Crops, Food, Biotechnology and Some Other Thoughts

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http://pmb.berkeley.edu/lemaux
https://clear-project.org

What will be covered?

1. Background on genes, genomes, genetic engineering, genome editing
2. What GE crops are commercialized? In the pipeline?
3. What is the regulatory structure for GE crops?
4. What are some food safety issues with GE foods?
5. What are some environmental issues with GE crops?
6. Some food for thought…

Tour d'Onion

Or, what makes an onion and onion?

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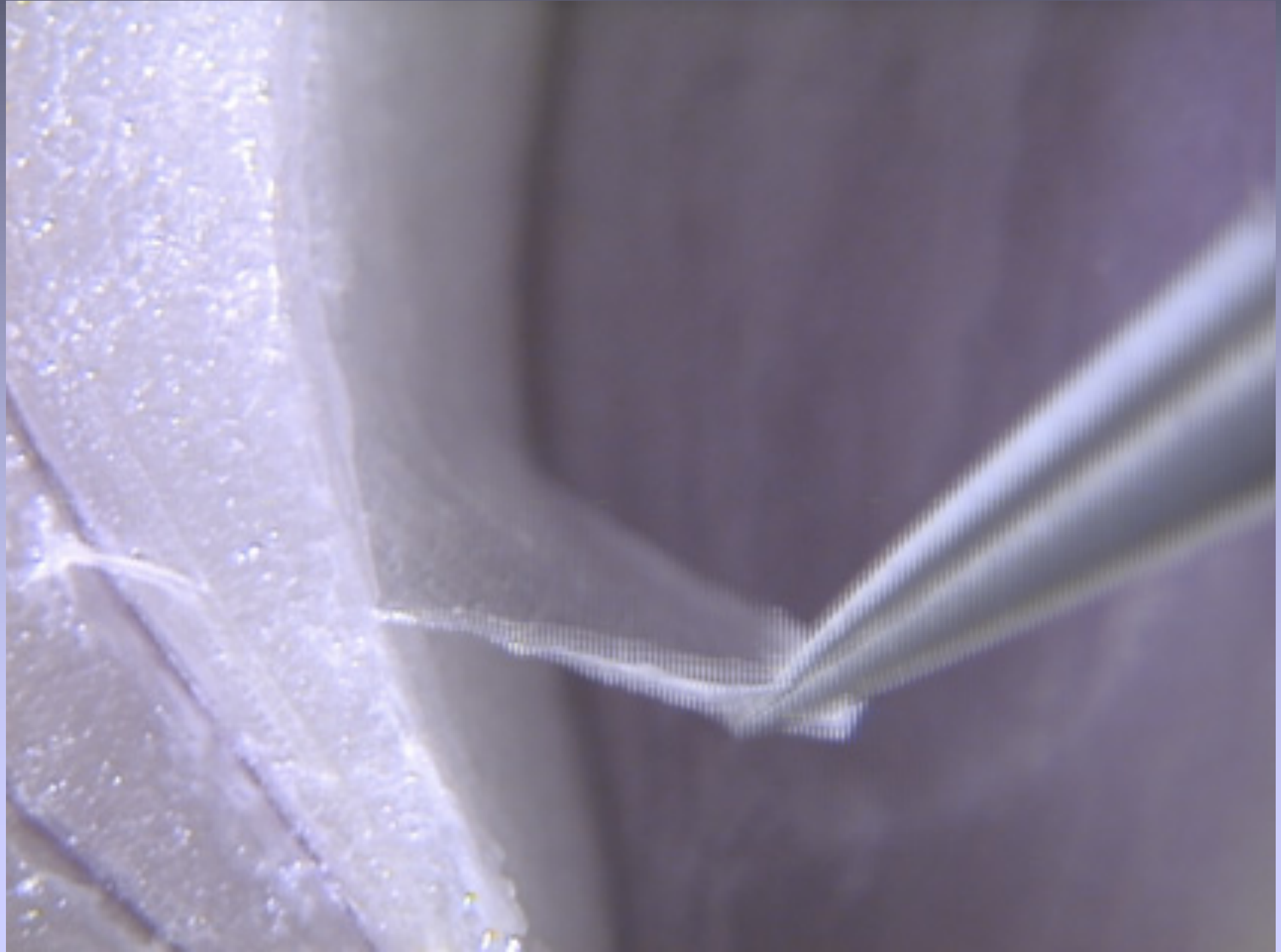
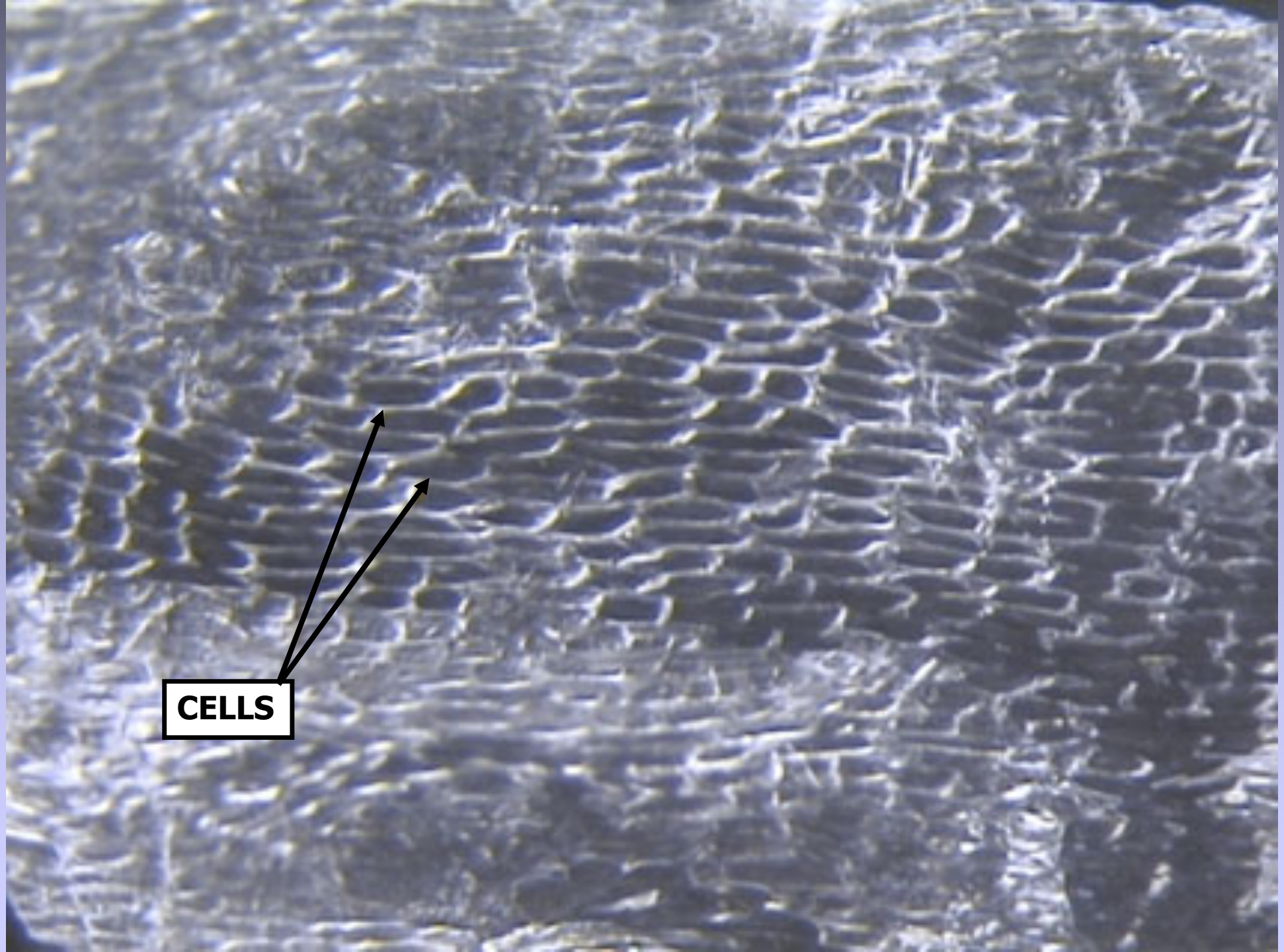
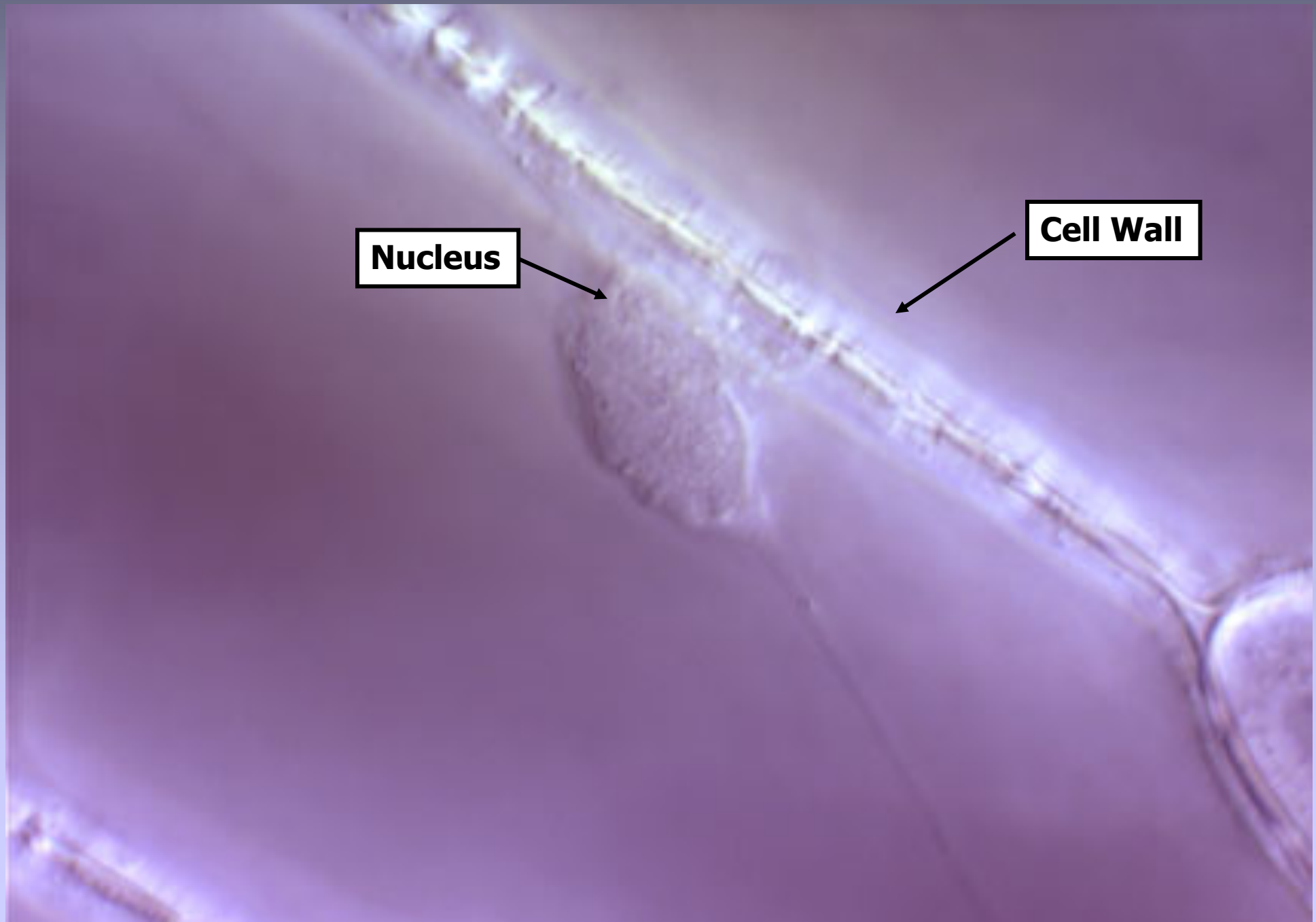
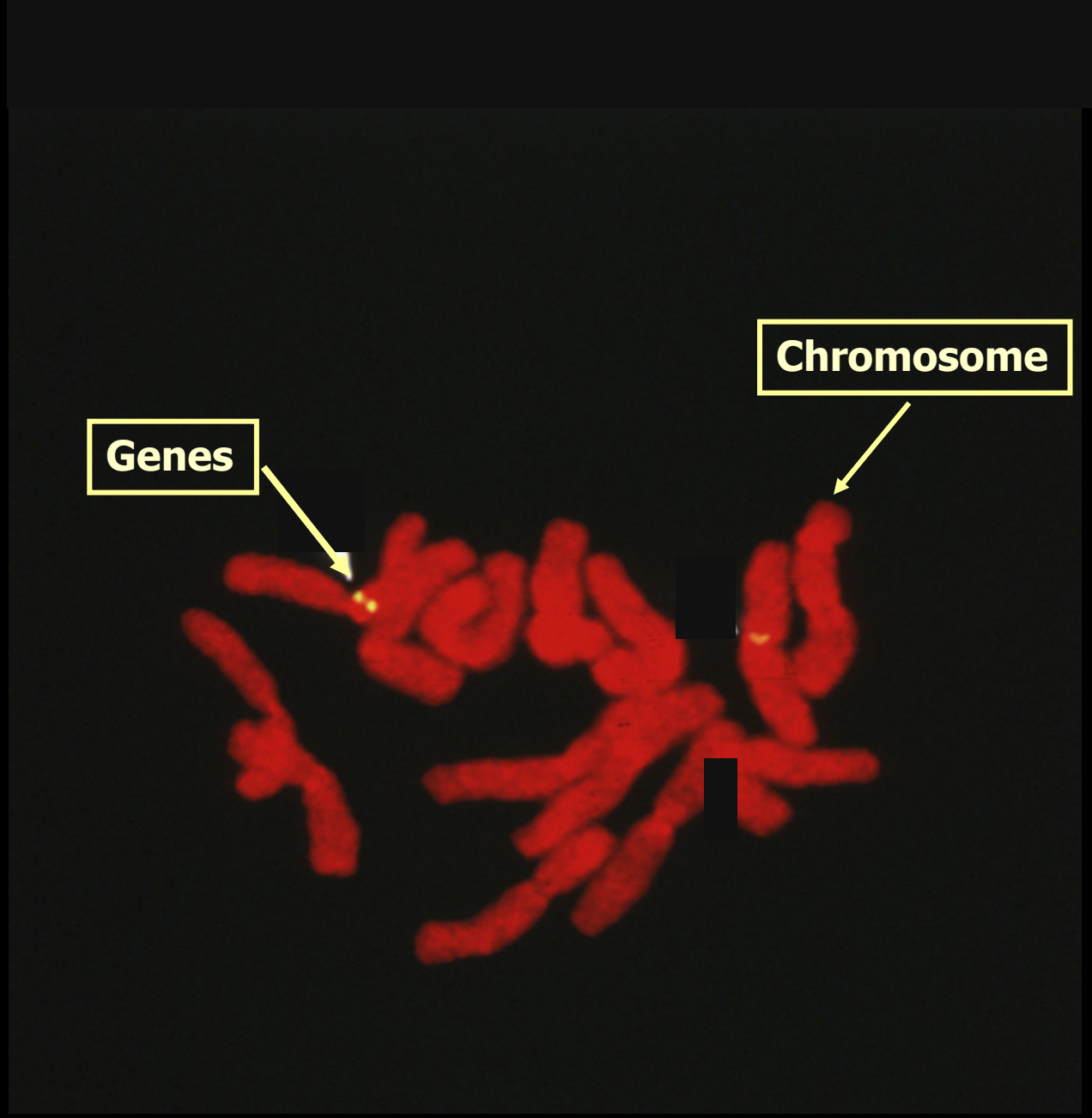



