



***Genetically Engineered Foods  
What Do I Need to Know?***



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***What will we talk about?***

***1. What about genes, genetics, genetic engineering?***

***2. What are GMO's? What GMO's are in our food?***

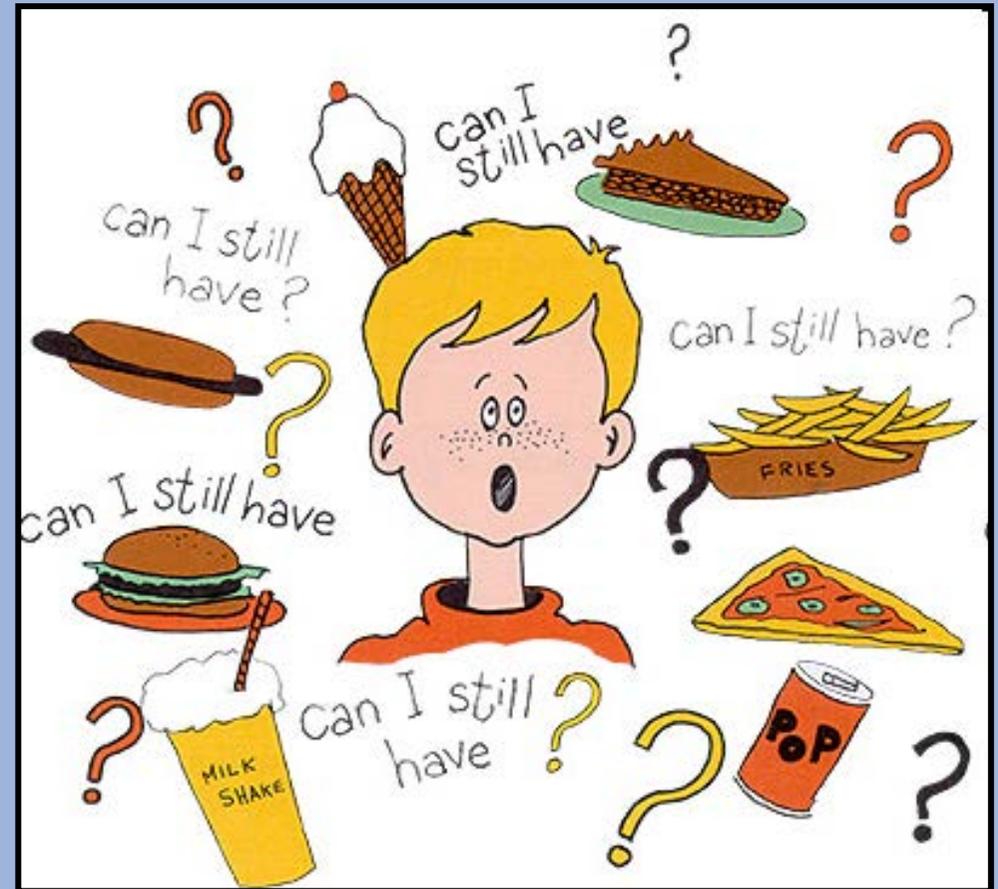
***3. What's in the pipeline?***

***4. How does the U.S. regulate them?***

***5. Are they safe to eat? What about labeling?***

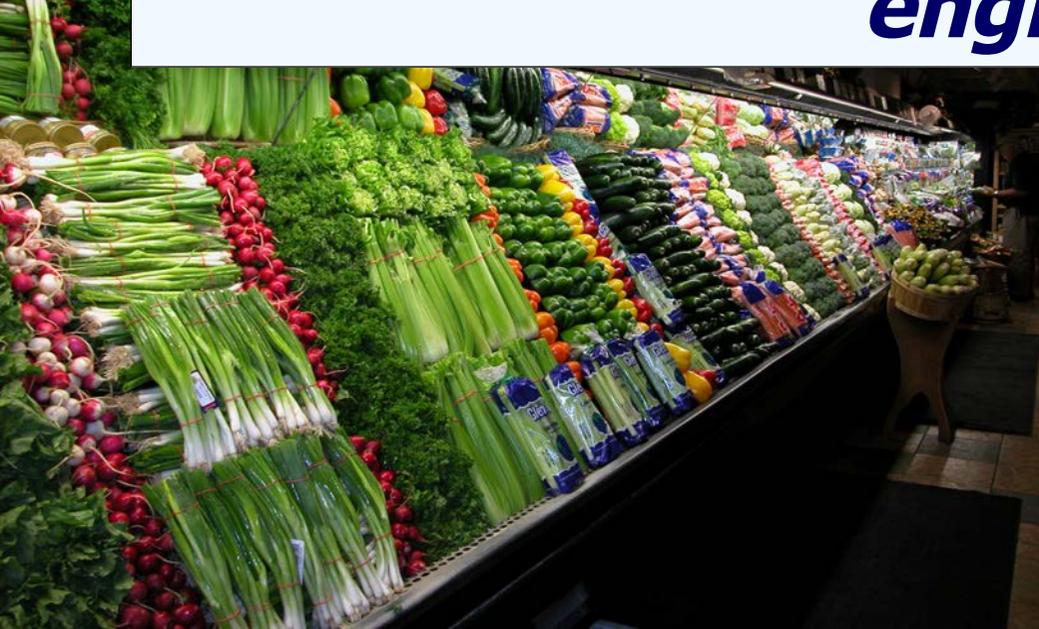
**Consumers depend on dietitians and nutritionists as two of the most believable information resources on genetics as it relates to their diet and nutrition.**

***So, what do we know about the genetics of foods?***





***Background on genes, genetics, genetic engineering***



# HOW MUCH DNA DO YOU EAT?\*



HAMBURGER  
(60mg)



ONION RINGS  
(10mg)



**All living things contain DNA – including the foods we eat**

**First we'll start with some basics on genetics...**

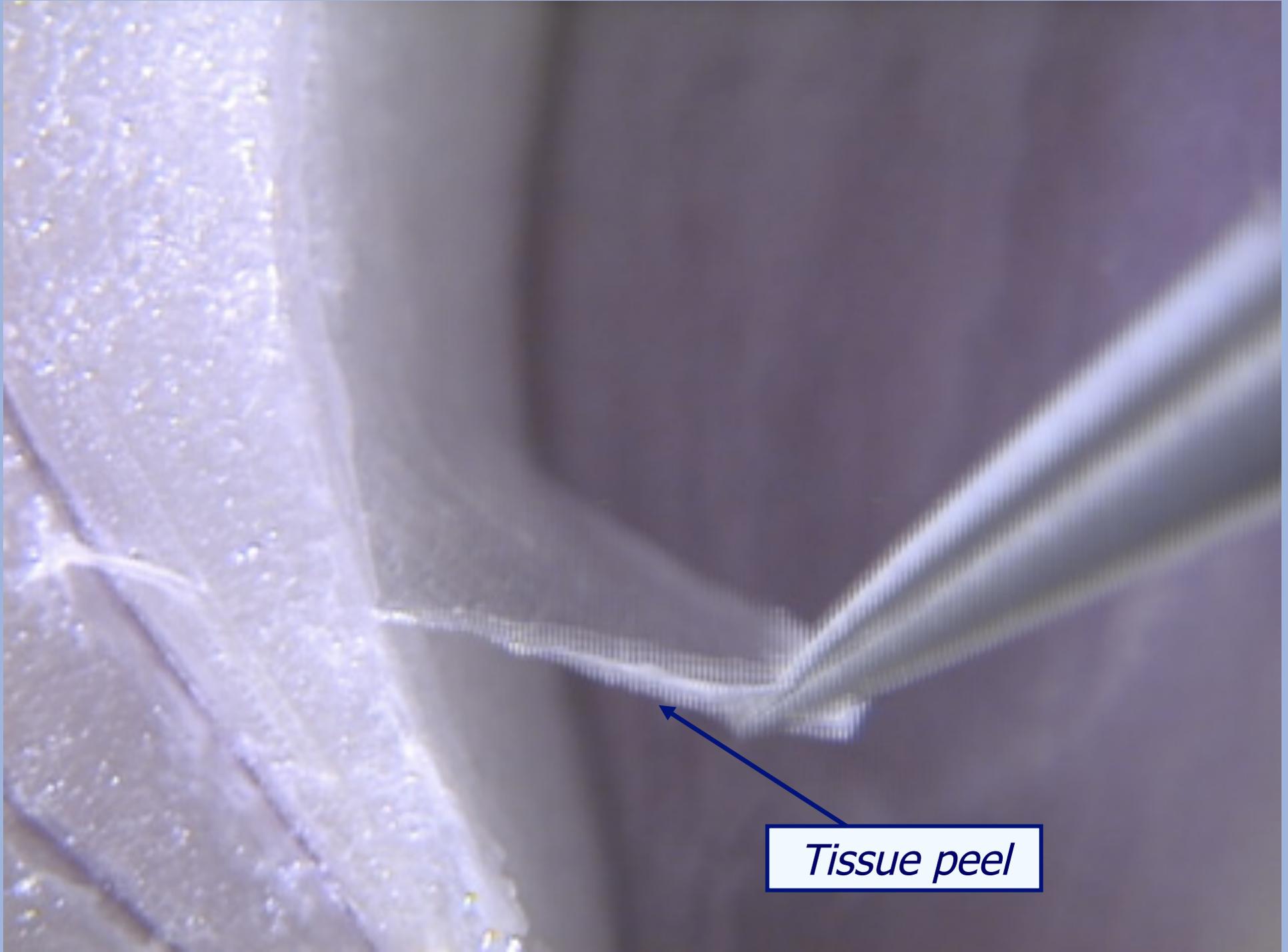
WHOLE BANANA  
(50mg)

All living things have DNA, the chemical that contains all information responsible for the way it looks and how it works. That chemical, a string approximately 5 feet long, can be isolated. The isolated DNA in each food is seen in the tube on the right.

