

Crops, Foods, Biotechnology and Labeling



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1. Background on genes, genetics and genetic engineering (aka biotechnology, GMOs)

2. What engineered (GE) crops have been commercialized? What's in the pipeline?

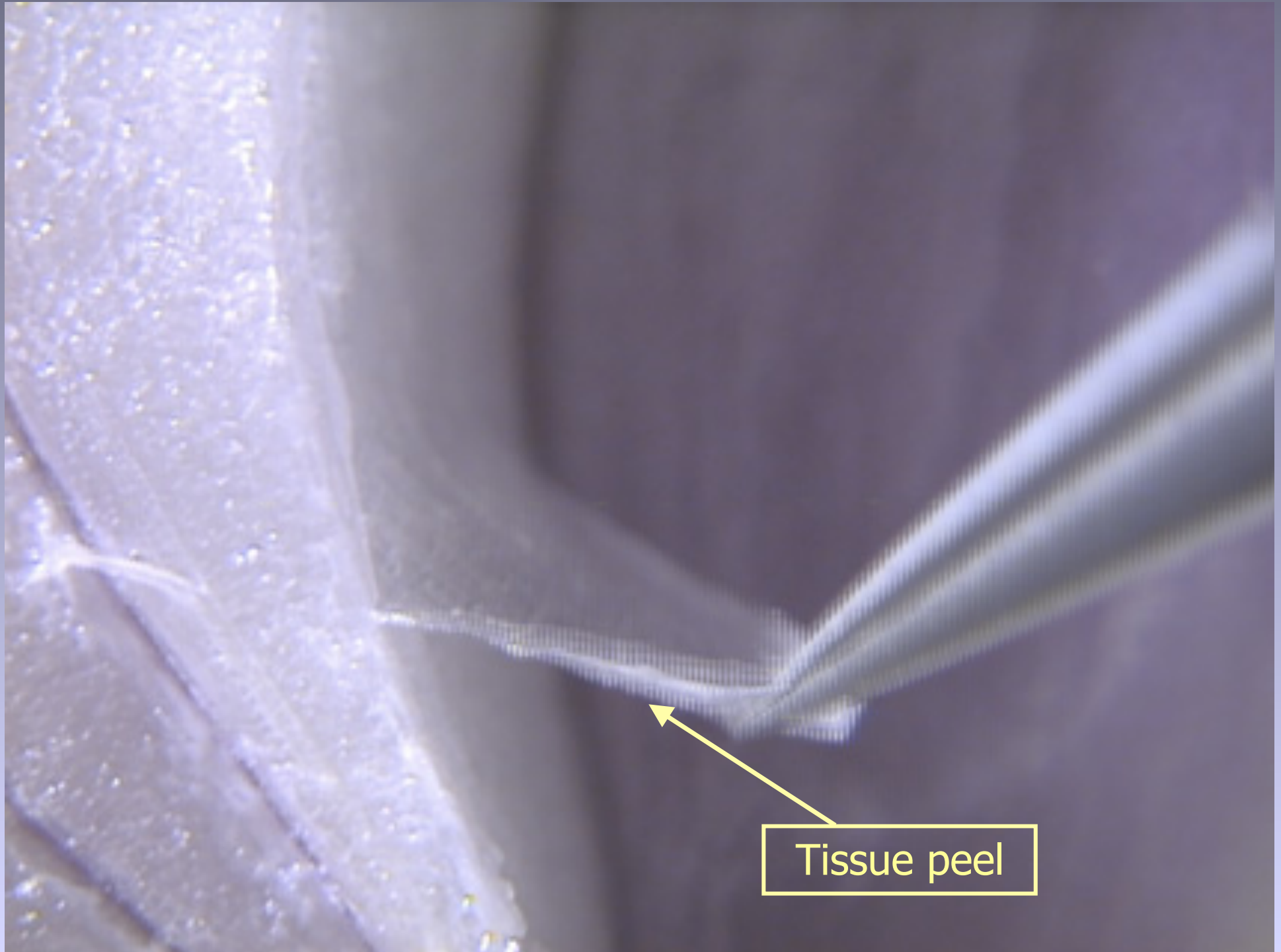
3. What is the regulatory structure for GE crops?

4. What are some food safety, environmental and other issues with GE foods? What about labeling?

Tour d'Onion



Or what makes an onion, an onion?



Tissue peel

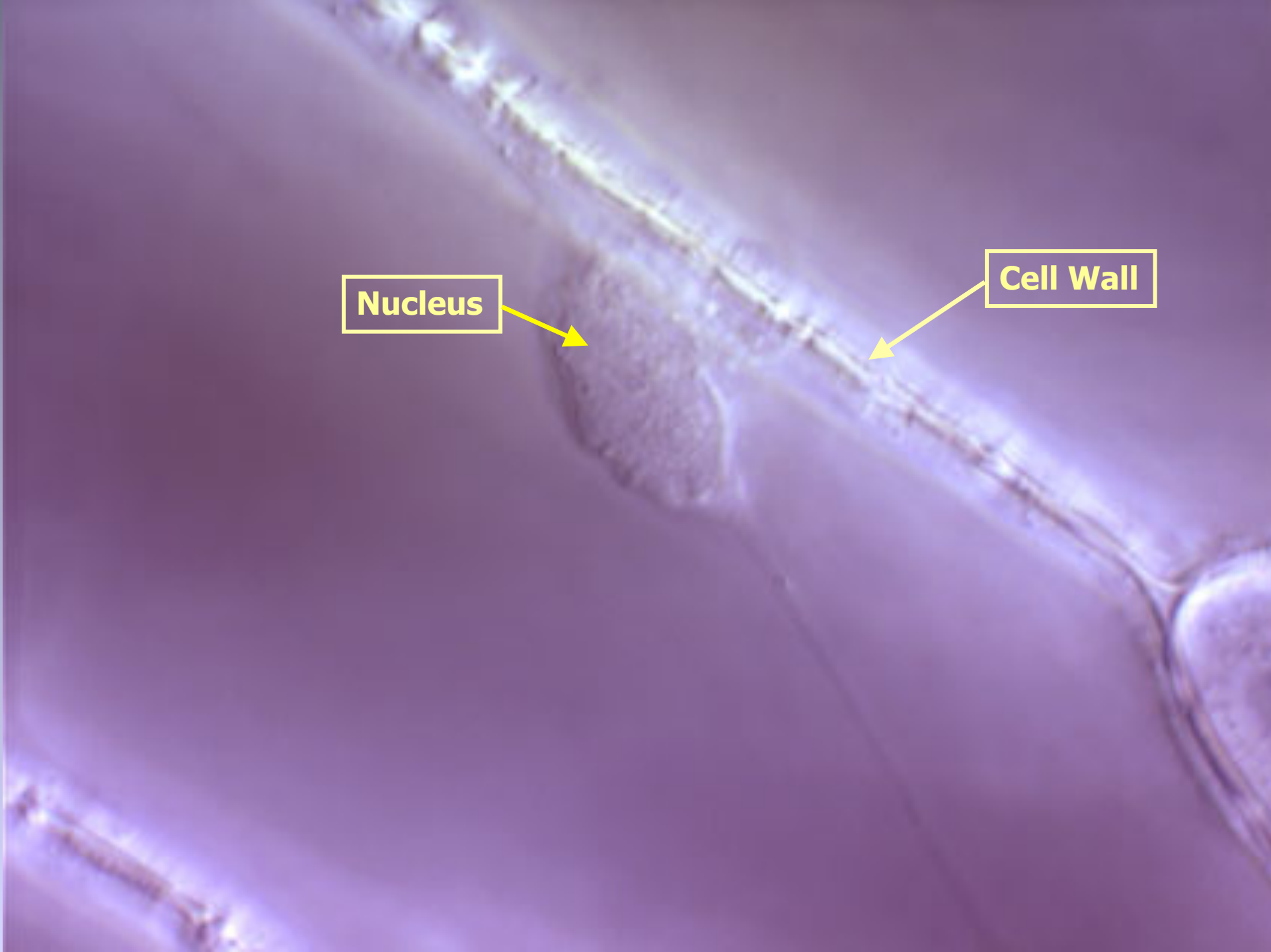


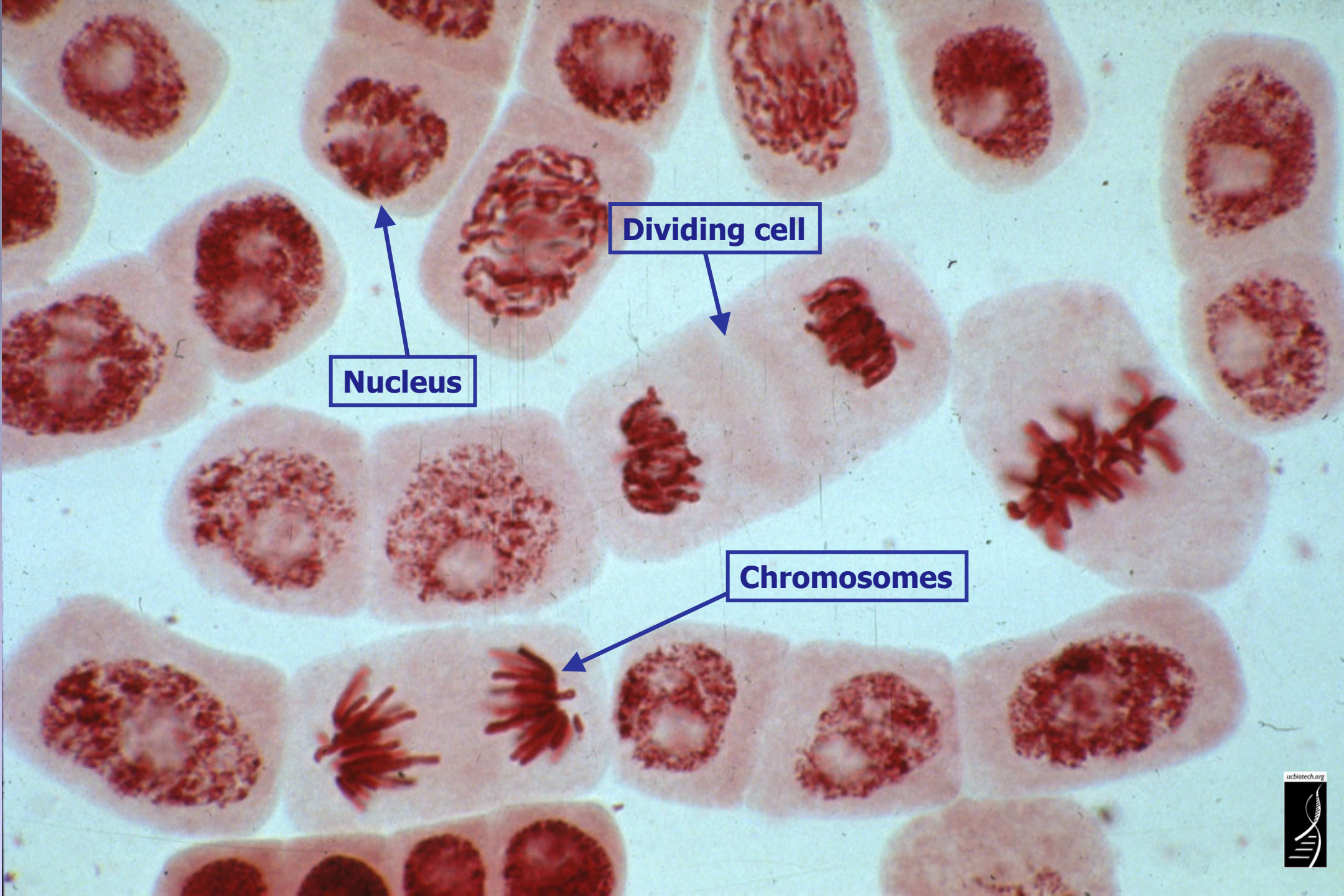
A high-magnification micrograph showing a dense network of plant tissue cells. The cells are roughly rectangular or polygonal in shape, with prominent cell walls that create a honeycomb-like pattern. The interior of the cells appears lighter, while the walls are darker. Two yellow arrows originate from a label box on the left and point to specific cells within the tissue.

