UK.

*Present address: Faculty of Veterinary Science, University of Sydney, NSW 2567, Australia.
†These authors contributed equally to this work.
‡To whom correspondence should be addressed. E-mail: Lst21@cam.ac.uk

www.sciencemag.org SCIENCE VOL 331 14 JANUARY 2011 223

X	Farmers
X	Consumers
	Environment
X	Needy

www.roslin.ed.ac.uk/public-interest/gm-chickens

GE Livestock Traits

Disease Resistance

Mastitis-resistant cows (inflammation of mammary gland)

ARTICLES

nature biotechnology

Nature Biotechnology 23:445-451. 2005

Genetically enhanced cows resist intramammary *Staphylococcus aureus* infection

Robert J Wall[1], Anne M Powell[1], Max J Paape[2], David E Kerr[3], Douglas D Bannerman[2], Vernon G Pursel[1], Kevin D Wells[4], Neil Talbot[1] & Harold W Hawk[1]

Mastitis, the most consequential disease in dairy cattle, costs the US dairy industry billions of dollars annually. To test the feasibility of protecting animals through genetic engineering, transgenic cows secreting lysostaphin at concentrations ranging from 0.9 to 14 mg/ml in their milk were produced. *In vitro* assays demonstrated the milk's ability to kill *Staphylococcus aureus*. Intramammary infusions of *S. aureus* were administered to three transgenic and ten nontransgenic cows. Increases in milk somatic cells, elevated body temperatures and induced acute phase proteins, each indicative of infection, were observed in all of the nontransgenic cows but in none of the transgenic animals. Protection against *S. aureus* mastitis appears to be achievable with as little as 3 mg/ml of lysostaphin in milk. Our results indicate that genetic engineering can provide a viable tool for enhancing resistance to disease and improve the well-being of livestock.

X	Farmers
X	Consumers
	Environment
X	Needy

GE Crop Traits

Disease Resistance

Species Restoration

Using hybrid American Chestnut trees to capture carbon

Posted on June 21, 2009 by MB-BigB

Professor Jacobs stands next to an American Chestnut tree

Most of the emphasis on stopping global warming has been on reducing the amount of carbon and GWG's emitted into the atmosphere, but the other side of the coin is worth exploring too. There are a number of carbon sequestration projects being looked at, but Douglass Jacobs, an associate of forestry and natural resources at Purdue University, is looking into a more low-tech solution – the reintroduction of hybridized American chestnut trees. Basically, the American Chestnut tree was almost killed off by the chestnut blight in the beginning of the 1900's, and was practically eliminated from this country's forests. The American Chestnut tree grows far faster than most trees – creating almost 3 times as much biomass as other trees in the same amount of time – thereby storing more carbon in a shorter amount of time.

	Farmers
	Consumers
X	Environment
	Needy

GE Crop Traits

Stress Tolerance

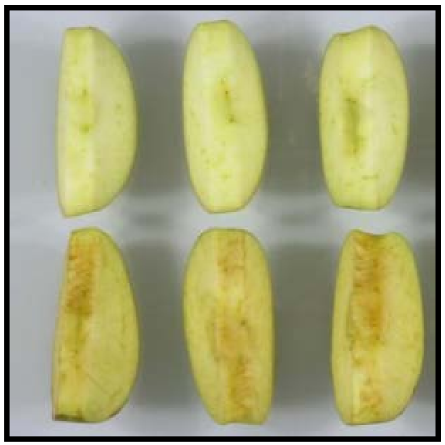
X	Farmers
	Consumers
X	Environment
X	Needy

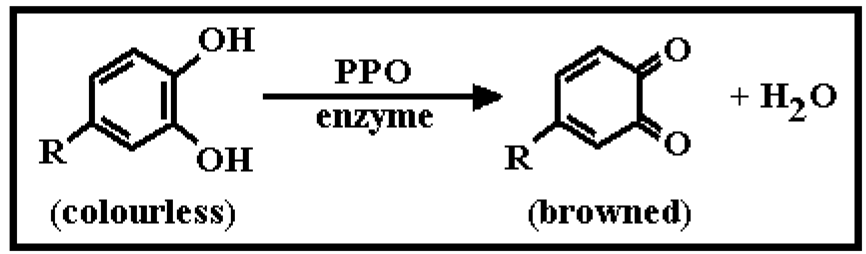
GE Crop Traits

Increased Storage

Non Browning Apples and Potatoes

Silencing a gene that leads to discoloration





	Farmers
X	Consumers
	Environment
X	Needy

GE Crop Traits

Medicinal Uses

A Potato a Day Keeps the Cholera Away

	Farmers
	Consumers
	Environment
X	Needy

Biologist are using genetic engineering to insert a new gene into potatoes. These gene causes the plants to produce a chemical, called a B-protein, that is a harmless part of cholera toxin, or poison. When children eat a certain amount of these genetically altered potatoes, they become vaccinated against cholera.

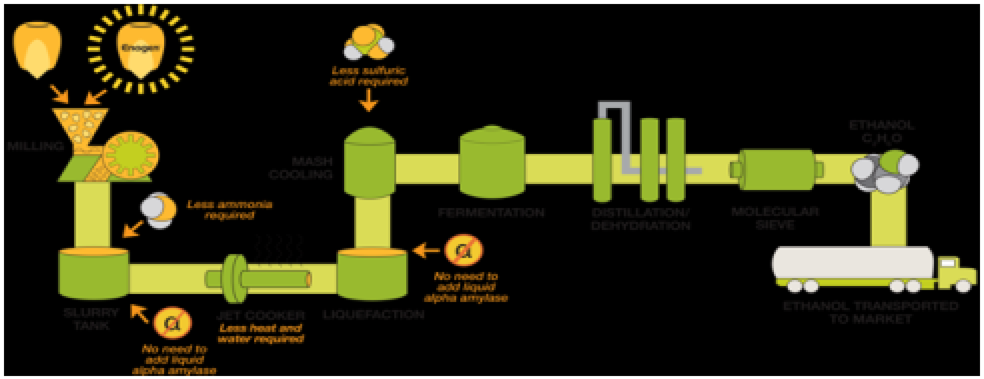
GE Crop Traits
Medicinal Uses

Tobacco plants used to create the experimental treatment given to the two U.S. patients infected with Ebola at the KBP facilities in Kentucky. Courtesy of Kentucky BioProcessing

	Farmers
X	Consumers
	Environment
X	Needy

GE Crop Traits

Industrial Uses - Biofuels



Enogen corn, developed by Syngenta, contains a microbial gene that causes it to produce an enzyme (alpha amylase) that breaks down corn starch into sugar, the first step toward making ethanol.

Genetically Modified Trees Could Clean Up Paper Industry

By Carl Engelking | April 4, 2014 1:28 pm

353

100 million gallon/year plant can save:

- **450,000 gallons of water**
- **1.3 million KWh of electricity**
- **244 billion BTUs of natural gas**

- **reducing carbon dioxide emissions by 106 million pounds**

	Farmers
X	Consumers
X	Environment
	Needy

GE Crop Traits
Industrial Uses - Biofuels

MCFA: C6:0-C14:0 fatty acids

Jet fuel specifications and conversion of oil to alkanes is most efficient and economical with saturated C12-C14 fatty acids

Detergents, cosmetics, lubricants and applications in food industry

Designing jet fuels of the future

Date posted: February 3, 2012

Roger Winstead photo

Drs. Heike Sederoff and Amy Grunden look to extremophile genes to enhance oil production in marine algae and an oilseed crop.

Using micro-organisms able to survive in some of the most extreme environments on Earth, two CALS researchers are working to turn plants and algae into oil-producing factories efficient enough to help solve the problem of the world's diminishing petroleum reserves.

Drs. Amy Grunden and Heike Sederoff have spent the past two years working on ways to make the microscopic marine algae *Dunaliella* produce more fatty acids that can be processed into fuels, and they recently won a grant to find ways to make camelina, an oilseed crop, more suitable for North Carolina's growing conditions.

With federal stimulus funding awarded through the National Science Foundation, Grunden, associate professor

X	Farmers
	Consumers
X	Environment
	Needy

GE Crop Traits

Toxin removal

Plant Mol Biol. 2004 Nov;56(4):661-9.

Engineering cyanogen synthesis and turnover in cassava (Manihot esculenta).