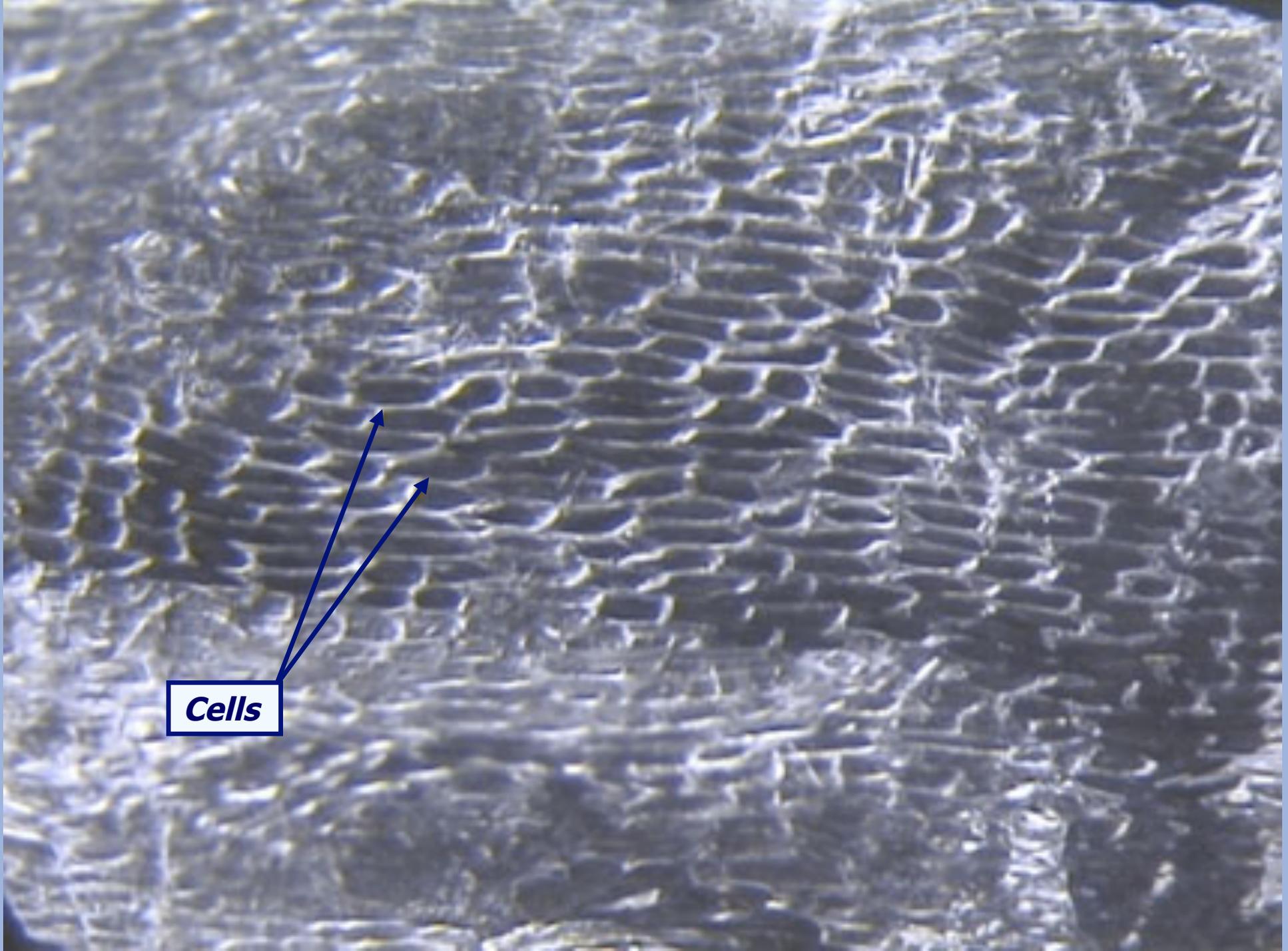
# *Tour d'Onion*



***Or what makes an onion, an onion?***



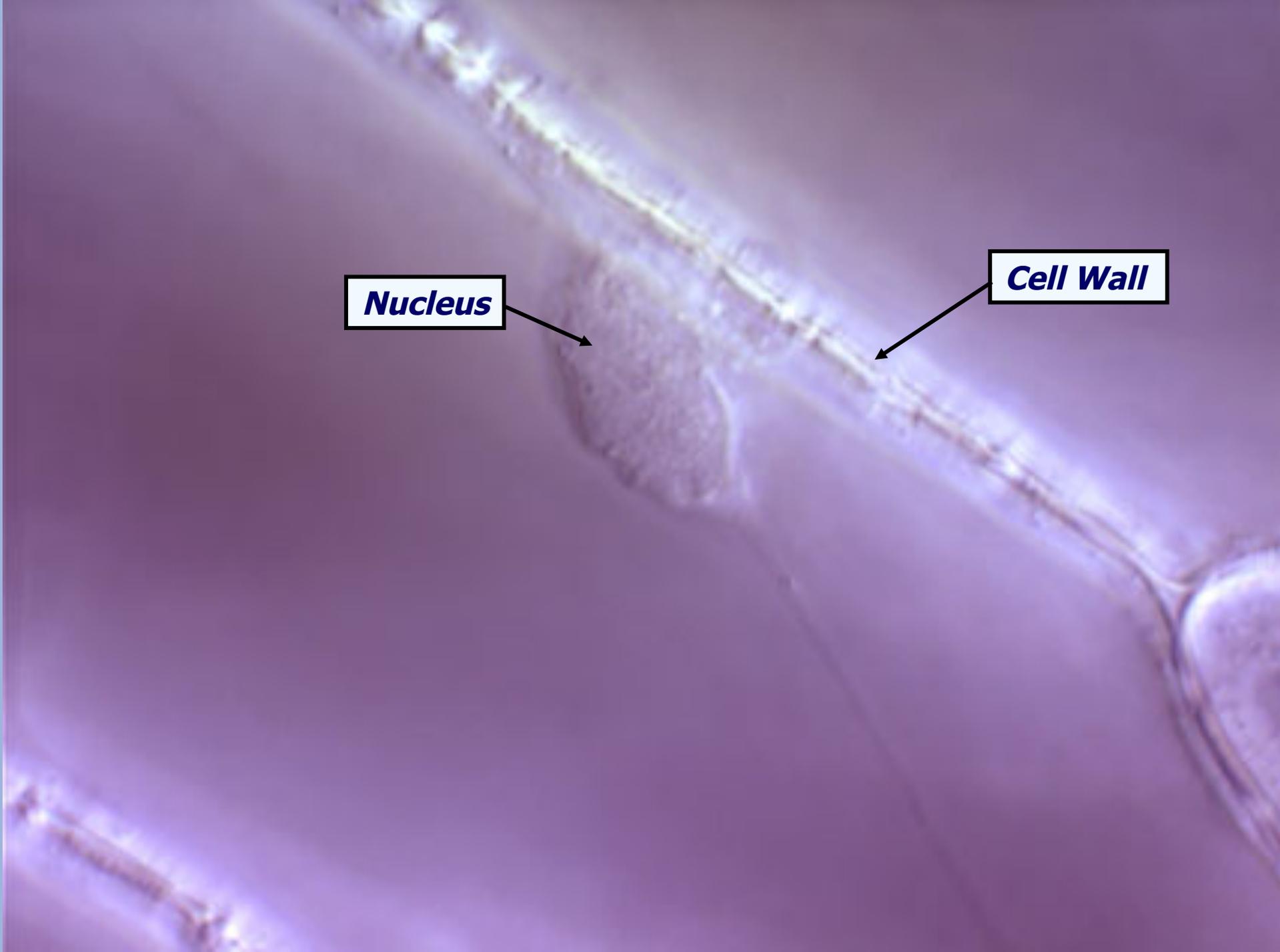
*Tissue peel*

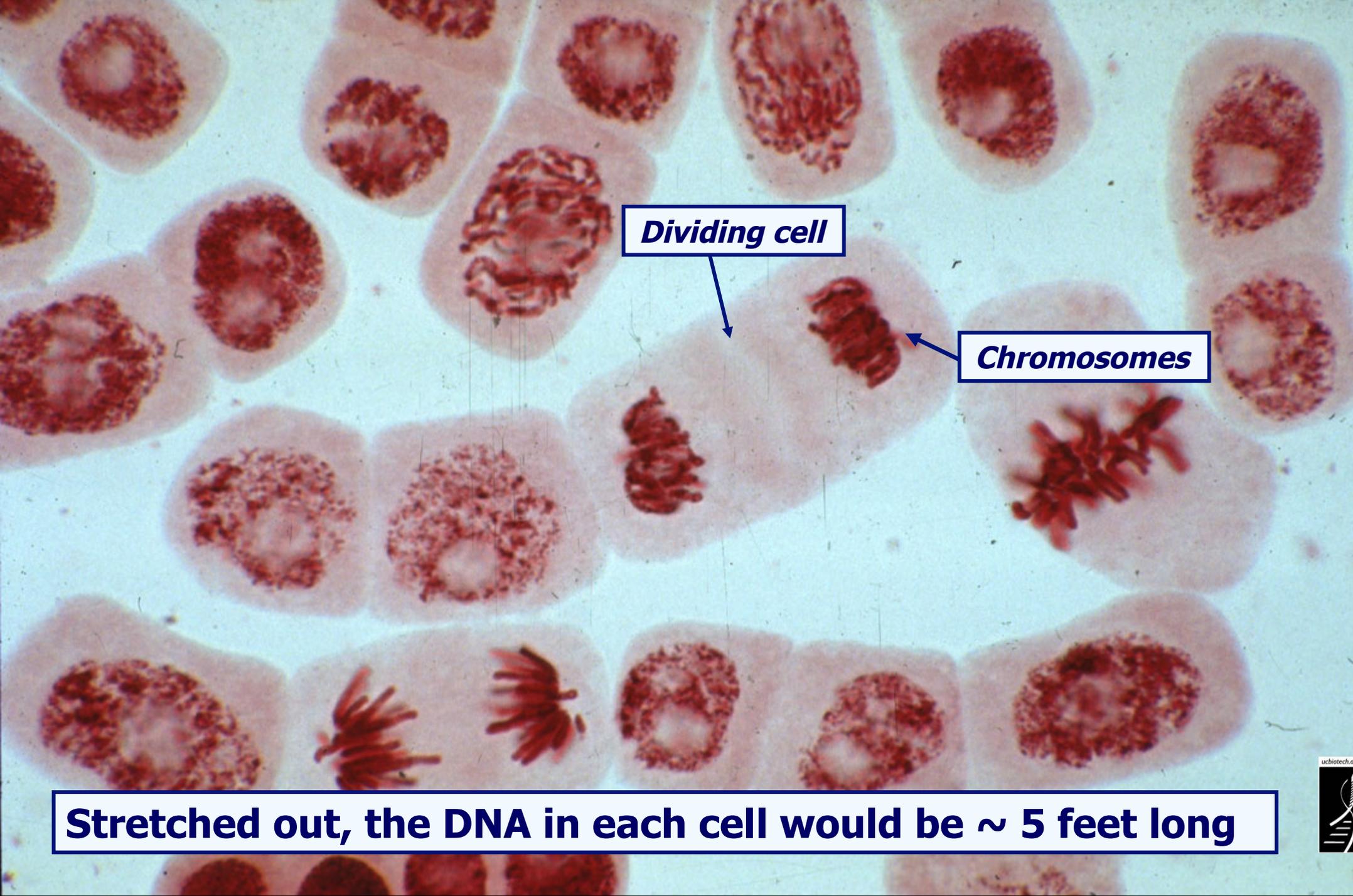


**Cells**

***Nucleus***

***Cell Wall***





***Dividing cell***

***Chromosomes***

**Stretched out, the DNA in each cell would be ~ 5 feet long**



# How can you use genetics to create a new wheat crop – with better nutritional qualities – using an ancient wheat variety?



X



What happens to the genetic information from the two parents?

*Triticum monococcum*

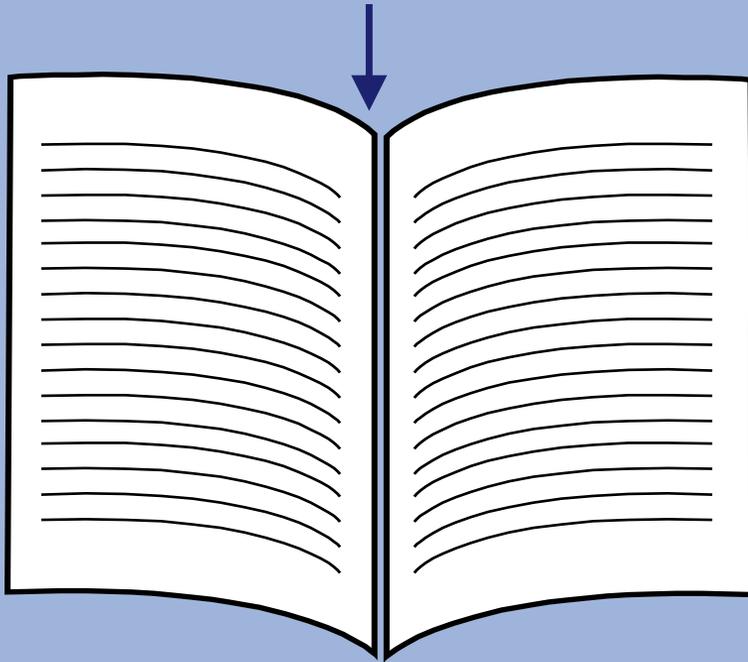
*Triticum aestivum*