CELLS


Nucleus
Cell Wall


Dividing cell
Chromosomes

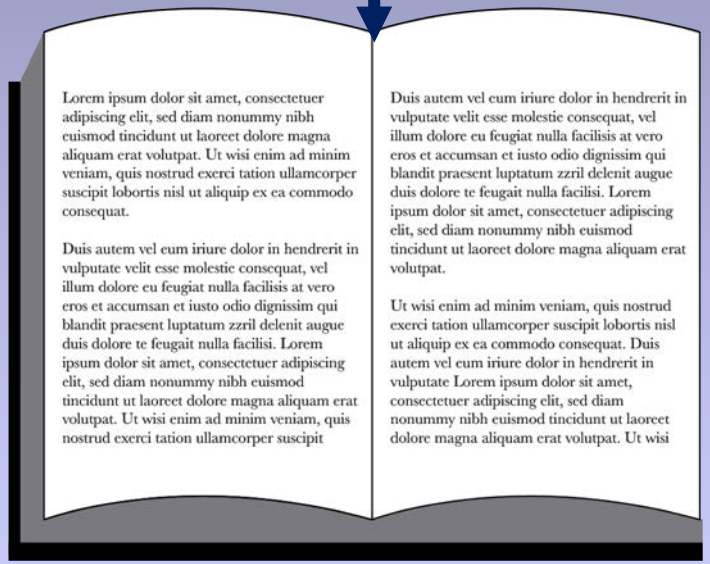

Chromosome
Genes

Genetic information in cell is responsible for traits

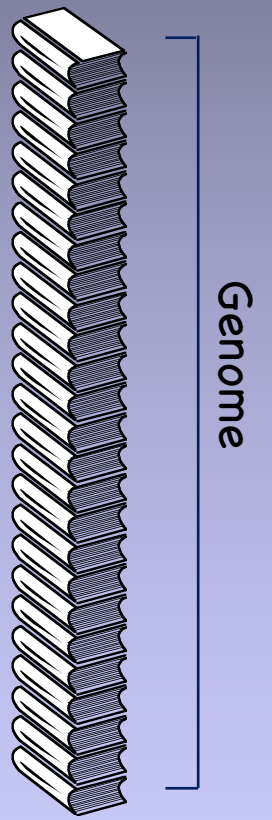
Chemical units in DNA represented by alphabetic letters

...CTGA**C**CTAATGCC**G**TA...

...CTGA**A**CTAATGCC**T**TA...



1700 books
1000 pages each



1700 books
(or 1.7 million pages)

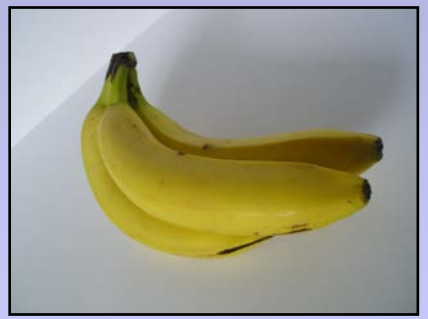
Sometimes mistakes happen when copying information in books (genomes) → creating changes, called mutations

Mutations Have Gotten These Plants from Looking Like This…

To Looking Like They Are Now

Carrot

Eggplant



Banana

Broccoli,
Kale,
Cabbage

Since 1950's intentional mutation breeding has created >3200 crops – e.g., 600 maize, rice, wheat varieties. Although modified genetically, they are not under regulations for genetically engineered (GMO) varieties.

Photo by Stephen Ausmus, USDA

Modern Example

Japanese Farmer Creates Mongee Banana With Softer, Digestible Skin

2/22/2018 A-peeling? Japanese farmers invent edible banana skin | World news | The Guardian

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

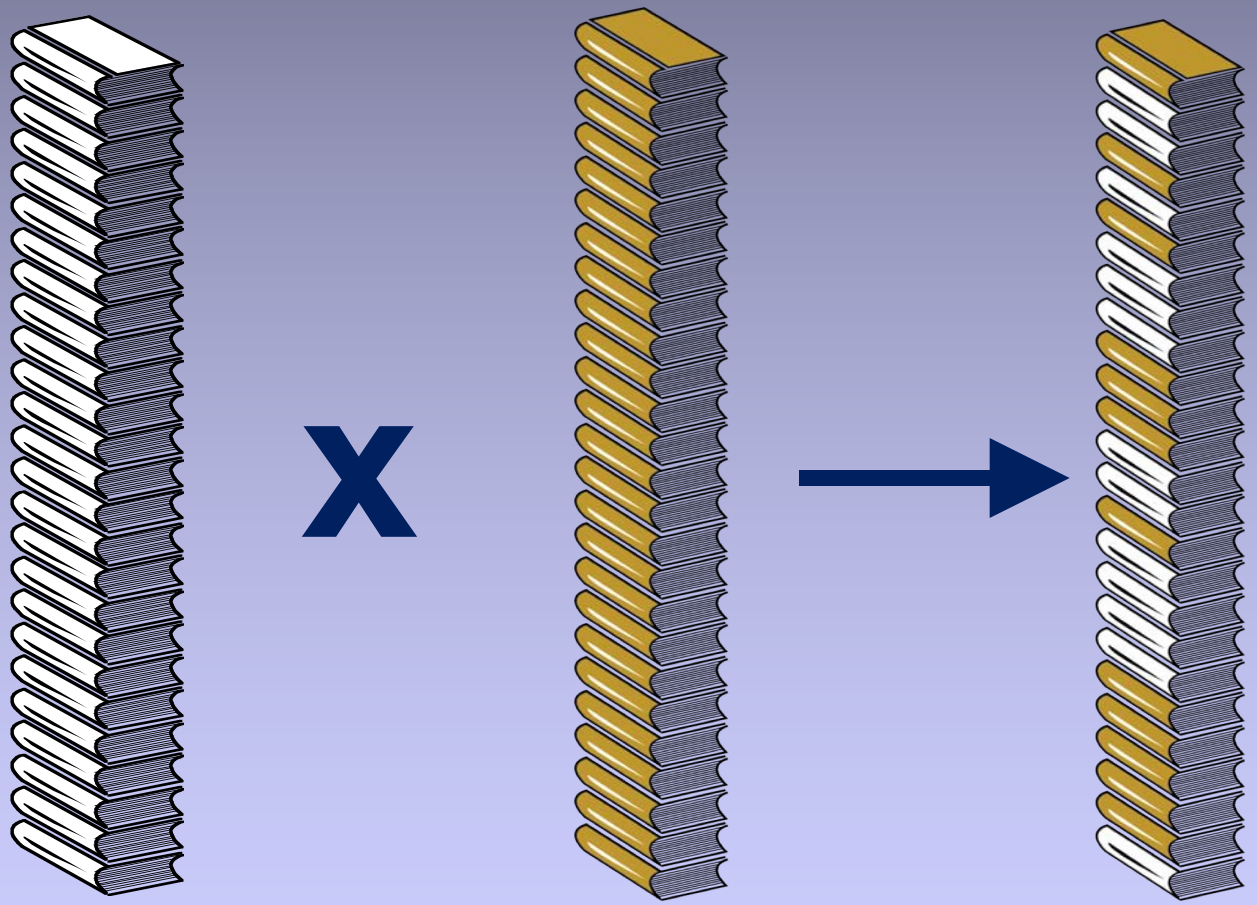
Triticum monococcum

Ancient variety

Triticum aestivum

Modern bread variety

Hybridization or Cross-breeding of Wheat



Random retention of information from each parent

1700 books (or 1.7 million pages)

1700 books (or 1.7 million pages)

1700 books (or 1.7 million pages)

Genetic modification by hybridization is not GE or GMO

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SOURCE: "Triple Null: New Genetically Modified Soybean A Big Benefit For Food Allergies", Science 2.0, 5/4/15.
http://www.science20.com/news_articles/triple_null_new_genetically_modified_soybean_a_big_benefit_for_food_allergies-155306

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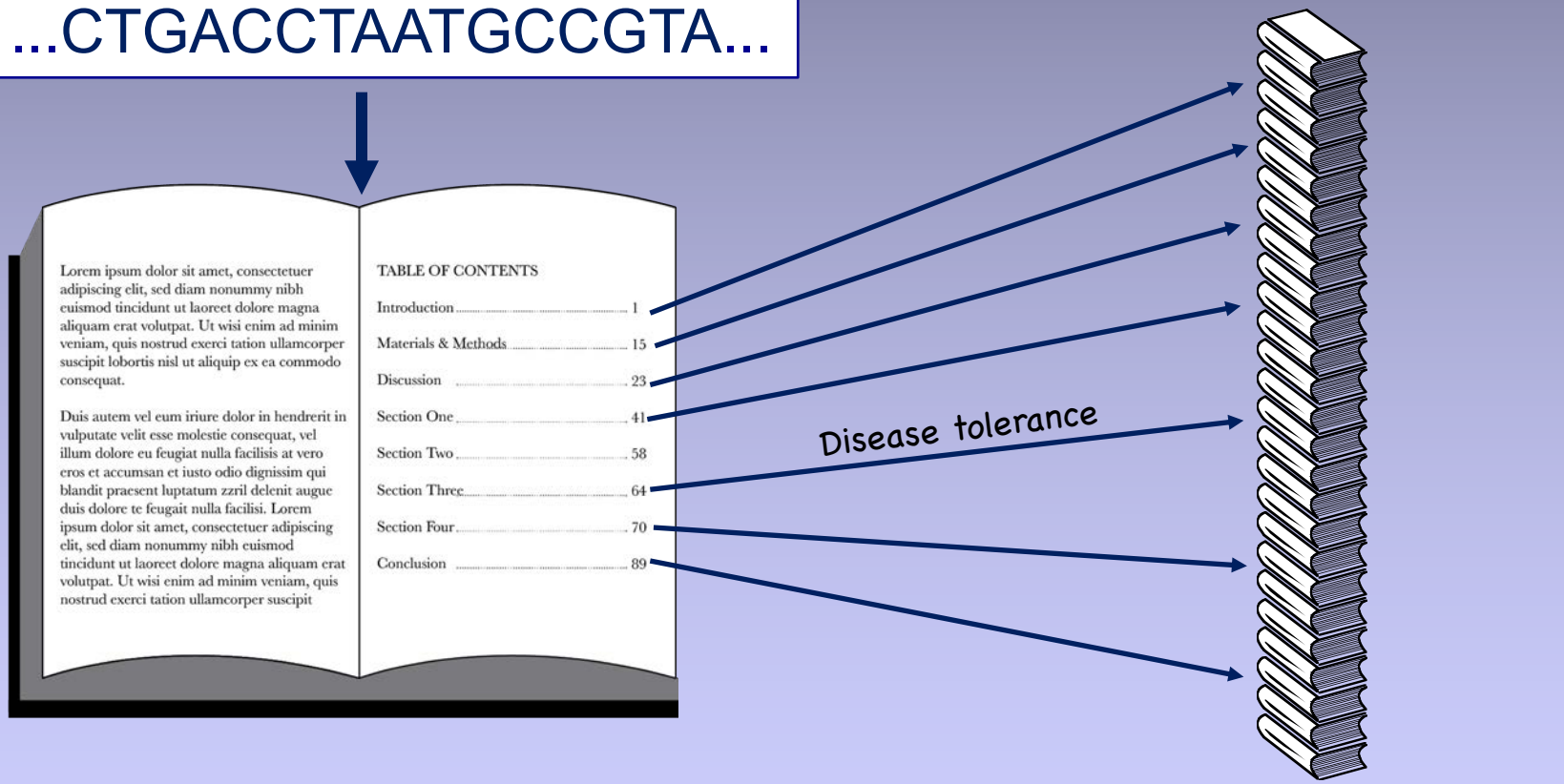
Breeding efforts were critical to increases in crop production…

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

New Breeding Method

Uses table of contents of genes for marker assisted selection

...CTGACCTAATGCCGTA...