Siritunga D[1], Sayre R.

⊕ Author information

Abstract

Cassava is the major root crop for a quarter billion subsistence farmers in sub-Saharan Africa. It is valued for its ability to grow in adverse environments and the food security it provides. Cassava contains potentially toxic levels of cyanogenic glycosides (linamarin) which protect the plant from herbivory and theft. The cyanogens, including linamarin and its deglycosylated product, acetone cyanohydrin, can be efficiently removed from the root by various processing procedures. Short-cuts in processing, which may occur during famines, can result in only partial removal of cyanogens. Residual cyanogens in cassava foods may cause neurological disorders or paralysis, particularly in nutritionally compromised individuals. To address this problem and to further understand the function of cyanogenic glycosides in cassava, we have generated transgenic cassava in which cyanogenic glycoside synthesis has been selectively inhibited in leaves and roots by antisense expression of CYP79D1/D2 gene fragments. The CYP79D1/D2 genes encode two highly similar cytochrome P450s that catalyze the first-dedicated step in cyanogenic glycoside synthesis. Transgenic plants in which the expression of these genes was selectively inhibited in leaves had substantially reduced (60- 94% reduction) linamarin leaf levels. Surprisingly, these plants also had a greater than a 99% reduction in root linamarin content. In contrast, transgenic plants in which the CYP79D1/D2 transcripts were reduced to non-detectable levels in roots had normal root linamarin levels. These results demonstrate that linamarin synthesized in leaves is transported to the roots and accounts for nearly all of the root linamarin content. Importantly, transgenic plants having reduced leaf and root linamarin content were unable to grow in the absence of reduced nitrogen (NH_3) . Cassava roots have previously been demonstrated to have an active cyanide assimilation pathway leading to the synthesis of amino acids. We propose that cyanide derived from linamarin is a major source of reduced nitrogen for cassava root protein synthesis. Disruption of linamarin transport from leaves in CYP79D1/D2 anti-sense plants prevents the growth of cassava roots in the absence of an alternate source of reduced nitrogen. An alternative strategy for reducing cyanogen toxicity in cassava foods is to accelerate cyanogenesis and cyanide volatilization during food processing. To achieve this objective, we have expressed the leaf-specific enzyme hydroxynitrile lyase (HNL) in roots. HNL catalyzes the breakdown of acetone cyanohydrin to cyanide. Expression of HNL in roots accelerated cyanogenesis by more than three-fold substantially reducing the accumulation of acetone cyanohydrin during processing relative to wild-type roots.

PMID: 15630626 [PubMed - indexed for MEDLINE]

	Farmers
X	Consumers
	Environment
X	Needy

http://www.sciencedaily.com/releases/2003/05/030514080833.htm

GE Crop Traits

Toxin removal

Transgenic Research
June 2006, Volume 15, Issue 3, pp 277–289

Mycotoxin Reduction in Bt Corn: Potential Economic, Health, and Regulatory Impacts

Authors Authors and affiliations

Felicia Wu

Article
Received: 01 July 2005
Accepted: 16 November 2005
DOI: 10.1007/s11248-005-5237-1

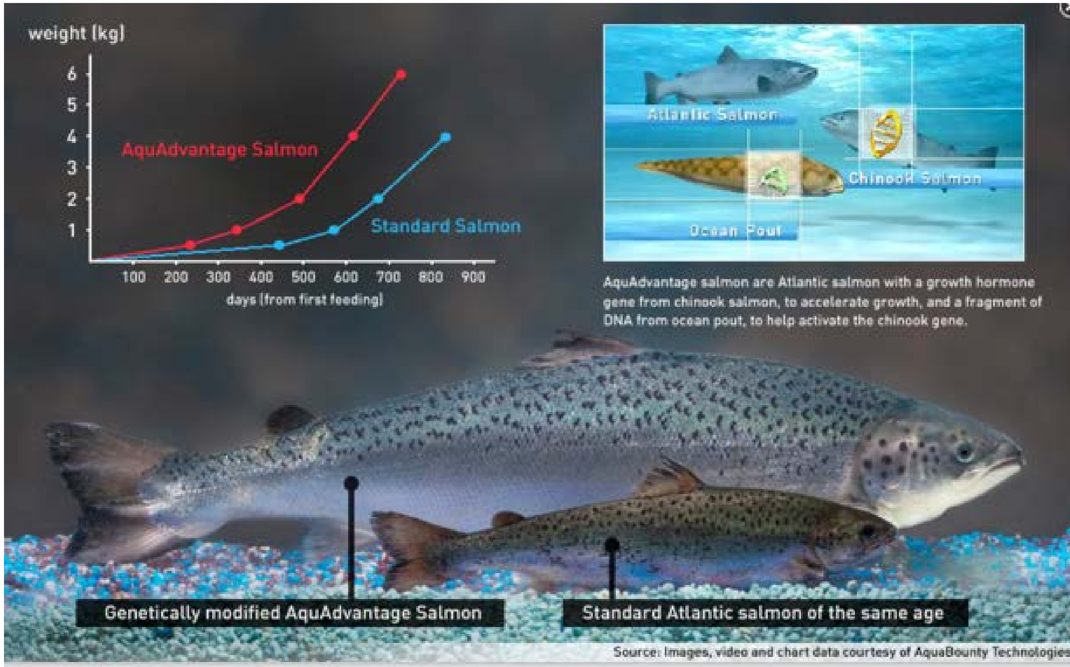
Cite this article as:
Wu, F. Transgenic Res (2006) 15: 277. doi:10.1007/s11248-005-5237-1

Abstract

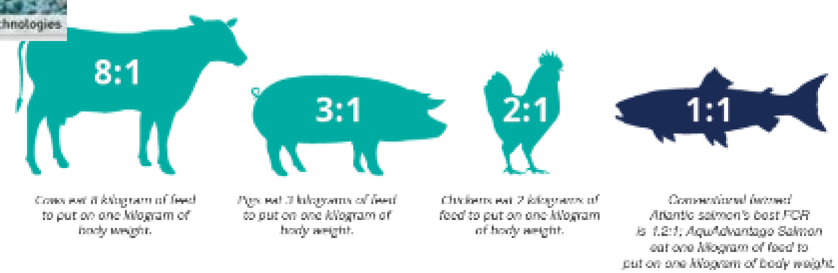
Genetically modified (GM) Bt corn, through the pest protection that it confers, has lower levels of mycotoxins: toxic and carcinogenic chemicals produced as secondary metabolites of fungi that colonize crops. In some cases, the reduction of mycotoxins afforded by Bt corn is significant enough to have an economic impact, both in terms of domestic markets and international trade. In less developed countries where certain mycotoxins are significant contaminants of food, Bt corn adoption, by virtue of its mycotoxin reduction, may even improve human and animal health. This paper describes an integrated assessment model that analyzes the economic and

	Farmers
X	Consumers
	Environment
X	Needy

GE Livestock Traits
Improved metabolism



X	Farmers
X	Consumers
X	Environment
X	Needy



GE Livestock Traits

Improved metabolism

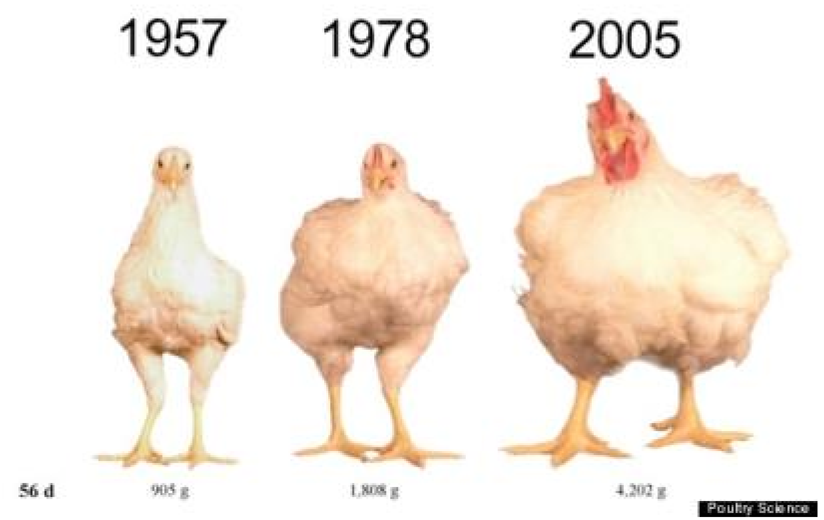
Chronology of AquAdvantage® Salmon and AquaBounty Technologies

1989

- Initial R&D with transgenic salmon begins at Memorial University of Newfoundland.
- Canadian researchers create the AquAdvantage® transgene (genetic construct) which expresses Chinook salmon growth hormone under the control of an Ocean Pout promoter.
- The founder animal from which the AquAdvantage® line was derived was created by microinjection of the transgene into fertilized eggs of wild Atlantic salmon.