**Ancient variety Modern bread variety**

# ***Information in the wheat genome***

***Chemical units represented by alphabetic letters***

***...CTGACCTAATGCCGTA...***

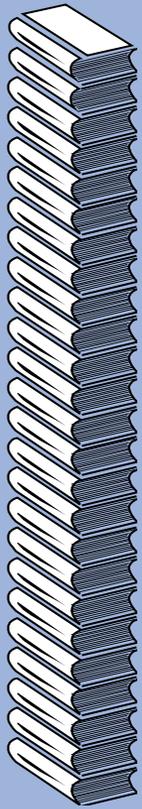


***1700 books  
1000 pages each***



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

# Hybridization or breeding of wheat



**X**



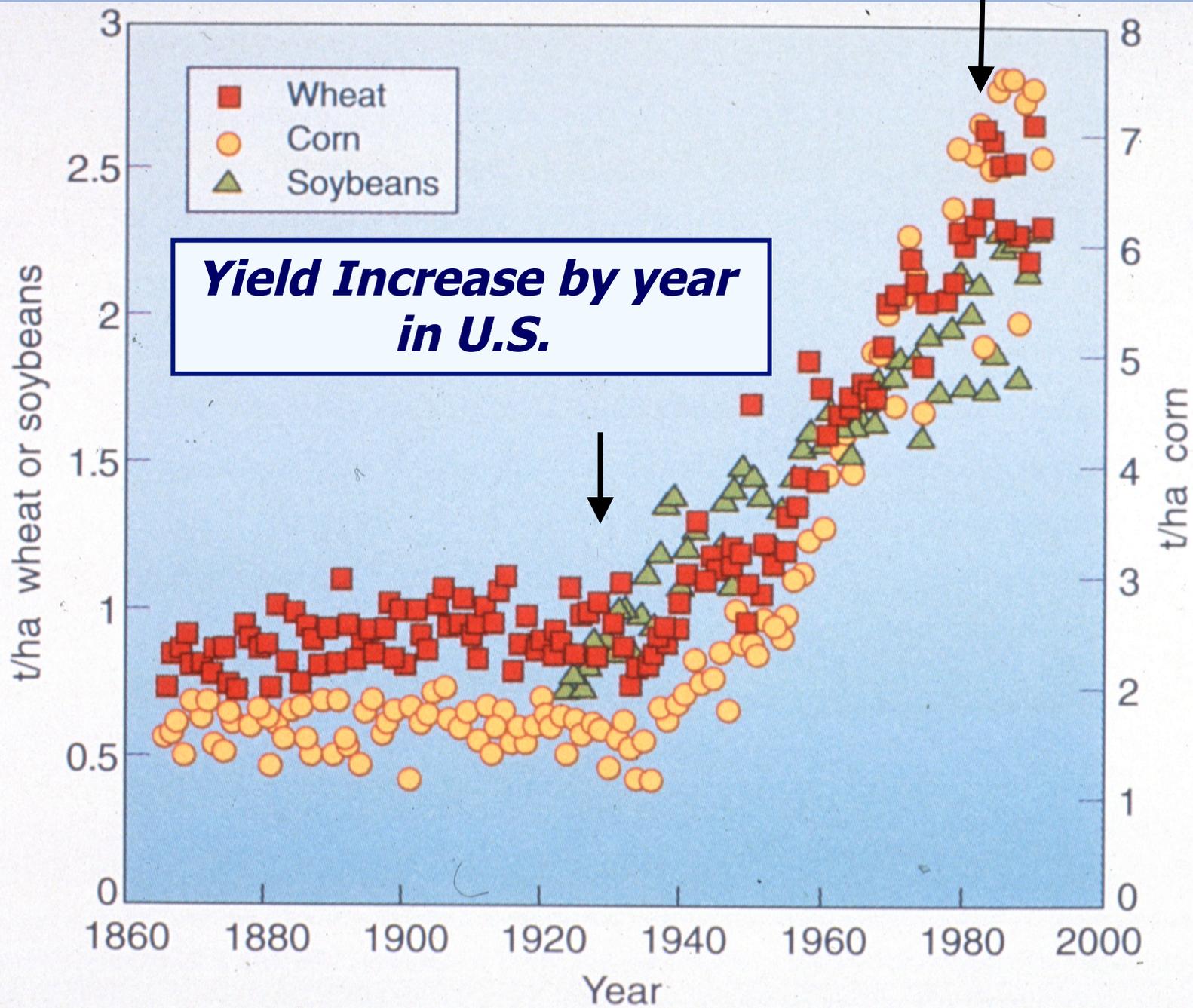
*Random retention of ~50% of the information from each parent*

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

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

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

**Genetic modification that is not GE or GMO**



# Table of contents for wheat information

...CTGACCTAATGCCGTA...