1700 books
(or 1.7 million pages)

Genetic modification that is not GE or GMO

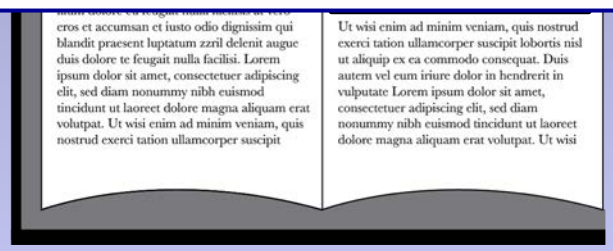
Can't we just do all modifications this way?

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

Protection limited to diversity in crop and compatible relatives

Also modify genomes with genetic engineering → GMOs

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



One-half page equivalent to a gene

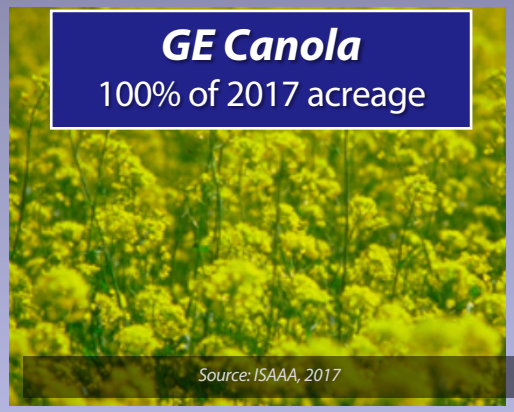
gene(s) randomly in genome

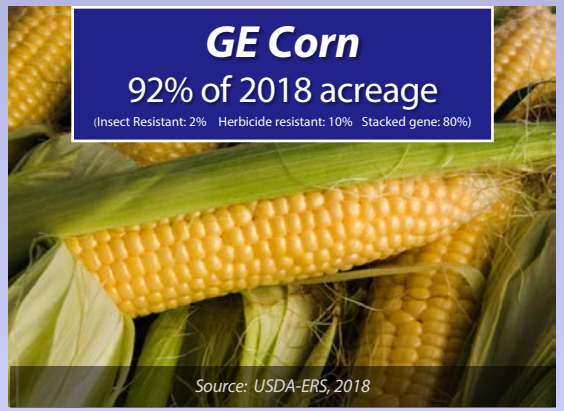
1700 books (or 1.7 million pages)

1700 books (or 1.7 million pages)

Genetic modification by genetic engineering is GE or GMO

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





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

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

Herbicide-tolerant - engineered with gene to tolerate herbicide application

Crops with stacked traits - Bt and HT - are available

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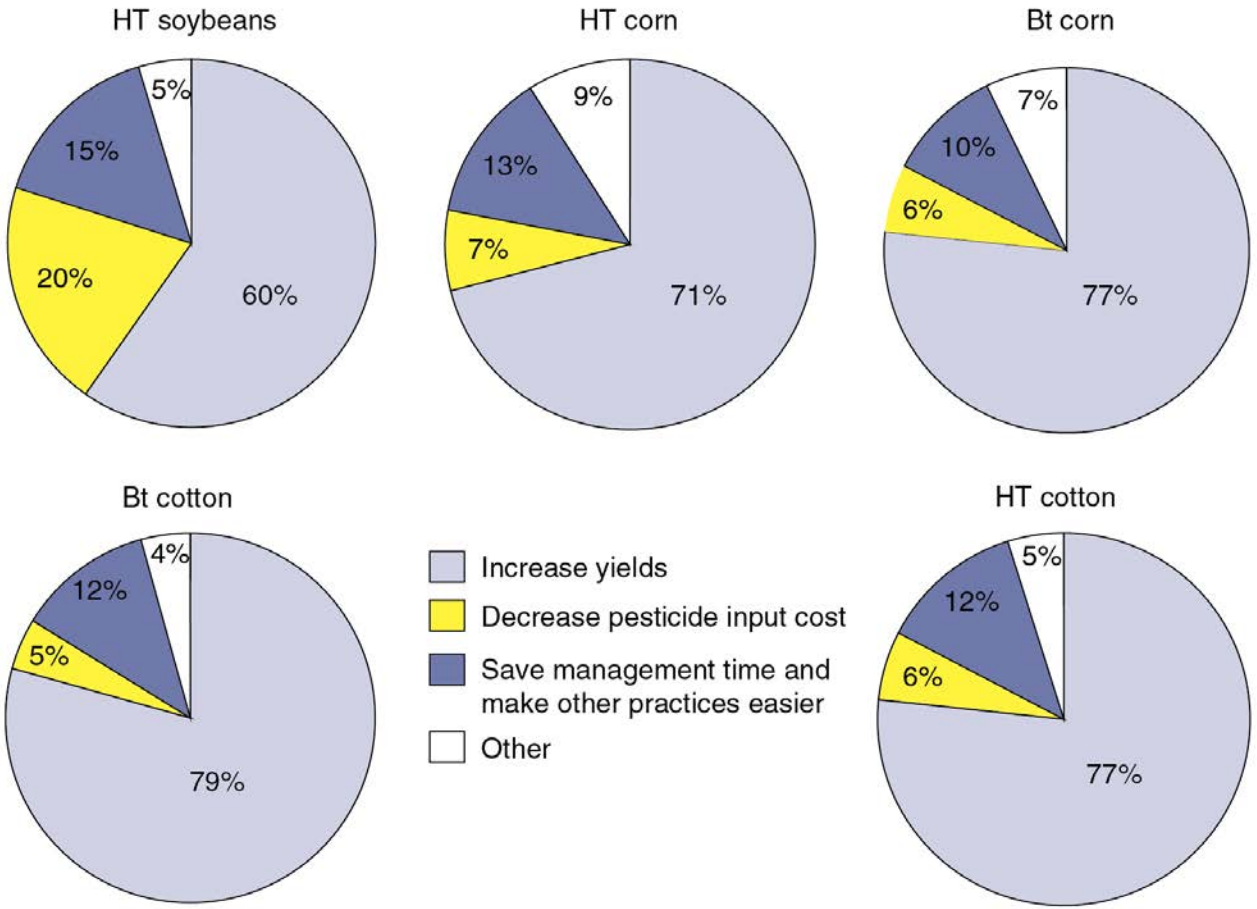
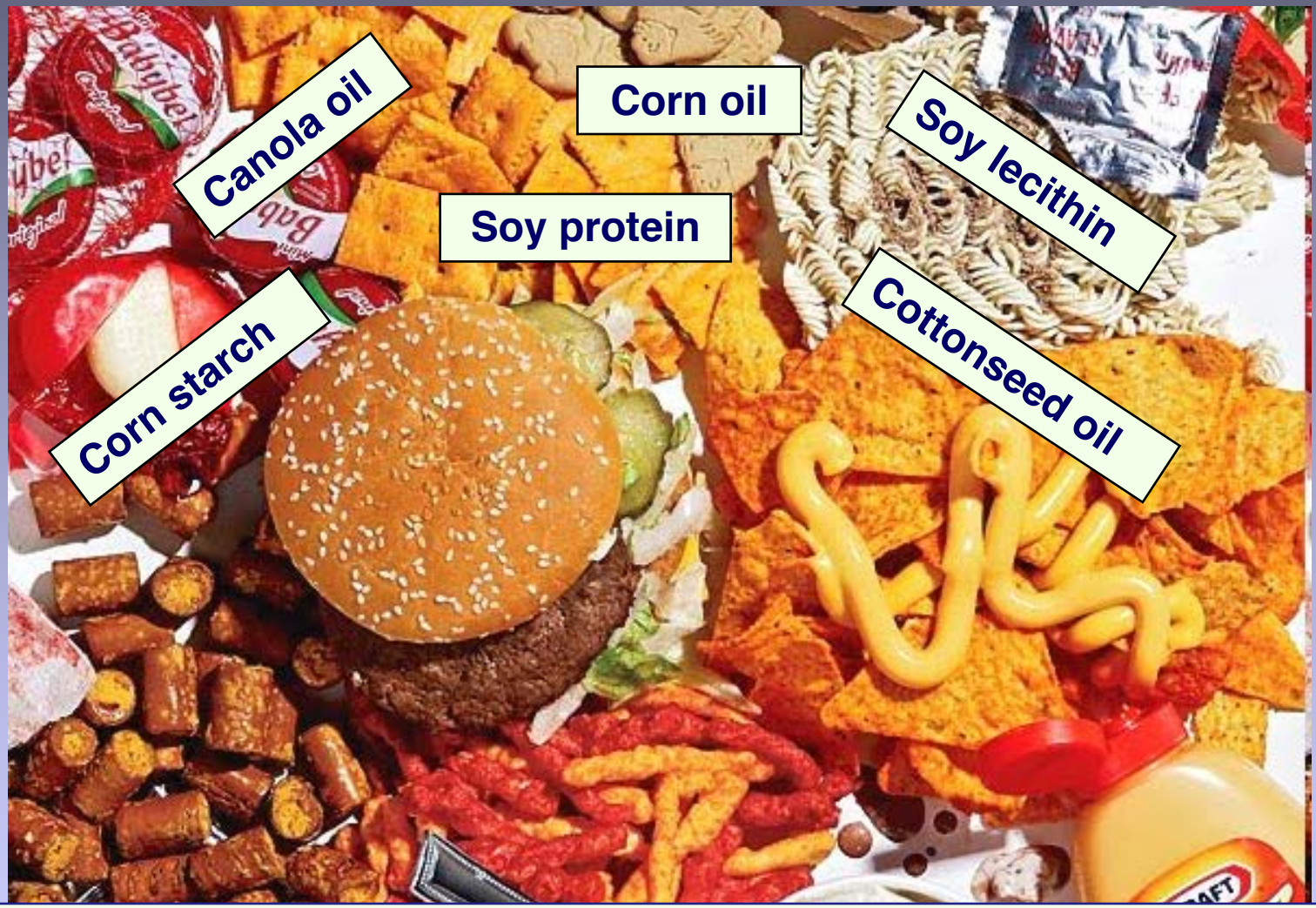
Why do U.S. growers use GE crops?



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

SOURCE: Fernandez-Cornejo, J., Wechsler, S., Livingston, M. and Mitchell, L. 2014. Genetically Engineered Crops in the United States. USDA Economic Research Service Report No. 162, February 2014.