CELLS

Nucleus

Cell Wall





Nucleus

Dividing cell

Chromosomes



How are genes and chromosomes manipulated to create a new plant variety by classical breeding?



Triticum monococcum

Ancient variety



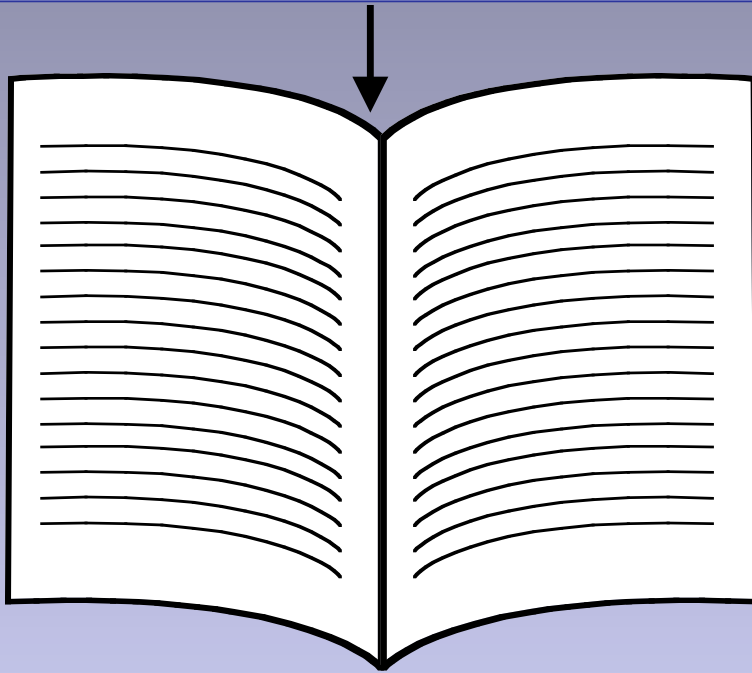
Triticum aestivum

Modern bread variety

Information in the wheat genome

Chemical units represented by alphabetic letters

...CTGACCTAATGCCGTA...

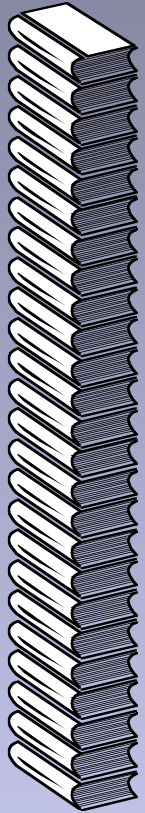


1700 books
1000 pages each



1700 books
(or 1.7 million pages)

Hybridization or cross breeding of wheat



X



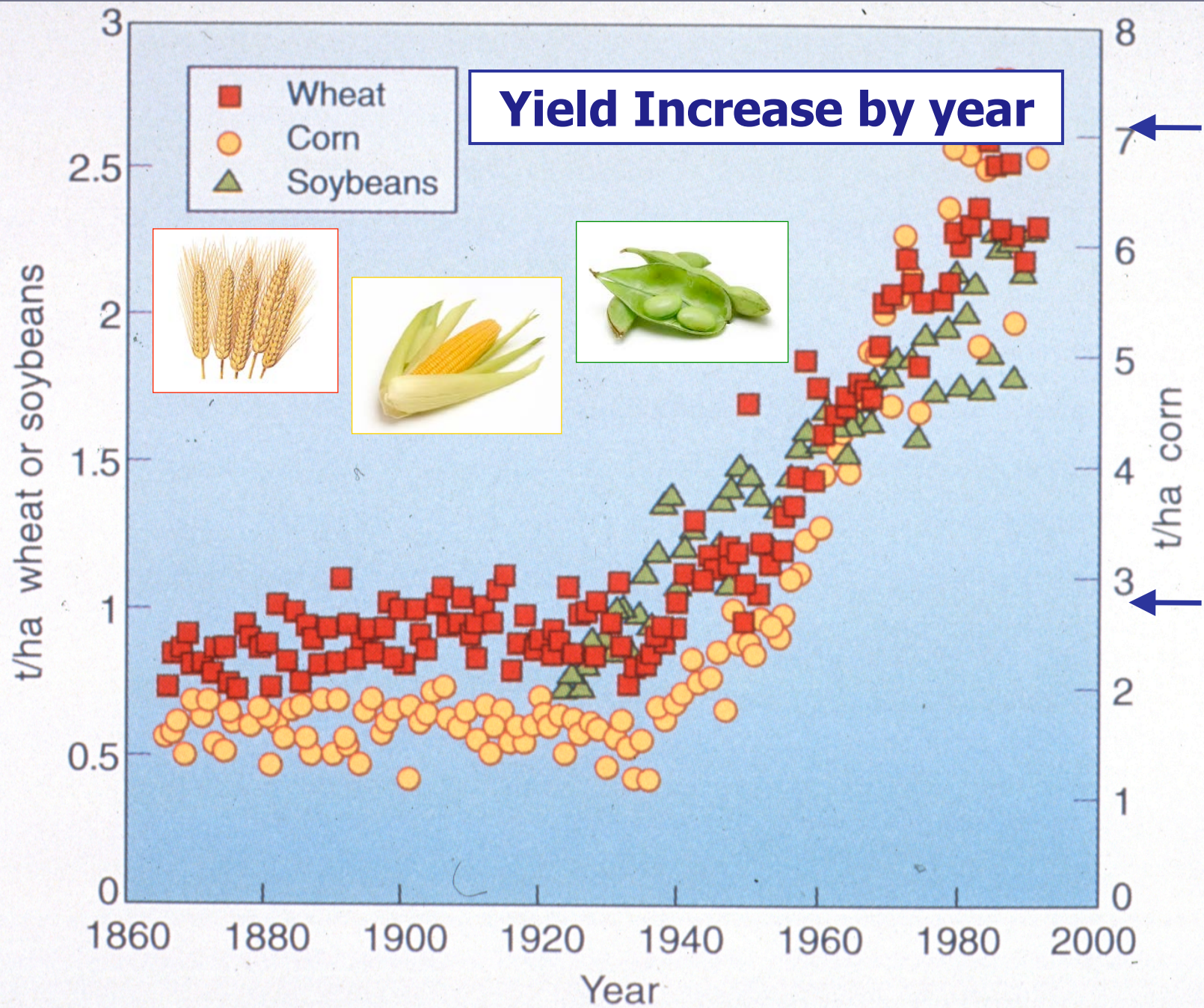
**Random
retention of
information
from each
parent**

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

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

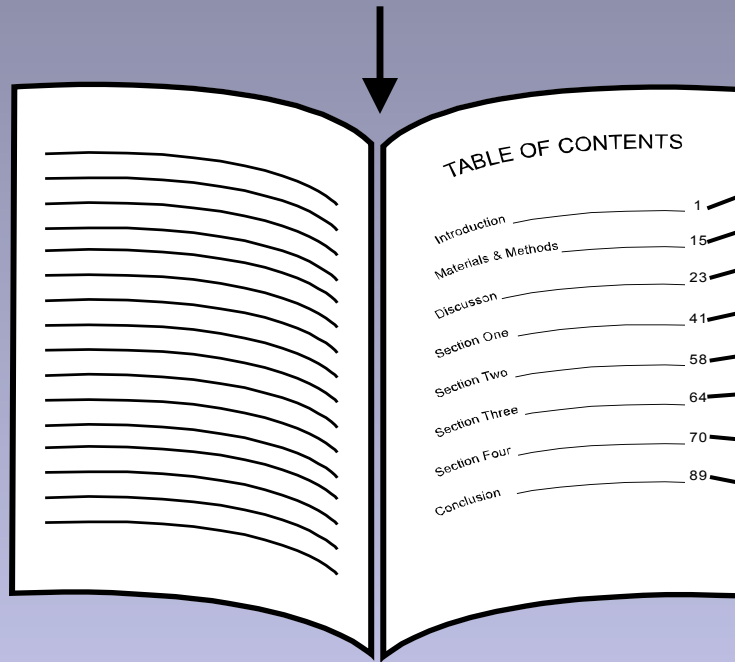
**1700 books
(or 1.7 million pages)**

Genetic modification that is not GE or GMO



Marker-Assisted Breeding

...CTGACCTAATGCCGTA...