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**Genomics**

**Genetic modification that is not GE or GMO**



**Used for  
Marker-  
Assisted  
Selection**

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

***Can't We Just Do All Modification This Way?***



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

***This type of modification limited to diversity in compatible relatives of crops***



***What are GMO's? What GMO's are in our food? What's in the pipeline?***



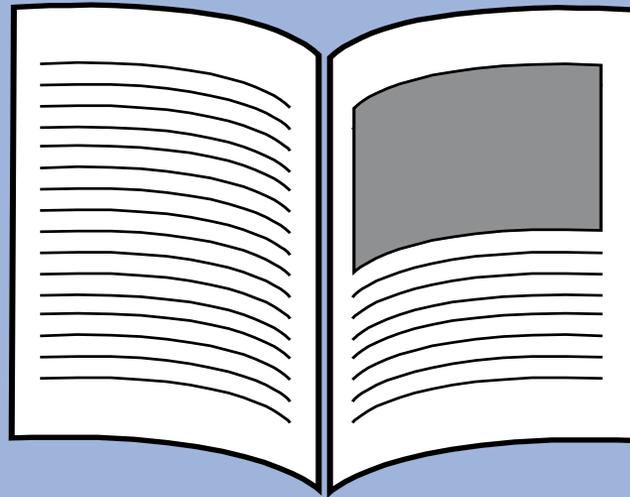


***But there are other ways to  
create new varieties using the  
modern tools of genetics***

# Genetic Engineering Methods



+



*One-half page  
equivalent to a gene*



*Inserts  
randomly  
in genome*



*Inserted  
gene(s)*



*1700 books*

*(or 1.7 million pages)*

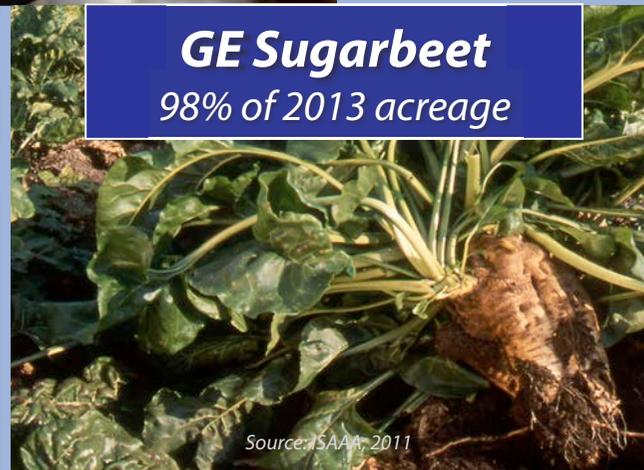
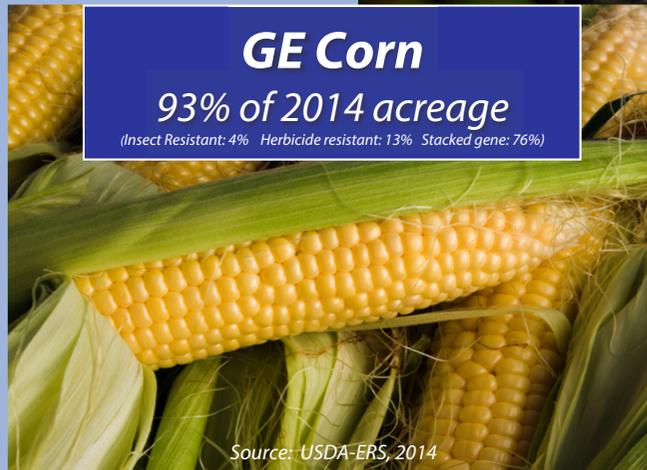
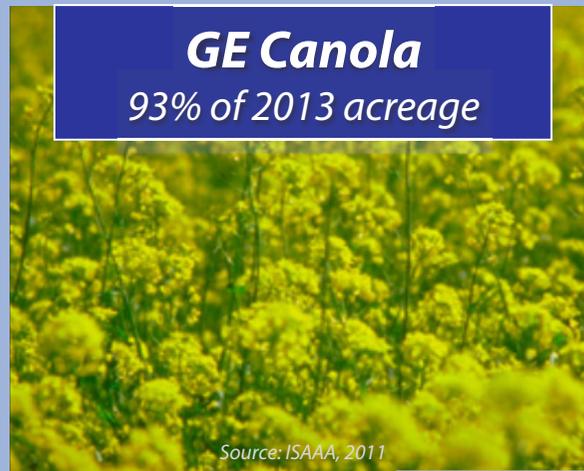
*1700 books*

*(or 1.7 million pages)*

***Genetic modification that is GE and GMO***

**What is  
commercially  
available?**

**Number of GE  
crops is limited**



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



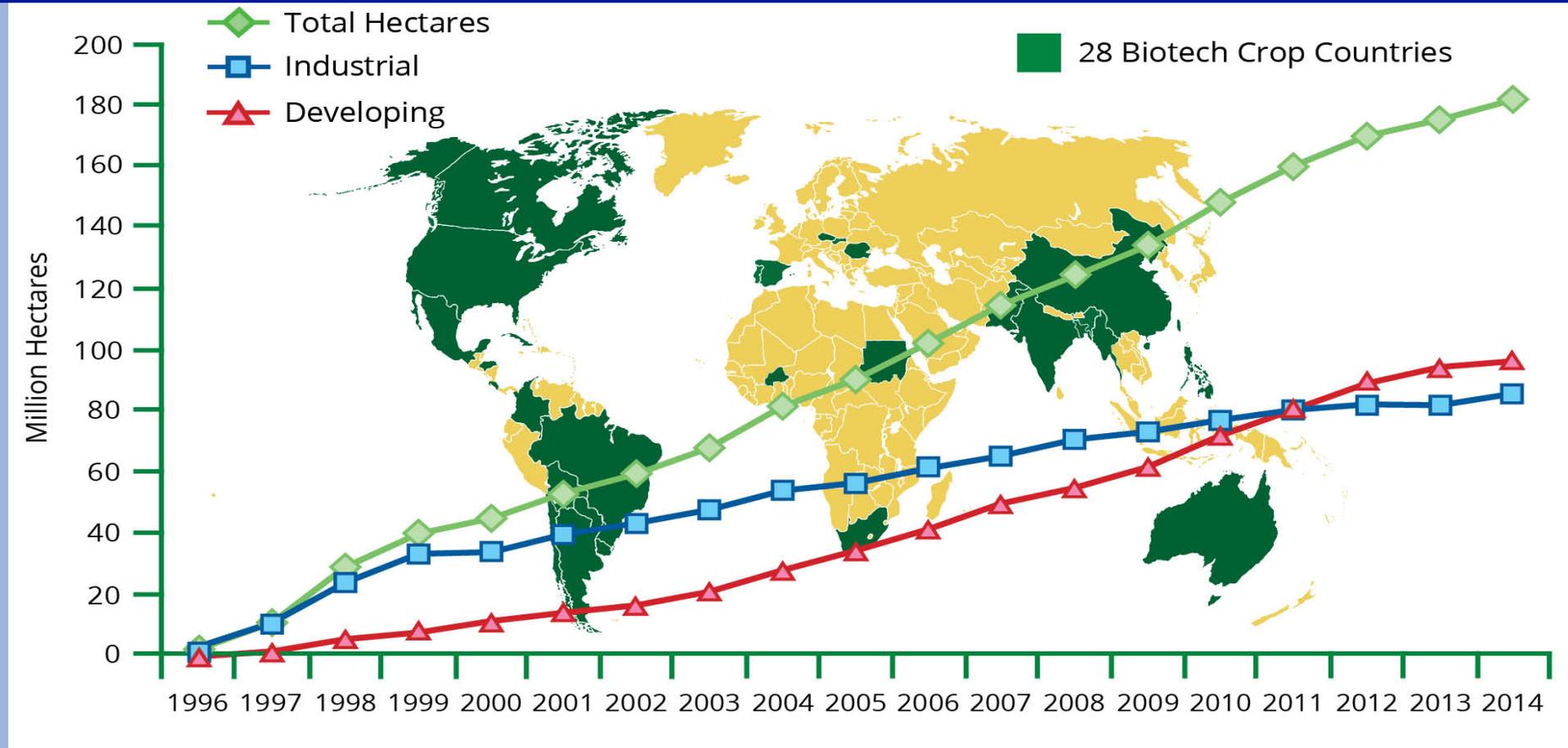
**Bt Crops - engineered for insect resistance using gene from naturally occurring bacterium**



