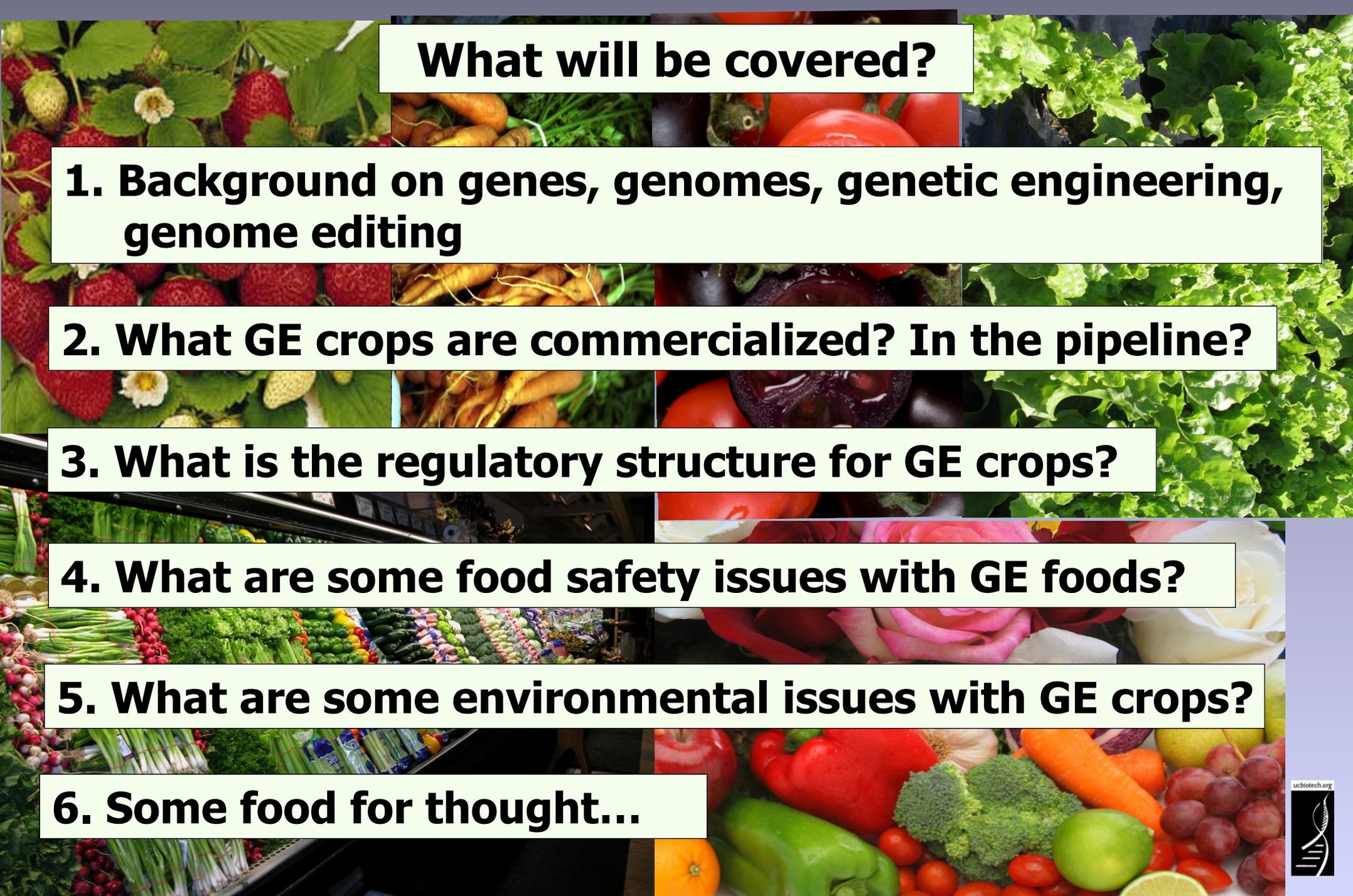




# GMOs: The Science and The Issues



*Peggy G. Lemaux*  
*University of California, Berkeley*  
<http://ucbiotech.org>  
<http://pmb.berkeley.edu/profile/plemaux#a1>



# 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?**

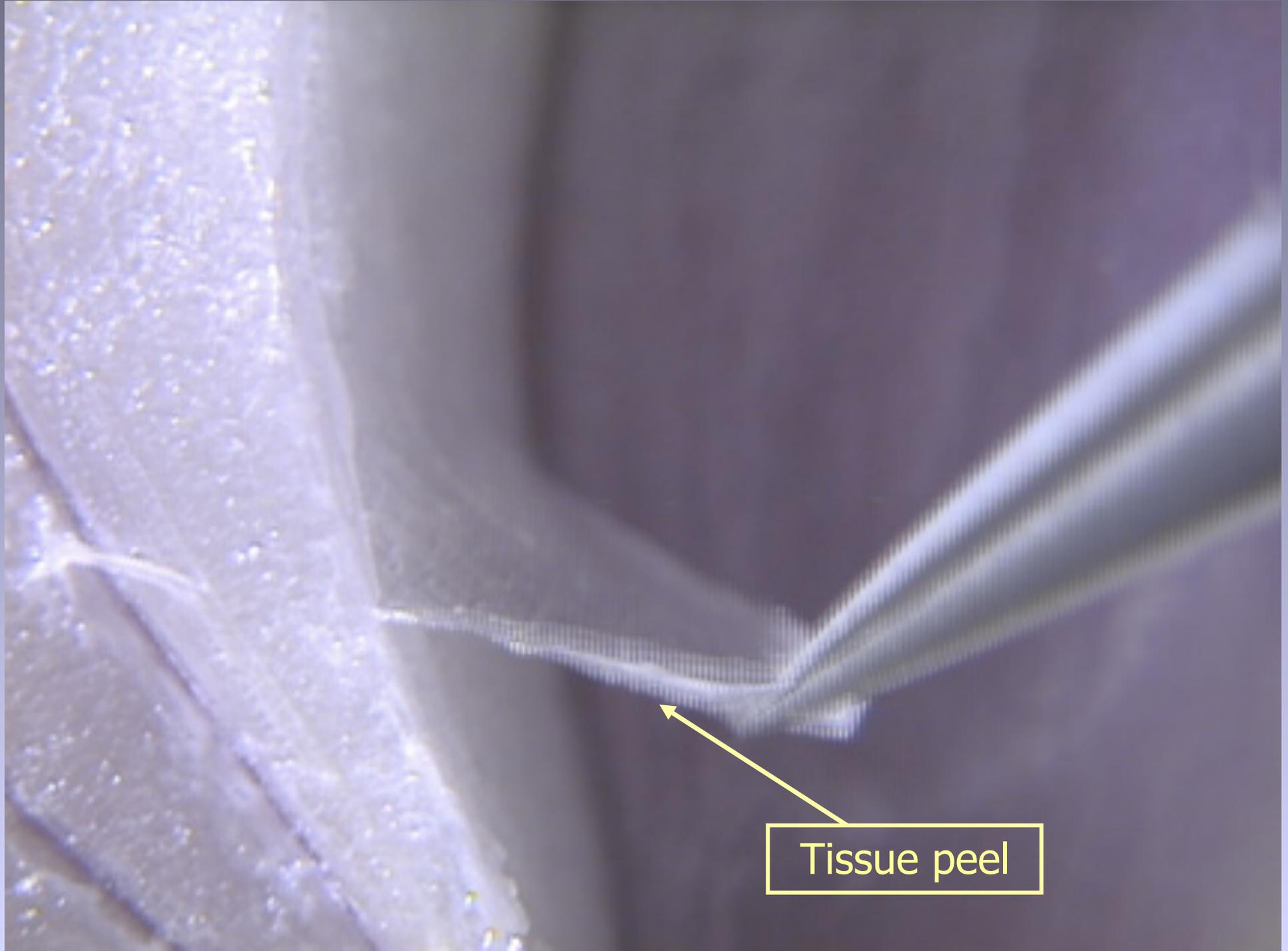
**5. What are some environmental issues with GE crops?**

**6. Some food for thought...**

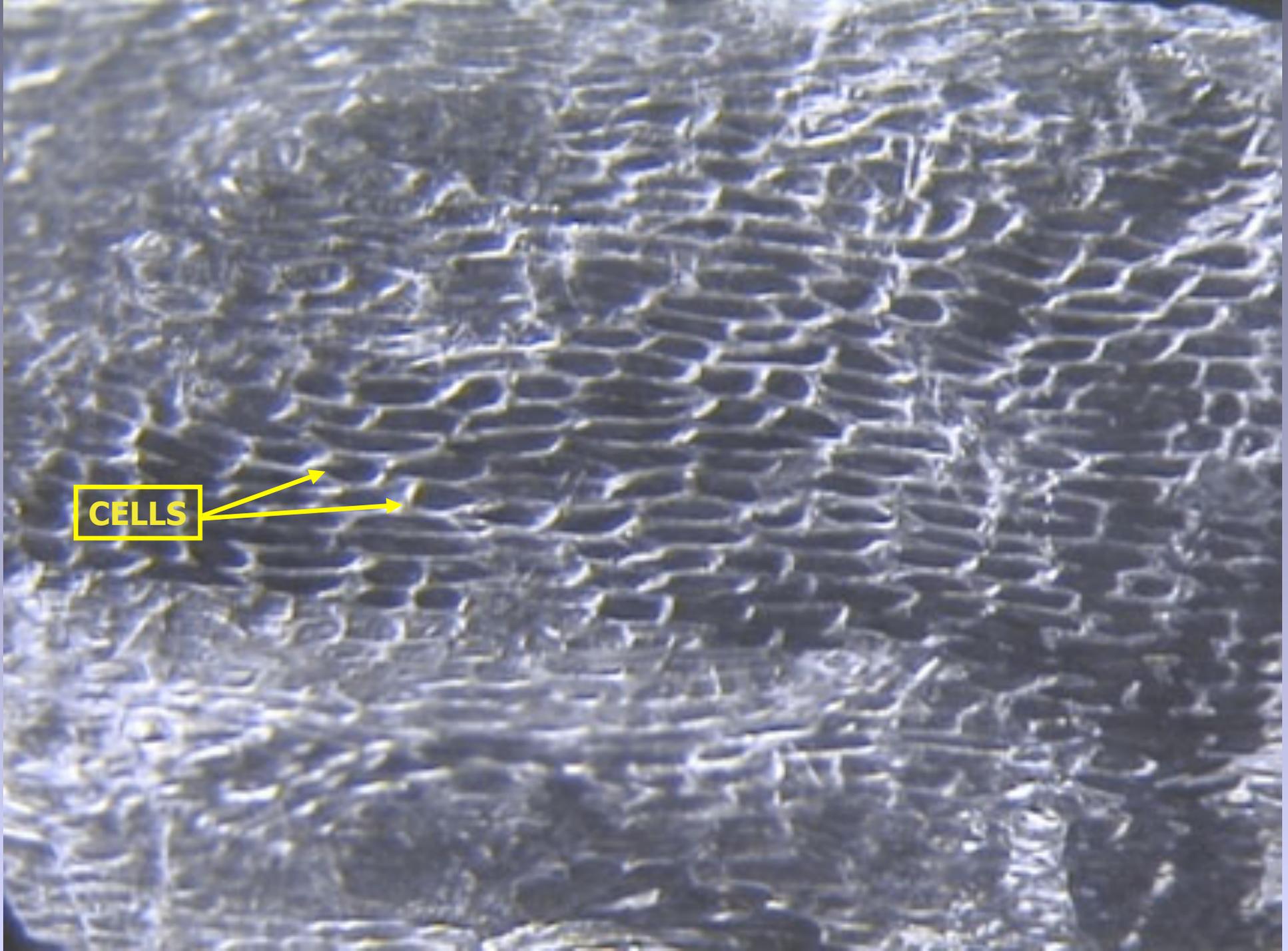
# *Tour d'Onion*



Or what makes an onion, an onion?