Uses a table of contents for genes to perform marker assisted selection

Genomics


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

Genetic modification that is not GE or GMO



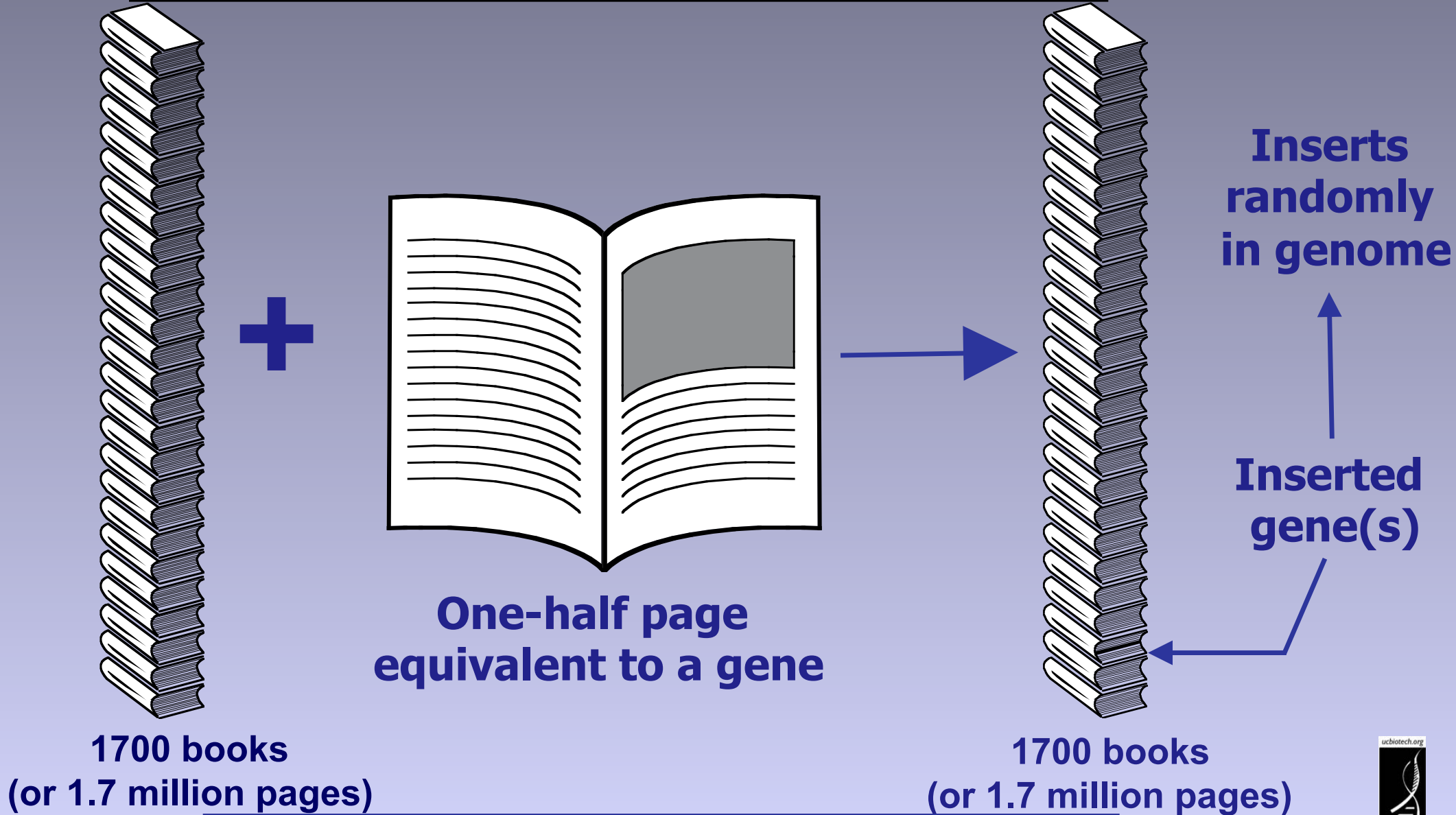
Marker-assisted selection was used to create rice protected against bacterial blight and blast disease

Limited to diversity in crop and compatible relatives



If a desired trait is from an incompatible plant or other organism, there are other ways to create new varieties using the modern tools of genetics

Genetic Engineering Methods



Genetic modification that is GE or GMO

How Do You Do Genetic Engineering?

How Do You Prepare the Half Page of Information to Introduce into Plants?

On switch

Gene of interest

Off switch

Marker

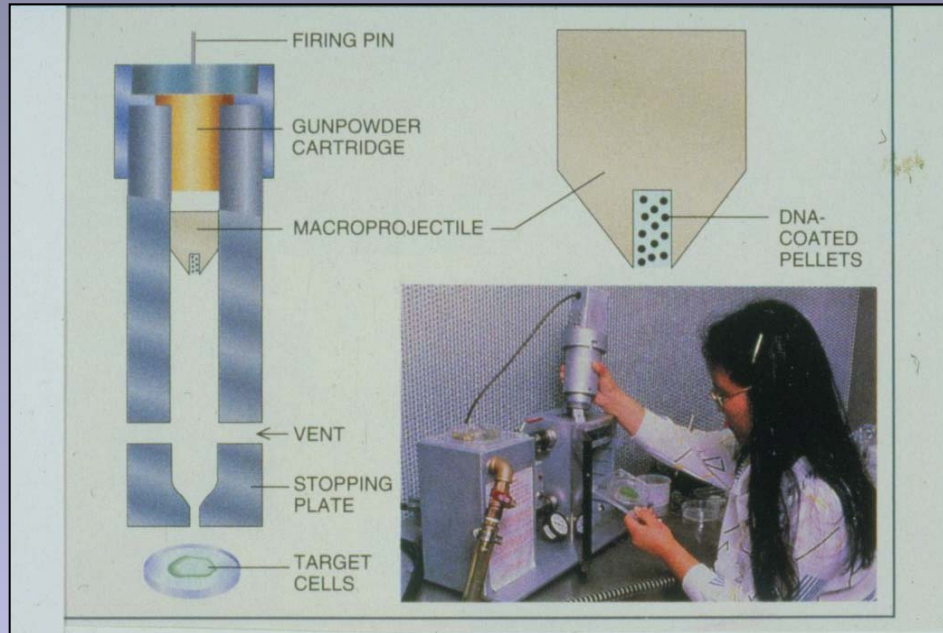
On switch: controls when and where gene product is made

Off switch: turns off production of gene product

Gene of interest: gene of interest you want to put into the plant

Marker: Indicates which plants have the gene of interest; antibiotic resistance, sugar usage

How Do You Introduce the Half-page into Plants?