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

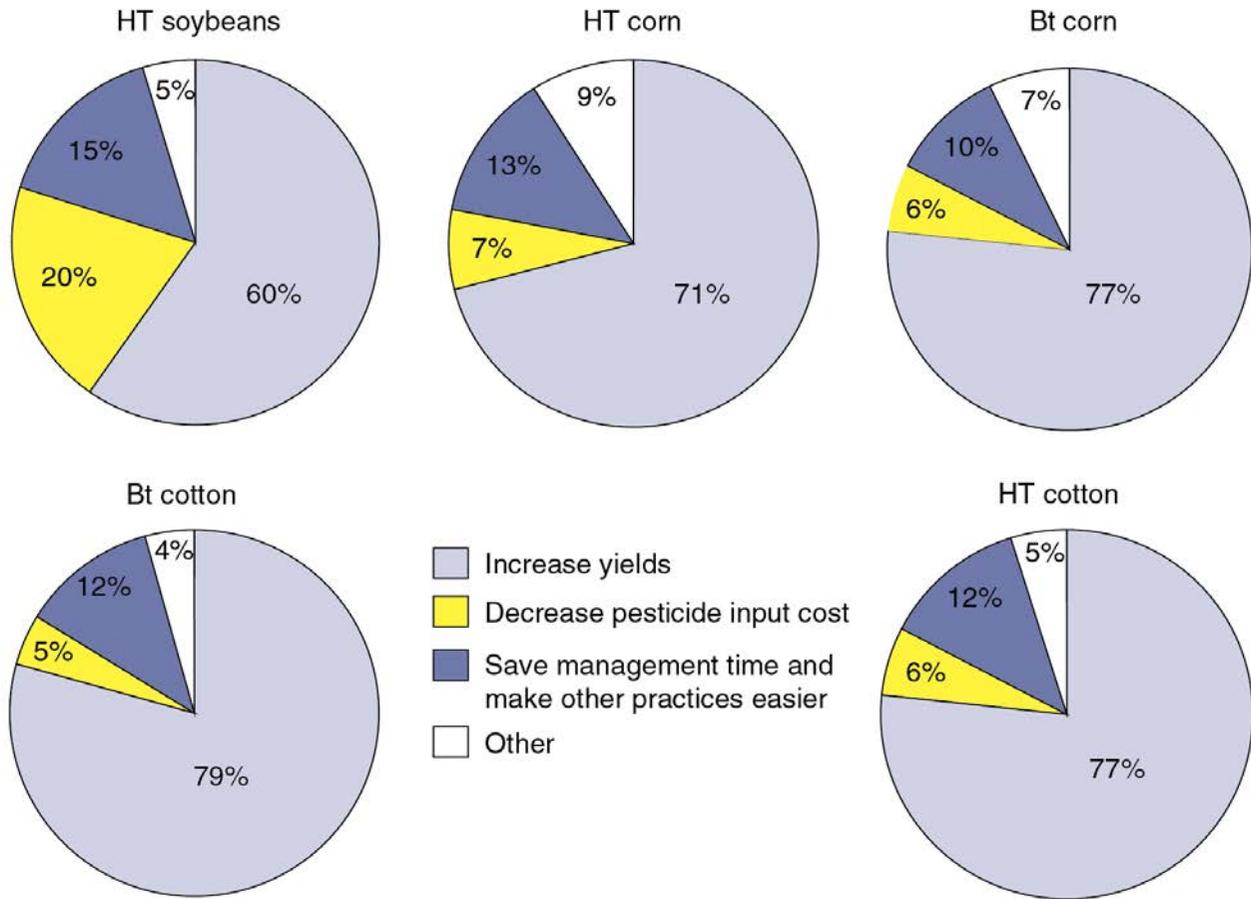
***Crops with stacked traits - both Bt and HT - are available***

# ***Despite limited crop and trait types, worldwide acreage is increasing in 20 developing, 8 developed countries***



***2014: 18 million farmers in 28 countries planted 448M acres (>4X size of California)  
>90% small acreage farmers in developing countries***

# Why do U.S. growers plant GE crops?



**Reasons vary from crop-to-crop but primary reason: 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***

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

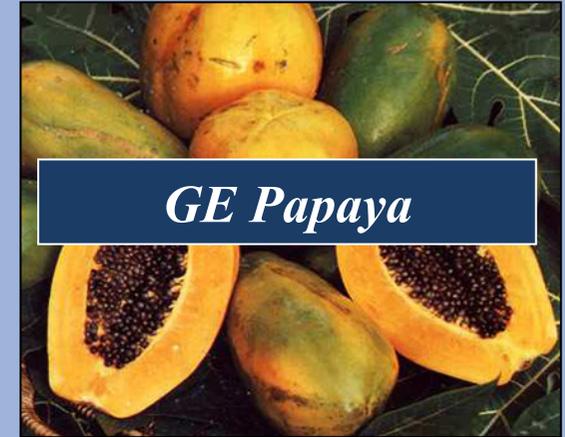
***But, only a few whole, GE foods are  
in the commercial U.S market***



***GE Sweet Corn***



***GE Squash***

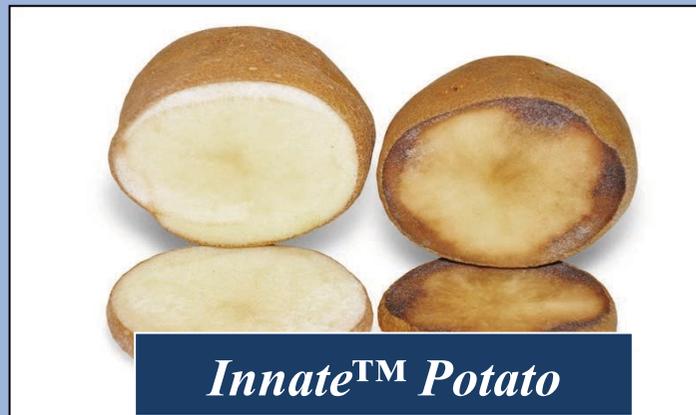


***GE Papaya***

***Two more are just being introduced***



***Arctic Apple™***



***Innate™ Potato***



***What's in the pipeline?***

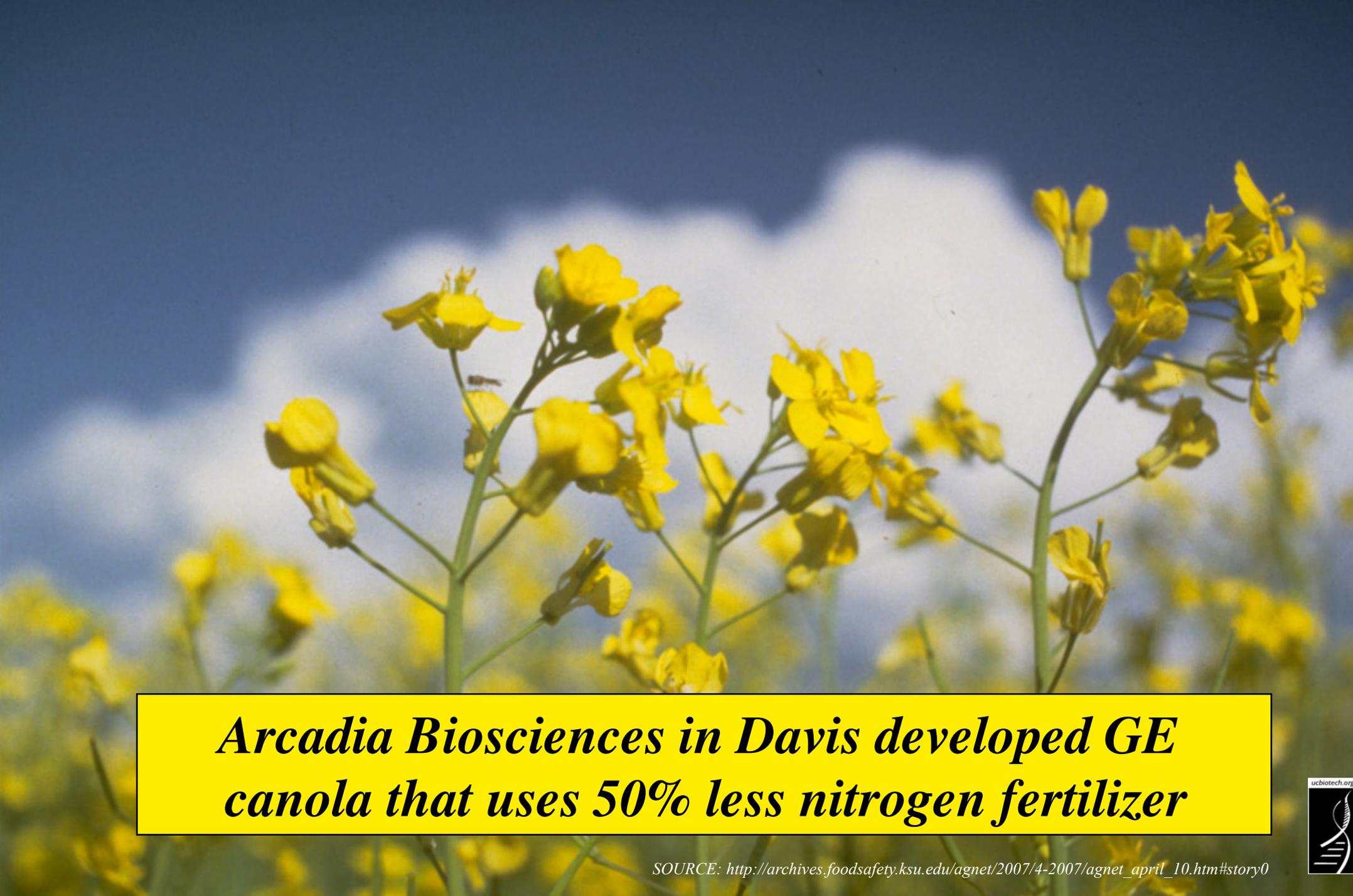




*Field Trials in California with Grape Root Stocks  
Engineered for Resistance to Fanleaf Virus*