Tissue peel



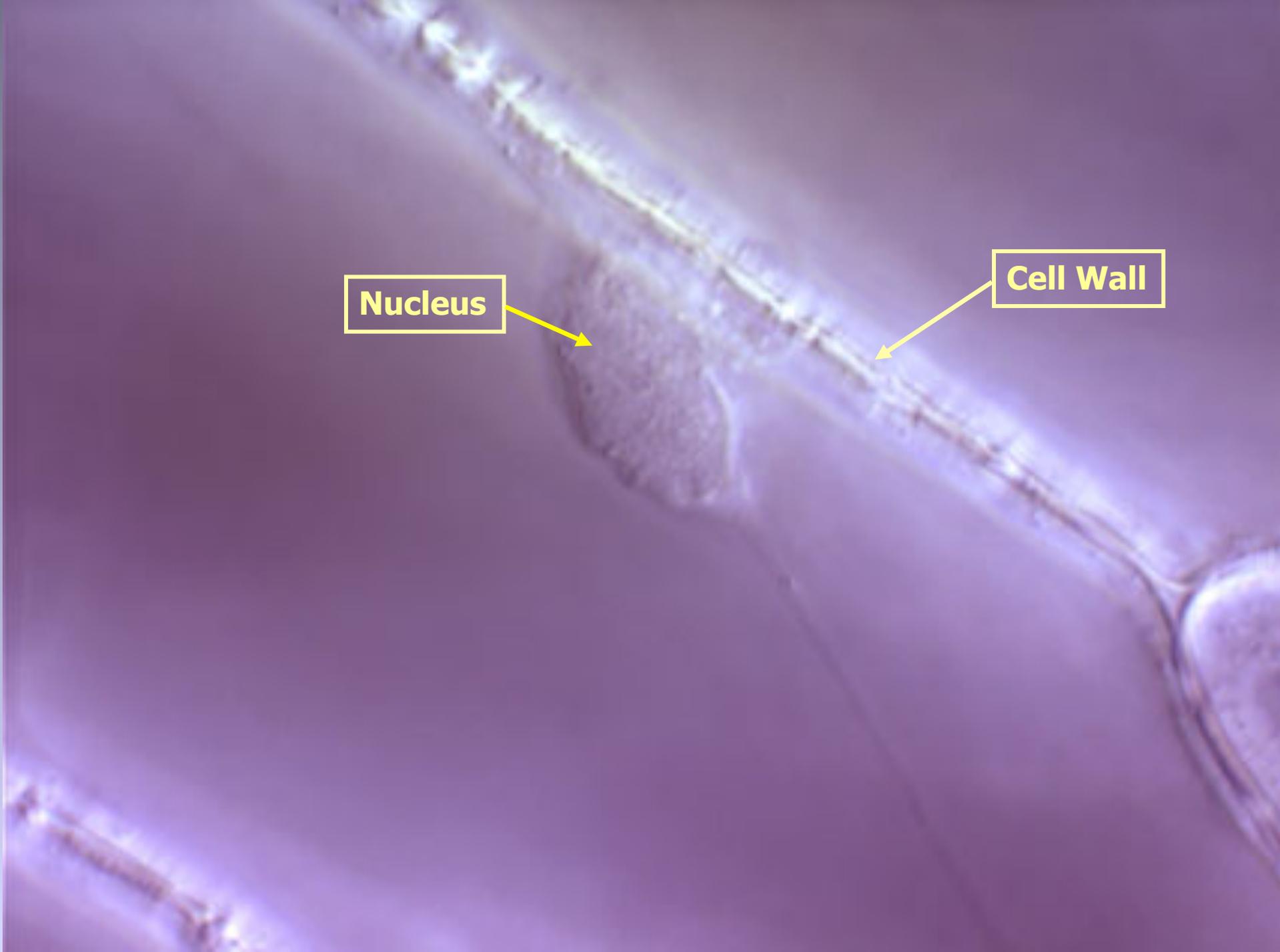
**CELLS**

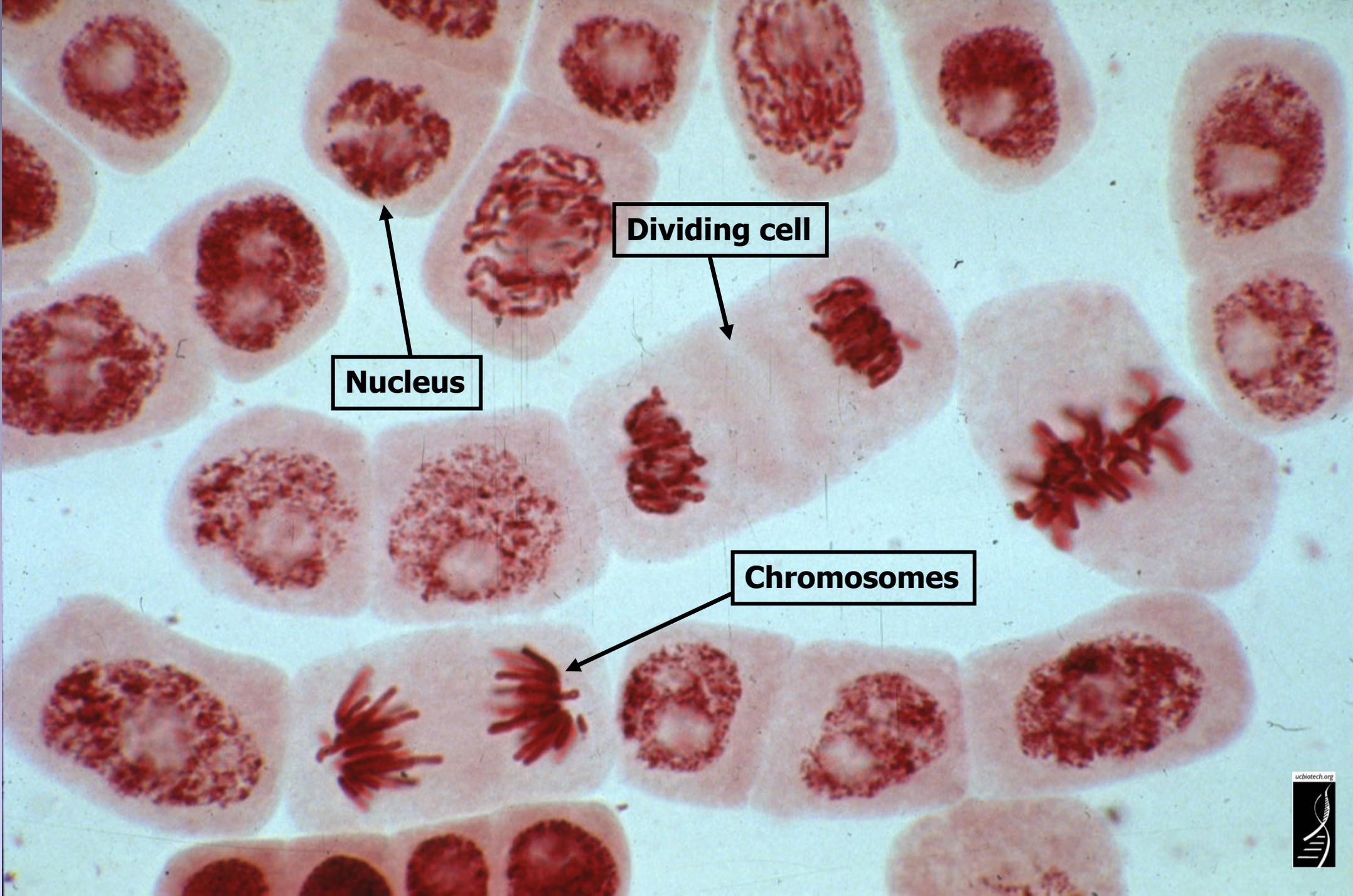


**Nucleus**



**Cell Wall**

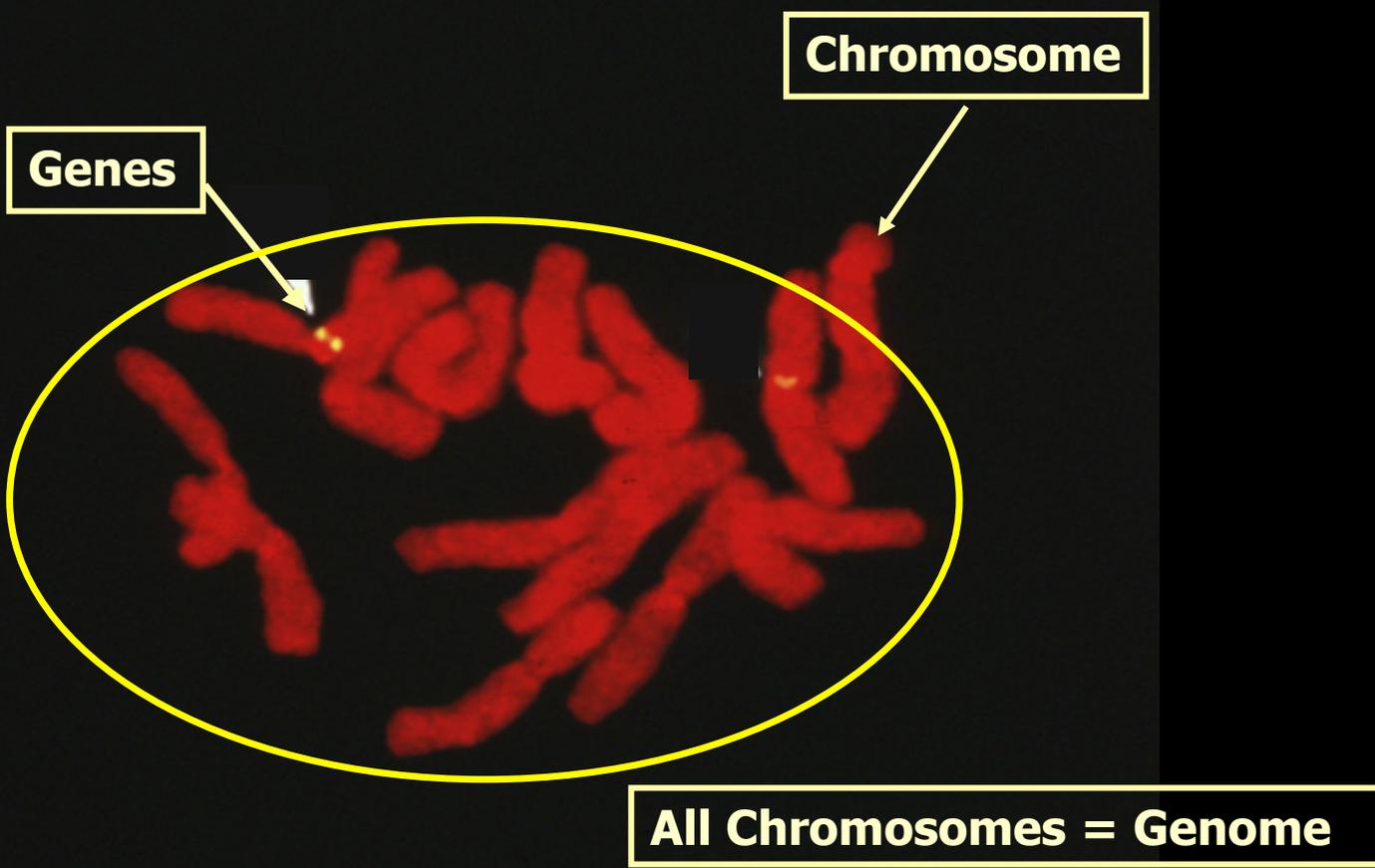




**Nucleus**

**Dividing cell**

**Chromosomes**



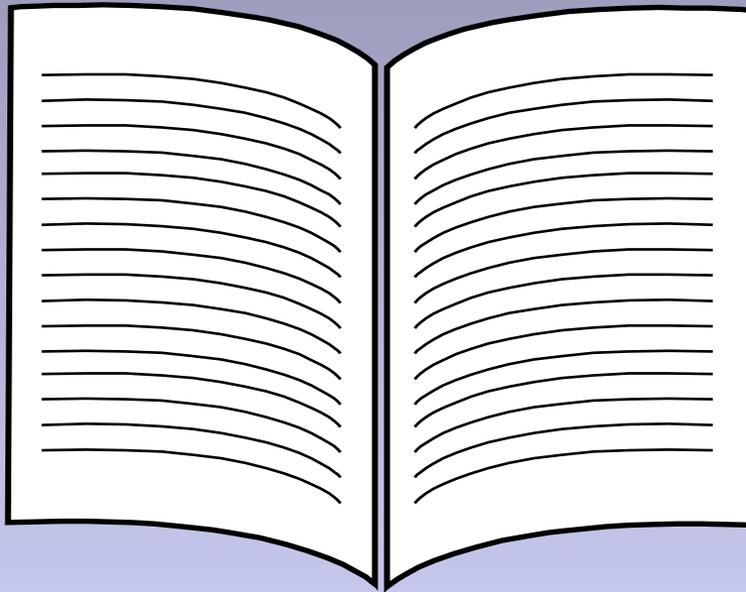
# Genetic information in the genome is responsible for traits

Represent chemical units in genome by alphabetic letters

...CTGACCTAATGCCGTA...