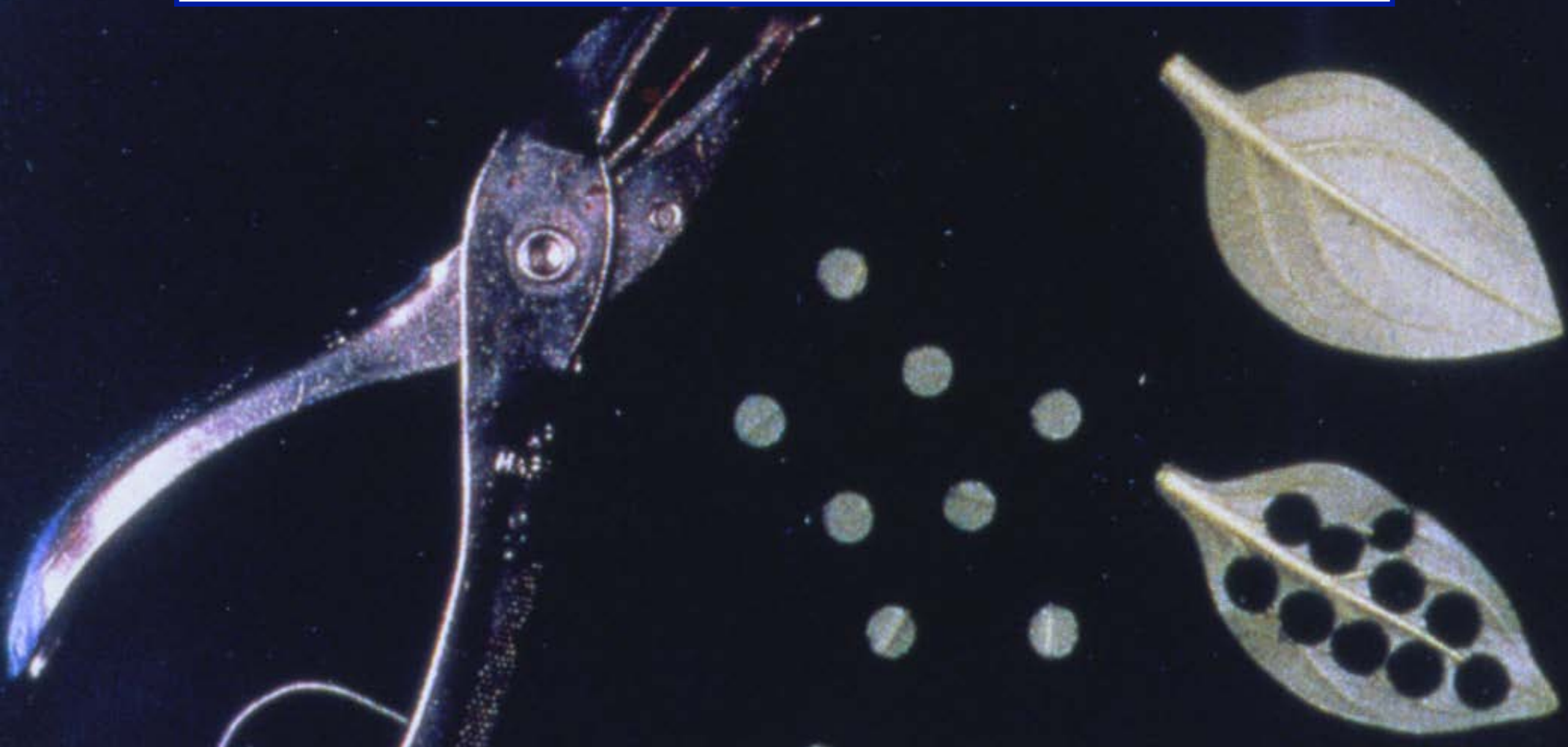
Gene gun



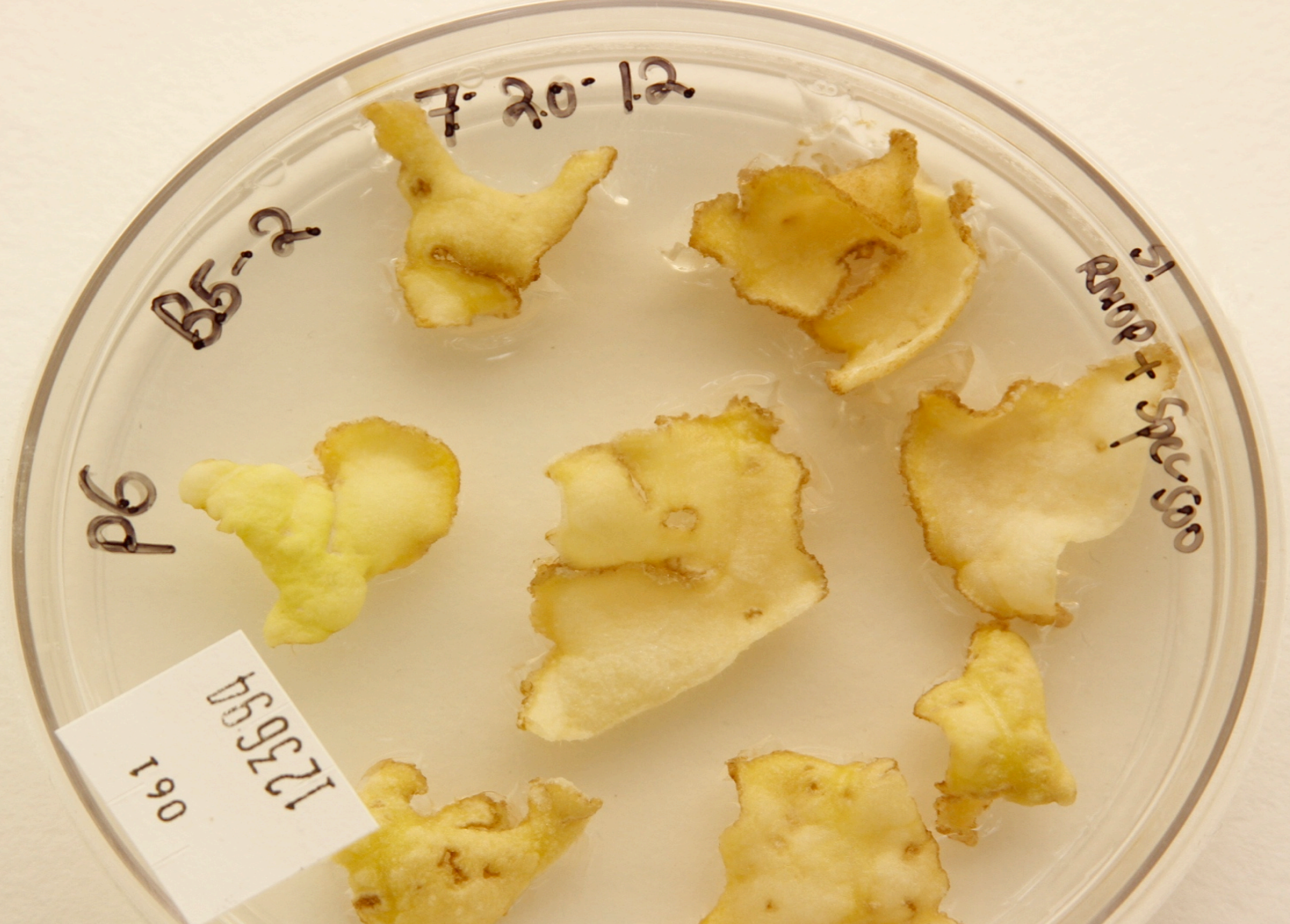
Agrobacterium

Both methods introduce DNA into the genetic information in plant cells

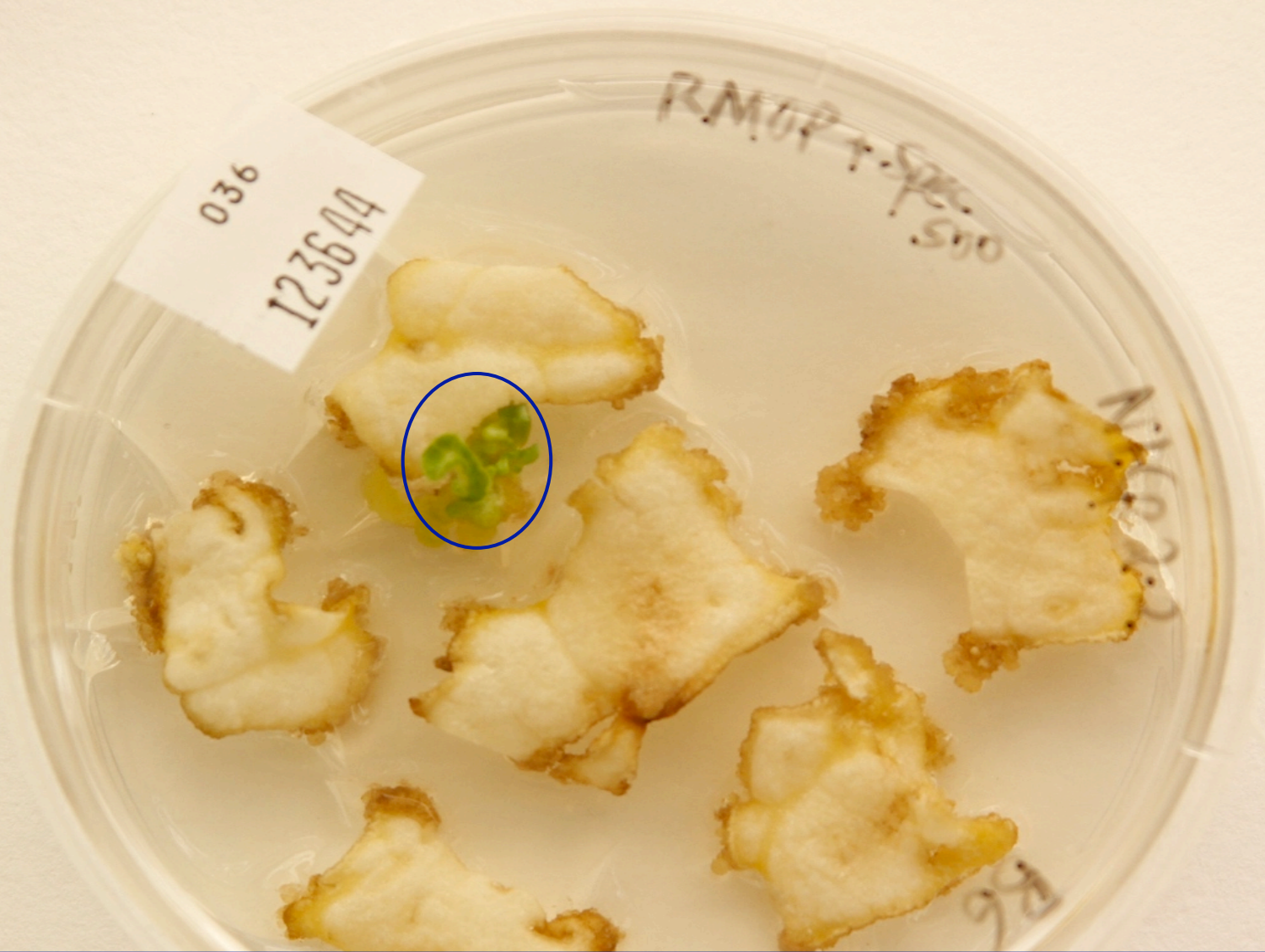
How Do You Get an Engineered Plant?



Cut pieces from the leaf. Introduce gene with gun or use Agrobacterium – both transfer genes into plant cells



Put leaf pieces on selection for marker gene. Tissue without marker gene dies, but...



Few cells receiving selection gene live and give rise to plantlet leaves. Dead leaf tissue is removed and..

Put into new medium, leaflets expand, roots form. Plants moved to soil. Every cell in new plant has introduced genes.



Number of different commercially available large acreage engineered (GE) crops is limited

GE Cotton

96% of 2014 acreage

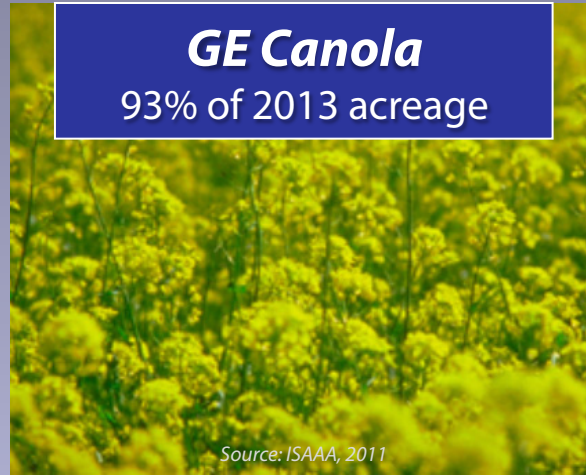
(Insect Resistant: 5% Herbicide tolerant: 12% Stacked gene: 79%)



Source: USDA-ERS, 2014

GE Canola

93% of 2013 acreage

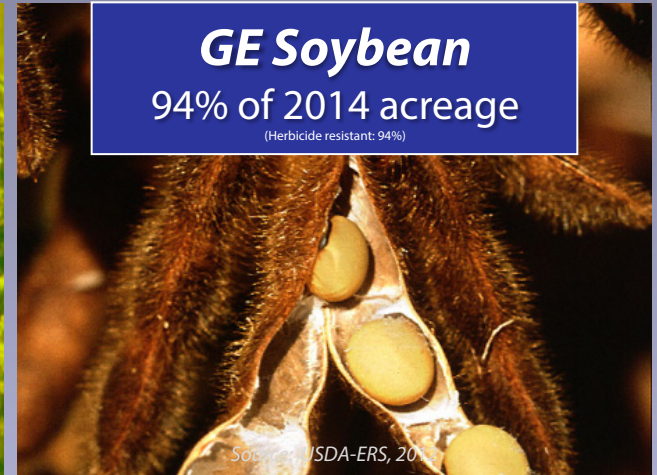


Source: ISAAA, 2011

GE Soybean

94% of 2014 acreage

(Herbicide resistant: 94%)