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



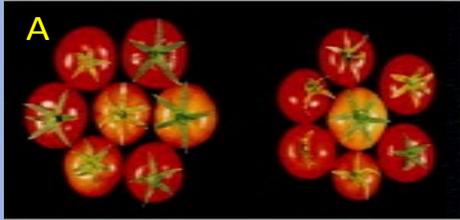


***Arcadia Biosciences in Davis developed GE  
canola that uses 50% less nitrogen fertilizer***

SOURCE: [http://archives.foodsafety.ksu.edu/agnet/2007/4-2007/agnet\\_april\\_10.htm#story0](http://archives.foodsafety.ksu.edu/agnet/2007/4-2007/agnet_april_10.htm#story0)



# *Salinity and Drought Tolerance - UC Davis Professor*



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*

# *2013 GE potato field study – Ireland*

*Desiree potato variety, highly susceptible to late blight, engineered with gene from wild potato variety*





*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>



*Tear-free onion developed  
by turning off tear-  
inducing enzyme*

SOURCE: "Scientists create 'no tears' onions", Herald and Weekly Times, 2/1/08  
[http://www.checkbiotech.org/green\\_News\\_Genetics.aspx?Name=genetics&infold=16834](http://www.checkbiotech.org/green_News_Genetics.aspx?Name=genetics&infold=16834)





© 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*



***How does the U.S. regulate GE crops and foods?***



# ***Three 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?***

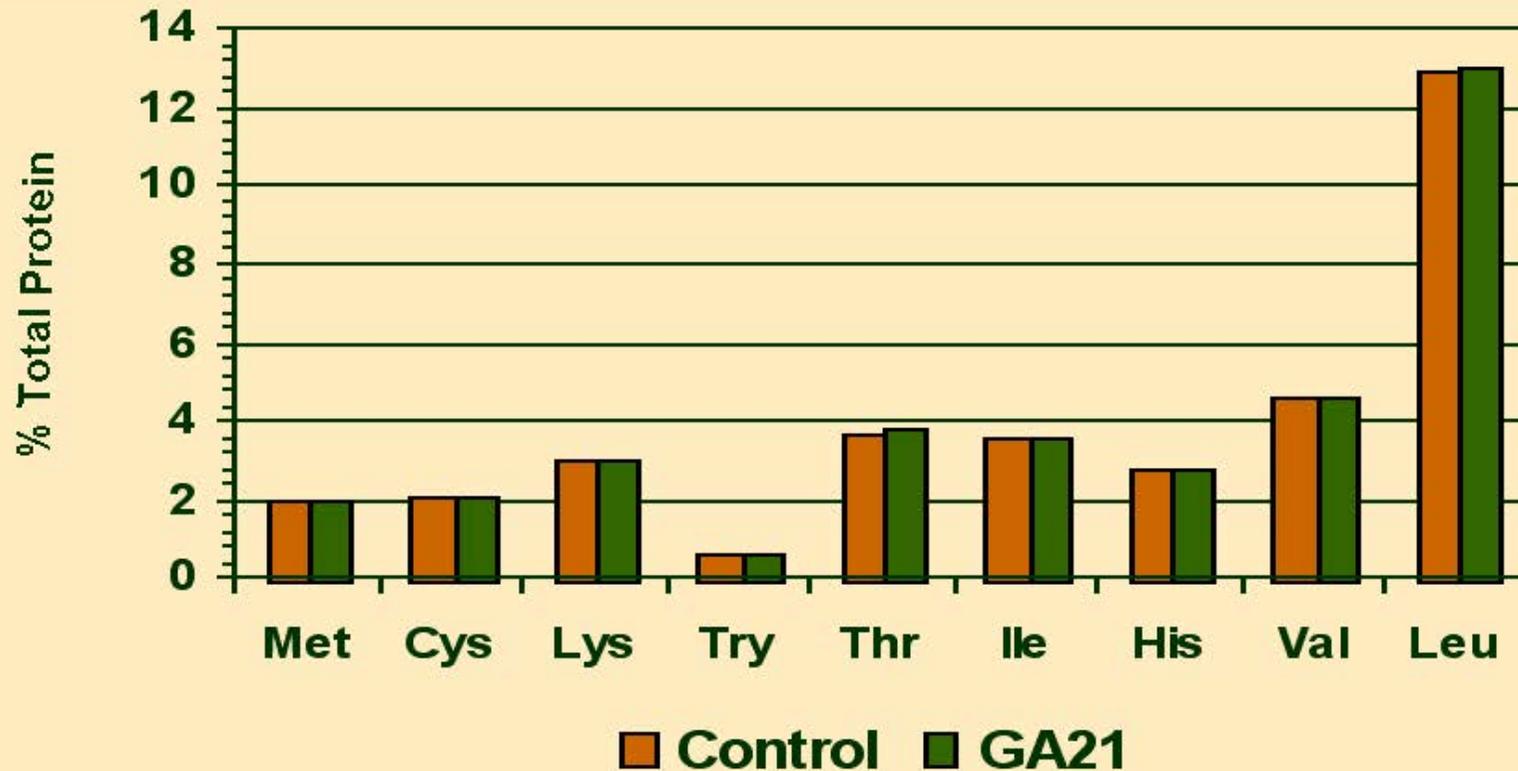
**Are they as safe as conventional foods?**

**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**

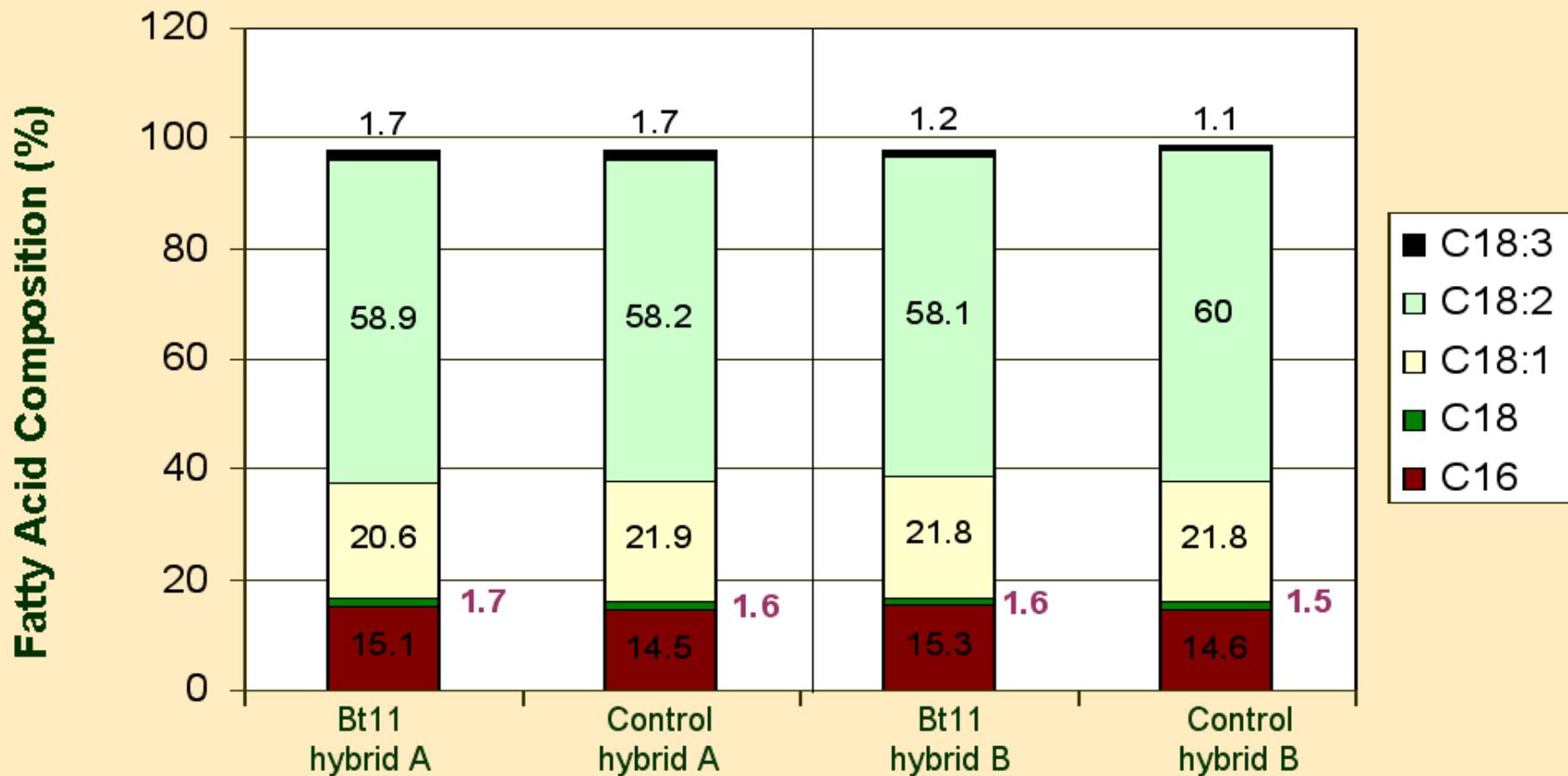
**The product of the introduced genetic  
information is tested separately?**