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

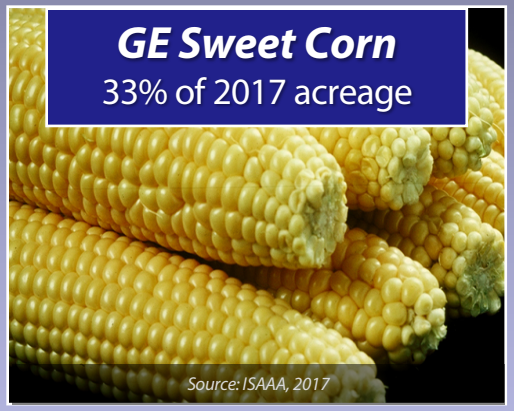
SOURCE: https://factsaboutgmos.org/disclosure-statement

There are only a few whole, genetically engineered foods in the US market

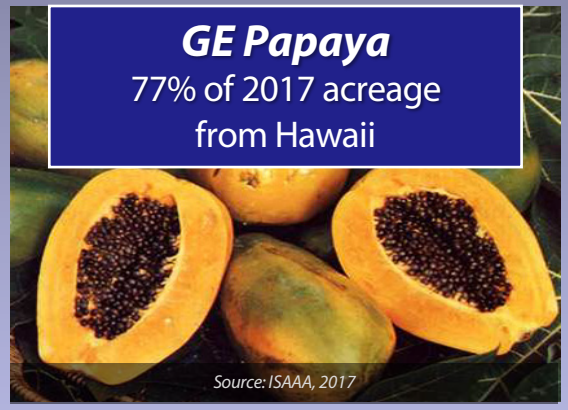
GE Squash
~2,417 acres in 2017


Source: ISAAA, 2017

GE Sweet Corn
33% of 2017 acreage


Source: ISAAA, 2017

GE Papaya
77% of 2017 acreage
from Hawaii


Source: ISAAA, 2017

Two more are just being introduced

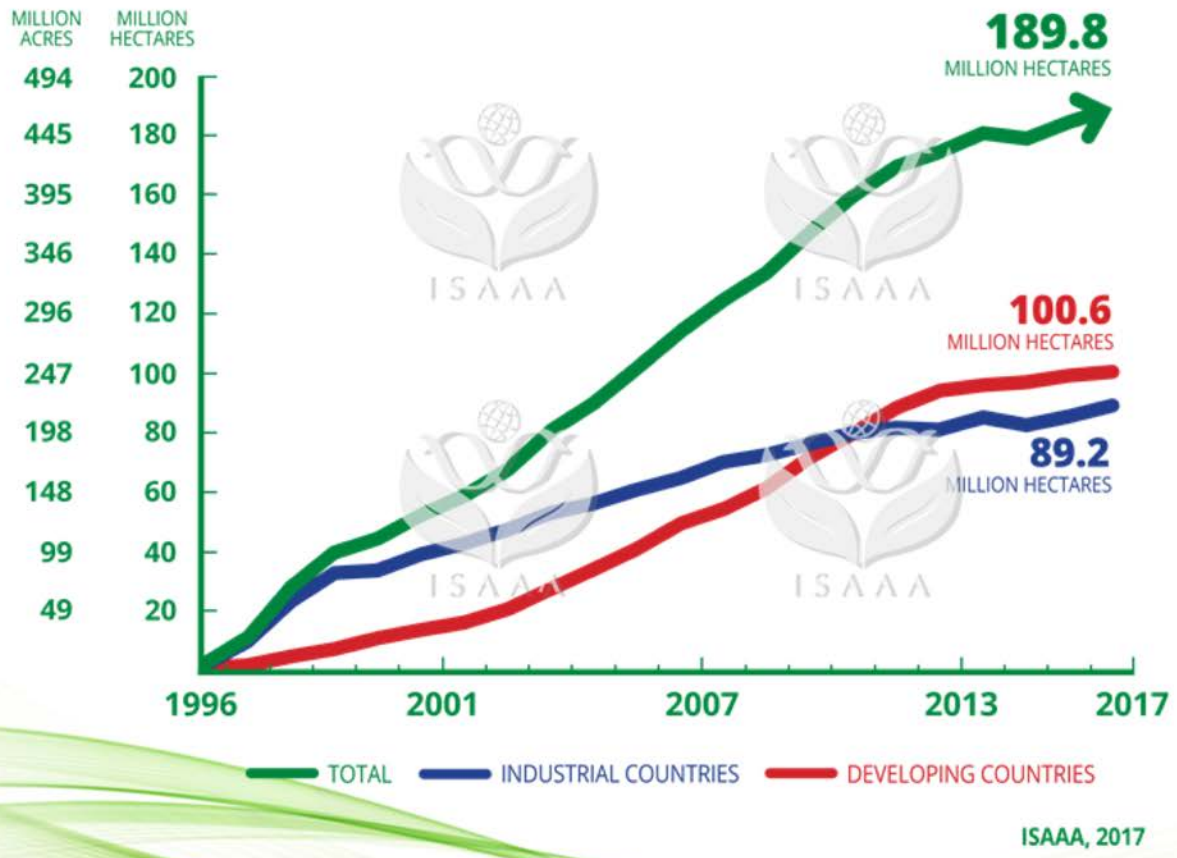
Arctic Apple™
249 acres in 2017


Source: ISAAA, 2017

Innate™ Potato
Generation 1: ~4,000 acres in 2017
Generation 2: ~2,000 acres in 2017

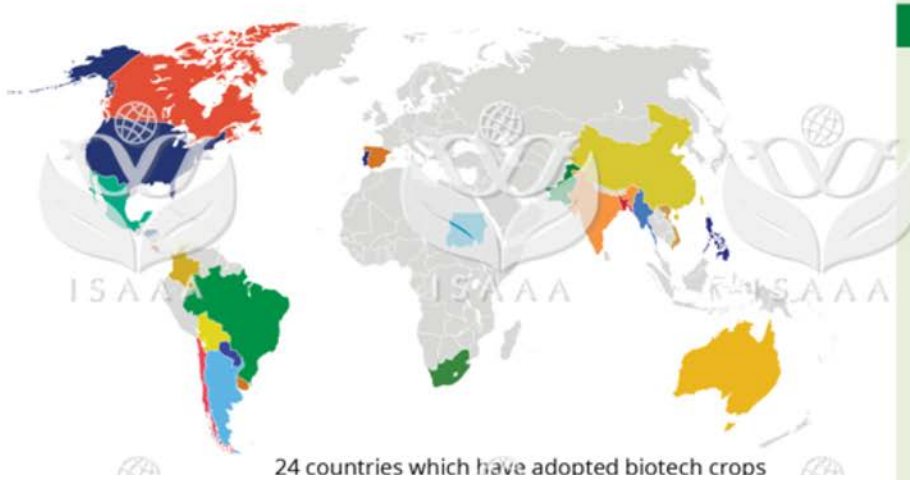
Source: ISAAA, 2017

Despite limited U.S. crop and trait types, worldwide acreage is increasing in 19 developing, 7 developed countries



In 2017, farmers in 24 countries planted 469M acres (190M hectares)
~4X size of Spain

Global Area of Biotech Crops, 2017: By Country (Million Hectares)



24 countries which have adopted biotech crops

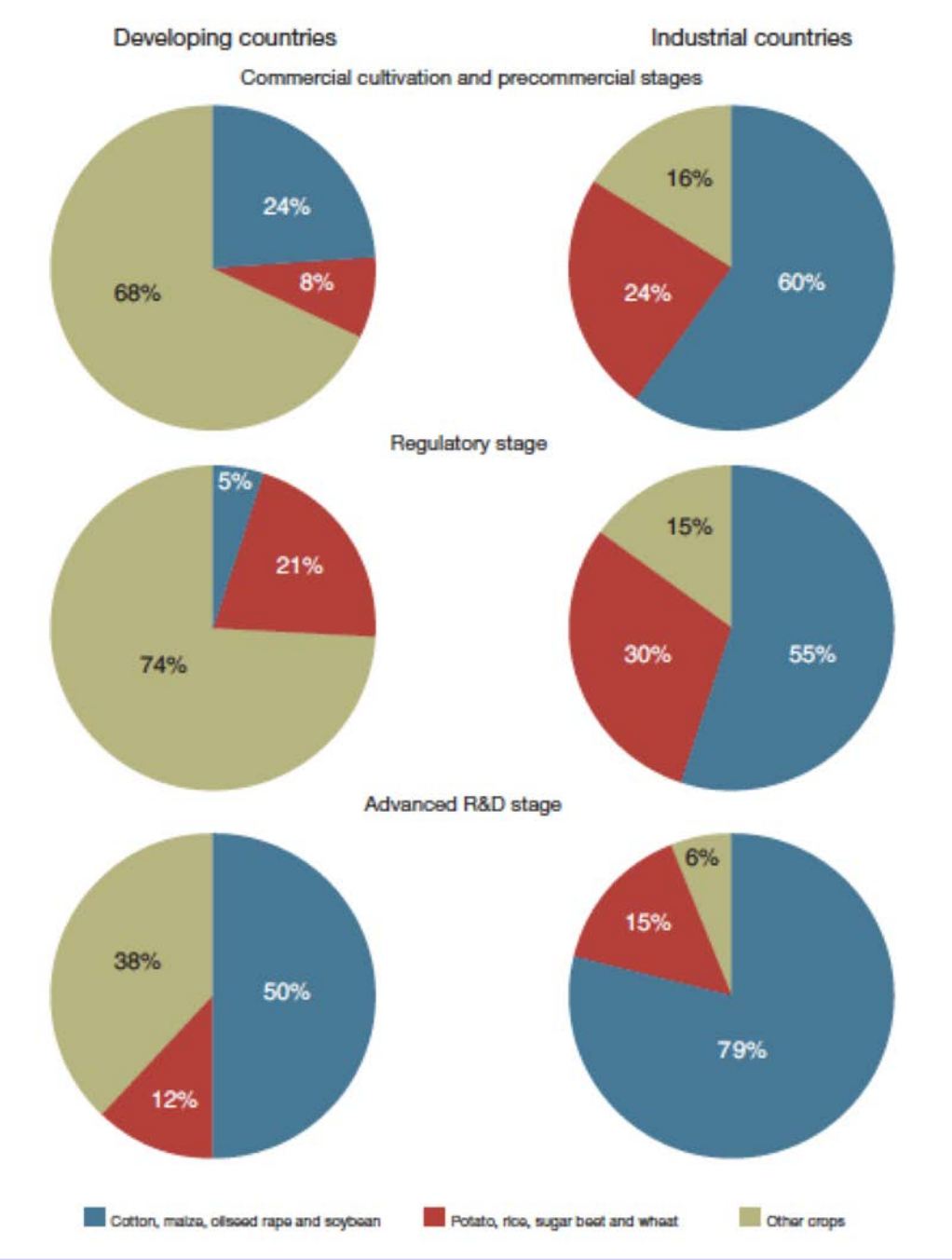
Here are the 24 countries where GE crops were planted in 2017

50,000 hectares, or more	
1. USA	75.0 million
2. *Brazil**	50.2 million
3. *Argentina**	23.6 million
4. Canada	13.1 million
5. *India**	11.4 million
6. *Paraguay**	3.0 million
7. *Pakistan**	3.0 million
8. *China**	2.8 million
9. *South Africa**	2.7 million
10. *Bolivia**	1.3 million
11. *Uruguay**	1.1 million
12. Australia	0.9 million
13. *Philippines**	0.6 million
14. *Myanmar**	0.3 million
15. *Sudan**	0.2 million
16. Spain	0.1 million
17. *Mexico**	0.1 million
18. *Colombia**	0.1 million

Less than 50,000 hectares	
*Vietnam**	Portugal
*Honduras**	*Bangladesh**
*Chile**	*Costa Rica**

** Developing countries*

ISAAA

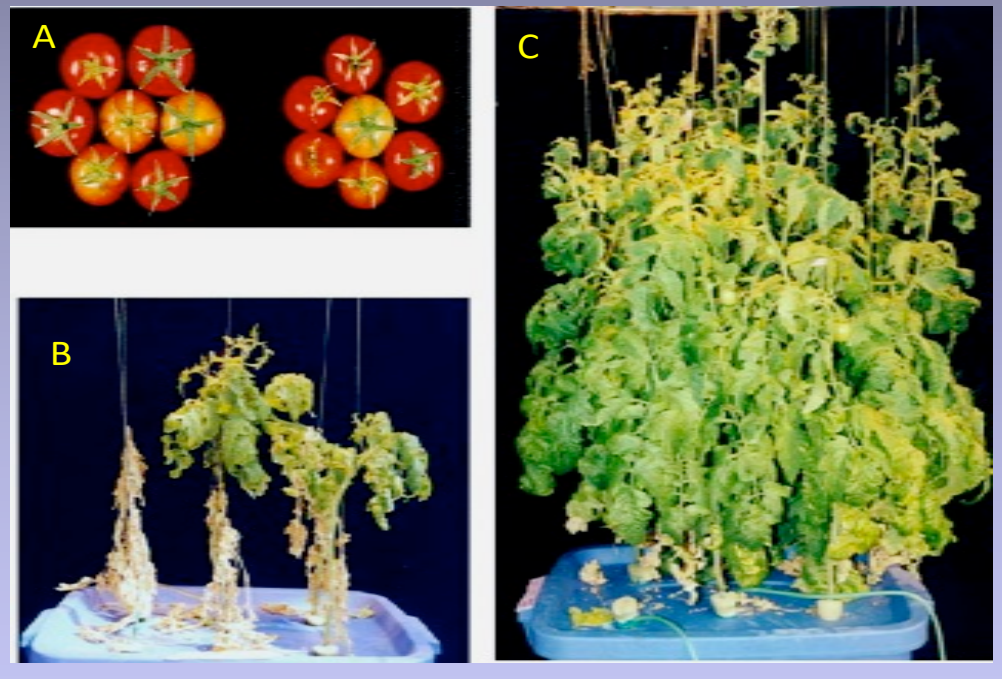


Developing countries have more diverse types of GE crops compared to those in industrial countries

Parisi et al. 2016. *Nature Biotechnology* 34: 31-36


WHAT'S IN THE
PIPELINE?