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



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



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

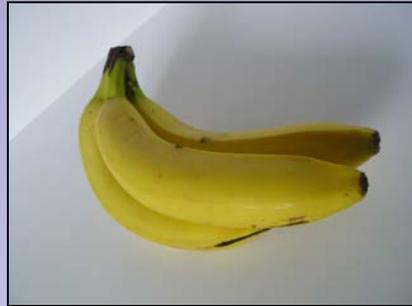
**To Looking Like They Are Now**



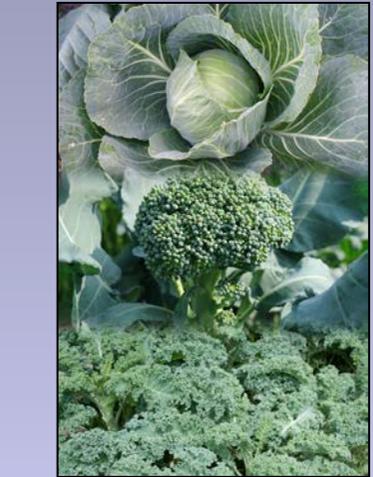
**Carrot**



**Eggplant**



**Banana**



**Broccoli,  
Kale,  
Cabbage**

**Intentional mutation breeding: used since the 1950s, creating >3200 officially released crops – like 600 maize, rice, wheat varieties. Although modified genetically, they are not under regulations used for genetically engineered (GMO) varieties.**



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



*Triticum monococcum*

**Ancient variety**



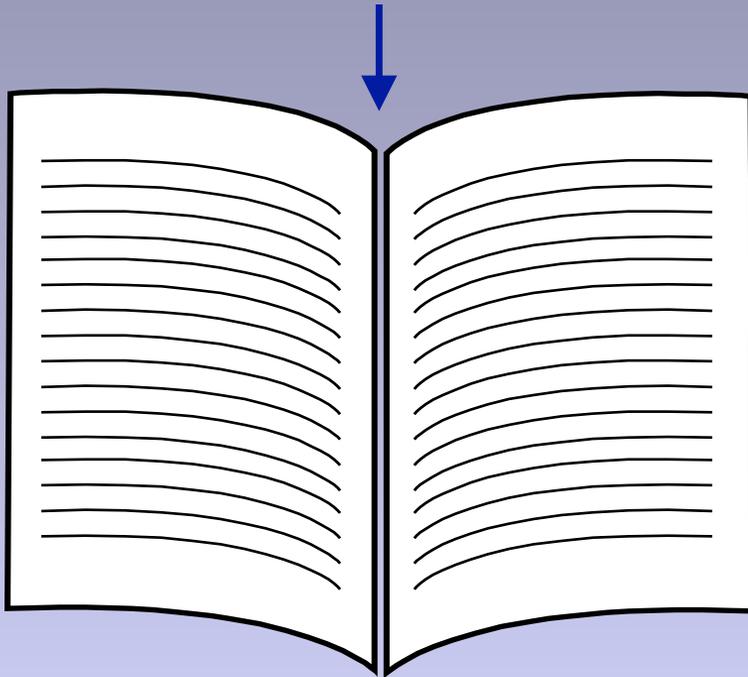
*Triticum aestivum*

**Modern bread variety**

# What does the information in the wheat genome look like?

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

...CTGACCTAATGCCGTA...

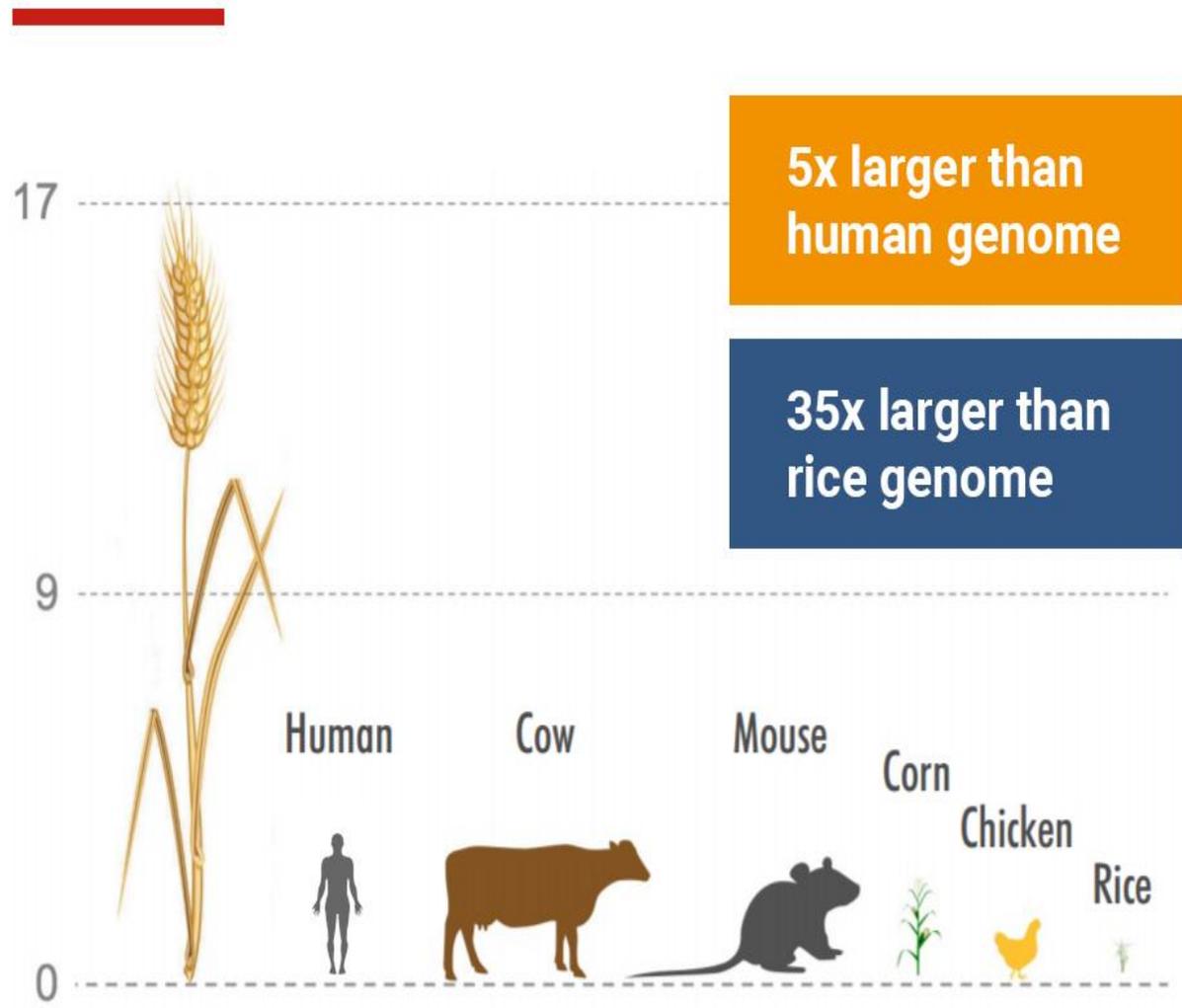


**1700 books**  
**1000 pages each**



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

# How does the wheat genome compare to the human genome?



Source: Earlham Institute communications team, Chris Bennett

# What happens when you breed wheat to create new varieties?



**X**



Random retention of ~50% of the 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)

***Example: New soybean variety with lower allergenicity and less anti-nutritional qualities created after many years of classical breeding efforts.***

SOURCE: "Triple Null: New Genetically Modified Soybean A Big Benefit For Food Allergies", Science 2.0, 5/4/15.  
[http://www.science20.com/news\\_article/triple\\_null\\_new\\_genetically\\_modified\\_soybean\\_a\\_big\\_benefit\\_for\\_food\\_allergies-155306](http://www.science20.com/news_article/triple_null_new_genetically_modified_soybean_a_big_benefit_for_food_allergies-155306)

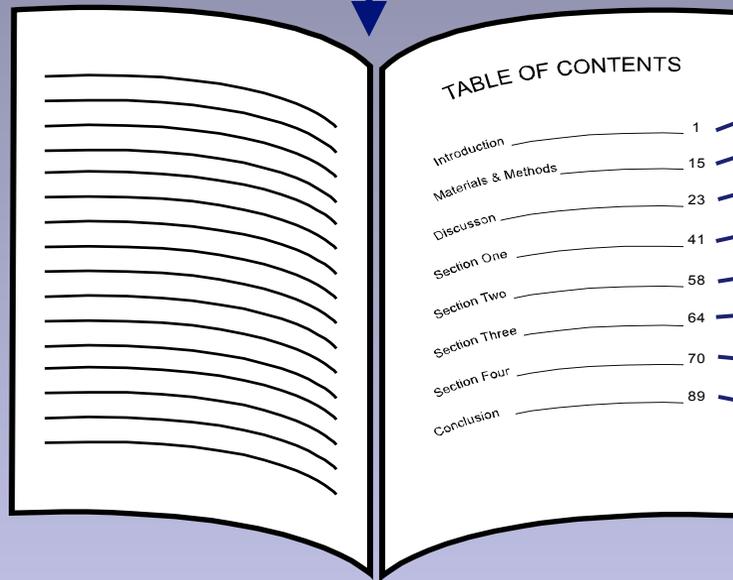


# ***Putting this in context, these breeding efforts were critical to increasing crop production...***

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

# Another means of modifying genomes uses a table of contents for gene locations

...CTGACCTAATGCCGTA...