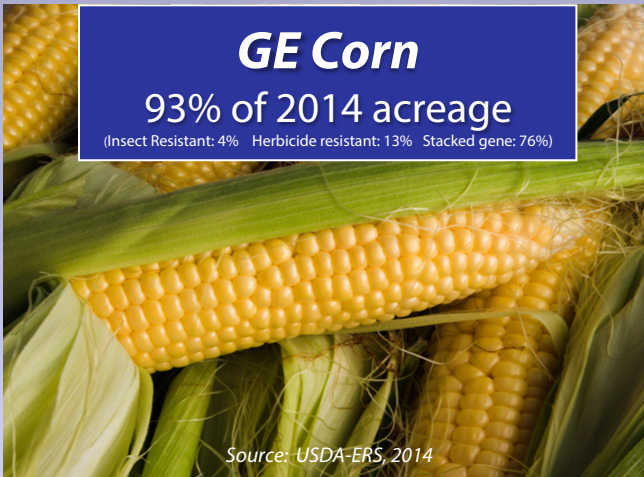


Source: USDA-ERS, 2014

GE Corn

93% of 2014 acreage

(Insect Resistant: 4% Herbicide resistant: 13% Stacked gene: 76%)



Source: USDA-ERS, 2014

GE Sugarbeet

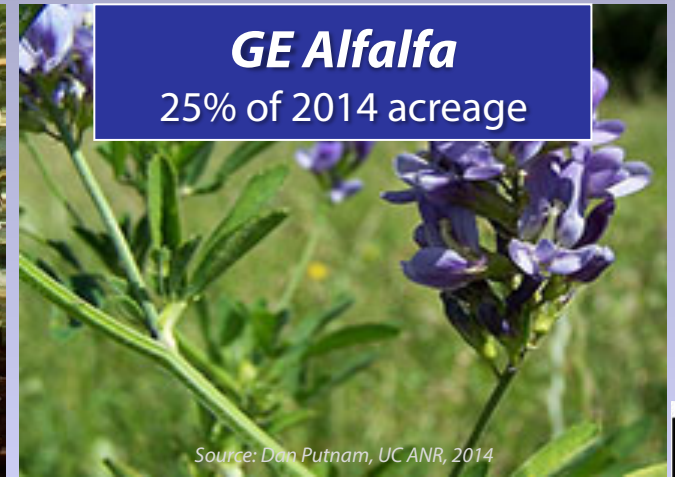
98% of 2013 acreage



Source: ISAAA, 2011

GE Alfalfa

25% of 2014 acreage



Source: Dan Putnam, UC ANR, 2014

**There are only a few whole, small
acreage GE foods in the U.S market**



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

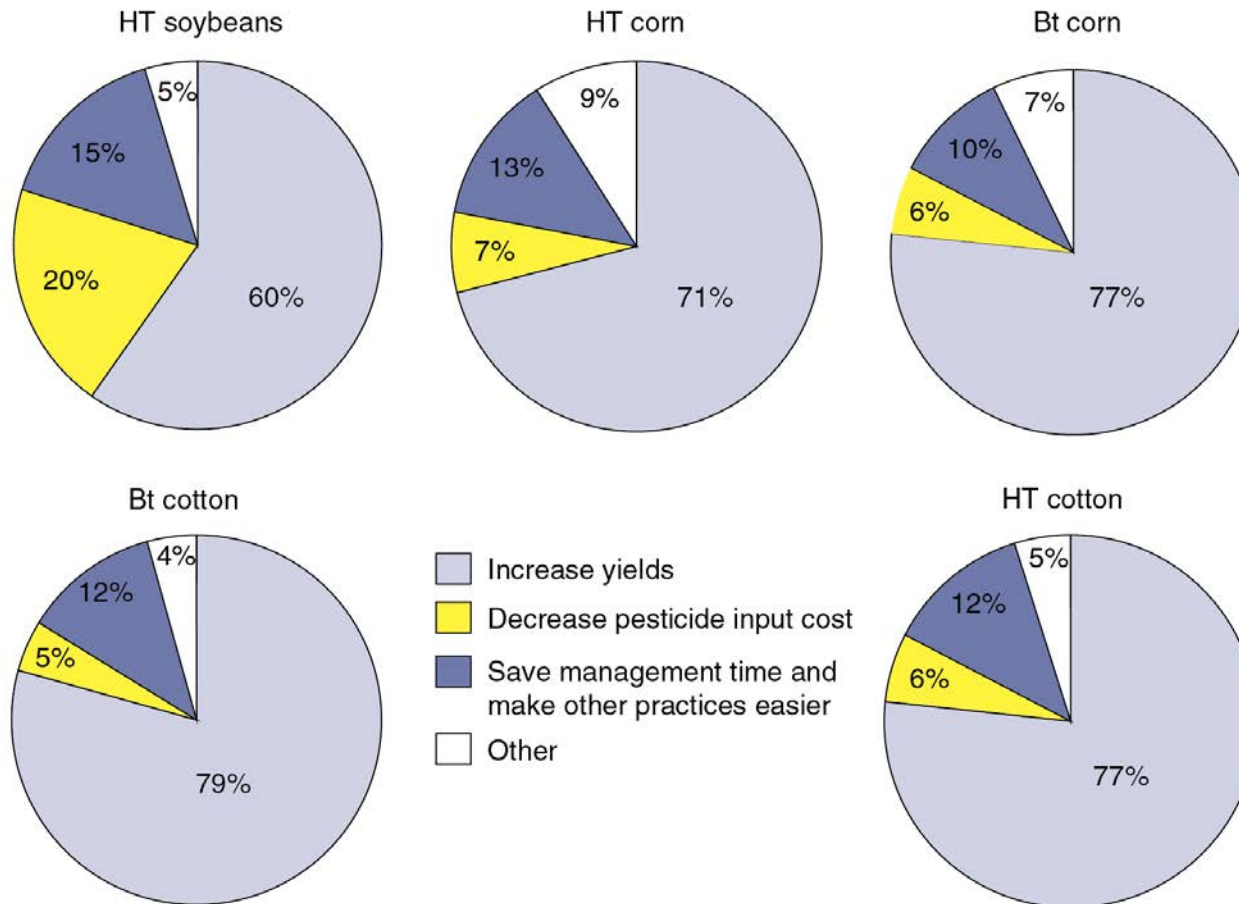


**Insect-tolerant Bt Crops -
engineered for resistance
using gene from naturally
occurring bacterium**



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

Why do growers adopt GE crops?



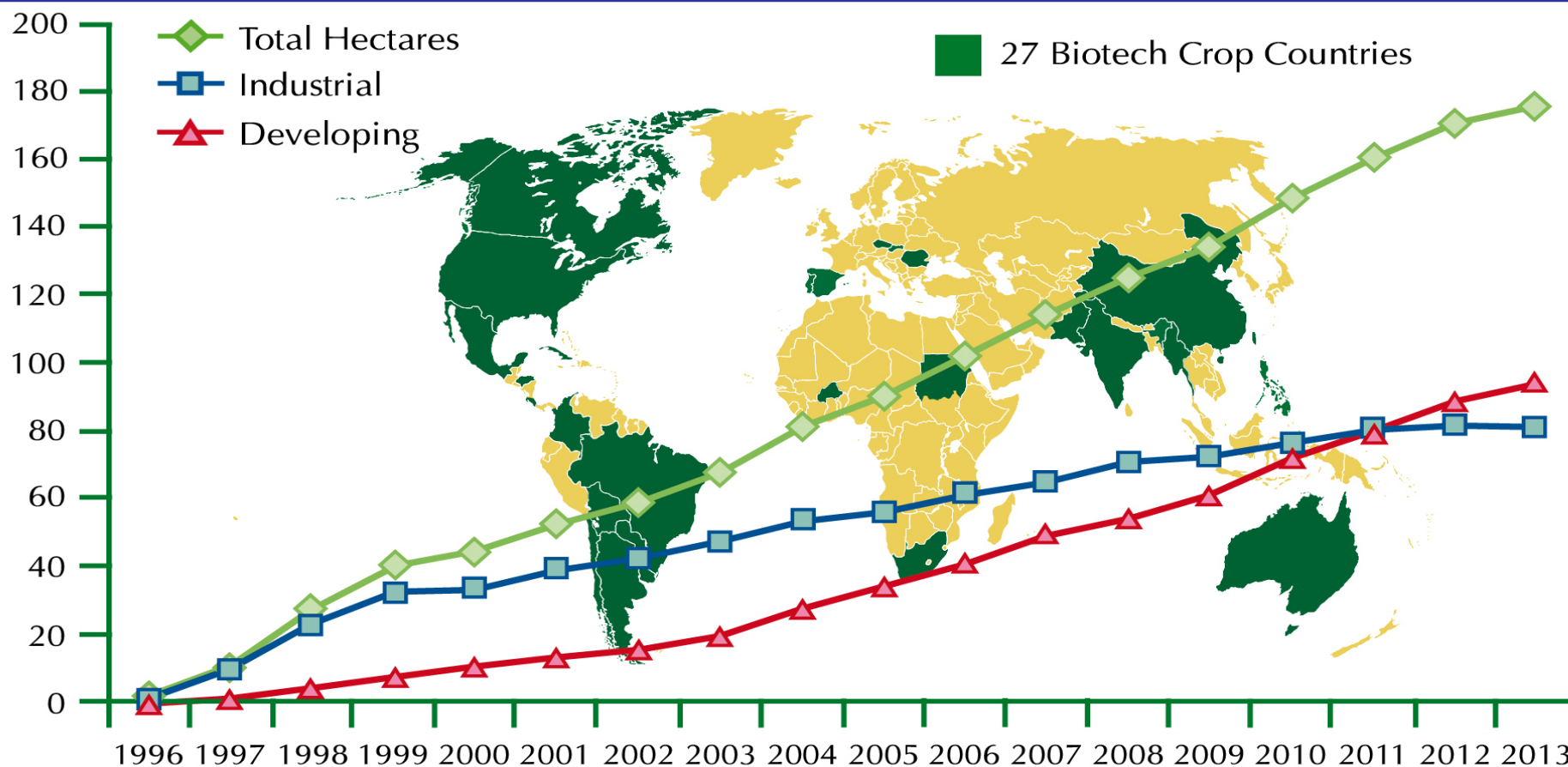
Reasons vary from crop-to-crop but predominant reason is to improve yield

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 75% of processed foods in U.S. have GE ingredients


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



2013: 15.4 million farmers in 27 countries
433M acres planted(>3X size of California)
>90% were small acreage farmers

WHAT'S IN THE PIPELINE?