1992

- AquAdvantage® Salmon is established from the F1 generation of the EO-1α line.



GE Livestock Traits

Improved metabolism

Enviropig™

The Enviropig™ is a genetically enhanced line of Yorkshire pigs with the capability of digesting plant phosphorus more efficiently than conventional Yorkshire pigs. These pigs produce the enzyme phytase in the salivary glands that is secreted in the saliva. When cereal grains are consumed, the phytase mixes with the feed as the pig chews. Once the food is swallowed, the phytase enzyme is active in the acidic environment of the stomach, degrading indigestible phytate in the feed that accounts for 50 to 75% of the grain phosphorus.

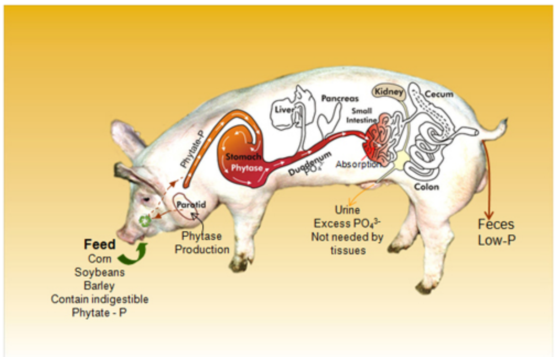


Figure 1. Phytase produced in the salivary glands and secreted in the saliva increases the digestion of phosphorus contained in feed grains.

Since the Enviropig™ is able to digest cereal grain phosphorus there is no need to supplement the diet with either mineral phosphate or commercially produced phytase, and there is less phosphorus in the manure. When the phosphorus depleted manure is spread on land in areas of intense swine production there is less potential of phosphorus to leach into freshwater ponds, streams and rivers. Because phosphorus is the major nutrient enabling algal growth that is the leading cause of fish kills resulting from anoxic conditions, and reduced water quality, the low phosphorus manure from Enviropigs has a reduced environmental impact in areas where soil phosphorus exceeds desirable levels. Therefore the enviropig biotechnology has two beneficial attributes, it reduces feed cost and reduces the potential of water pollution. Furthermore, the technology is simple, if you know how to raise pigs, you know how to raise Enviropigs!

X	Farmers
	Consumers
X	Environment
X	Needy

GE Crop Traits

Improved metabolism

Biotechnol Biofuels. 2015; 8: 175. PMCID: PMC4625952
Published online 2015 Oct 29. doi: 10.1186/s13068-015-0357-1

A photorespiratory bypass increases plant growth and seed yield in biofuel crop *Camelinasativa*

Jyoti Dalal,[✉] Harry Lopez, Naresh B. Vasani, Zhaohui Hu, Jennifer E. Swift, Roopa Yalamanchili, Mia Dvora, Xiuli Lin, Deyu Xie, Rongda Qu, and Heike W. Sederoff[✉]

Author information ▶ Article notes ▶ Copyright and License information ▶

Abstract

Go to:

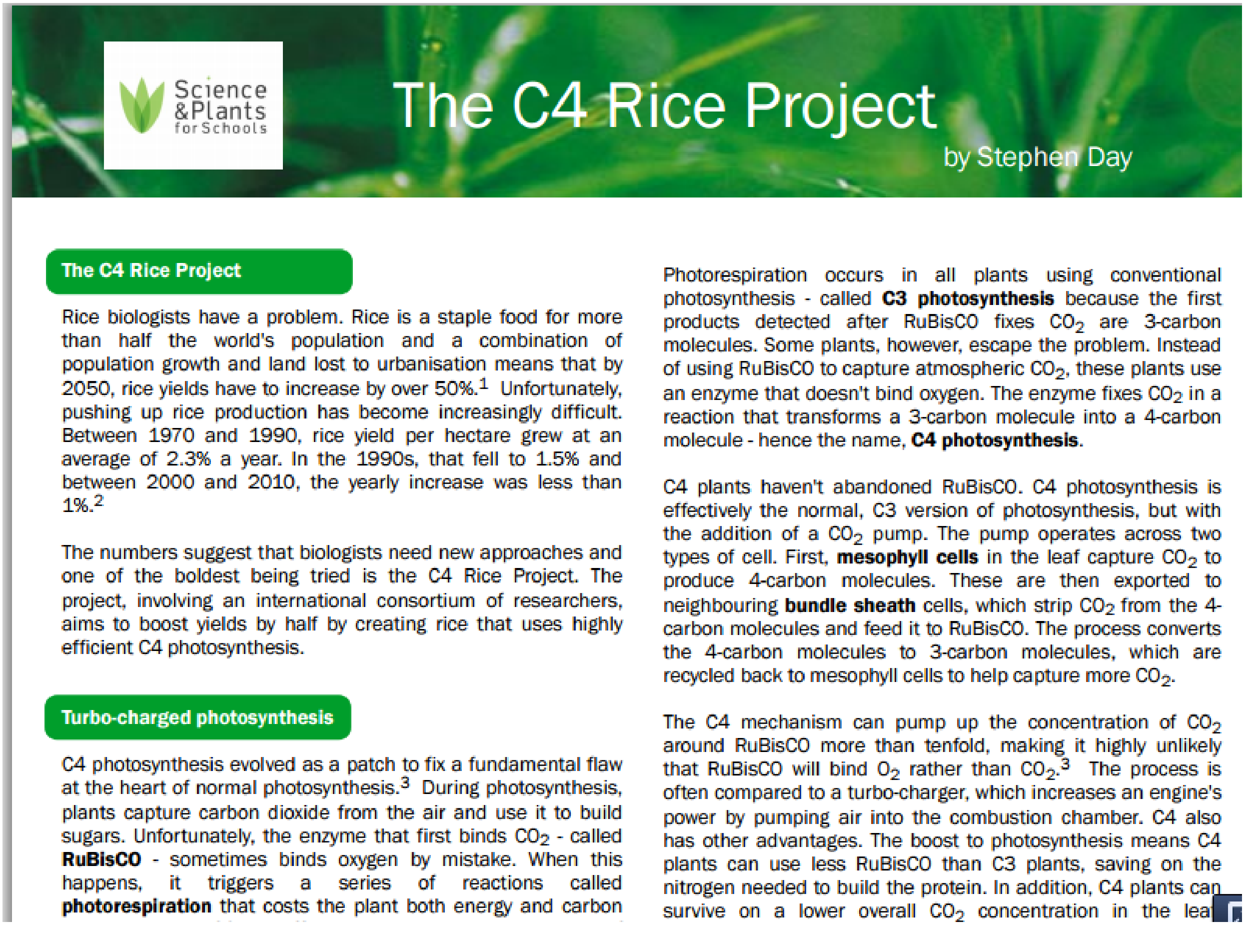
Background

Camelina sativa is an oilseed crop with great potential for biofuel production on marginal land. The seed oil from camelina has been converted to jet fuel and improved fuel efficiency in commercial and military test flights. Hydrogenation-derived renewable diesel from camelina is environmentally superior to that from canola due to lower agricultural inputs, and the seed meal is FDA approved for animal consumption. However, relatively low yield makes its farming less profitable. Our study is aimed at increasing camelina seed yield by reducing carbon loss from photorespiration via a photorespiratory bypass. Genes encoding three enzymes of the *Escherichia coli* glycolate catabolic pathway were introduced: glycolate dehydrogenase (GDH), glyoxylate carboxyligase (GCL) and tartronic semialdehyde reductase (TSR). These enzymes compete for the photorespiratory substrate, glycolate, convert it to glycerate within the chloroplasts, and reduce photorespiration. As a by-product of the reaction, CO_2 is released in the chloroplast, which increases

X	Farmers
	Consumers
	Environment
X	Needy

GE Crop Traits

Improved metabolism


Science &Plants for Schools

The C4 Rice Project

by Stephen Day

The C4 Rice Project

Rice biologists have a problem. Rice is a staple food for more than half the world's population and a combination of population growth and land lost to urbanisation means that by 2050, rice yields have to increase by over 50%.[1] Unfortunately, pushing up rice production has become increasingly difficult. Between 1970 and 1990, rice yield per hectare grew at an average of 2.3% a year. In the 1990s, that fell to 1.5% and between 2000 and 2010, the yearly increase was less than 1%.[2]

The numbers suggest that biologists need new approaches and one of the boldest being tried is the C4 Rice Project. The project, involving an international consortium of researchers, aims to boost yields by half by creating rice that uses highly efficient C4 photosynthesis.