Salinity and Drought Tolerance - UC Davis



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

Salt-tolerance

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

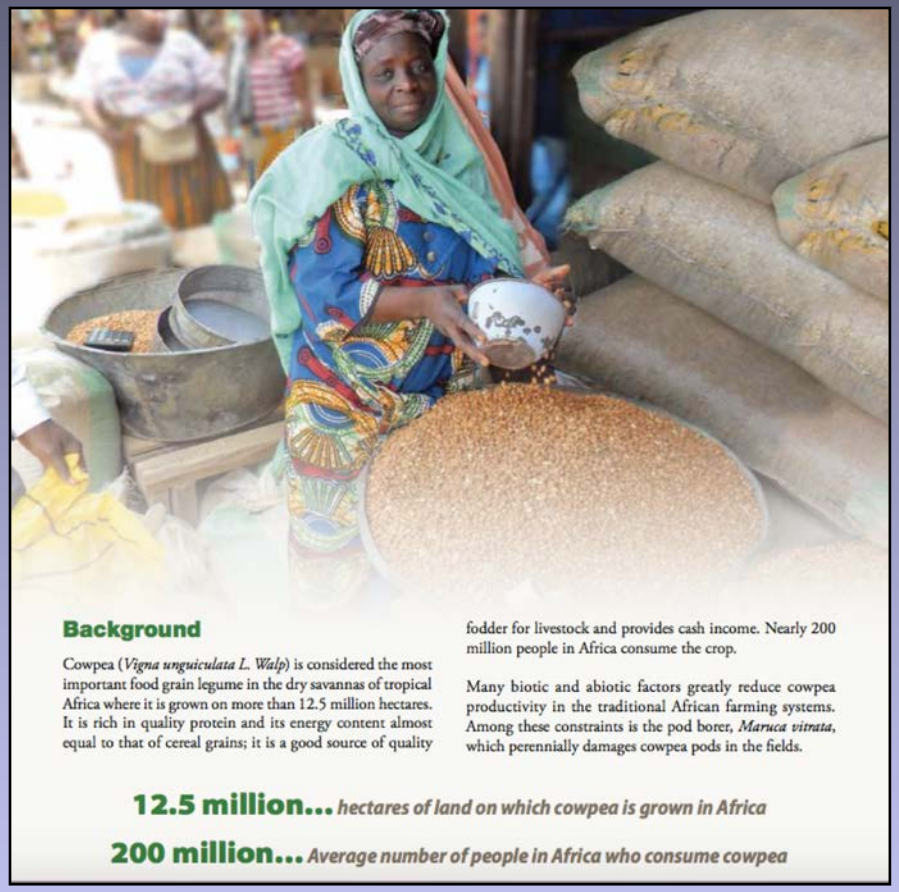
Drought-tolerance

Hanana M. 2011. Environ Rev 19: 121-140; Anjuman A et al. 2013 Mol. Biotechnol 54: 379-392

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

(Wageningen University)

Kessel, GJT. 2018. Development and validation of IPM strategies for the cultivation of cisgenically modified late blight resistant potato. Eur J Agron. 96:146.



Background

Cowpea (*Vigna unguiculata L. Walp*) is considered the most important food grain legume in the dry savannas of tropical Africa where it is grown on more than 12.5 million hectares. It is rich in quality protein and its energy content almost equal to that of cereal grains; it is a good source of quality fodder for livestock and provides cash income. Nearly 200 million people in Africa consume the crop.

Many biotic and abiotic factors greatly reduce cowpea productivity in the traditional African farming systems. Among these constraints is the pod borer, *Maruca vitrata*, which perennially damages cowpea pods in the fields.

12.5 million... *hectares of land on which cowpea is grown in Africa*

200 million... *Average number of people in Africa who consume cowpea*

Pod borer-resistant cowpea, an important food staple in Sub-Saharan Africa

Insect-resistant GMO cowpeas speed toward commercialization in Sub-Saharan Africa

February 21, 2017 | Vanguard

PRINTER FRIENDLY

2.3K 24 12

Sub-Saharan African farmers will soon have access to improved cowpea varieties that will lead to increases in yield.

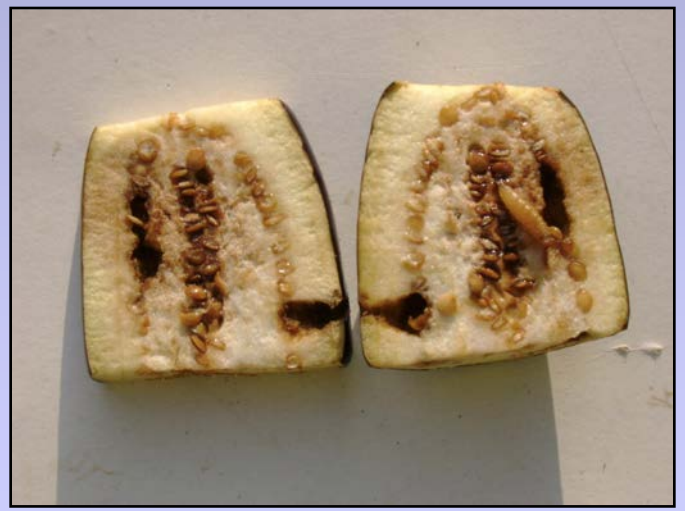
This follows the development of Maruca Resistant Cowpeas by a public-private partnership project...

...

These varieties are expected to reduce grain yield losses caused by the pod borer, Maruca vitrata, as well as reduce the need for insecticidal sprays.

Eggplant: an important, inexpensive, small acreage crop for Bengladesh and the Philippines

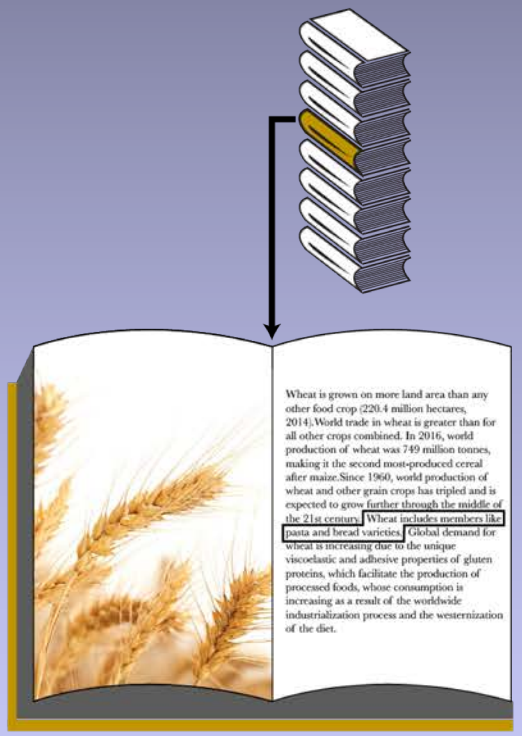
Biggest production problem in Asia is fruit and shoot borer, making fruit inedible. Control is spraying broad-spectrum insecticides 2-3 times/day!



In 2000 Mahyco developed Bt eggplant, resistant to borer, reducing infestations from 48-57% to 0.04-0.88% and increasing yields

Shelton et al. 2017.Bt Eggplant: A Genetically Engineered Minor Crop Comes of Age ISB News Report August 2017

New Genetic Method: Genome Editing-Mutation



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

MUTATION

Wheat includes members like pasta and bread varieties.

Changing "includes" to "contains"

Wheat contains members like pasta and bread varieties.

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EXAMPLES of edited products:

nature

NATURE | NEWS

Gene-edited CRISPR mushroom escapes US regulation

Jose A. Bernat Bacete/Getty Images

University

Dupont Develops Corn Using New CRISPR Technology

By KRISTOFOR HUSTED • APR 27, 2016

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LIZ WEST, FLICKR CREATIVE COMMONS

A new genetically engineered corn variety developed by one of the world's largest seed companies won't undergo the same review by regulators as other GMO crops.

Company

Capital Press
Agriculture Newspaper

Gene-edited camelina cleared by USDA

CRISPR-developed trait increases oil content

By MATEUSZ PERKOWSKI
Capital Press

A variety of camelina that's gene-edited to increase oil content can be grown without undergoing the USDA's regulatory process for biotech crops.

The agency has determined the camelina cultivar doesn't pose a plant pest risk, which means it's outside the USDA's regulatory jurisdiction over genetically modified organisms, or GMOs.

The crop's developer, Yield10 Bioscience, relied on a technology known as CRISPR to "knock out" a gene from camelina, eliminating a biological plant activity, thereby allowing it to produce more oil, said Kristi Snell, the company's chief science officer.

Camelina is an oilseed that's been studied as an alternative crop in Eastern Oregon and elsewhere in the arid West, since it's capable of surviving with minimal irrigation.

However, the crop isn't widely cultivated because it's currently not profitable enough for growers, said Snell. "You need to get the yield up to make it viable."

Yield10 Bioscience is examining the possibility of "stacking" the trait associated with increased oil content with

Turn to CAMELINA, Page 12

Wikimedia Commons

Camelina modified using CRISPR technology doesn't fall under the USDA's regulatory purview.

Company

Capital Press
Agriculture Newspaper

USDA won't regulate biotech wheat variety

Cultivar modified to 'knock out' mildew-susceptible gene

By MATEUSZ PERKOWSKI
Capital Press

A wheat variety rendered mildew-resistant through the targeted "knockout" of a gene can be commercialized without clearing USDA regulatory hurdles for biotech crops.

The agency's Animal and Plant Health Inspection Service has found that the cultivar doesn't fall under its jurisdiction for regulating genetically engineered crops, which is limited to possible plant pests and pathogens.

While the wheat was developed with genetic elements from disease-causing bacteria, they aren't contained in the crop and thus it's not subject to USDA's deregulatory process, which includes environmental analysis and public comment, according to APHIS.

Capital Press file

Wheat is shown in this file photo. The Animal and Plant Health Inspection Service has found that a new mildew resistant wheat cultivar doesn't fall under its jurisdiction for regulating genetically engineered crops.

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

Calyxt, a subsidiary of the biopharmaceutical company Cellectis, developed "MLO_KO" wheat with genetic sequences from bacteria and corn that remove a gene that suppresses the plant's defenses against powdery mildew.

The wheat's DNA is repaired during natural cellular processes and no foreign genetic material remains.

"It does not change the wheat's basic biology or produce a plant that would directly feed on, infect, parasitize, or contaminate plants, or adversely affect other organisms that are beneficial to plants," Calyxt said in a letter to APHIS.

The gene eliminated by Calyxt is involved in the plant's biological processes but the mildew fungus also relies on it to "trick" and penetrate the wheat crop, said Luc Mathis, the company's CEO.

Even without the gene, the wheat's biology remains unaffected due to other genes that perform duplicative roles, he said. "When you remove this function, the plant behaves normally."

Though the USDA has decided the wheat cultivar can be commercialized, Mathis said he doesn't expect the crop to be sold to farmers until 2022.

Calyxt must first conduct trials to ensure the trait is reliable in the field while simultaneously incorporating the mildew resistance into geographically suitable wheat varieties, he said.

Turn to WHEAT, Page 12

Company

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

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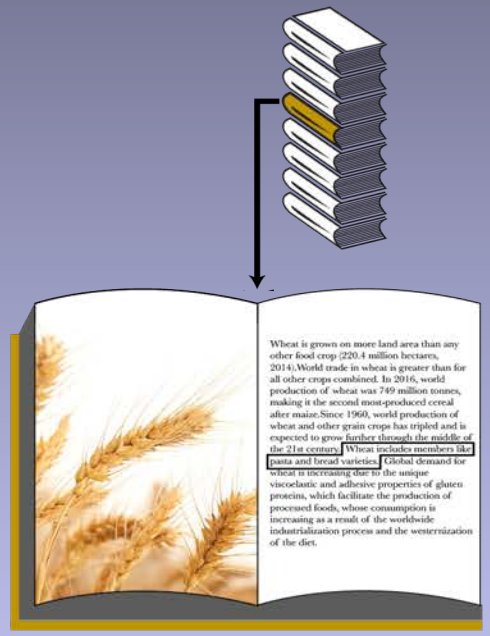
Another Way of Genome Editing-Modification



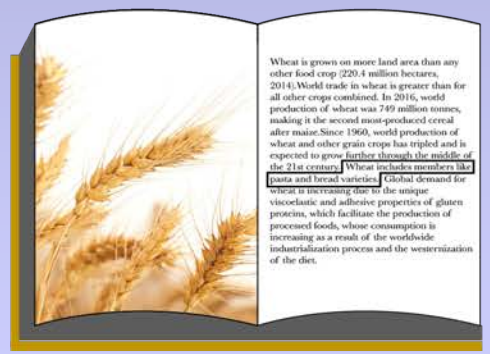
Inserts edits specifically in genome

MODIFICATION

Wheat includes members like pasta and bread varieties.