A close-up photograph of several green grapes. The surface of the grapes is covered with a fine, white, powdery substance, which is powdery mildew. The background is dark and out of focus.

*Australian researchers identify
grape genes that provide resistance
to powdery mildew*

SOURCE: Western Farm Press, volume 26, number 16



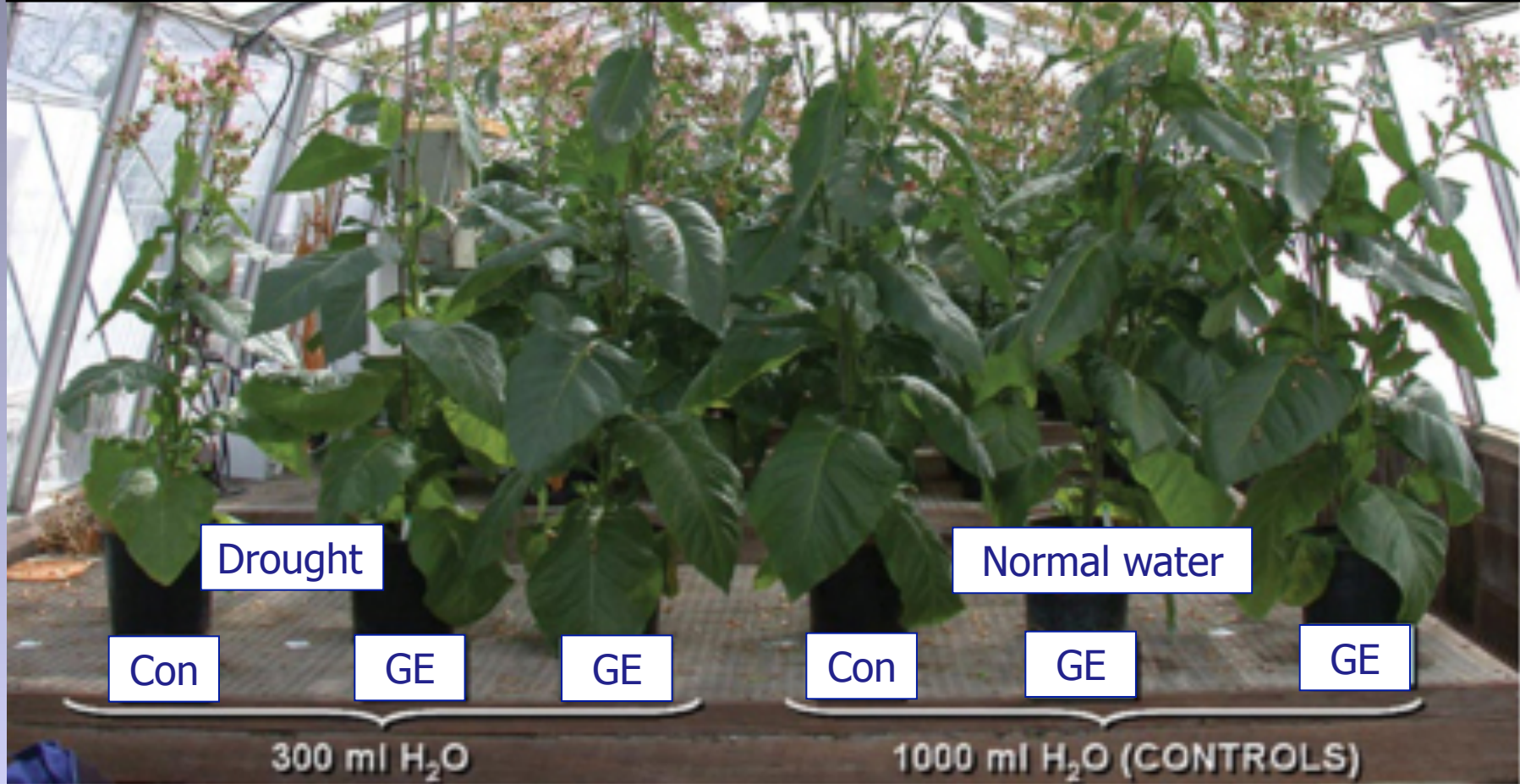


***Arcadia Biosciences develops GE canola that
uses 50% less nitrogen fertilizer***

SOURCE: http://archives.foodsafety.ksu.edu/agnet/2007/4-2007/agnet_april_10.htm#story0



UCD researcher engineers drought tolerance leading to vigorous growth after prolonged drought; control plants are stunted and die



SOURCE: Rivero, R.M., Kojima, M., Gepstein, A., Sakakibara, H., Mittler, R., Gepstein, S. and Blumwald, E. 2007. Delayed leaf senescence induces extreme drought tolerance in a flowering plant. *Proceedings of the National Academy of Sciences USA* 104: 19631-19636.

2013 GE Potato Field Trial – Ireland
Desiree potato, highly susceptible to late blight,
engineered with gene from wild potato variety





High anthocyanin purple GE tomatoes. Diets with 10% purple tomatoes increased lifespan of cancer-prone mice

What is the U.S. regulatory process governing engineered crops and foods?

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?

APHIS Determines Nonregulated Status – 111 granted

(8-2-2014)

**Once nonregulated, organism no longer requires
APHIS review for movement or release in U.S.**

- ✓ Alfalfa - HT – removed, reinstated
- ✓ Apple - PQ
- ✓ Corn - HT, IR, AP
- ✓ Cotton - HT, IR
- ✓ Soybean - HT, PQ
- ❖ Potato - IR, VR
- ❖ Tomato - PQ
- ✓ Squash - VR
- ✓ Canola – HT
 - ✓ Large-scale production
 - ❖ Not on market
- Papaya - VR
- ❖ Plum - VR
- Potato - PQ
- ❖ Rice - HT
- Rapeseed - HT, AP, PQ
- ✓ Sugar beet - HT - removed, reinstated
- ❖ Flax - HT
- ❖ Chicory - AP
- ❖ Tobacco – PQ
- ❖ Rose - PQ

(http://www.aphis.usda.gov/brs/not_reg.html)



© SIVB. Photo courtesy of the J.R.
Simplot Company



Innate™ (L) and traditional (R) potato
10 hours after cutting

*Low acrylamide, low sugar, bruising-resistant potato
engineered with only potato DNA –
deregulated by USDA APHIS, FDA safety clearance*

Canadian Okanagan Specialty Fruits will voluntarily label their nonbrowning GE apples, recently deregulated by USDA.



SOURCE: "This GMO Apple Won't Brown. Will That Sour The Fruit's Image?", Wisconsin Public Radio News, January 8, 2014.

<http://news.wpr.org/post/gmo-apple-wont-brown-will-sour-fruits-image>

Photo courtesy of Okanagan Specialty Fruits Inc.





*Aside from government, courts become involved.
Once deregulated, U.S. Circuit Court demands
full Environmental Impact Statement before
growers can resume planting GE sugar beets and
GE alfalfa*

Why Are GE Crops and Foods (GMOs) 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 GE organism on local fields



But pushback started in earnest in 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

Controversy Spread to U.S. in July 1999 with Letter from Greenpeace to Gerber Raising Issues about GE Ingredients in Baby Food

Wall Street Journal
Friday, July 30, 1999

Strained Peace

Gerber Baby Food,
Grilled by Greenpeace,
Plans Swift Overhaul

Gene-Modified Corn and Soy
Will Go, Although Firm
Feels Sure They Are Safe

Heinz Takes Action, Too

By LUCETTE LAGNADO

Staff Reporter of THE WALL STREET JOURNAL

The letter scrolling out of a fax machine at the Gerber baby-food company in Michigan May 28 was just one of many arriving that day and didn't even name the person it was meant for, but it sure got attention. Within days, it had found its way to Gerber's parent company in Switzerland, Novartis AG, and come to the attention of its CEO. There, executives soon were taking steps to overhaul a decades-old product

What are some food safety issues today?

- **Lack of peer-reviewed food safety tests**
- **Creation of allergens or activation of toxins**
- **Pharma crops contaminating food supply**
- **Labeling**
- **Gene flow from food to intestinal bacteria increasing antibiotic resistance**

**Meta-analysis review from France published 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

Another meta-analysis in 2014, using publicly available sources from 1983 to 2011 that tracked 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>



Nonetheless, on occasion widely publicized studies cast doubt on safety of GE foods, e.g., one published by French researcher in Sept. 2012

Later review by European Food Safety Authority found study had no merit – but that was not as widely publicized

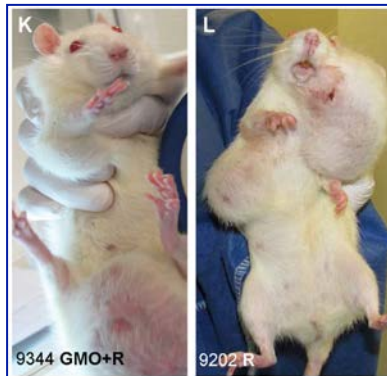
French academies trash GM corn cancer study

By RFI

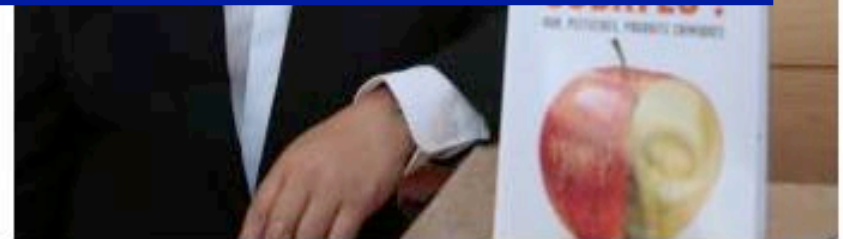
A controversial study that linked genetically modified maize to cancer in laboratory rats was "not reliable" and "spread fear among the public," French academies said in a joint statement.