# Substantial Equivalence: Amino Acids



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

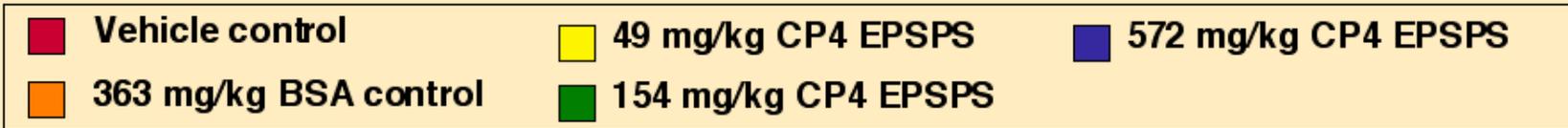
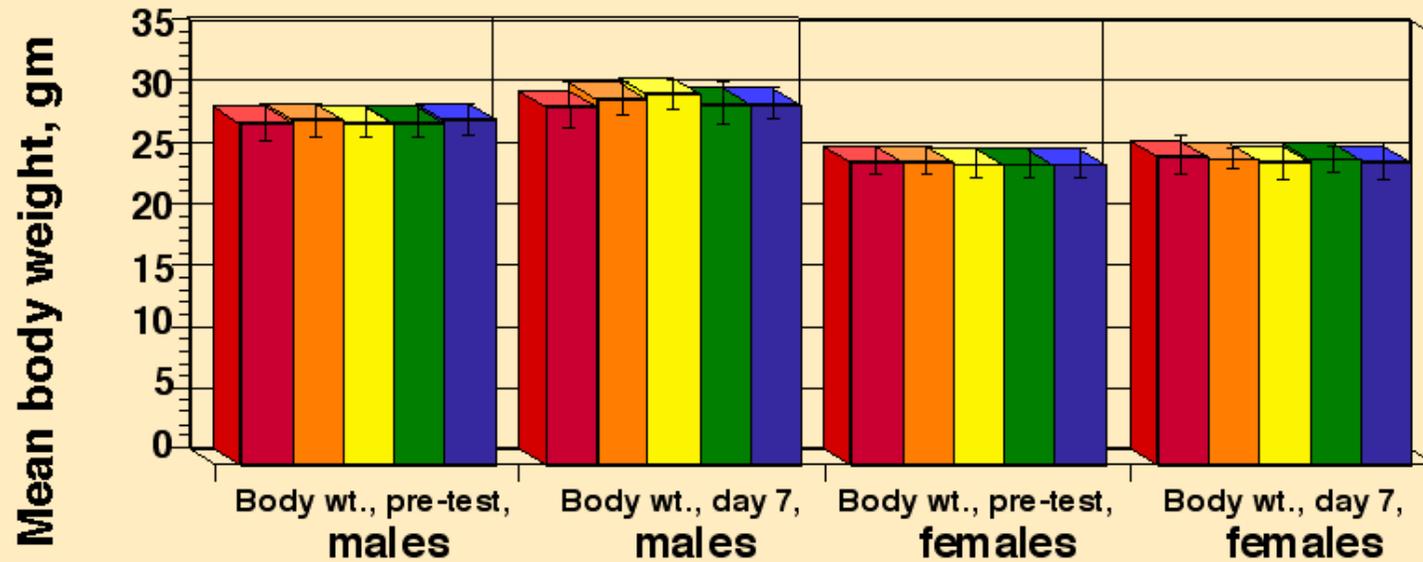
# Substantial Equivalence: Fatty Acids



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

# Toxicity Assessment: Roundup Ready/CP4 EPSPS protein

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





***What are some issues around GMO foods?***



***Are they safe to eat?***



***On occasion widely publicized studies cast doubt on safety of GE foods, e.g., a single study by French researcher in Sept. 2012***

***Later reviewed by European Food Safety Authority: study had no merit – but that was not as widely publicized***

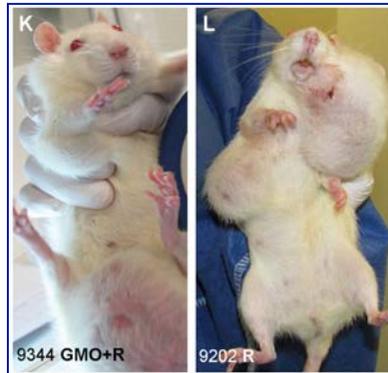
## French academies trash GM corn cancer study

By RFI

A controversial study that linked genetically modified maize to cancer



***Featured on Dr. Oz Show***



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



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

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

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



**BREAKING NEWS**  
**NEW STUDY SUGGESTS GMO SOY  
PRODUCES EXCESS FORMALDEHYDE**  
and disrupts natural plant metabolism

**Formaldehyde is a known carcinogen.  
GMO SOY IS CARCINOGENIC?**

[www.facebook.com/gmofreefl](http://www.facebook.com/gmofreefl) [www.facebook.com/gmofreeusa](http://www.facebook.com/gmofreeusa) [www.tsu.co/gmofreeusa](http://www.tsu.co/gmofreeusa) [www.gmofreeflorida.org](http://www.gmofreeflorida.org) [www.gmofreeusa.org](http://www.gmofreeusa.org)

The image features a dense field of green soybean plants. Two logos are visible: 'GMO FREE FLORIDA' and 'GMO FREE U.S.A.', both featuring a stylized green leaf and orange sun icon. The text is overlaid in white and red on the green background.

**Another single study –  
not as widely publicized**

***“European Food Safety  
Authority has formally  
examined Ayyadurai’s  
report on formaldehyde  
contamination of soy, and  
criticized both its methods  
and findings”***

SOURCE: “European Union reviews, rebukes bizarre Ayyadurai claim of formaldehyde in GMO soy”, Genetic Literacy Project, 1/8/16,  
<https://www.geneticliteracyproject.org/2016/01/08/european-union-reviews-rebukes-bizarre-ayyadurai-claim-formaldehyde-gmo-soy/>



# ***Are GM foods safe?***

***2012 French meta analysis of many published studies showed:***

- GM 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 generations) feeding trials of GE feed in animals***



***maize***

***potato***



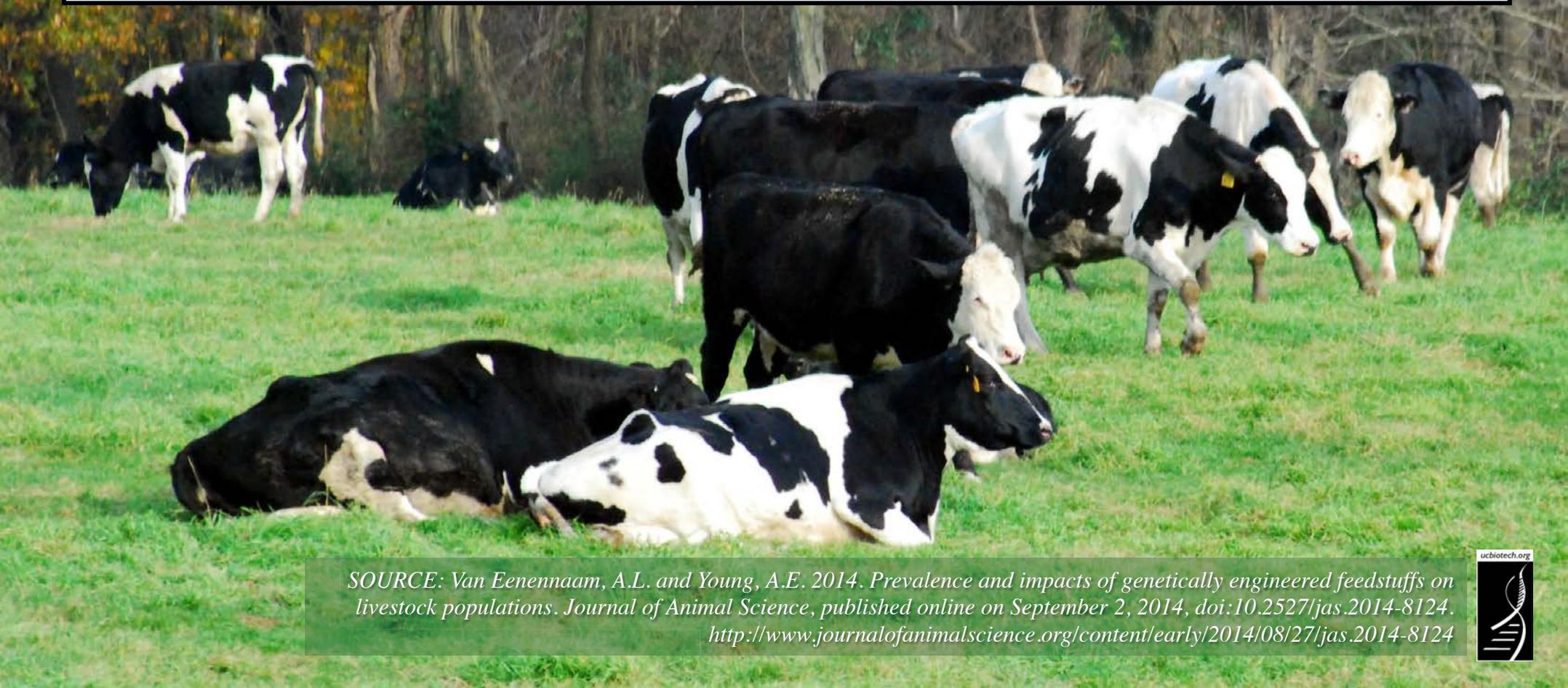
***soy***

***rice***



***triticale***

***A second larger meta analysis in 2014, using public studies from 1983 to 2011, tracking over 100 billion animals raised on GE feed, concluded: "no unfavorable or perturbed trends in livestock health and productivity".***