Turbo-charged photosynthesis

C4 photosynthesis evolved as a patch to fix a fundamental flaw at the heart of normal photosynthesis.[3] During photosynthesis, plants capture carbon dioxide from the air and use it to build sugars. Unfortunately, the enzyme that first binds CO_2 - called **RuBisCO** - sometimes binds oxygen by mistake. When this happens, it triggers a series of reactions called **photorespiration** that costs the plant both energy and carbon

Photorespiration occurs in all plants using conventional photosynthesis - called **C3 photosynthesis** because the first products detected after RuBisCO fixes CO_2 are 3-carbon molecules. Some plants, however, escape the problem. Instead of using RuBisCO to capture atmospheric CO_2, these plants use an enzyme that doesn't bind oxygen. The enzyme fixes CO_2 in a reaction that transforms a 3-carbon molecule into a 4-carbon molecule - hence the name, **C4 photosynthesis**.

C4 plants haven't abandoned RuBisCO. C4 photosynthesis is effectively the normal, C3 version of photosynthesis, but with the addition of a CO_2 pump. The pump operates across two types of cell. First, **mesophyll cells** in the leaf capture CO_2 to produce 4-carbon molecules. These are then exported to neighbouring **bundle sheath** cells, which strip CO_2 from the 4-carbon molecules and feed it to RuBisCO. The process converts the 4-carbon molecules to 3-carbon molecules, which are recycled back to mesophyll cells to help capture more CO_2.

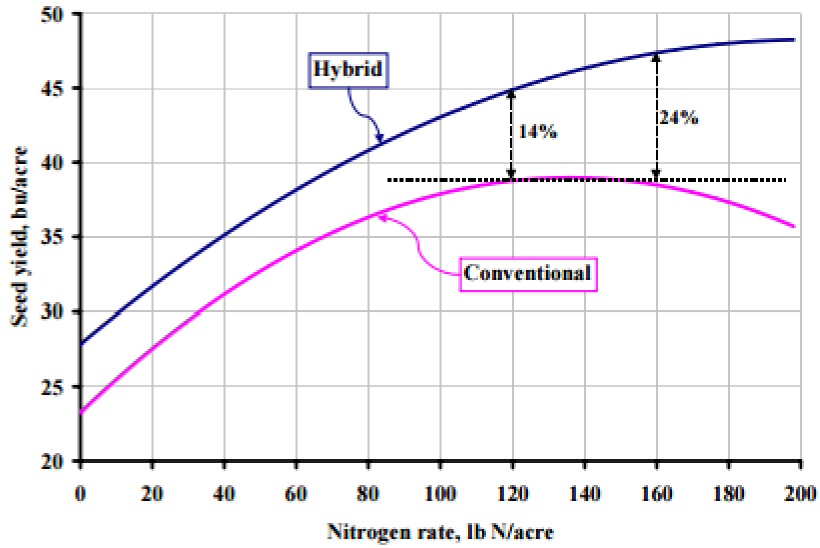
The C4 mechanism can pump up the concentration of CO_2 around RuBisCO more than tenfold, making it highly unlikely that RuBisCO will bind O_2 rather than CO_2.[3] The process is often compared to a turbo-charger, which increases an engine's power by pumping air into the combustion chamber. C4 also has other advantages. The boost to photosynthesis means C4 plants can use less RuBisCO than C3 plants, saving on the nitrogen needed to build the protein. In addition, C4 plants can survive on a lower overall CO_2 concentration in the lea

X	Farmers
	Consumers
X	Environment
X	Needy

GE Crop Traits

Improved breeding

Hybrid varieties for self-pollinated crops

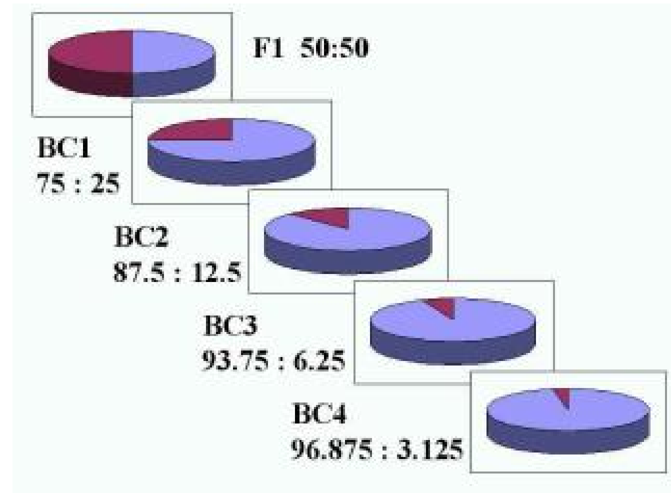


Comparison of overall yield obtained for canola hybrids to that of conventional canola cultivars based on applied N rates (Westco 17 site-years; 1999-2002).

http://www.brettyoung.ca/images/file/Hybrid%20vs%20Conventional%20Fertility.pdf

X	Farmers
	Consumers
	Environment
X	Needy

GE Crop Traits
Improved breeding



X	Farmers
	Consumers
	Environment
X	Needy

RNA interference (RNAi)

X	Farmers
	Consumers
X	Environment
X	Needy

Ornamentals

/ ISAAA / Resources / Publications / Pocket K / Biotechnology in Ornamental Plants

Foldable Version (PDF)

English

Document Version (PDF)

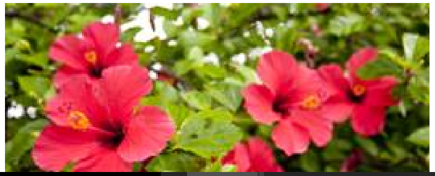
English

Pocket K No. 47: Biotechnology in Ornamental Plants

Ornamental plants are grown for decoration, rather than food or raw materials. They are most often intentionally planted for aesthetic appeal. However, ornamental plants also serve some less obvious uses such as for fragrance, for attracting wildlife and for cleaning the air.[1] Ornamentals encompass a wide array of plants and are classified into several groups: cutflowers, ornamental grasses, lawn or turf grasses, potted and indoor plants, bedding plants, trees and shrubs.

Cutflowers are those cut from the plant, thorns trimmed, and ready to be used in fresh flower arrangements. Common cutflowers include roses, carnations, chrysanthemums, tulips, lilies and gerberas.[2] **Ornamental grasses** are allowed to grow to its full potential and are used in the landscape in the same way as perennials or other ornamental plants. These include the sedges, rushes, restios, and cat-tails.[3] **Lawn or turf grasses** are perennial grasses or creeping legumes that ensure a complete cover of the ground as desired in places like private lawns, golf courses and sporting fields.[4]

Potted and indoor plants are grown in residences and offices for decorative purposes, positive psychological effects, or health reasons such as indoor air purification. Common potted plants are bonsais, cacti, Dracaena, Ficus, poinsettia, and bromeliads.[4] Bedding plants are grown, usually in quantity, in pots or flats in greenhouses and are intended to be transplanted to a flower garden, hanging basket, window box, or other outdoor planters. Some important bedding plants are impatiens, marigolds, and petunias.[5]



Trees and Shrubs are cultivated for gardens and landscaping. Ornamental trees include cherry blossoms, cedar, mulberry and different palms. Meanwhile, ivy, lavender, magnolia, Hibiscus and Ficus species are the most common ornamental shrubs.[4]

X	Farmers
X	Consumers
X	Environment
	Needy

RNA interference (RNAi)

Large-Scale Field Application of RNAi Technology Reducing Israeli Acute Paralysis Virus Disease in Honey Bees (*Apis mellifera*, Hymenoptera: Apidae)