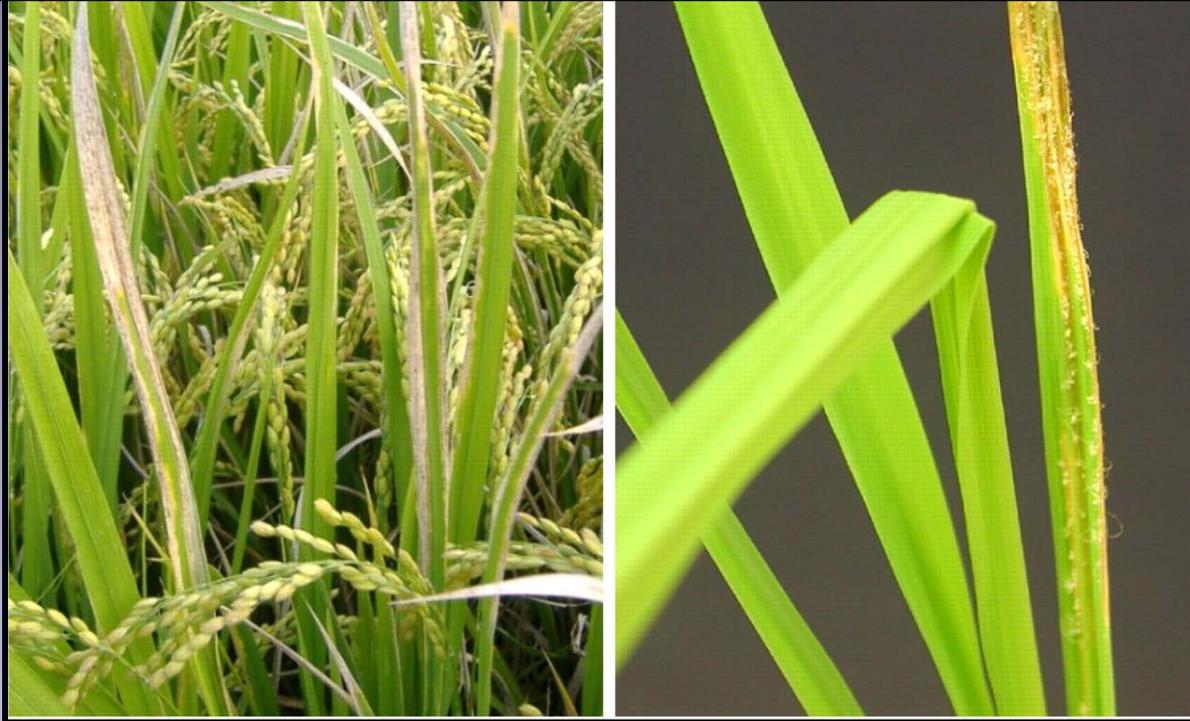


**Genomics**

1700 books  
(or 1.7 million pages)

Used for  
Marker-  
Assisted  
Selection

**Can't we just do all modifications this way?**



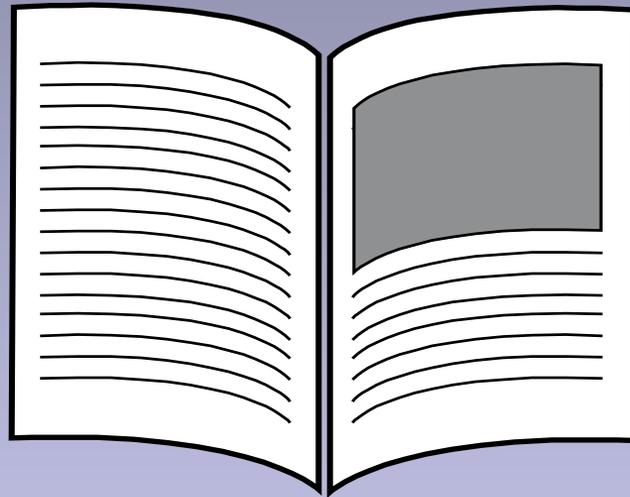
**Marker-assisted selection used to protect rice against bacterial blight and blast disease**

**Protection limited to diversity in crop and compatible relatives**

# Another means to modify genomes uses genetic engineering to create "GMOs"



+



One-half page  
equivalent to a gene



Inserts  
randomly  
in genome



Inserted  
gene(s)



1700 books  
(or 1.7 million pages)

1700 books  
(or 1.7 million pages)

# ***Classical Breeding***

compared to

# ***Genetic Engineering***

Uses plant machinery in plant

Gene exchange is random  
involving whole genome

When/where gene expressed  
not controlled by breeder

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

Uses plant machinery in laboratory

Gene exchange is specific  
involving single or few genes

When/where gene expressed  
controlled precisely

Source of gene from any  
organism

**How do you engineer a crop,  
wheat, for example?**

# What Is Engineered into the Plant?

## Gene of Interest & Marker Gene & On/Off Switches



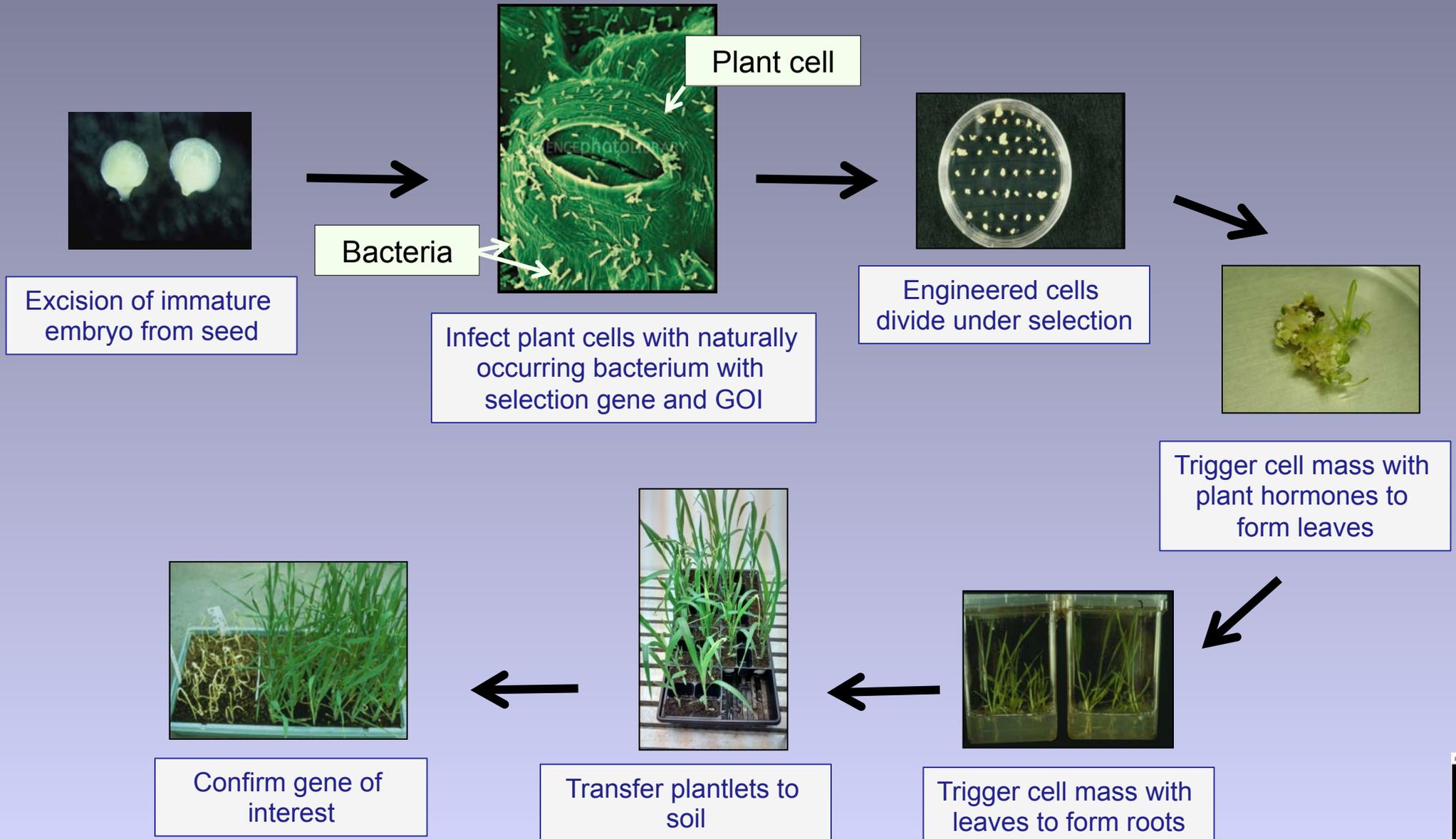
**Promoter:** controls when and where gene is made

**Off switch:** stops expression of gene

**Gene of interest:** gene you want to introduce into plant

**Marker:** used to identify which cells have gene of interest

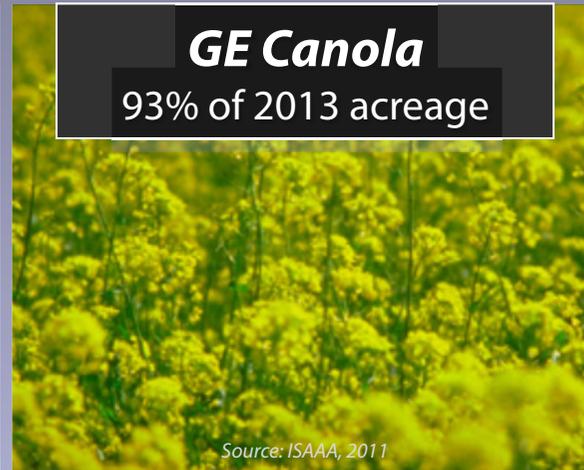
# Genetic Engineering of Wheat



# Number of different commercially available large acreage GE crops is limited



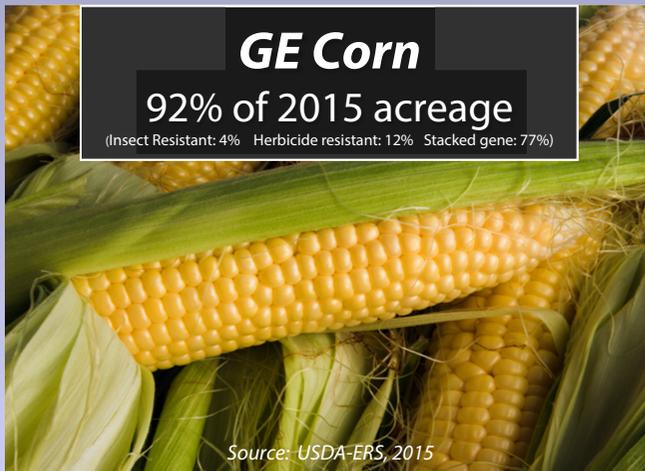
**GE Cotton**  
94% of 2015 acreage  
(Insect Resistant: 5% Herbicide tolerant: 10% Stacked gene: 79%)  
Source: USDA-ERS, 2015



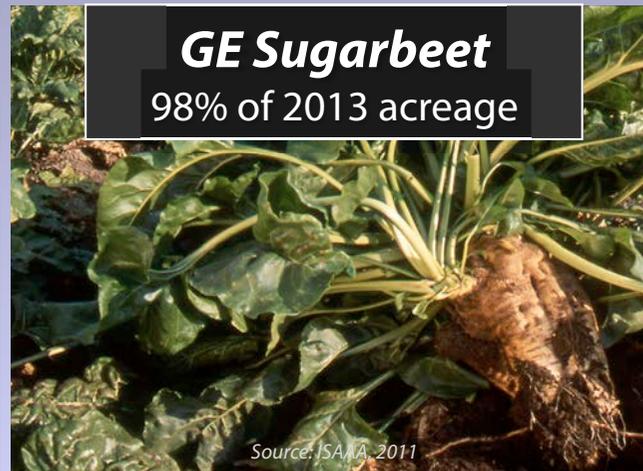
**GE Canola**  
93% of 2013 acreage  
Source: ISAAA, 2011



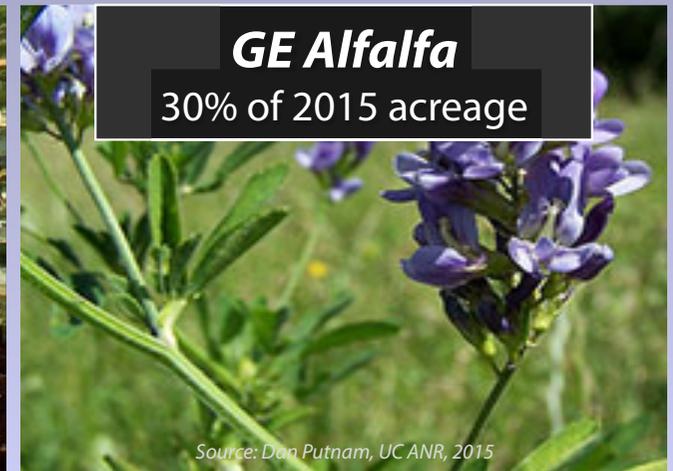
**GE Soybean**  
94% of 2015 acreage  
(Herbicide resistant: 94%)  
Source: USDA-ERS, 2015