Changing "includes" to "may contain" **INSERTION**

Wheat may contain members like pasta and bread varieties.



Wheat includes members like pasta and bread varieties.

Changing "includes" to "has" **DELETION**

Wheat has members like pasta and bread varieties.

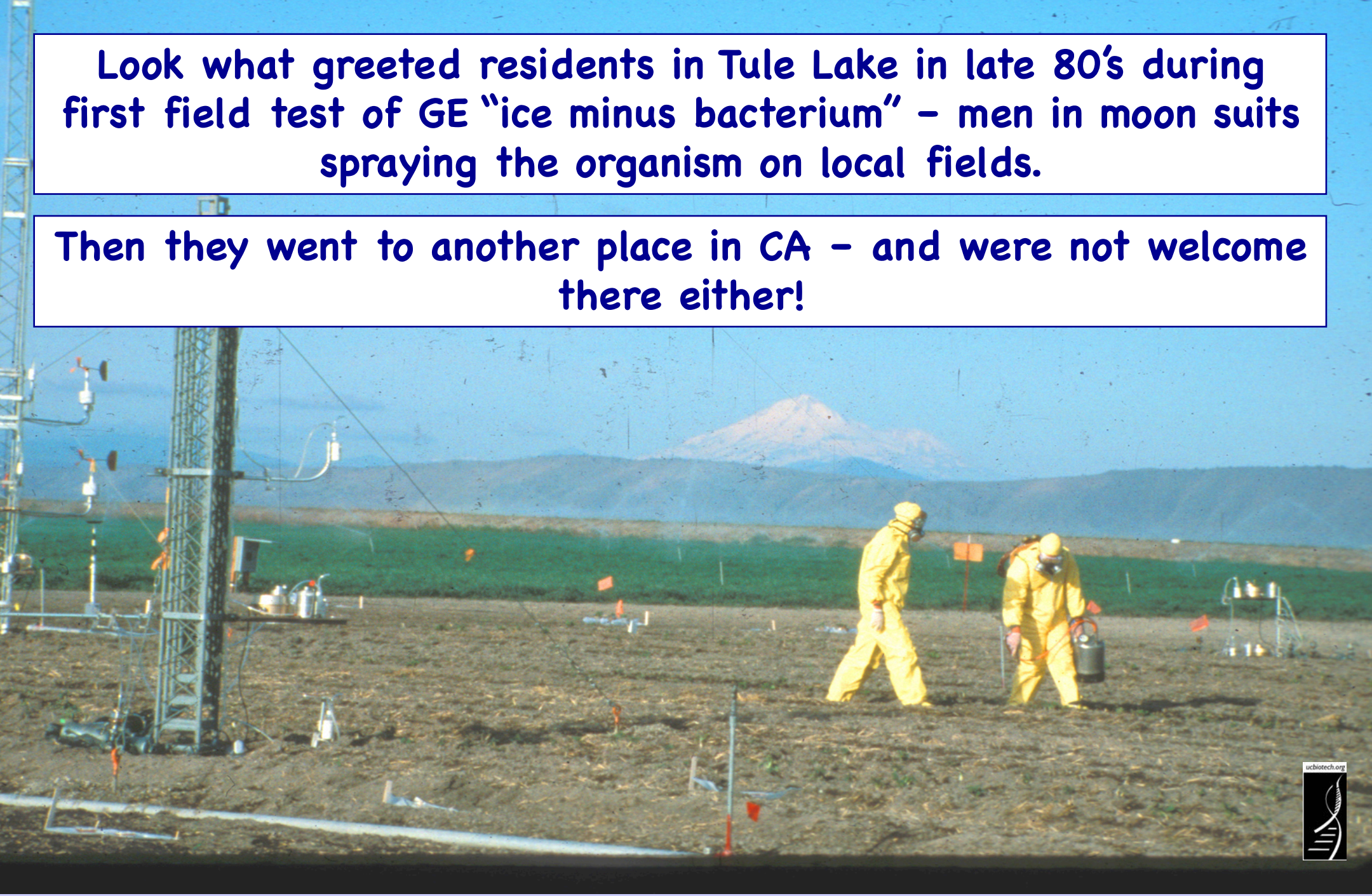
This type of genome editing *may or may not be* GE or GMO for federal regulation

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

ucbiotech.org

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 they went to another place in CA – and were not welcome there either!



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

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

1999
Lord Melchett participating in GM protest

And there are issues in the U.S. too

2014
GM maize protest in Germany

What are some issues with GE crops & foods?

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

What are some issues with GE crops & foods?

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U.S. Regulatory Agencies

USDA

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

Plant pest?

FDA

- Food safety
- Feed safety

Danger to people?

EPA

- Pesticidal plants
  - -tolerance exemption
  - -registrations
- Herbicide registration

Risk to environment?

Are they as safe as conventional foods?

Regulation based
substantial equivalence

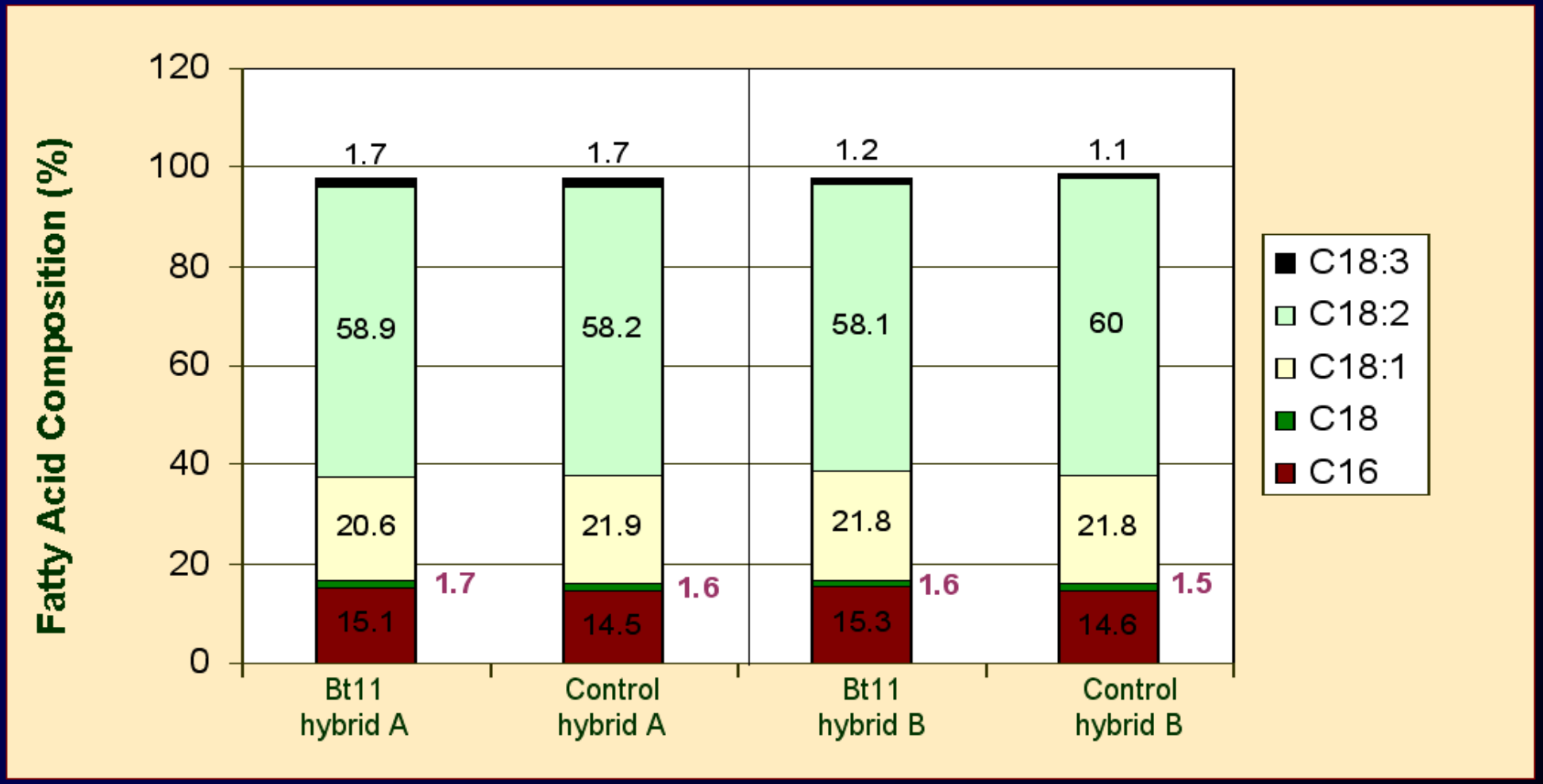
Which means modified food has essentially all characteristics of nonmodified food except for introduced trait

Product of introduced genetic information tested for safety separately

How is substantial equivalence tested?

SOURCE: Safety of Genetically Engineered Foods: Aproaches to Assessing Unintended Health Effects 2004. Natl Acad Press

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.

Regulation based on 1986 regulatory system, creates problems:

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

Genetically engineered crops that fly under the US regulatory radar

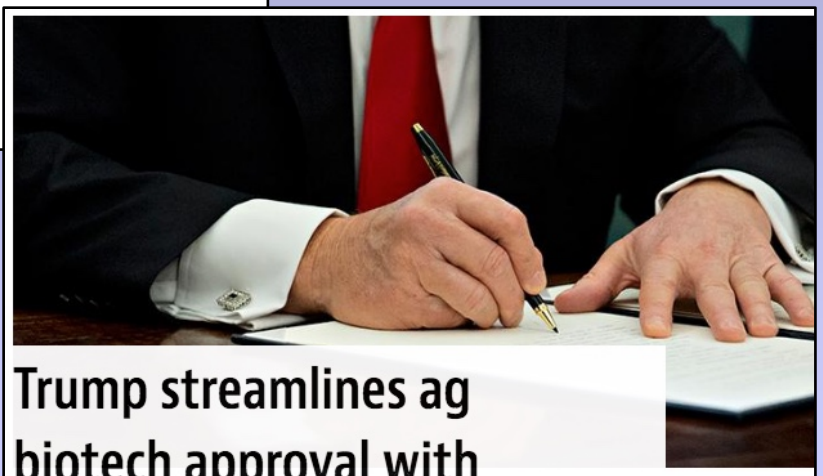
To the Editor:

Recently, the US Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) has categorized as outside the scope of its regulations several genetically engineered (GE) crops that rely on either new approaches or new wrinkles on traditional recombinant DNA techniques in their provenance. Indeed, a survey of recent inquiries to APHIS suggests that the number of entities seeking nonregulated status for their products has been on the increase. Many of these inquiries originate from public institutions or small biotech companies, suggesting that the use of technologies, such as null segregants, novel delivery systems, cisgenesis/intragenesis and site-directed nucleases, may be a deliberate strategy for smaller entities to navigate the US GE crop regulatory framework. The fact that the US Coordinated Framework is on the one hand failing to oversee these new product types and on the other overregulating GE crops and technologies with proven track records of safety should be a cause for concern. We conclude that it is time to reevaluate the US regulatory framework for GE crops and build a system that is based on science, with enough flexibility to evolve with accumulating scientific knowledge and technologies and, importantly, that allows the participation of small companies and public sector institutions.

On July 2, 2015, Obama White House Initiative announced plan to modernize biotech regulation, but no progress until…

Executive Order on Agricultural Biotechnology June 11, 2019

- Agencies to regulate end products, not processes used to make them. So, genetically edited pest resistant product not treated differently from one made with traditional breeding.
- Biotech products to be regulated proportional to risks.
- Perhaps applies only to gene edited products, not transgenic products or GMOs - still regulated on a case-by-case review.



Trump streamlines ag biotech approval with executive order

SOURCE:Berezow A. "Trump's Executive Orders Move Biotech, Healthcare in right Direction". ACSH Weekend Highlights. July 5, 2019.

EU and other countries are making decisions on gene edited products – some accepting, some not.

- **Canada, Australia** and **Brazil** regulate GE and edited products by assessing the product itself, not the process used. Also **Argentina**.
- Countries, like those in the **European Union**, take a more process-oriented, or precautionary, approach.
- In **Chile**, GE crops are grown for seed production but not crop production.
- 2001 regulation in **China** states that every GE product must pass safety assessment and receive biosafety certificate and license before cultivation.
- In **India**, a GE Appraisal Committee makes regulatory decisions.
- Very mixed situation in **Africa**, varying from country to country

SOURCE: Mackelprang B, Lemaux PG. 2019 "Genetically Engineered & Edited Plants and Foods: An analysis of existing and evolving issues" Ann Rev Plant Biology..