Wayne Hunter, James Ellis, Dennis vanEngelsdorp, Jerry Hayes, Dave Westervelt, Eitan Glick, Michael Williams, Ilan Sela, Eyal Maori, Jeffery Pettis, Diana Cox-Foster, Nitzan Paldi

Published: December 23, 2010 • http://dx.doi.org/10.1371/journal.ppat.1001160

Article | **Authors** | **Metrics** | **Comments** | **Related Content**

Abstract

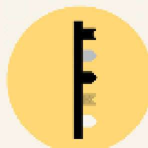
The importance of honey bees to the world economy far surpasses their contribution in terms of honey production; they are responsible for up to 30% of the world's food production through pollination of crops. Since fall 2006, honey bees in the U.S. have faced a serious population decline, due in part to a phenomenon called Colony Collapse Disorder (CCD), which is a disease syndrome that is likely caused by several factors. Data from an initial study in which investigators compared pathogens in honey bees affected by CCD suggested a putative role for Israeli Acute Paralysis Virus, IAPV. This is a single stranded RNA virus with no DNA stage placed taxonomically within the family Dicistroviridae. Although subsequent studies have failed to find IAPV in all CCD diagnosed colonies, IAPV has been shown to cause honey bee mortality. RNA interference technology (RNAi) has been used successfully to silence

X	Farmers
	Consumers
X	Environment
X	Needy

RNA interference (RNAi)

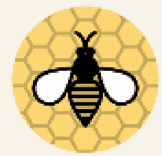
RNAI VERSUS THE BEE KILLER

A technique called RNA interference can alter how genes make proteins —and possibly fight pests like the varroa mite. —*Jennifer Chaussee*

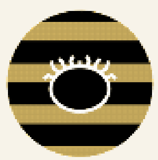


To create the proteins for, say, a functional immune system, cells use single strands of genetic material called messenger RNA. The exact sequence for this mRNA is different for each protein.

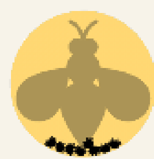
RNA interference happens naturally in cells: A strand of RNA attaches itself to the mRNA, breaking it up and interrupting the protein-making process.



Scientists can induce RNA interference—or RNAi—by feeding bees sugar syrup laced with RNA coded to attack the mRNA for specific proteins in a varroa mite. (The bee, with different genes, isn't harmed.)



When a mite sucks the hemolymph—bee blood, basically—the synthetic RNA enters the mite's system and attacks the mRNA it uses to produce the proteins that help it breathe, eat, or reproduce.



Without the necessary mRNA, the mite can't produce all the proteins it needs to live. Bye-bye, bug.

Who benefits most from crop biotech (GMO)?

Table 2 Average impact on yield, by technology, for developed and developing countries

Technology	Difference in yield (%)	Number of results	Minimum (%)	Maximum (%)	Standard error of the mean (%)
Developed countries	6	59	–12	26	1.0
Herbicide-tolerant cotton	0	6	–12	17	3.8
Herbicide-tolerant soybean	7	14	0	20	1.7
Herbicide-tolerant and insect-resistant cotton	3	2	–3	9	5.8
Insect-resistant corn	4	13	–3	13	1.6
Insect-resistant cotton	7	24	–8	26	1.9
Developing countries	29	107	–25	150	2.9
Herbicide-tolerant corn	85	1			
Herbicide-tolerant soybean	21	3	0	35	11
Insect-resistant corn	16	12	0	38	4
Insect-resistant corn (white)	22	9	0	62	6.9
Insect-resistant cotton	30	82	–25	150	3.5

Yield difference for adopters was calculated as (GM yield – conventional yield)/conventional yield, averaging yields across surveys, geographies, years and methodologies. The difference in the number of results reported in Tables 1 and 2 is due to two results reported as 'positive' with no numerical value. A two-tailed *t*-test shows a significant difference between the average yields of developed and developing countries ($t = 7.48$, df = 134, $P < 0.0005$).

http://www.nature.com/nbt/journal/v28/n4/pdf/nbt0410-319.pdf

Who benefits most from crop biotech (GMO)?

Developing Countries

Why are all the GMO traits aimed at increasing production rather than adding value to nutrition of foods or other health benefits?

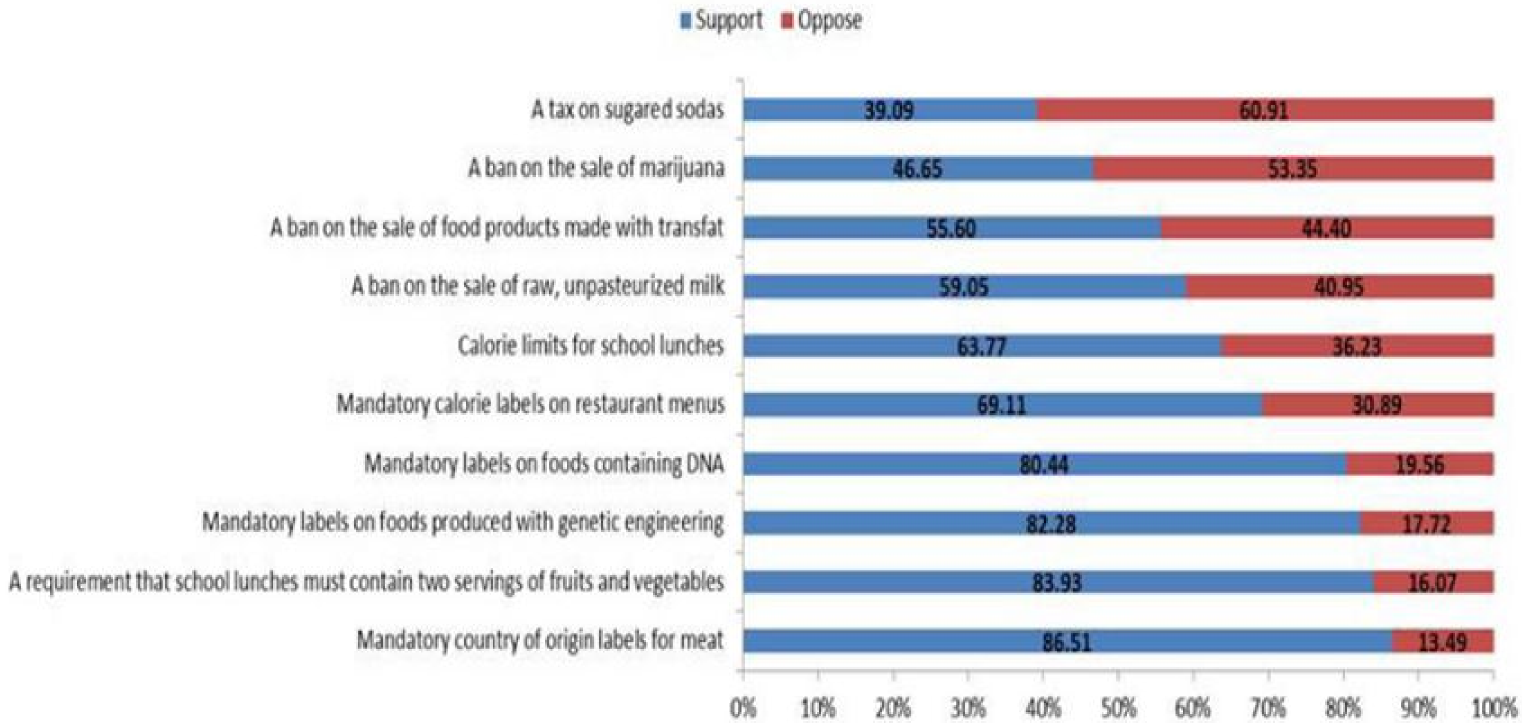
Risings costs, lengthening review periods and pervasive uncertainty about which technologies will be acceptable in different markets have dampened revenues and investments and lowered the potential for plant biotechnology to contribute to global food security. **The costs for regulatory testing and registration process in 2011 was about 35.1 million dollars.**

Peter W.B. Phillips Distinguished Professor at the Johnson-Shoyama Graduate School of Public Policy at University of Saskatchewan, Canada
https://croplife.org/wp-content/uploads/2014/04/Getting-a-Biotech-Crop-to-Market-Phillips-McDougall-Study.pdf

Why are all the GMO traits aimed at increasing production rather than adding value to nutrition of foods or other health benefits?