Featured on Dr. Oz Show



Claim that Monsanto's RR corn causes tumors in rats



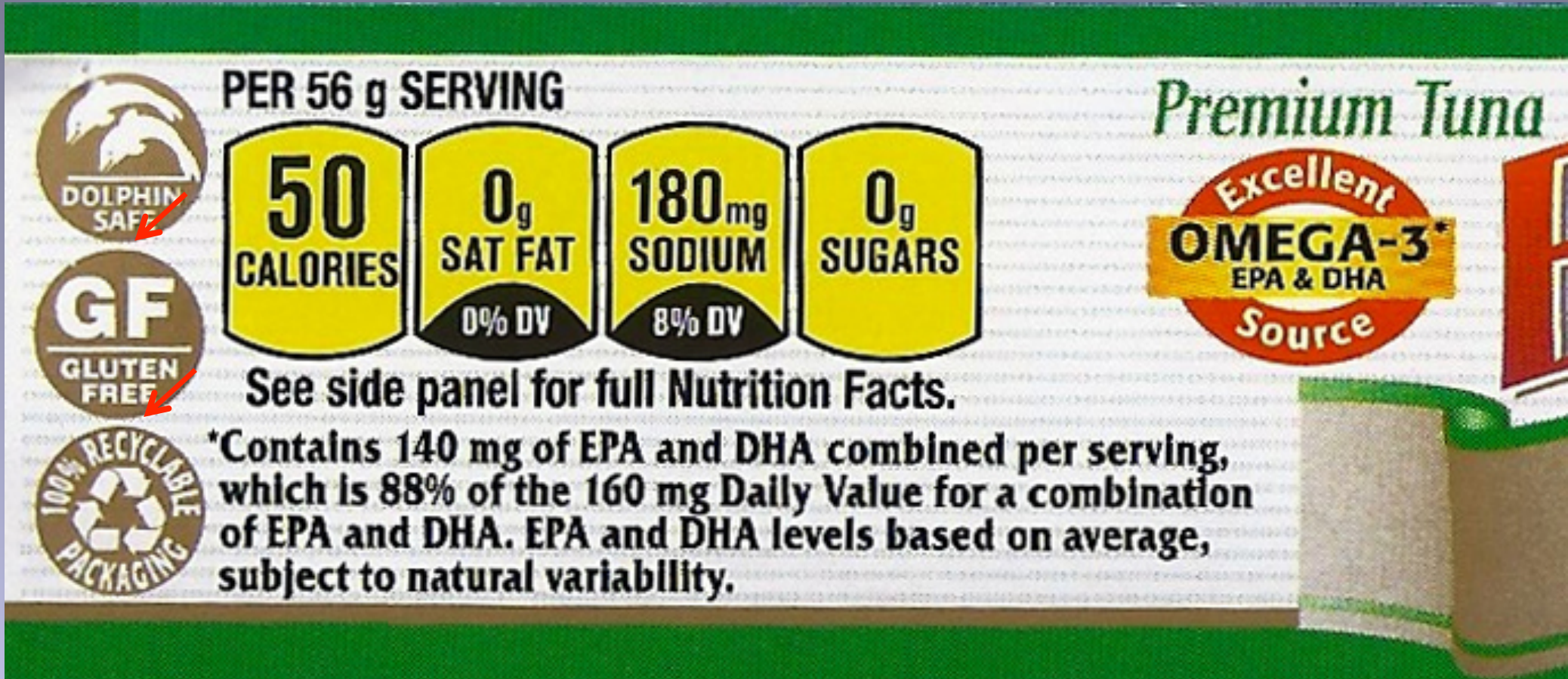
The report's author, Gilles-Eric Séralini, with his book All Guineapigs
AFP /Jacques Demarthon

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

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

What about labelling?





**Labels abound on foods— from gluten-free to dolphin-safe
— none are mandated. There are also no federally
mandated labels on foods with GE ingredients except
under specific circumstances.**

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 language.



But there is the potential for a patchwork of local labeling laws due to efforts in some states to pass such laws to be placed on products with GE ingredients – this would be difficult for commerce and for enforcement.

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>



**Already there are non-legislative labeling efforts,
like the Non-GMO Project label**

**Although a recent study shows that presence of
GMO labels do not lead people to believe GMOs
are more or less safe**



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



Food industry seeks voluntary GMO labeling

By Associated Press, Published: February 6



WASHINGTON — People who want to know more about genetically modified ingredients in their food would be able to get it on some packages, but not others, under a plan the industry is pushing.

Large food companies worried they might be forced to add “genetically modified” to packaging are proposing voluntary labeling of those engineered foods, so the companies could decide whether to use them or not.

The effort is an attempt to head off state-by-state efforts to require mandatory labeling. Recent ballot initiatives in California and Washington state failed, but several state legislatures are considering labeling requirements, and opponents of engineered ingredients are aggressively pushing for new laws in several states.

The move comes as consumers demand to know more about what’s in their food. There’s very little science that says genetically engineered foods are unsafe. But opponents say there’s too much unknown about seeds that are altered in labs to have certain traits, and that consumers have a right to know if they are eating them. The seeds are engineered for a variety of reasons, many of them to resist herbicides or insects.

Food industry is pushing for a bill requiring FDA to create voluntary labels for GE foods and to require safety reviews of GE foods before being sold

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





[MENU](#) [NUTRITION](#) [FOOD WITH INTEGRITY](#) [WHAT'S HAPPENING](#) [CATERING](#) [TALK TO US](#)



[LOCATIONS](#)

Chipotle's recent labeling decision has pressed the issue

FOOD WITH INTEGRITY

G-M-OVER IT



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

"USDA offers to verify food companies' claims that products contain no GMO's"

"This decision adds GE ingredients to the agency's audit program that verifies various food claims, e.g., grass-fed, antibiotic-free and humanely raised. Program is voluntary. Producers asking for non-GMO verification will pay a fee"



**This just
announced last
week but issue is
not yet resolved.**

SOURCE: "U.S. action on GMOs stops far short of mandatory labels", San Francisco Chronicle, 5/14/15.
<http://www.sfgate.com/science/article/U-S-plan-to-vouch-for-GMO-free-foods-disappoints-6264407.php>



What are some environmental and other issues?

- **Transfer of engineered genes to non-GMO/organic crops?**
- **Development of herbicide-tolerant weeds or pesticide-resistant insects**
- **Spread of pharmaceutical genes into commercial crops?**
- **Loss of genetic diversity?**
- **Gene patents and intellectual property?**



One major issue is co-existence between organic and engineered crops and foods

Co-existence laws have been created in much of Europe and some states, like Oregon, are developing regulations as well



“Oregon governor to propose legislation to facilitate coexistence”

OUR VIEW

Coexistence possible for all crops

Aides to Oregon Gov. John Kitzhaber say he will propose legislation later this month to facilitate the coexistence of conventional, organic and genetically modified crops within the state.

It's a promising announcement, but unfortunately short on details.

Producers of Oregon's high-value specialty seed crops and organic producers have legitimate concerns about the potential for cross-pollination with GMO crops. Farmers who grow, or who may in the future want to grow, GMO crops must be allowed to produce crops approved by the federal government.

They are not mutually exclusive objectives.

with Kitzhaber.

The idea was to avoid a patchwork of county regulation, and to give the Oregon Department of Agriculture time to work out a reasonable scheme that addresses legitimate concerns of organic and conventional growers of high-value crops who fear contamination from genetically engineered pollen.

The governor then appointed a task force to frame the controversy over genetically modified organisms and inform lawmakers' decisions on possible statewide legislation later.

The task force consisted of stakeholders representing all camps, who predictably found it difficult to agree on much except there needs

say the state could pass legislation giving the ODA the authority to establish restrictions on where and how GMO crops could be grown. They point to a mapping system used by seed growers in the Willamette Valley.

They would also like a mechanism for compensating farmers if their crops are cross-pollinated.

Supporters of GMO crops favor a more voluntary approach. They say neighbors should be able to work out the particulars among themselves with minimal regulation.

We prefer as soft a touch as possible. But once the Legislature is involved, we're past the point where neighbors can reach accommodations.

*SOURCE: “Coexistence possible for all crops”, Capital Press, 2/2/15.
<http://www.capitalpress.com/Opinion/Editorials/20150116/coexistence-possible-for-all-crops>*