What are some issues with GE crops & foods?

- Regulatory oversight
- Lack of peer-reviewed food safety tests
- Labeling
- Environmental issues
- Some additional food for thought…

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

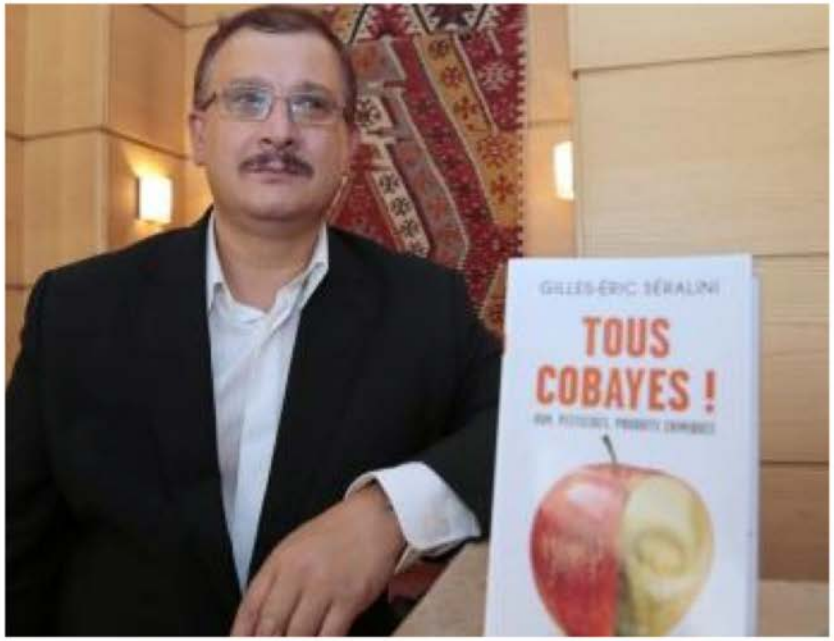
Later reviewed by European Food Safety Authority and found to have no merit

But did you ever hear that?

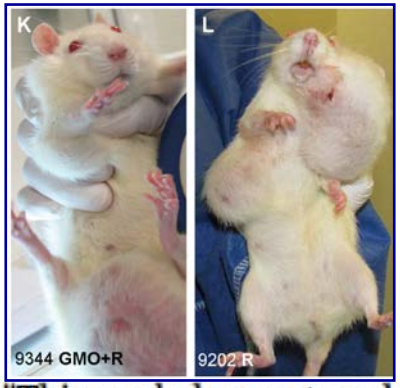
French academies trash GM corn cancer study

By **RFI**

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



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



Claim that Monsanto's RR corn causes tumors in rats

"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 th names of the national academies of agriculture, medicine, pharmacy, science, technology and veterinary studies.

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What about other published studies?

Meta-analysis from France in 2012 showed GE foods are nutritionally equivalent to non GE foods and 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

potato

soy

rice

triticale

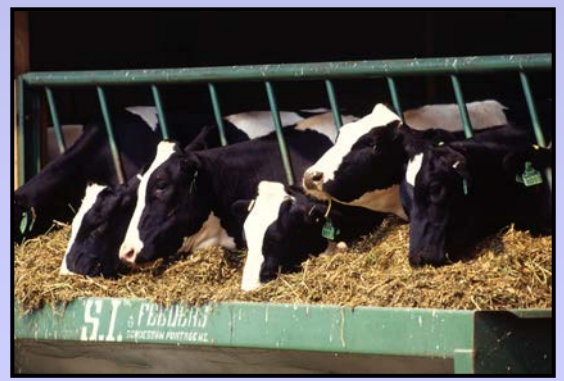
SOURCE: Snell C, Bernheim A, Berge J-P, Kuntz M, Pascal G, Paris A, Ricroch AE. 2012. Assessment of the health impact of GM plant diets in long-term and multigenerational animal feeding trials: A literature review. Food and Chemical Toxicology 50: 1134-1148.

2014 study

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

Conclusions:

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



SOURCE: "**Prevalence and impacts of genetically engineered feedstuffs on livestock populations**"
A. L. Van Eenennaam and A. E. Young, *J. Animal Science* September 2014

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What are some issues with GE crops & foods?

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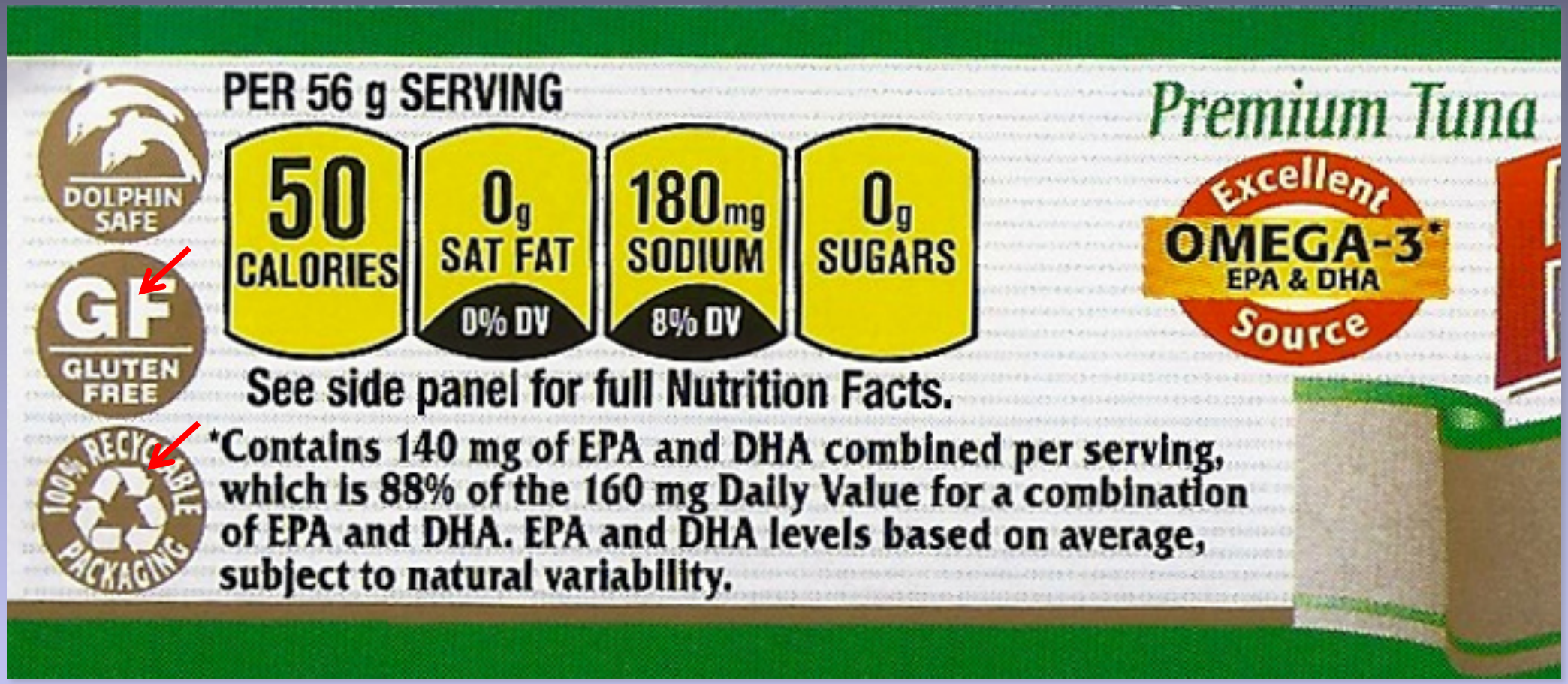

There are already many labels on foods- from gluten-free to dolphin-safe - none are mandated.

What about labeling for GE foods?

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

July 8, 2016: Senate passes bill for mandatory **national** system for GM disclosures on food products; Obama signed on July 29. Nullified Vermont's labeling law

Law requires USDA to decide what ingredients in food are from GE organisms; labels to be added using words, pictures or a scannable bar code for smartphones. Starting in 2020.

http://deltafarmpress.com/soybeans/senate-passes-roberts-stabenow-gmo-labeling-bill-preempts-vermonts

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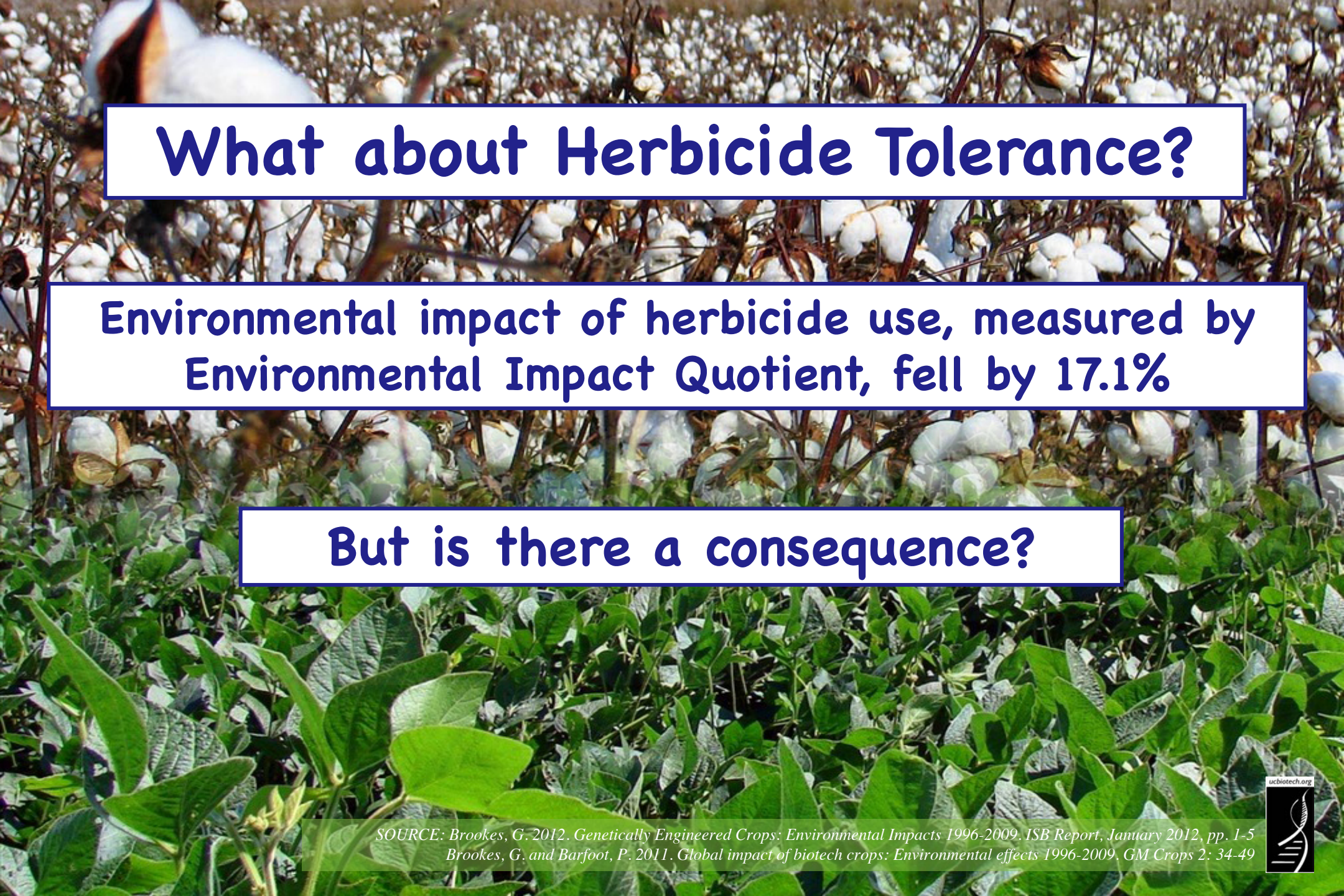
Insect Resistance

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



What about Herbicide Tolerance?

Environmental impact of herbicide use, measured by Environmental Impact Quotient, fell by 17.1%

But is there a consequence?