- **Farmer will pay for technology**
- **Will consumers accept and be willing to pay for technology?**
- **Increased nutritional benefits constitute a material difference and will have to be labeled**

Why are all the GMO traits aimed at increasing production rather than adding value to nutrition of foods or other health benefits?

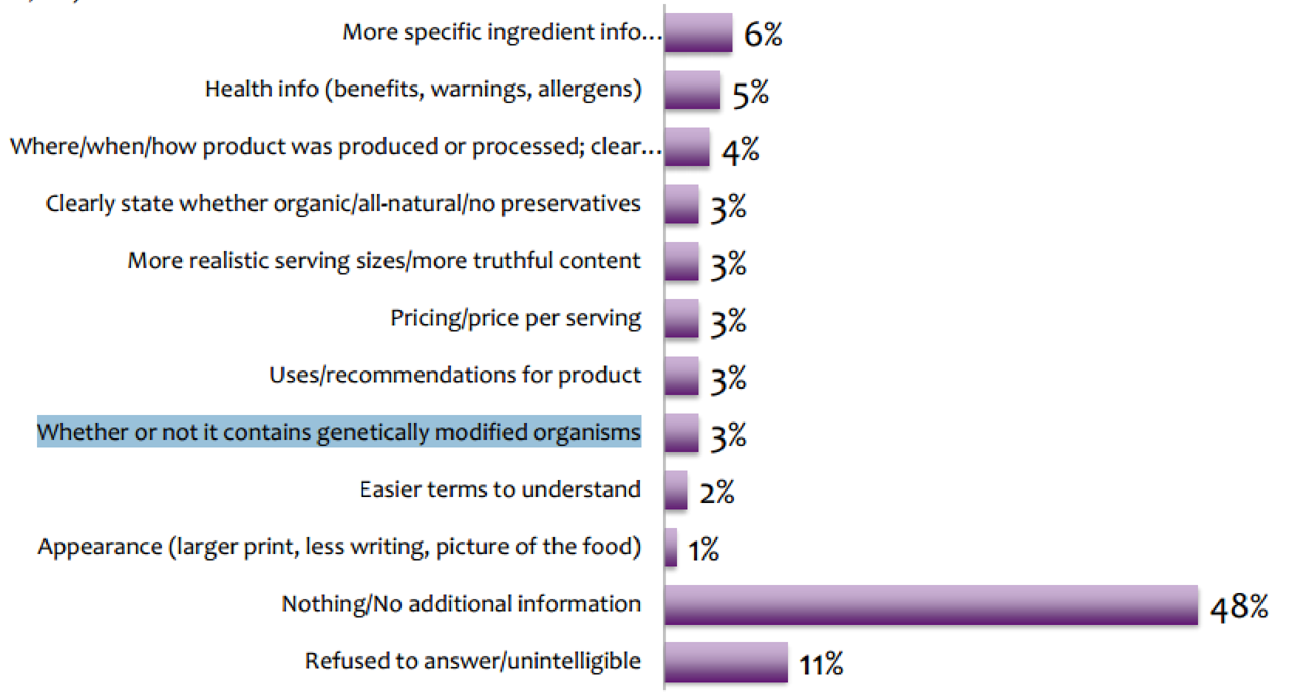


Source: Food Demand Survey (FooDS), Oklahoma State University, 2015
http://agecon.okstate.edu/faculty/publications/4975.pdf

Few Americans feel any additional information is needed on food packages.

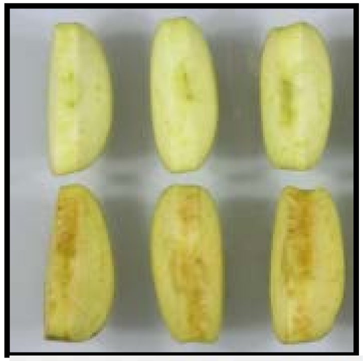
What other information that is not currently on the food package, if any, would you like to see there? Top responses to open-ended question

2013 All (n=1,006)



International Food Information Council Foundation
2013 Food & Health Survey

Why are all the GMO traits aimed at increasing production rather than adding value to nutrition of foods or other health benefits?




Plant Biotechnology Journal

Alleviating peanut allergy using genetic engineering: the silencing of the immunodominant allergen Ara h 2 leads to its significant reduction and a decrease in peanut allergenicity

Summary


Purple Tomatoes Go GMO to Cure Cancer

Researchers at John Innes Centre in the UK have used successfully created a purple tomato by using genes from the common snapdragon flowering plant. Tomatoes natively possess the genes required to make themselves purple but normally these genes lie dormant. By inserting borrowed genes from the snapdragon plant, the researchers engineered the tomato to activate the usually dormant genes. The tomato plant was designed intelligently with promoter sections of DNA inserted in front of the snapdragon genes, so that the tomato plant would only turn its ripening fruits purple and not its leaves.

Are “GMO’s“ safe?

Are “GMO’s“ less healthy?

Current U.S. Regulatory Context
The Coordinated Framework

Three regulatory agencies have oversight
for biotechnology products under existing legislation

USDA

- Plants and seeds
- Animal biologics
- Meat and poultry

FDA

- Food and feed
- Human biologics
- Drugs
- GE animals
- Medical devices

EPA

- Plant Pesticides (PIPs)
- Herbicides
- Chemicals and microbials

Shipping	Public Health	'Pesticidal' Substances
Plant/Animal Protection Acts	Food Drug Cosmetic Act	FIFRA

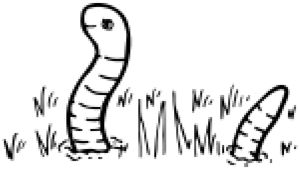
NEPA

Categories of safety assessments for GMO's

- Molecular Characterization
- Protein Characterization/Food & Feed safety
- Agronomic and Compositional Equivalence
- Environmental safety

Plant Incorporated Protectants (PIP) Ecotoxicological Studies

- Collembola
- Honeybee
- Fish
- Daphnia
- Avian
- Ladybeetle
- Soil Stability
- Earthworm
- Lacewing



Are non-GMO foods necessarily more healthy?

Food and Chemical Toxicology

Volume 50, Issues 3–4, March–April 2012, Pages 1134–1148

Review

Assessment of the health impact of GM plant diets in long-term and multigenerational animal feeding trials: A literature review

Chelsea Snell[a], Aude Bernheim[b], Jean-Baptiste Bergé[c], Marcel Kuntz[d], Gérard Pascal[e], Alain Paris[f], Agnès E. Ricroch[b]

Show more

DOI: 10.1016/j.fct.2011.11.048

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Abstract

The aim of this systematic review was to collect data concerning the effects of diets containing GM maize, potato, soybean, rice, or triticale on animal health. We examined 12 long-term studies (of more than 90 days, up to 2 years in duration) and 12 multigenerational studies (from 2 to 5 generations). We referenced the 90-day studies on GM feed for which long-term or multigenerational study data were available. Many parameters have been examined using biochemical analyses, histological examination of specific organs, hematology and the detection of transgenic DNA. The statistical findings and methods have been considered from each study. Results from all the 24 studies do not suggest any health hazards and, in general, there were no statistically significant differences within parameters observed. However, some small differences were observed, though these fell within the normal variation range of the considered parameter and thus had no biological or toxicological significance. If required, a 90-day feeding study performed in rodents, according to the OECD Test Guideline, is generally considered sufficient in order to evaluate the health effects of GM feed. The studies reviewed present evidence to show that GM plants are nutritionally equivalent to their non-GM counterparts and can be safely used in food and feed.

http://www.sciencedirect.com/science/article/pii/S0278691511006399

Are non-GMO foods necessarily more healthy?

European Commission - A decade of EU-funded GMO research

The main conclusion to be drawn from the efforts of more than 130 research projects, covering a period of more than 25 years of research, and involving more than 500 independent research groups, is that biotechnology, and in particular GMOs, are not per se more risky than e.g. conventional plant breeding technologies.

https://ec.europa.eu/research/biosociety/pdf/a_decade_of_eu-funded_gmo_research.pdf

Are non-GMO foods necessarily more healthy?