**GE Corn**  
92% of 2015 acreage  
(Insect Resistant: 4% Herbicide resistant: 12% Stacked gene: 77%)  
Source: USDA-ERS, 2015



**GE Sugarbeet**  
98% of 2013 acreage  
Source: ISAAA, 2011



**GE Alfalfa**  
30% of 2015 acreage  
Source: Dan Putnam, UC ANR, 2015



**Number of different traits available in GE crops is also limited**

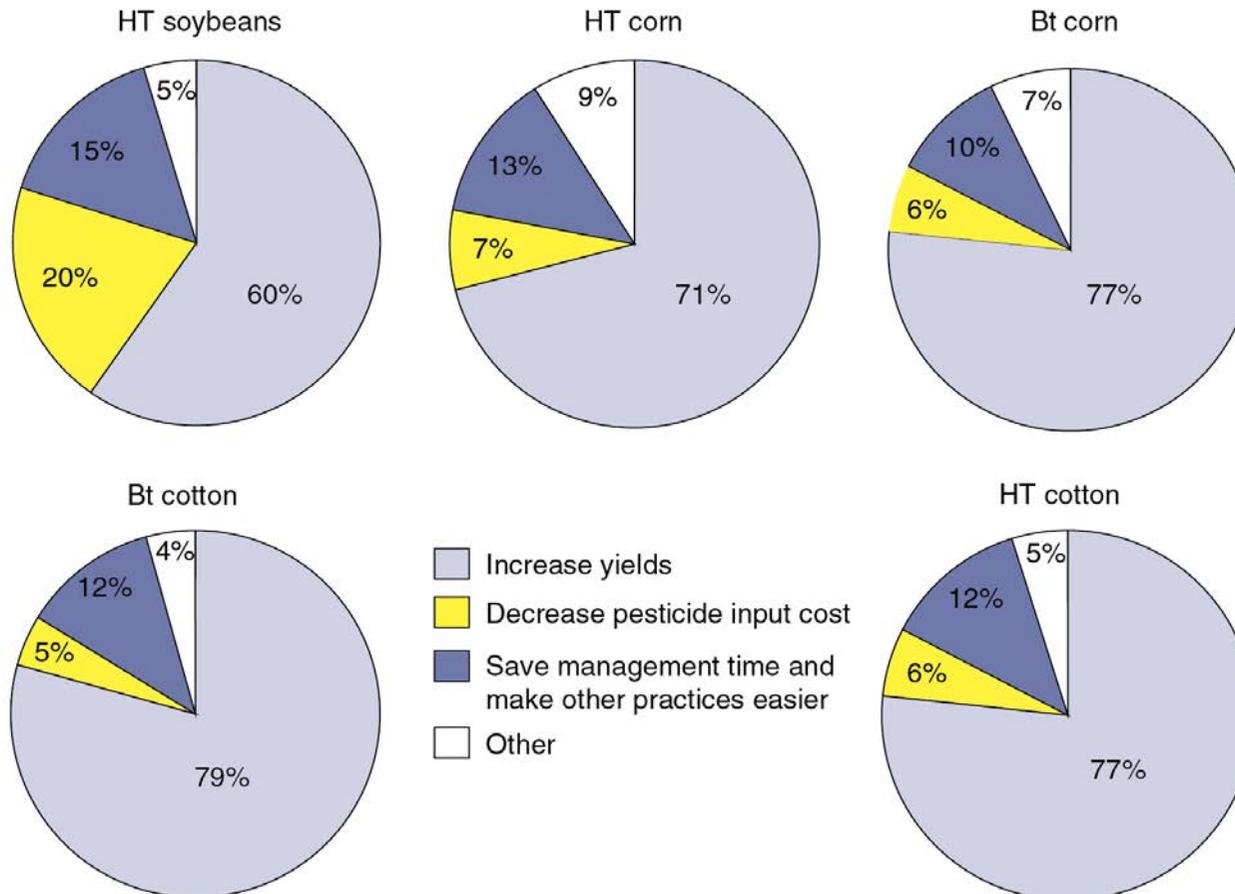


**Bt Crops - engineered for insect resistance using gene from naturally occurring bacterium**



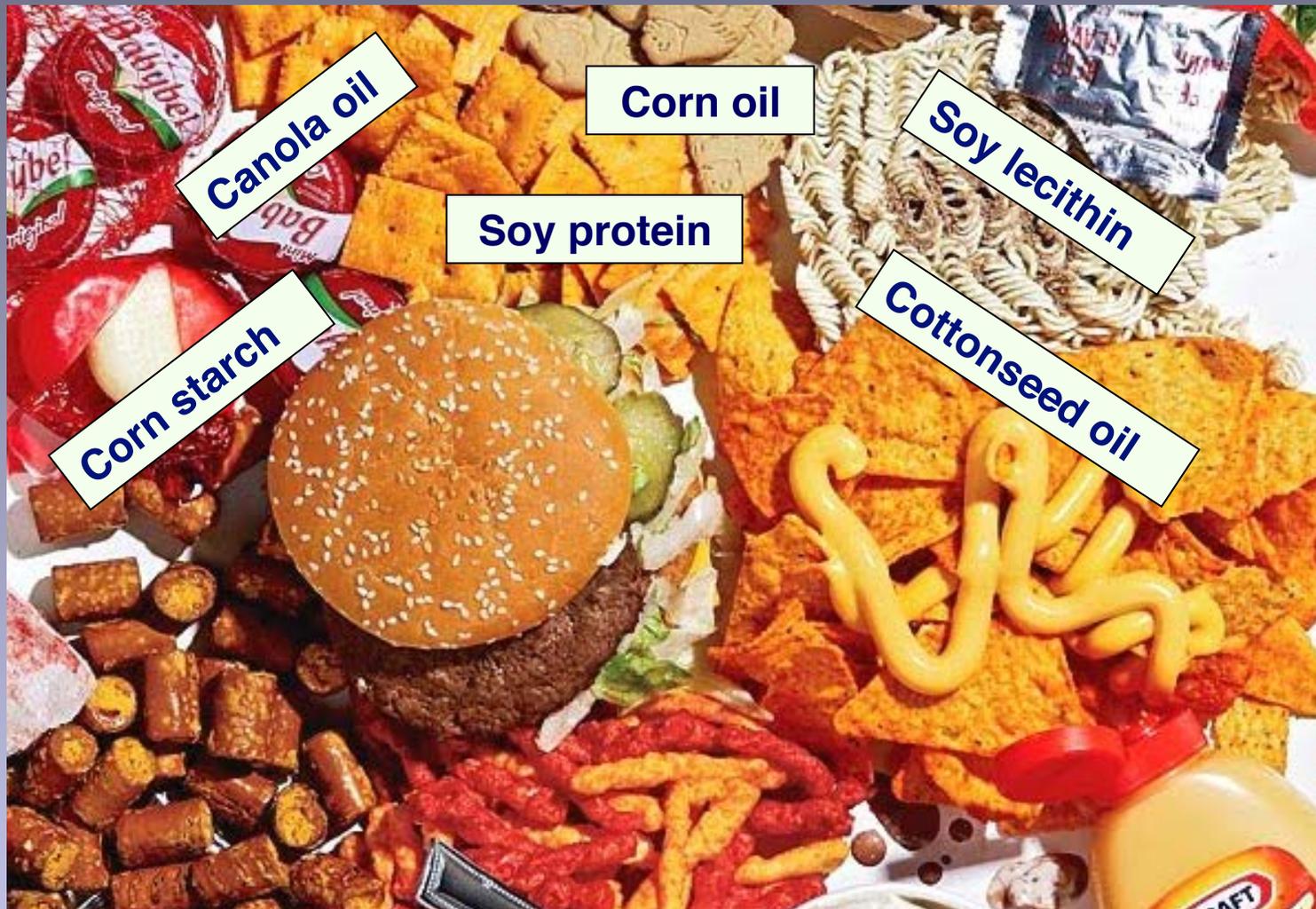
**Herbicide-tolerant - engineered with genes to tolerate herbicide application**