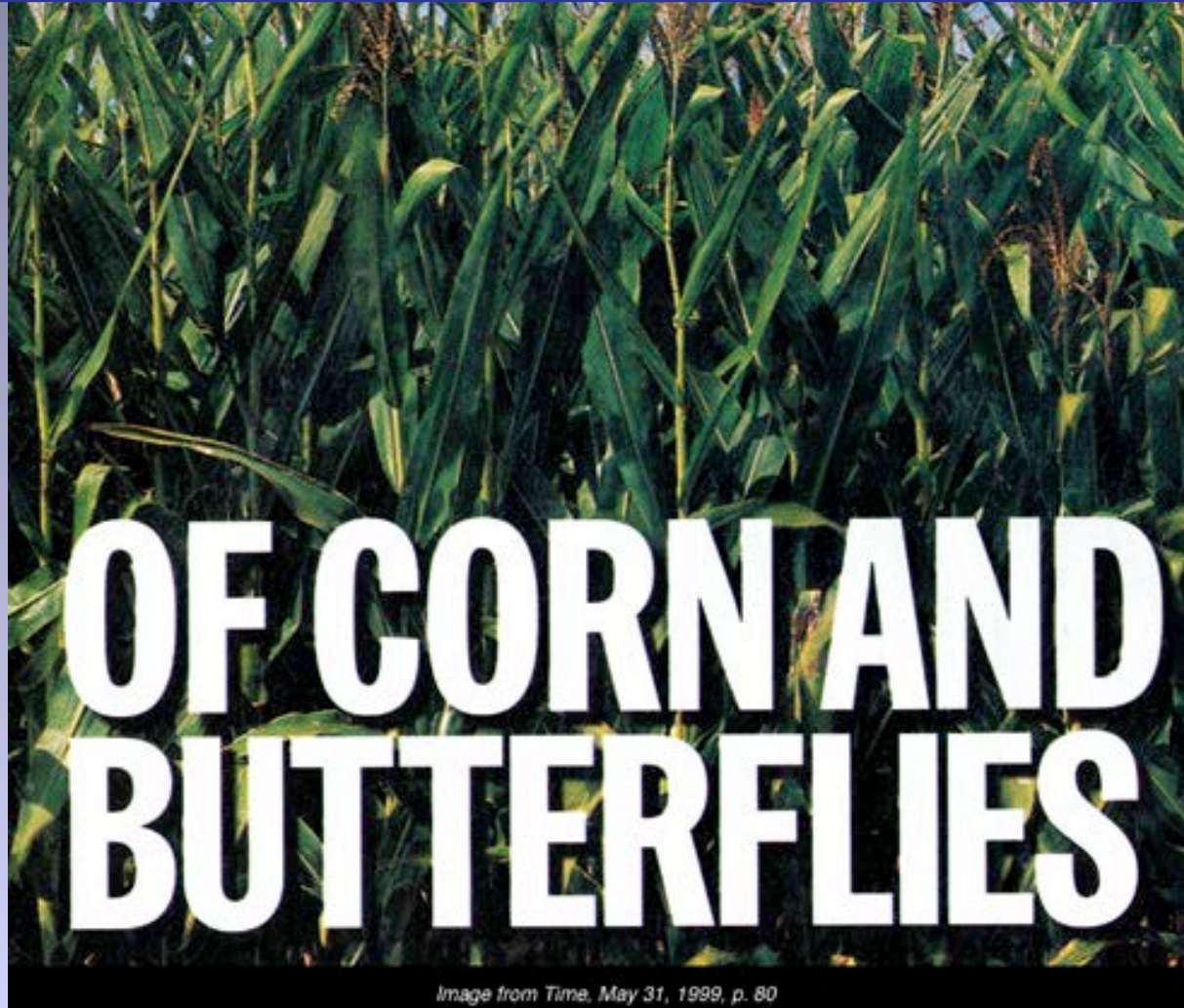
Insect Resistance

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

Another issue is development of herbicide- or insect-tolerant weeds

To date minimal insect resistance has occurred

In late 90's negative impact of Bt corn pollen on monarchs surfaced. After much research, effects were found to be minimal, but...





Groups seek glyphosate limits to protect butterflies

By MATEUSZ PERKOWSKI
Capital Press

Environmental groups seeking federal protection for monarch butterflies blame the use of genetically modified crops for the insect's steep decline.

Petitioners claim that while there were as many as 1 billion monarchs as recently as the 1990s, their numbers have dropped to around 33 million.

If the U.S. Fish and Wildlife Service agrees to list the species as threatened or endangered, protecting the insect may involve pesticide restrictions that affect biotech crops.

The alleged link between transgenic crops and the drop in monarch butterfly populations is milkweed, a plant that monarch larvae feed upon exclusively.

"A primary threat to the monarch is the drastic loss of milkweed caused by increased and later-season use of the herbicide glyphosate in conjunction with widespread planting

of genetically engineered corn and soybeans in the Corn Belt region of the United States and to planting of genetically engineered cotton in California," the environmentalist petition said.

In the past, many herbicides had trouble killing milkweed because it's a perennial that regenerates from its roots, said Bill Freese, science policy analyst for the Center for Food Safety, a non-profit involved in the petition.

Glyphosate, on the other hand, is absorbed by the plant's roots and destroys it completely, he said.

After glyphosate-resistant biotech crops became common in the 1990s, farmers began spraying much more of the herbicide, Freese said.

They also applied it after crops had begun growing, rather than killing weeds before the crops emerged — the effect was that milkweed was already sprouting and susceptible to the chemical, he said.

"Timing is also a factor," Freese said.

While several types of aggressive weeds have developed resistance to glyphosate due to frequent spraying, hundreds have not, including milkweed, he said. "Each weed is really different."

If the federal government extends Endangered Species Act protection to the monarch butterfly, the listing could result in restrictions on how often glyphosate and other herbicides can be used on crops, Freese said.

As a consequence, farmers may plant fewer acres of genetically engineered crops, since they wouldn't be able to spray the chemicals over the top of crops in certain fields, he said.

The Biotechnology Industry Organization, which represents biotech companies, would not comment on the petition or the effect of transgenic crops on milkweed and monarchs.

Farmers can play a key role in the recovery of the species, said Sarina Jepsen,

endangered species program director for the Xerces Society, an environmental group involved in the petition.

"We've seen real leadership from the agricultural sector in restoring habitat for the monarch butterfly," Jepsen said.

If the insect is listed as threatened, the Fish and Wildlife Service could enact 4(d) Special Rules that would allow routine farming practices to continue as long as they don't contribute to the insect's extinction, she said.

Jepsen said she didn't want to speculate about impacts to agriculture at this point, but she said 4(d) rules have been proposed for another butterfly species, the Dakota skipper, which the agency has proposed listing as threatened.

Under those rules, grazing would be disallowed in certain counties in Minnesota and North Dakota and farmers would face restrictions on when they can cut grass for hay.

...Impact of RoundUp on monarchs resurfaces due to impact on milkweed — an exclusive feedstock for butterfly larvae



Herbicide Tolerance

Environmental impact associated with herbicide and insecticide use, as measured by the Environmental Impact Quotient, fell by 17.1%

But was 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*

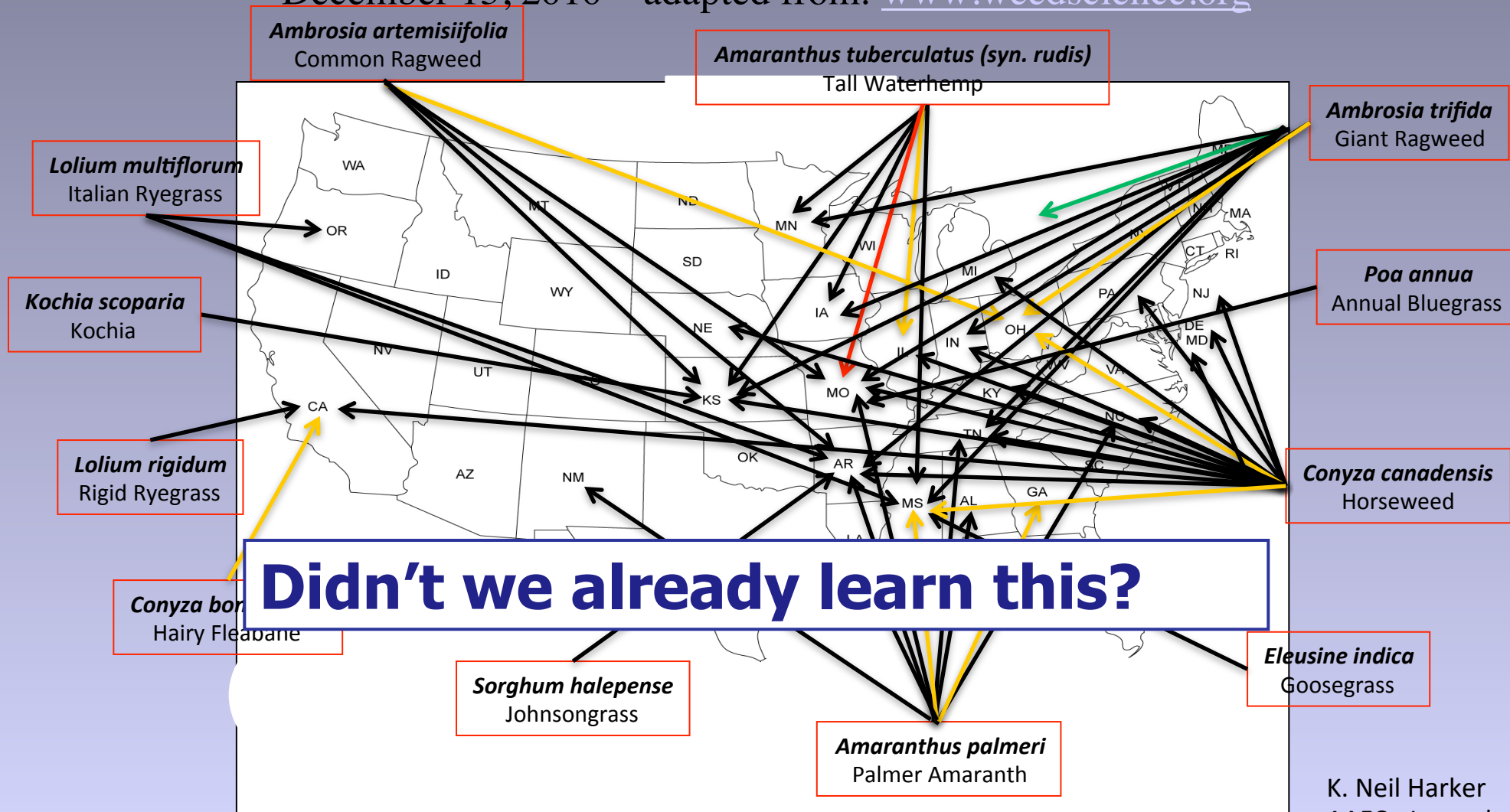
“When any single herbicide mechanism of action is used repeatedly without alternative management tactics, selection pressure becomes intense for plants that are tolerant or resistant to that herbicide.”

“There is now a large and growing threat to soil conservation gains because of the dire need...to manage resistant weeds...”

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

Glyphosate- Resistant Weeds – USA

December 13, 2010 – adapted from: www.weedscience.org



K. Neil Harker
AAFC - Lacombe, AB

Investigative report

Monsanto's practices weed out competition

Licensing pacts, science

Numerous issues go beyond science and facts

in United States

- Large agrichemical companies are creating today's commercial GE crops.
- They control most of the intellectual property.
- This may or may not be good for agriculture.

cent of all soybeans and 80 percent of all corn grown in the U.S., the company also is using its wide reach to control the ability of new biotech firms to get wide distribution for their products, according to a review of several Monsanto licensing

A farmer holds Monsanto's Roundup Ready soybean seeds. Confidential contracts detailing Monsanto Co.'s business practices reveal how the world's biggest seed developer protects its dominance over the multibillion-dollar market for genetically altered crops, an Associated Press investigation has found.

Dan Gill/Associated Press

SOURCE: Capital Press, December 18, 2009

Where to get more information on the issues?



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.