Europe (87)

Czech Republic	Biology Centre of the Academy of Sciences of the Czech Republic	White Book: Genetically Modified Crops (2009)
France	French Academy of Sciences	Genetically Modified Plants (2002)
Germany	National Academy of Sciences (Leopoldina) | German Academy of Science and Engineering (acatech) | Berlin-Brandenburg Academy of Sciences and Humanities	In support of a new policy on Green Genetic Engineering (2009)
Germany	Union of the German Academies of Science and Humanities (8 academies)	Are There Health Hazards for the Consumer from Eating Genetically Modified Food? (2006)
Germany	Federal Ministry of Education and Research	BMBF Research Programme: Biological safety research on genetically modified organisms (2014)
Italy	National Academy of Science | Lincean Academy	Plant biotechnology and GMO variety (2007)
Italy	Joint statement of 14 scientific intitutions of Italy	Food safety and GMOs. Consensus Document (2004)
Italy	Joint statement of 21 scientific intitutions of Italy	Coexistence of Traditional, Organic and Genetically Modified Crops (2006)
Netherlands	Plant Research International – Wageningen UR	Sustainability of current GM crop cultivation (2011)
Spain	Declaration promoted by the Spanish Bioindustry Association (ASEBIO) and signed by more than 150 Spanish scientists from different universities and research institutes.	Science, progress and environment (2007)
Spain	Declaration promoted by the National Association of Plant Breeders (ANOVE) and signed by 14 Spanish institutions	Press release (2010)

United Kingdom	Royal Society of London	Transgenic Plants and World Agriculture (2000) | Genetically modified plants for food use and human health—an update (2002) | Reaping the benefits: Science and the sustainable intensification of global agriculture (2009)
United Kingdom	Royal Society of Medicine	Genetically modified plants and human health (2008)
United Kingdom	Royal Society of Edinburgh	RSE Calls for a Rational GM Debate (2015)
United Kingdom	Biochemical Society UK	Genetically Modified Crops, Feed and Food: A Biochemical Society position statement (2011)
United Kingdom	British Medical Association	Genetically modified foods and health: a second interim statement (2004)
United Kingdon	Letter signed by 32 scientific and agricultural institutions	Letter to Scottish Government from research organisations (2015)
United Kingdon	Science and Technology Committee – House of Commons (UK)	EU regulation on GM Organisms not 'fit for purpose' (2015)
Vatican	Pontifical Academy of Sciences	Transgenic Plants for Food Security in the Context of Development (2010)
European Union	European Commission	*A Decade of EU Funded GMO Research* (2010)
European Union	European Academies Science Advisory Council (EASAC)	Planting the future: opportunities and challenges for using crop genetic improvement technologies for sustainable agriculture (2013)

https://ec.europa.eu/research/biosociety/pdf/a_decade_of_eu-funded_gmo_research.pdf

Are non-GMO foods necessarily more healthy?

North America (22)

Canada	Royal Society of Canada	Elements of Precaution: Recommendations for the Regulation of Food Biotechnology in Canada (2001)
Canada	Health Canada	Safety Assessment of Genetically Modified Foods (Undated)
USA	National Academy of Sciences (NAS)	Transgenic Plants and World Agriculture (2000) | Impact of Genetically Engineered Crops on Farm Sustainability in the United States (2010)
USA	Institute of Medicine (IOM) & National Research Council (NRC) of the National Academies.	Safety of Genetically Engineered Foods: Approaches to Assessing Unintended Health Effects (2004)
USA	National Academies (IOM, NRC, NAS, NAE)	A Science-Based Look at Genetically Engineered Crops (The study will be ready in 2016)
USA	American Medical Association (AMA)	Council on Science and Public Health Report (2012)
USA	American Association for the Advancement of Science (AAAS)	Statement by the AAAS Board of Directors On Labeling of Genetically Modified Foods (2012)
USA	American Council of Science and Health (ACSH)	Biotechnology and Food (Second Edition) (2000)
USA	Society of Toxicology (SOT)	The Safety of Genetically Modified Foods Produced through Biotechnology (2003)
USA	American Dietetic Association	Position of the American Dietetic Association: Agricultural and food biotechnology (2006)
USA	Genetics Society of America	Assessing Benefits and Risks of Genetically Modified Organisms (2001)
USA	American Society for Cell Biology (ASCB)	ASCB Statement in Support of Research on Genetically Modified Organisms (2009)

USA	American Society for Microbiology (ASM)	Statement of the American Society for Microbiology on Genetically Modified Organisms (2000)
USA	American Phytopathological Society (APS)	APS Statement on Biotechnology and its Application to Plant Pathology (2001)
USA	Society for In Vitro Biology (SIVB)	Position Statement on Crop Engineering (Undated)
USA	Crop Science Society of America	CSSA Perspective on Biotechnology (2001)
USA	Council for Agricultural Science and Technology (CAST)	Crop Biotechnology and the Future of Food: A Scientific Assessment (2005)
USA	Federation of Animal Sciences Societies (FASS) – *representing the American Dairy Science Association (ADSA), American Society of Animal Science (ASAS) and the Poultry Science Association (PSA).*	FASS Facts On Biotech Crops – Impact on Meat, Milk and Eggs (2001)
USA	Food and Drug Administration (FDA)	Questions & Answers on Food from Genetically Engineered Plants (2015)

https://ec.europa.eu/research/biosociety/pdf/a_decade_of_eu-funded_gmo_research.pdf

Are non-GMO foods necessarily more healthy?

FOOD FOR THOUGHT

Why Did Vitamins Disappear From Non-GMO Breakfast Cereal?

December 5, 2014 · 3:50 PM ET

DAN CHARLES

When they actually arrived on supermarket shelves, though, there was a mysterious change in their list of ingredients. Four vitamins that previously had been added to Grape-Nuts — vitamins A, D, B-12 and B-2 (also known as riboflavin) — were gone. Riboflavin vanished from Cheerios.

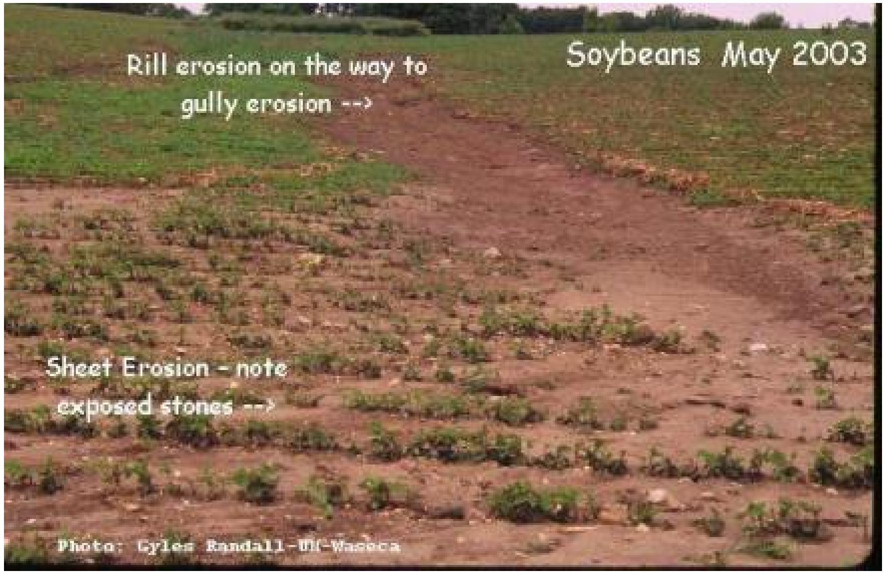
Are non-GMO foods necessarily more healthy?

Do GMOs contribute to monoculture?

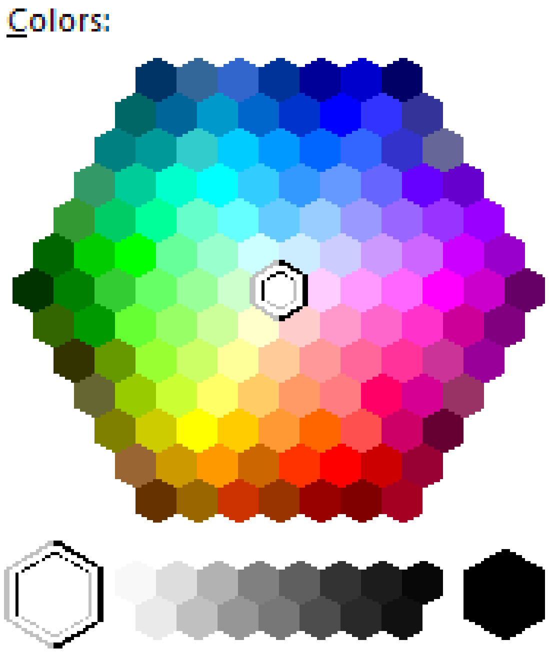
Why do most farmers use GMOs?