*SOURCE: Van Eenennaam, A.L. and Young, A.E. 2014. Prevalence and impacts of genetically engineered feedstuffs on livestock populations. Journal of Animal Science, published online on September 2, 2014, doi:10.2527/jas.2014-8124. <http://www.journalofanimalscience.org/content/early/2014/08/27/jas.2014-8124>*



***What are some issues around GMO foods?***



***What about labeling?***





PER 56 g SERVING

**50**  
CALORIES

**0g**  
SAT FAT  
0% DV

**180mg**  
SODIUM  
8% DV

**0g**  
SUGARS



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.

Premium Tuna



***Labels already abound on foods— from gluten-free to dolphin-safe – none are mandated. Why aren't there federally mandated labels on foods with GE ingredients.***

***There are FDA labeling rules for engineered foods...***

***Genetically engineered foods are subject to same labeling laws as all other foods and food ingredients***

***GE food must be labeled if there are:***

- 1. Different nutritional characteristics,***
- 2. Genetic materials from a known allergenic source*  
***e.g., peanut, egg*****
- 3. Elevated levels of antinutritional or toxic compounds***

***No label needed if food is essentially equivalent in safety, composition and nutrition***

# BE A STICKLER

PRODUCE CODES DEMYSTIFIED

**4 DIGIT CODE**  
STARTING WITH 3 OR 4



**CONVENTIONALLY  
GROWN**



**5 DIGIT CODE**  
STARTING WITH 9



**ORGANIC**



**5 DIGIT CODE**  
STARTING WITH 8



**GENETICALLY  
MODIFIED**



*And there are existing PLU labels, which indicate whether whole fresh foods are GE, organic or conventional*

# ***Do consumers want labeling?***

***Can you think of any information that is not currently included on food labels that you would like to see on food labels? What types of information would that be?***

	<u>2001</u>	<u>2006</u>	<u>2014</u>
• Yes	<b>26%</b>	<b>18 %</b>	<b>26%</b>
– Ingredients (i.e., fats, salt)	6%	3%	23%
– Other	11%	5%	25%
– Genetically altered	2%	1%	0%
• No	<b>74%</b>	<b>82%</b>	<b>74%</b>

*(International Food Information Council)*

***With an open-ended question about what food labeling information is missing, few consumers mention genetically altered foods***

***If simply asked whether they want food labeling of genetically engineered foods, two-thirds of U.S. consumers say yes.***

- ***66% of Americans favor*** requiring food manufacturers put labels on products that contain genetically modified organisms, or foods grown from seeds engineered in labs.
  - ***7% opposed*** to the idea
  - ***24% neutral***

*(Associated Press-GfK poll Jan. 2015)*

# ***But, do consumers act on labeling information?***



***66% of UK consumers think GE food labeling is important...***

***But only 2% actively look for GE content when buying foods***

# National GM Labeling Laws and Policies

Type of GM labeling	Countries that enforce labeling policies	Countries with partially enforced or unenforced labeling policies	Countries with probable plans to introduce a labeling policy
<u>Mandatory</u>	Australia, Brazil, <u>China</u> , <u>European Union</u> , <u>Japan</u> , New Zealand, Norway, Russia, Saudi Arabia, South Korea, Switzerland, Taiwan	Croatia, Ecuador, El Salvador, Indonesia, Malaysia, Mauritius, Serbia, Sri Lanka, Thailand, Ukraine, Vietnam	Nigeria, Uganda, UAE, Zambia
<u>Voluntary</u>	Argentina, <u>Canada</u> , Chile, Hong Kong, Kenya, Philippines, South Africa, <u>USA</u>		Peru

***One complicating problem with current system: other nations have specific, labeling laws for GE, although rules and enforcement vary dramatically among countries, making international trade difficult***

# *What's the current status of labeling GE foods in the U.S.?*



*In some states, like California and Washington voters rejected ballot propositions to require mandatory labeling of foods with GE ingredients.*

*In other states, like Vermont, labeling laws are set to take effect this year*

**Vermont Right to Know GMOs**  
A Collaborative Project of Cedar Circle Farm, NOFA-VT,  
Rural Vermont and VPIRG

HOME LEARN MORE RESOURCES FAQ DONATE ACTION CENTER EVENTS WHO WE ARE

**Donate to the Food Fight Fund!**

**FOOD FIGHT FUND VERMONT**

The Vermont Food Fight Fund was established by the Vermont Legislature in April 2014 as a special fund to support the State's implementation and administration of its first-in-the-nation clear Genetically Engineered food labeling law, including in litigation anticipated to be filed against it. Together we can win!

**DONATE TO THE FUND!**

H.112 bill signed

**“It's Law.”**

-Governor Peter Shumlin

VTRightToKnow.org

**Federal spending bill rejects anti-GMO labeling push!**

December 16, 2015

In a win for the 90% of Americans who support labeling GMO products, the federal spending bill released this morning not only rejected industry's push for anti-labeling language, but included a provision requiring labeling for genetically engineered salmon!



***By 2018, all products in U.S. and Canadian stores must be labeled to indicate whether they contain genetically modified organisms (GMOs)***

## The New York Times

March 8, 2013

### Major Grocer to Label Foods With Gene-Modified Content

By STEPHANIE STROM

Whole Foods Market, the grocery chain, on Friday became the first retailer in the United States to require labeling of all genetically modified foods sold in its stores, a move that some experts said could radically alter the food industry.

***Companies have also become involved in different ways in GMO labeling.***

grown in the United States, for example, have been genetically modified. The alterations make soybeans resistant to a herbicide used in weed control, and causes the corn to produce its own insecticide. Efforts are under way to produce a genetically altered apple that will spoil less quickly,



***If a decision at the national level is not made soon – in some way – a potpourri of state labeling bills will make interstate commerce very difficult- similar to existing issues with international trade.***

SOURCE: “GMO Labeling Bill Voted Down In Senate”, Huffington Post, 5/22/13  
[http://www.huffingtonpost.com/2013/05/23/gmo-labeling-bill-genetically-modified-food\\_n\\_3325972.html](http://www.huffingtonpost.com/2013/05/23/gmo-labeling-bill-genetically-modified-food_n_3325972.html)



## GMO labeling bill would trump states

Share 3.6k Tweet 149 LinkedIn Share 7 Share 18 143



Vermont could become the first state to set its own GMO rules. | AP Photo

By JENNY HOPKINSON | 4/9/14 4:57 PM EDT

Food manufacturers don't have to label products that contain genetically modified ingredients, and now they have a bill that would keep it that way.

Rep. Mike Pompeo on Wednesday morning introduced **The Safe and Accurate Food Labeling Act of 2014**, a bill that would give ultimate authority of GMO labeling to the Food and Drug Administration, which favors a voluntary approach to the issue. The measure, which has the support of the food, biotechnology and agriculture industries, looks to nullify efforts in no less

# ***What is happening at the federal level?***

## ***Current bill pending in Congress***

- Requires safety reviews of GE foods before sale;***
- Prevents states from having their own labeling laws;***
- Prevents FDA from requiring labeling of GE foods only if they're engineered;***
- Passed in House; awaiting Senate action since Aug 2015***

***So, labeling issue is not yet resolved and probably won't be until after the election.***

SOURCE: "Food industry seeks voluntary GMO labeling", Washington Post, February 6, 2014.

[http://www.washingtonpost.com/politics/federal\\_government/food-companies-propose-voluntary-gmo-labels/2014/02/06/78d2487c-8f4e-11e3-878e-d76656564a01\\_story.html](http://www.washingtonpost.com/politics/federal_government/food-companies-propose-voluntary-gmo-labels/2014/02/06/78d2487c-8f4e-11e3-878e-d76656564a01_story.html)



***In the meantime, more than 30 food companies will participate in SmartLabel™ in late 2015, early 2016***



Welcome to SmartLabel™

***SmartLabel™ will give consumers information on ingredients, allergens, animal welfare, environmental policies and content of GMO's***

Source: <http://fortune.com/2015/12/02/food-smart-label-grocery/>





***Other issues about GMO crops and foods?***



***Questions?***



**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.