# Why do growers adopt GE crops?



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

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 U.S market

## *GE Squash*

~25,000 acres in 2011



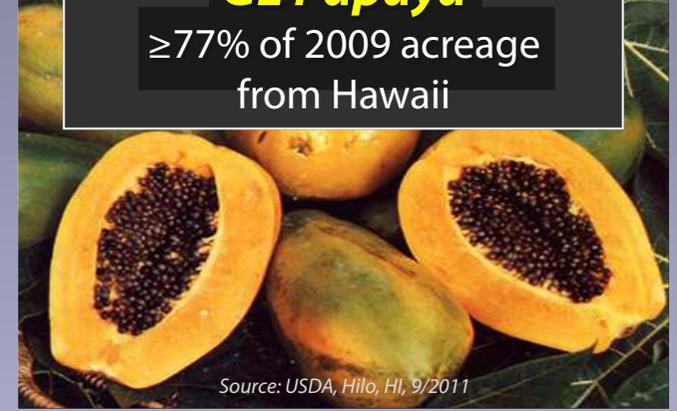
Source: Non-GMO Project

## *GE Sweet Corn* Acreage unknown



## *GE Papaya*

≥77% of 2009 acreage from Hawaii

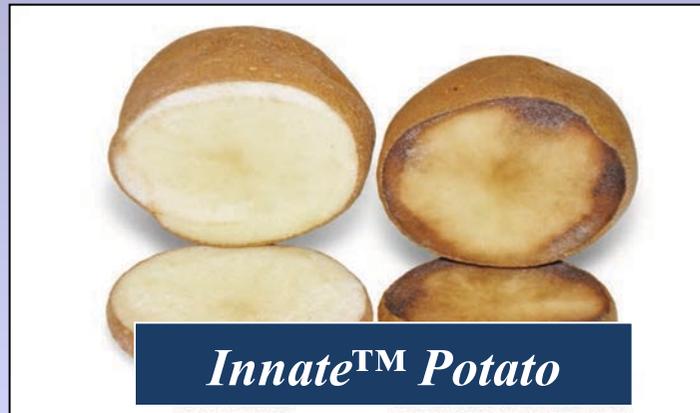


Source: USDA, Hilo, HI, 9/2011

# Two more are just being introduced

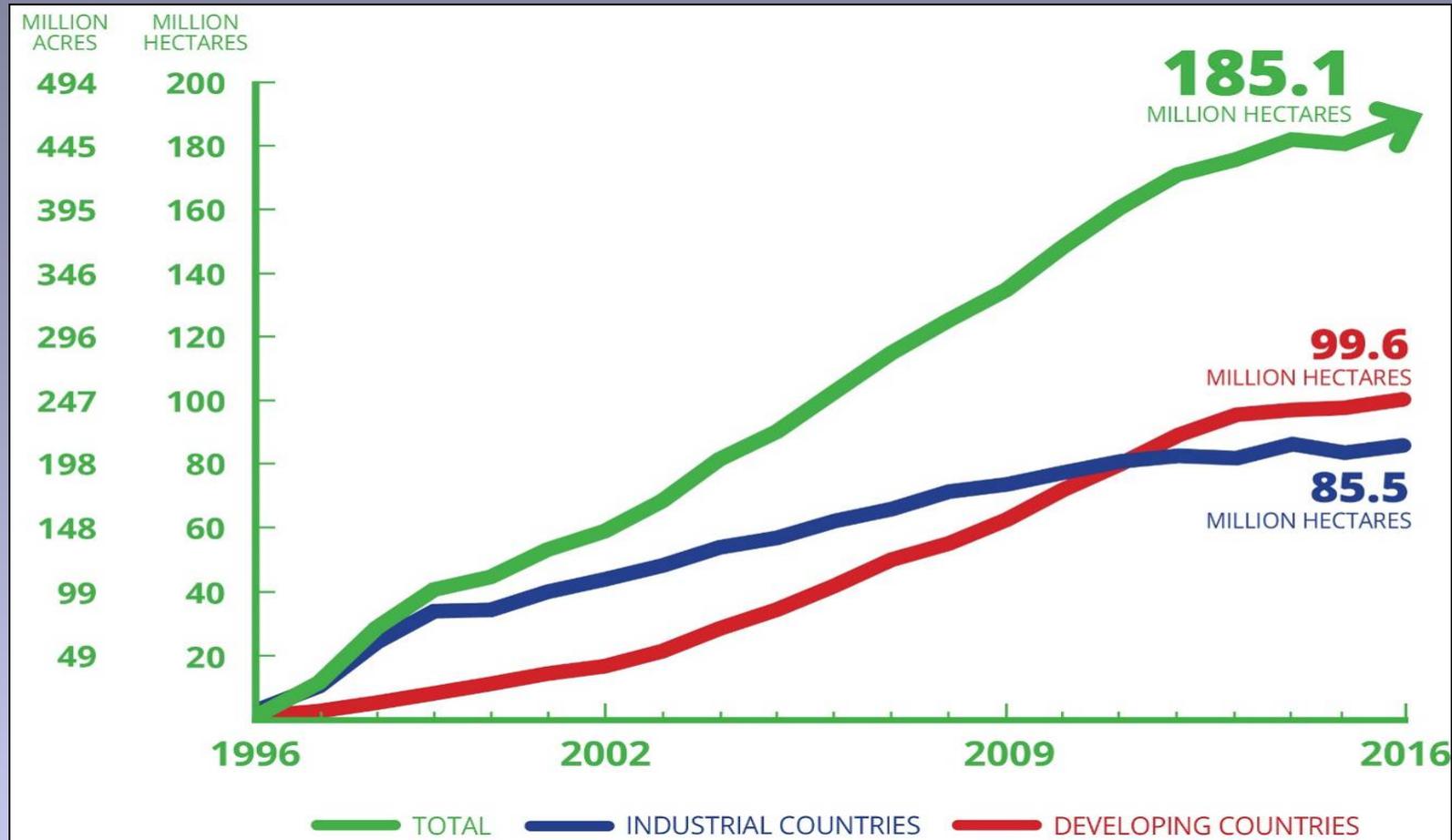


*Arctic Apple™*



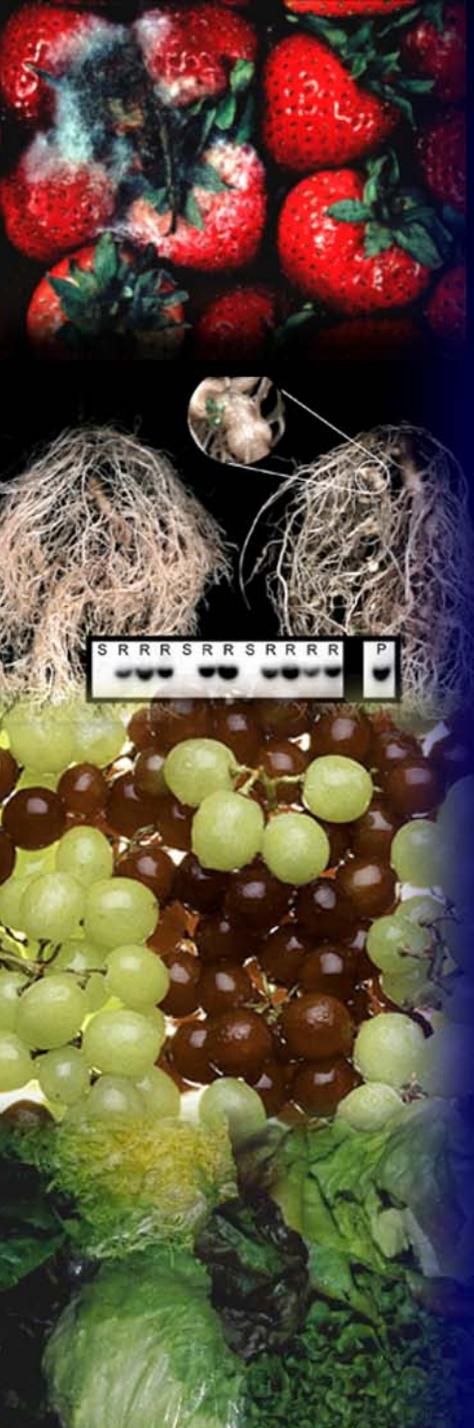
*Innate™ Potato*

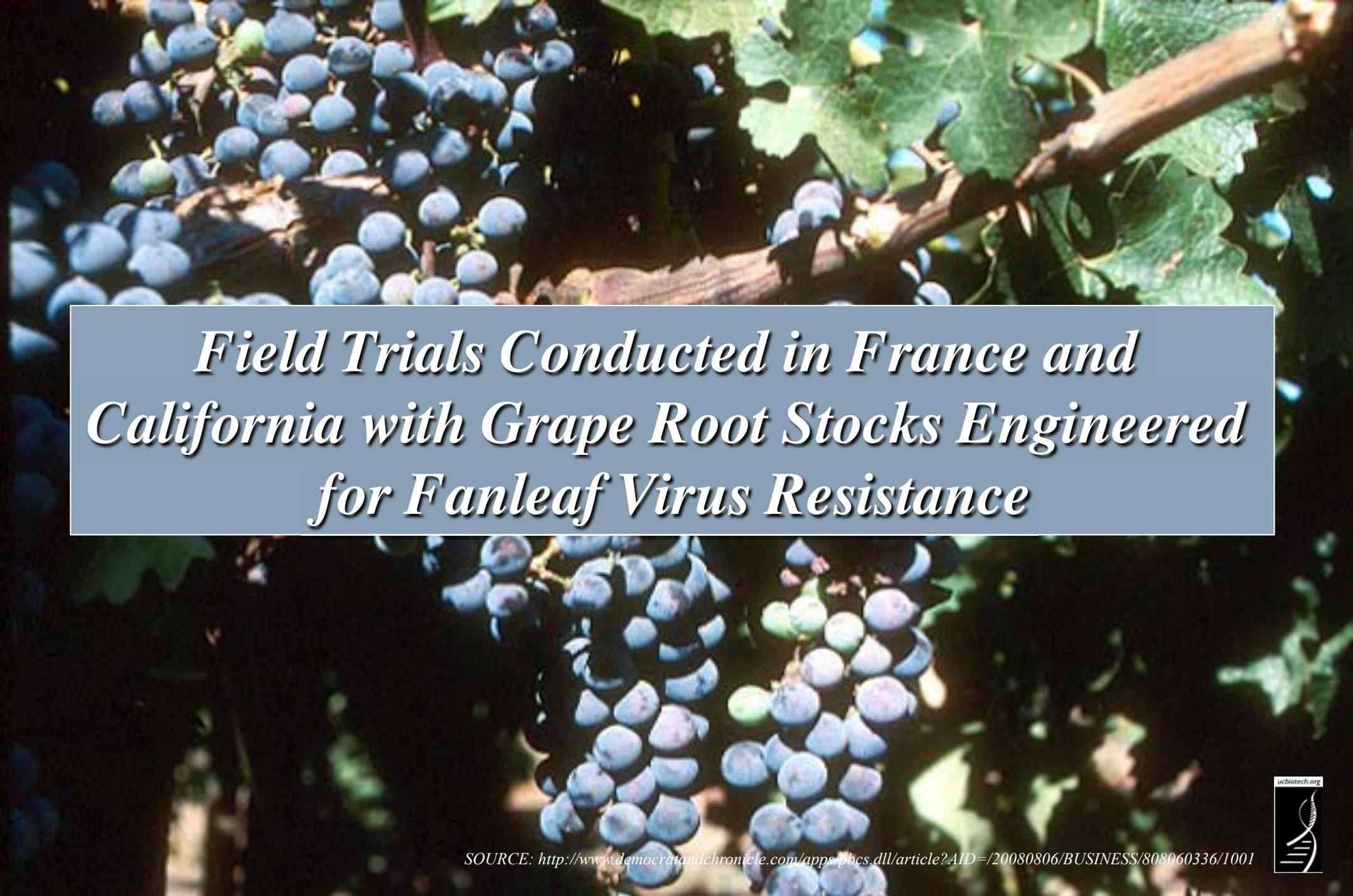
**Despite the same limited U.S. crop and trait types, worldwide acreage is increasing in 19 developing, 7 developed countries**



**In 2016 ~18 million farmers in 26 countries planted 457M acres (>4X size of California) – 54% in developing countries; 41% stacked traits**

# ***WHAT'S IN THE PIPELINE?***





*Field Trials Conducted in France and  
California with Grape Root Stocks Engineered  
for Fanleaf Virus Resistance*

SOURCE: <http://www.democratandchronicle.com/apps/pbcs.dll/article?AID=/20080806/BUSINESS/808060336/1001>



# *Greening disease tolerance could involve genetic engineering of citrus or insect pathogen*

**The New York Times**

July 27, 2013

## **A Race to Save the Orange by Altering Its DNA**

By AMY HARMON

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

“It’s here” was all his grove manager needed to say to force him over to the side of the road.

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

“O.K.,” he said finally on that fall day in 2005, “let’s make a plan.”

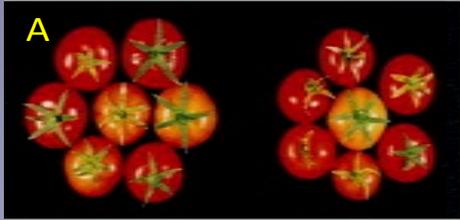
In the years that followed, he and the 8,000 other Florida growers who supply most of the nation’s orange juice poured everything they had into fighting the disease they call citrus greening.

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

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



# Salinity and Drought Tolerance - UC Davis



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



AtNHX1



Wild type  
15 days drought, 7 days re-watered



IPT gene

*Salt-tolerance*

*Drought-tolerance*



*Engineering tomato to increase health-promoting compounds*

© John Innes Centre

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

# Engineering cowpeas to resist attack by pod-borer to increase yields for 200M African consumers



## 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

## 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.



# *Golden Rice engineered to contain bioavailable pro-Vitamin A*



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



*Genetically engineered petunias  
change colors throughout the day*

SOURCE: "Would You Like to Grow Color-Changing Flowers?", Smithsonian Magazine, 2/14/15  
<http://www.smithsonianmag.com/innovation/would-you-like-to-grow-color-changing-flowers-180954245/>  
#FwapELxi5XLiGivK.99





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

<http://www.newscientist.com/article/dn25644-american-chestnut>

***Engineered tobacco produces antibodies making up Zmapp, the drug used to treat ebola virus patients***

SOURCE: "Bob Simon's final 60 Minutes: Grinding progress of ZMAPP Ebola GMO drug", Genetic Literacy Project, 2/17/15.  
<http://geneticliteracyproject.org/2015/02/17/bob-simons-final-60-minutes-grinding-progress-of-zmapp-ebola-gmo-drug/>



## Chinese Researchers Stop Wheat Disease with Gene Editing

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

By [David Talbot](#) on July 21, 2014

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

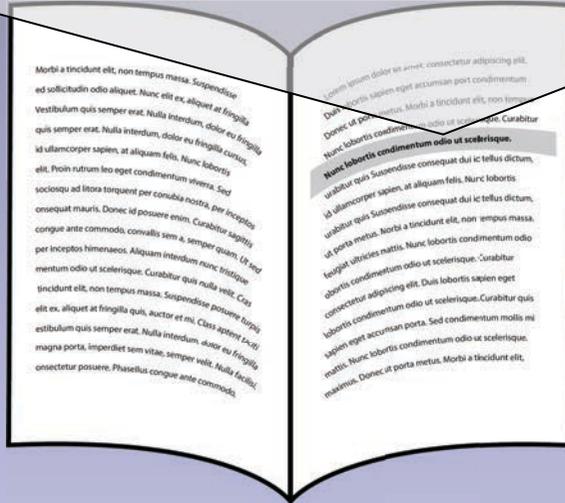


*Wheat resistant to powdery mildew created  
using new genome-editing techniques*