My Background with Biotechnology

My Background with Biotechnology



My Background with Biotechnology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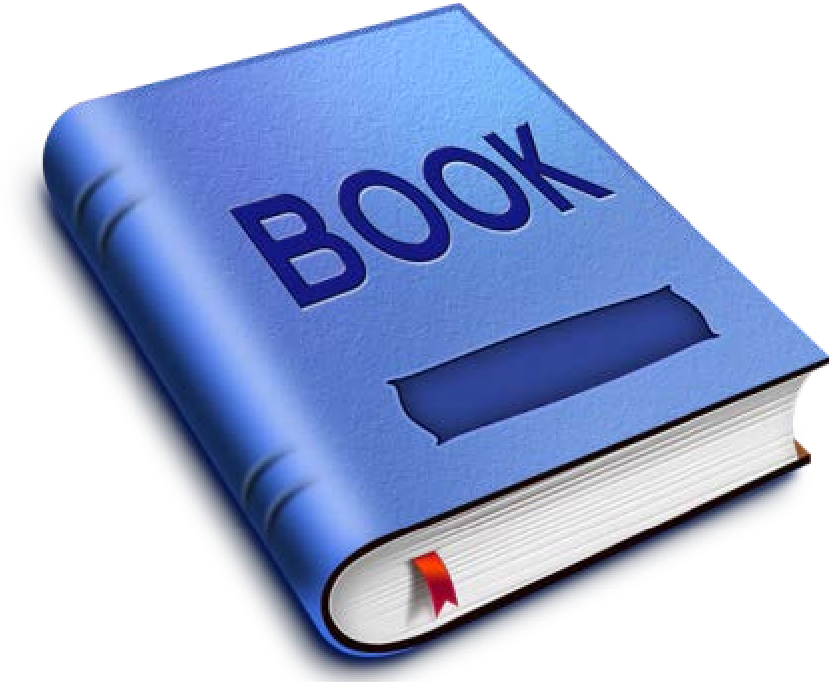
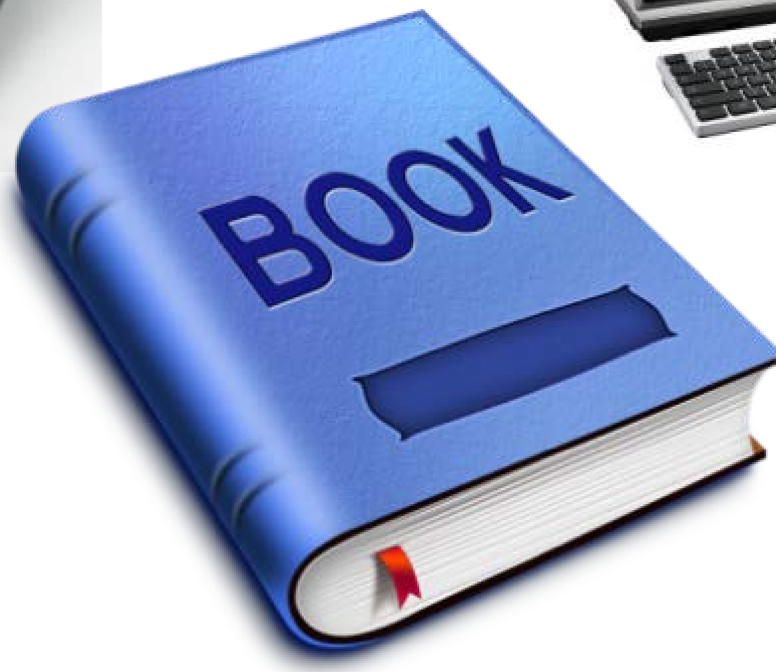
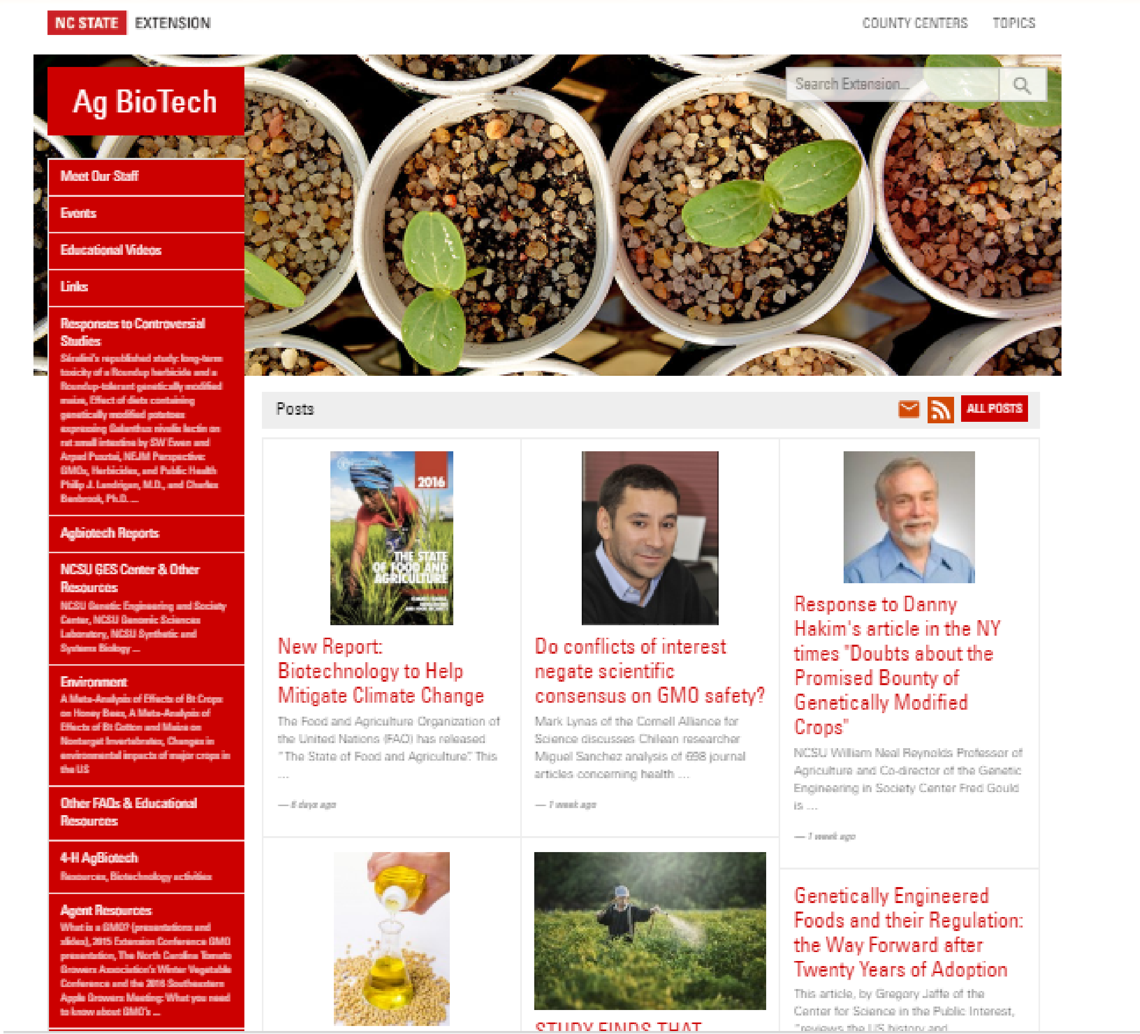

BOOK


BOOK

"First, think about how they fit into sustainable agriculture: Do they reduce pesticide use? Do they reduce soil erosion? Do they reduce nitrates leaching into the soil? Do they increase yields? If so, then that's an improvement to our agricultural system."

- Raoul Adamchak, Manager of Certified Organic Market Garden at the UC Davis Student Farm.


whoops



agbiotech.ces.ncsu.edu