SOURCE: Brookes, G. 2012. Genetically Engineered Crops: Environmental Impacts 1996-2009. ISB Report, January 2012, pp. 1-5
Brookes, G. and Barfoot, P. 2011. Global impact of biotech crops: Environmental effects 1996-2009. GM Crops 2: 34-49

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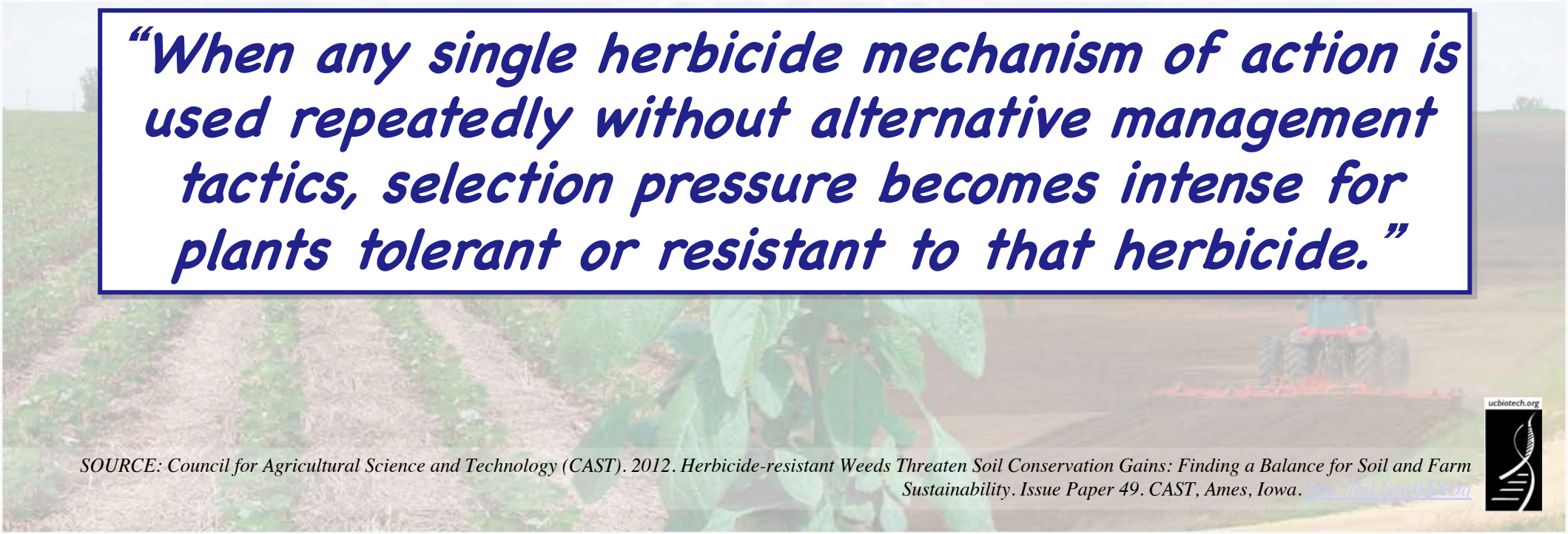
CAST® Issue Paper
Number 49
February 2012

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

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



SOURCE: Council for Agricultural Science and Technology (CAST). 2012. Herbicide-resistant Weeds Threaten Soil Conservation Gains: Finding a Balance for Soil and Farm Sustainability. Issue Paper 49. CAST, Ames, Iowa. http://bit.ly/xOqXOq

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Morning Ag Clips

friend/0

WEED MANAGEMENT ...

2 COMMENTS

Are we at a tipping point with weed control?

Like antibiotic-resistant "superbugs," resistant weeds can't be killed by herbicides

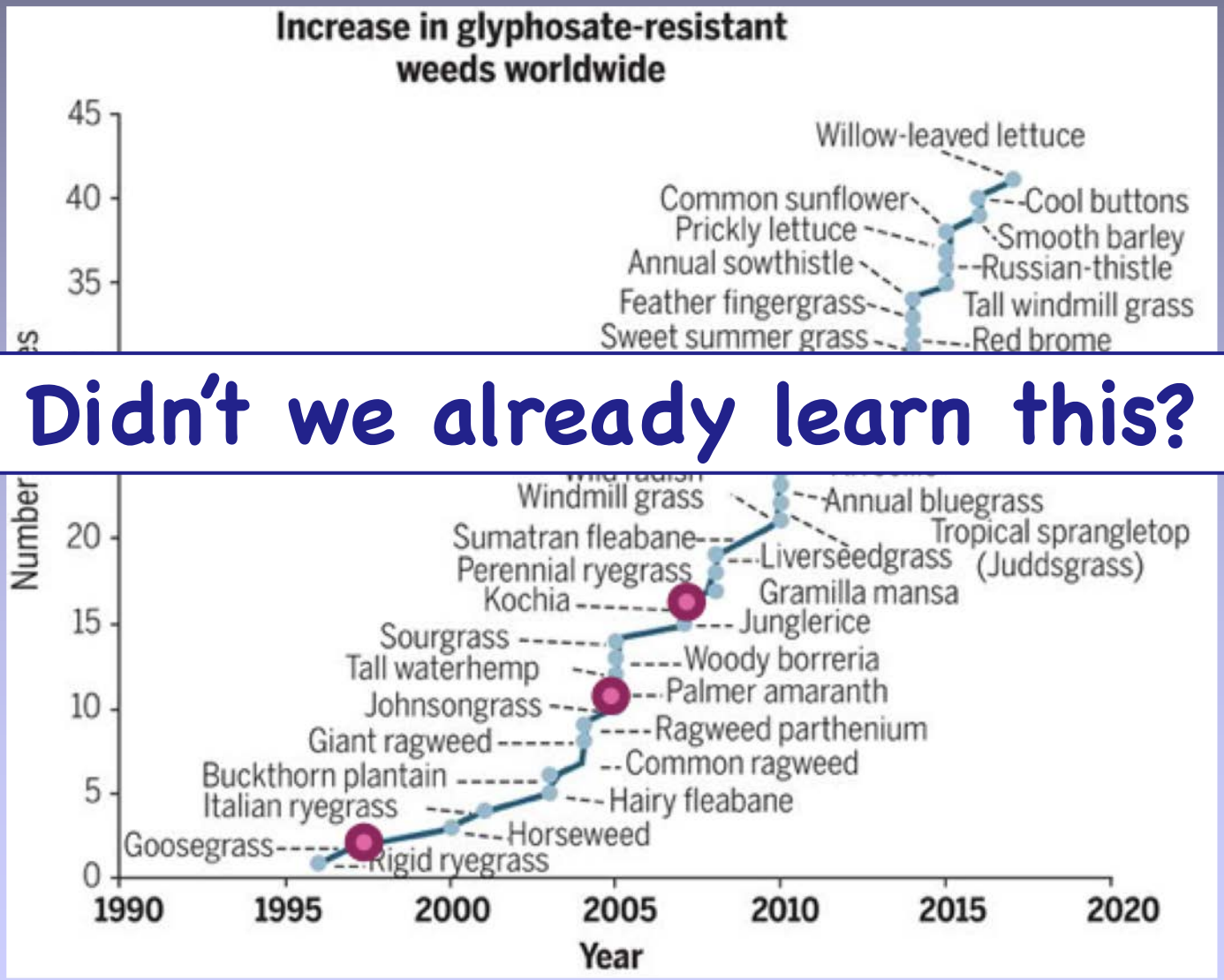
PUBLISHED ON **OCTOBER 5, 2017**

"We've reached a critical tipping point in our ability to control agricultural weeds with herbicides currently on the market." And no new classes have been developed in 30 yrs!

Researcher Adam Davis from the University of Illinois says we're close to losing chemical control of weeds like Palmer amaranth in some locations. (Patrick Tranel)

Davis AS, Frisvold GB. "Are herbicides a once in a century method of weed control?" 2017. Pest Management Science. DOI: 10.1002/ps4643

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



Didn't we already learn this?

=EPSP Synthase gene amplification Science, 2018

And there are/were ways to avoid this

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

SOURCE: "Breeders working on new GM sugar beet variety", Capital Press, December 18, 2015
http://www.capitalpress.com/Idaho/20151218/breeders-working-on-new-gm-sugar-beet-variety

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Consider This…

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

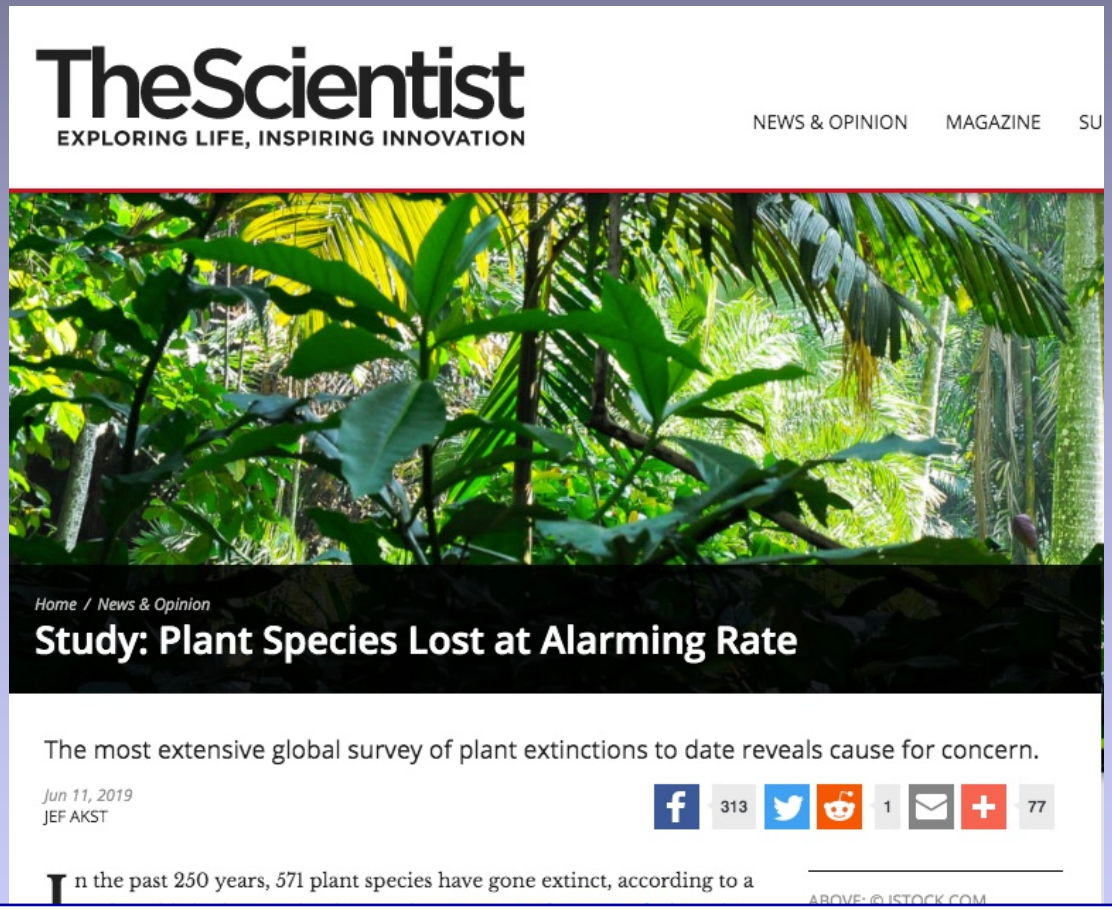
Source: United Nations http://www.un.org/apps/news/story.asp?NewsID=51526#.WRC5wFPytp8

And this…

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

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

And this…



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Study: Plant Species Lost at Alarming Rate

The most extensive global survey of plant extinctions to date reveals cause for concern.

Jun 11, 2019
JEF AKST

313 1 77

In the past 250 years, 571 plant species have gone extinct, according to a

ABOVE: © ISTOCK.COM

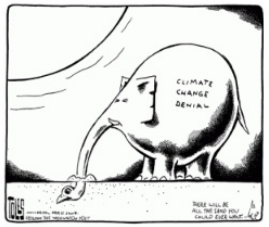
Loss of diversity

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

SOURCE: Akst, J. The Scientist June 11, 2019

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

‹ Previous Next ›



NPR "All Things Considered" interviewed CSW director Rick Piltz, Rep. Bob Inglis (R-South Carolina), and environmentalist Bill McKibben for an October 23 lead story on Republicans and denial of the scientific evidence for human-caused climate change. The war on climate science has developed over a long period, but today is arguably worse than ever. Compared with the radical know-nothing litmus test for politicians we see now, on climate science most of the Bush Administration, bad as it was, was downright nuanced and moderate.Link to archived 11-minute audio webcast.

A majority of Republican members of Congress, and the vast majority of Republican candidates for Congress this year, are turning against the science of climate change and appearing to deny the evidence that human activity, our burning of fossil fuels, in causing global climate change.

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And this…

Climate Change?

climate change

Lynette Cook/Science Source

SCIENCE

The 'Great Dying' Nearly Erased Life On Earth. Scientists See Similarities To Today

It was the biggest extinction in Earth's history. A new Smithsonian exhibit notes that some of the same things that killed over 90% of ocean species 250 million years ago are happening now.

LISTEN · 4:23 + PLAYLIST

Lastly this

Big mergers "could change food supplies and costs worldwide"

1. U.S.: Dow Chemical bought Dupont-Pioneer
2. Germany: Bayer bought Monsanto
3. China: ChemChina buys Syngenta

This $170B in consolidations will profoundly affect future global agriculture

And frankly this scares me!

Source" Colvin, G. "China's $43Billion Bid for Food Security" *Fortune* May 2017: 79-86.

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

http://ucbiotech.org