# What is Genome Editing?



It is this one sentence which will be modified  
It is that new sentence which will be modified



**Inserts  
specifically  
in genome**

**Find target text, cut out, paste in new modified text**

**This type of genome editing  
is not being regulated as GE  
or GMO by USDA**

1700 books  
(or 1.7 million  
pages)

1700 books  
(or 1.7 million pages)

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



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

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



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

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



**2014**  
GM maize protest in Germany



**1999**  
Lord Melchett participating in GM protest

**And there are issues in the U.S. too**

# 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?

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

# 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?

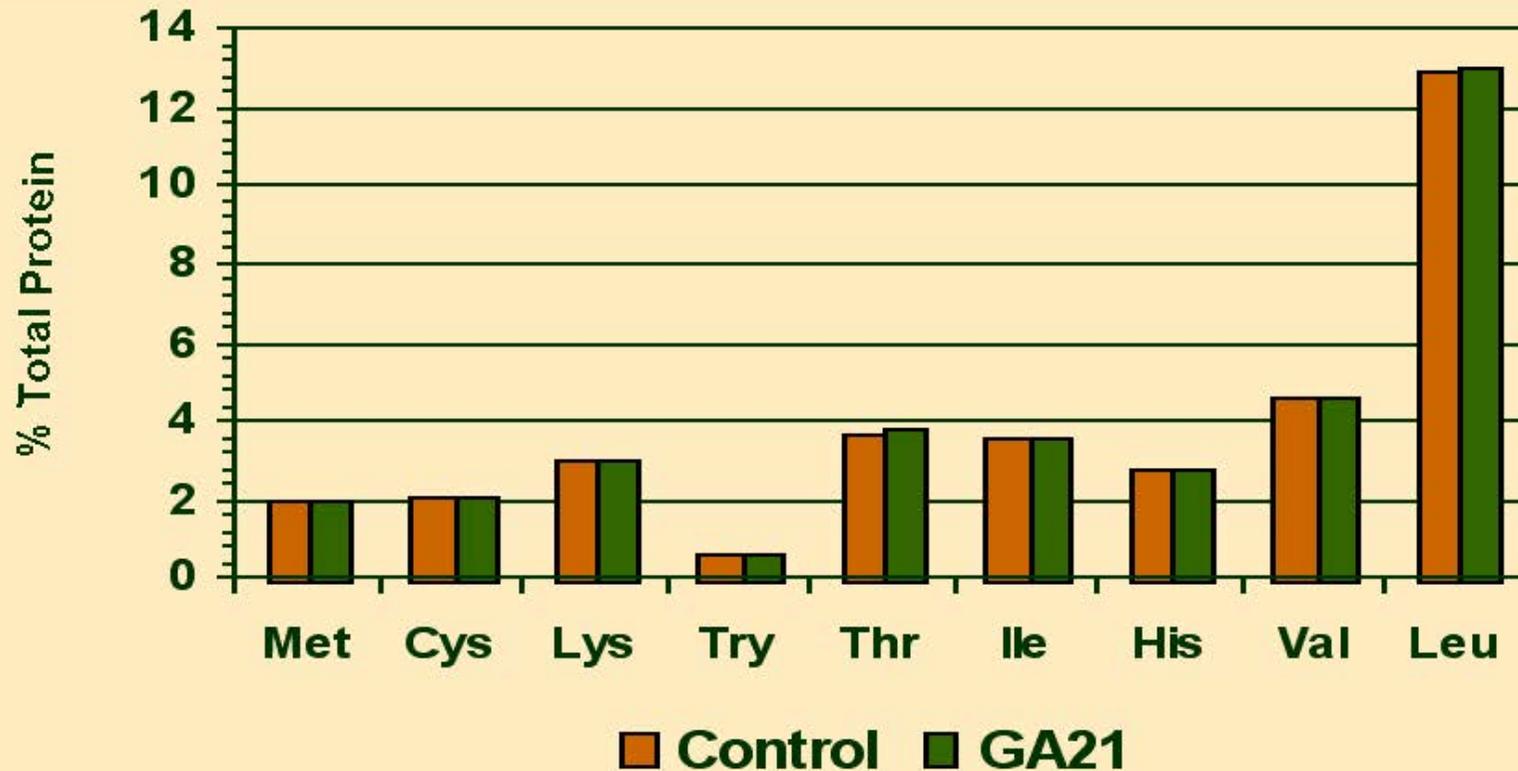
This is based on the concept of substantial equivalence

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

Product of introduced genetic information tested for safety separately

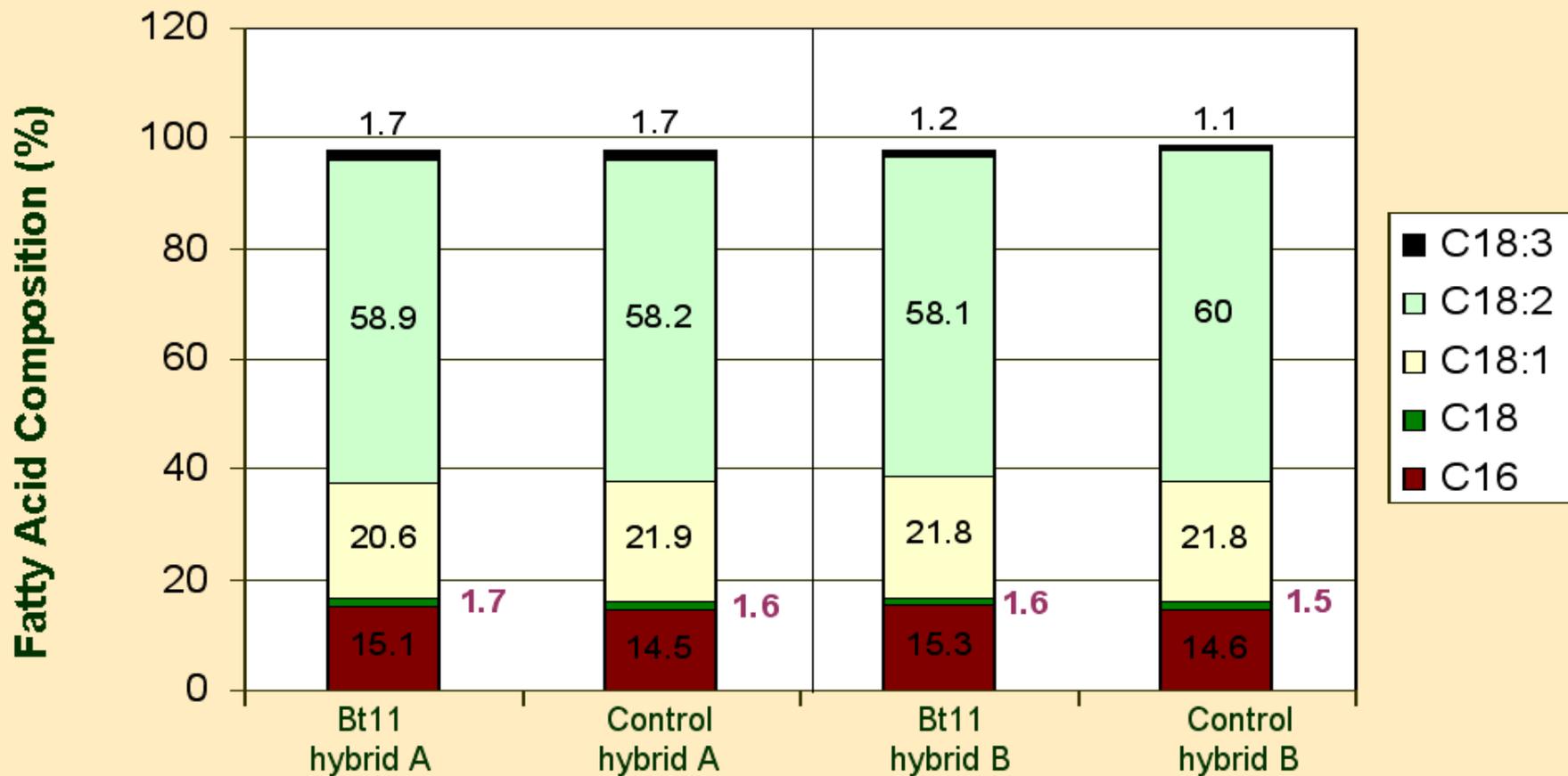
How is substantial equivalence tested?

# Substantial Equivalence: Amino Acids



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

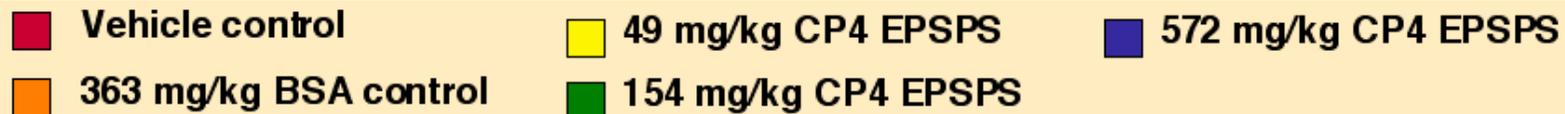
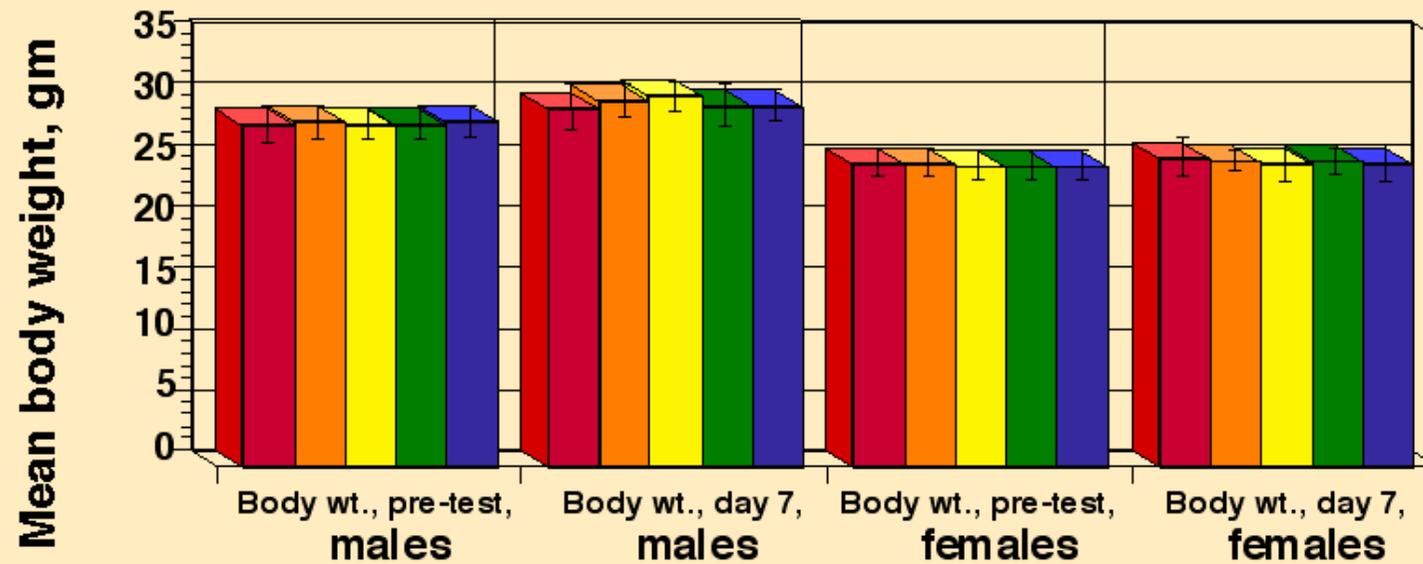
# Substantial Equivalence: Fatty Acids



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

# Toxicity Assessment: Roundup Ready/CP4 EPSPS protein

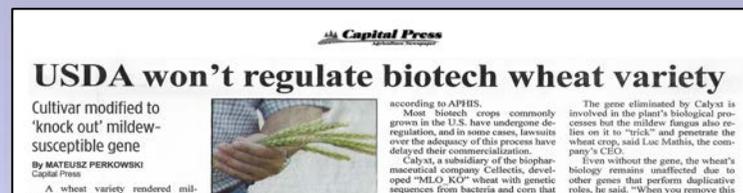
*No deleterious effects at highest dose (572mg/kg)*



# But regulation is based on an outdated, 1986 regulatory system, which has caused problems:

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

## EXAMPLES:



**In April 2016: USDA APHIS decided not to regulate a mushroom and corn genetically modified with genome editing.  
Reason: no DNA from plant pest or other species introduced.**

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

## Genetically engineered crops that fly under the US regulatory radar

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

the scope of its regulations several genetically

Coordinated Framework is on the one hand

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

inquiries to APHIS suggests that the number of entities seeking nonregulated status for

conclude that it is time to reevaluate the US regulatory framework for GE crops and

### Also decide regulation for products created with genome editing

institutions or small biotech companies, suggesting that the use of technologies, such as null segregants, novel delivery systems,

scientific knowledge and technologies and, importantly, that allows the participation of small companies and public sector institutions.



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

### **Update to Coordinated Framework specifies agency roles and responsibilities through:**

- **Agency-specific overviews of regulatory roles.**
- **Case studies demonstrate how product developers might navigate regulatory framework.**
- **Table summarizes regulatory responsibilities and coordination across EPA, FDA, and USDA for various biotechnology products.**

comprehensive summary of the roles and responsibilities of the three principal regulatory agencies initiative

**But here are still questions to be answered and awaits current administration actions...**



# 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...

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

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

**But did you ever hear that on Dr. Oz?**

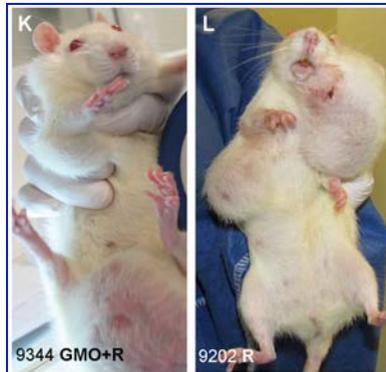
## French academies trash GM corn cancer study

By RFI

A controversial study that linked genetically modified maize to cancer in laboratory "scientific experiment" six in a



**Featured on Dr. Oz Show**



**Claim that Monsanto's RR corn causes tumors in rats**



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

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

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



**What have other published studies shown?**

## **Meta-analysis from France in 2012 showed GE foods:**

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

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



**maize**

**potato**



**soy**

**rice**



**triticale**

## 2014 study

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



## Conclusion:

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



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

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

# What are some issues with GE crops & foods?

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



PER 56 g SERVING

**50**  
CALORIES

**0g**  
SAT FAT  
0% DV

**180mg**  
SODIUM  
8% DV

**0g**  
SUGARS

Premium Tuna



See side panel for full Nutrition Facts.



\*Contains 140 mg of EPA and DHA combined per serving, which is 88% of the 160 mg Daily Value for a combination of EPA and DHA. EPA and DHA levels based on average, subject to natural variability.

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

# Food Safety News

Breaking news for everyone's consumption

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

BY DAN FLYNN | MARCH 25, 2014

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

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



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

SOURCE: "GE Labeling Resurrected in California, Petition For Ballot Measure Circulating in Colorado", March 25, 2014, Food Safety News.  
<http://www.foodsafetynews.com/2014/03/gm-labeling-resurrected-in-california-petition-circulating-for-initiative-in-colorado/#.UznX9q1dVLM>



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



SOURCE: "GMO Labeling: These Numbers Will Astound You", The Motley Fool, 2/7/15  
<http://www.fool.com/server/printarticle.aspx?file=/investing/general/2015/02/07/gmo-labeling-these-numbers-will-astound-you.aspx>

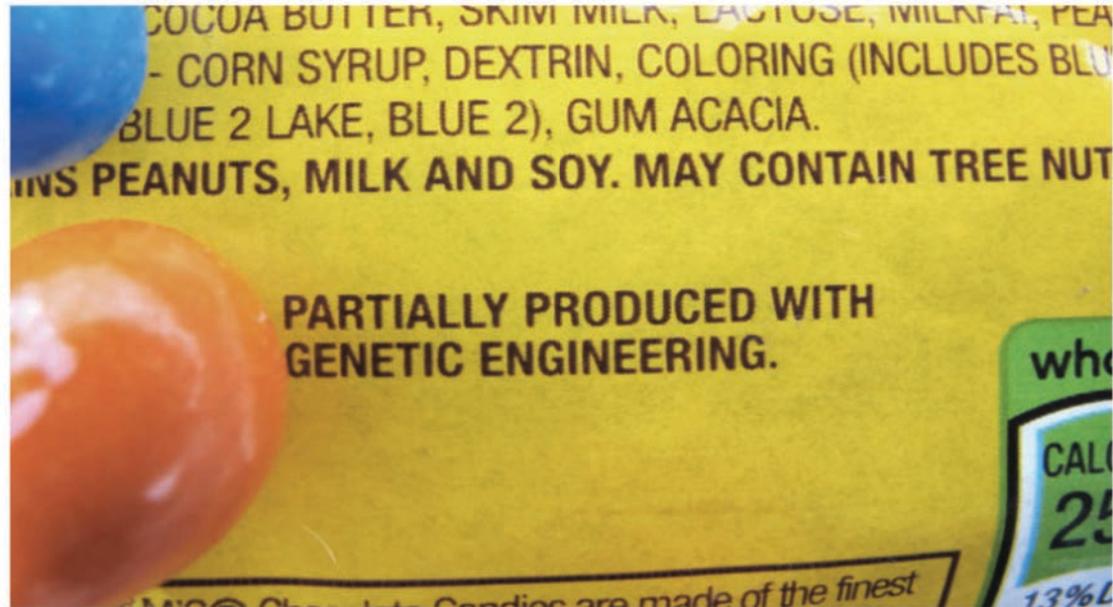
SOURCE: Costanigro, M. and Lusk, J.J. 2014. The signaling effect of mandatory labels on genetically engineered food. *Food Policy* 49: 259-267



# Senators Reach Deal On National GMO Labeling Bill

June 23, 2016 · 6:39 PM ET

PEGGY LOWE



A new disclosure statement on a package of peanut M&M's candy notes they are "partially produced with genetic engineering."

**And then...**

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

**Legislation requires USDA to decide what ingredients are from genetically engineered organisms; then labels are added on foods using words, pictures or bar codes, scannable with smartphones.**

# 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...

## **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 associated with herbicide use, as measured by the 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



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

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



# March 2017...and the problem continues

## Glyphosate-resistant tumbleweed poses problem for farmers

By **ERIC MORTENSON**  
Capital Press

An advocate of direct seeding and no-till farming hopes Northeastern Oregon wheat growers don't give up the practice in wake of news that patches of Russian thistle, or tumbleweed, have developed resistance to glyphosate, the herbicide commonly used to control weeds in wheat fields.

Judit Barroso, a weed sci-



and direct seeding practices, in which seeds and fertilizer are planted into the stubble of the previous crop with minimal disturbance of the soil.

Executive Director Kay Meyer said a couple strategies have emerged to cope with glyphosate resistant Russian thistle. There's no "silver bullet," she said, but some farmers may be able to break the weed cycle by rotating in other cash crops rather than

follow the grain-fallow-grain pattern year after year. Austrian peas may be an option for some, she said.

Cover crops may break disease cycles and build up soil, but some producers are worried they would take too much moisture from land that otherwise would lie fallow, she said.

Technology may hold an answer as well, Meyer said. New spot spray systems such

as WeedIt and WeedSeeker can optically identify and spray only growing weeds, not bare ground. Such systems can reduce chemical use by 80 percent, Meyer said, and the savings might allow growers to use more expensive chemicals other than glyphosate.

The technology is expensive, but in some cases farmers might jointly purchase and share the system, she said.

# What are some issues with GE crops & foods?

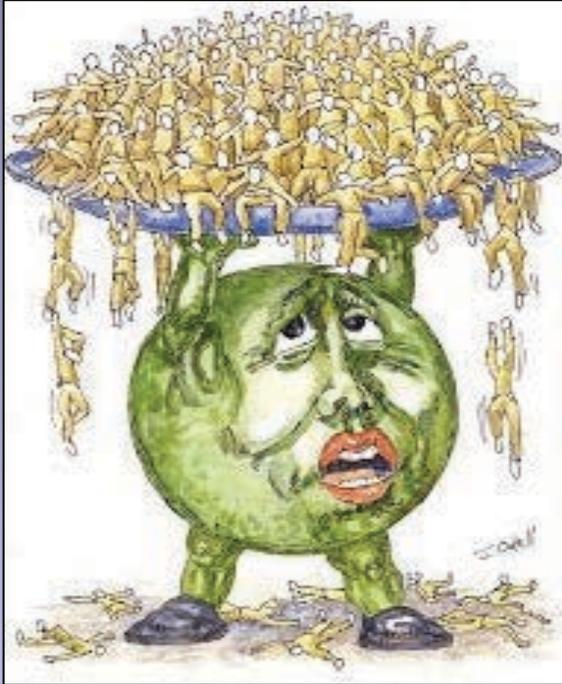
- Regulatory oversight
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# Consider This As Food For Thought



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

# That raises the question: Can We Feed The Planet Without Destroying It?



## Here's what we need to do:

- Reduce crop waste
- Reduce consumer waste, meat consumption
- Increase public funding for ag research & development
- Advance socioeconomic & environmental aspects of farming, focusing on sustainable practices
- Integrate appropriate seed technology with appropriate management practices
- Inform consumers about challenges farmers face in developed and developing countries

## **Also...Consider This As Food For Thought**

**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.**

## Also...Consider This As Food For Thought

**Big mergers “could change food supplies and costs worldwide”**

- 1. U.S.: Dow Chemical is buying Dupont-Pioneer**
- 2. Germany: Bayer is buying Monsanto**
- 3. China: ChemChina is buying Syngenta**

**This \$170B in consolidation deals will have a profound effect on future of global agriculture**

**And frankly this scares me!**

THE FUTURE OF

AGRICULTURE

# CHINA'S \$43 BILLION BID FOR FOOD SECURITY

ChemChina's acquisition of ag-tech giant Syngenta is part of a broader strategy that could change food supplies and costs worldwide.

By Geoff Colvin

▲ PHOTOGRAPHS BY STEFEN CHOW

# Where to get more information on the issues?



**ucbiotech.org** SCIENCE-BASED INFORMATION & RESOURCES ON AGRICULTURE, FOOD & TECHNOLOGY

ABOUT US | NEWS | ISSUES & RESPONSES | GMO LABELING | RESOURCES | LINKS | GLOSSARY | SEARCH

Select Language ▼

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

## FEATURED LECTURE VIDEO



**"Feast, Famine and the Future of Food"**

Outreach in Biotechnology  
Food for Thought Lecture Series  
Oregon State University  
January 25, 2012

### BIOTECHNOLOGY INFORMATION



**Labeling:**  
Informational resources available.



**Review articles:**  
Focused on food, environmental and socioeconomic issues of GE crops and foods.

[Part 1](#) | [Part 2](#)

### RESOURCES FOR OUTREACH & EXTENSION, RESEARCHERS & TEACHERS

#### DNA for Dinner 4-H curriculum:

For grades 5-8, covers topics from plant diversity to genetic engineering. Each of the five lessons has 3 to 5 activities.



#### New Game: Who's In Your Family?

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



#### Slide Archive:

Extensive collection of PP slides on agriculture & biotechnology.

#### Available on loan:

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



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

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

### HELPFUL SITES

#### Academics Review

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



Biofortified website  
Provides factual information to foster discussion about agriculture, especially plant genetics and genetic engineering.

Animal Genomics & Biotechnology Cooperative Extension Program, UC Davis



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

