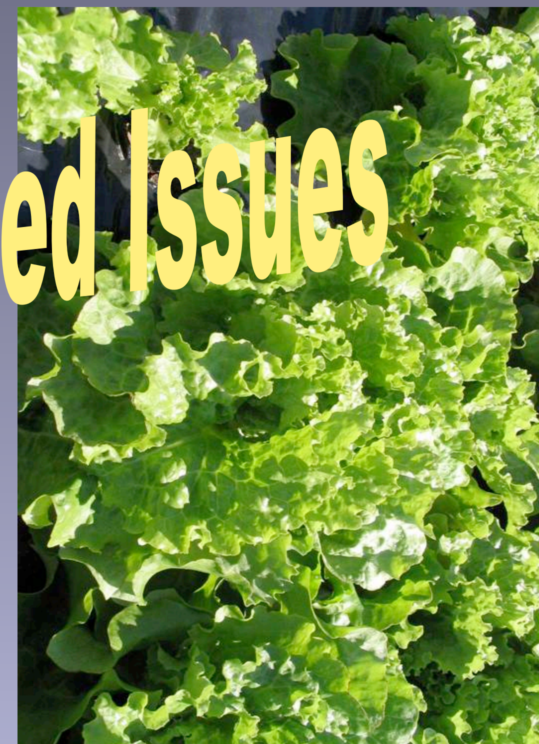
The Science of GMOs and Related Issues



Peggy G. Lemaux
University of California, Berkeley
http://ucbiotech.org
http://pmb.berkeley.edu/~lemaux

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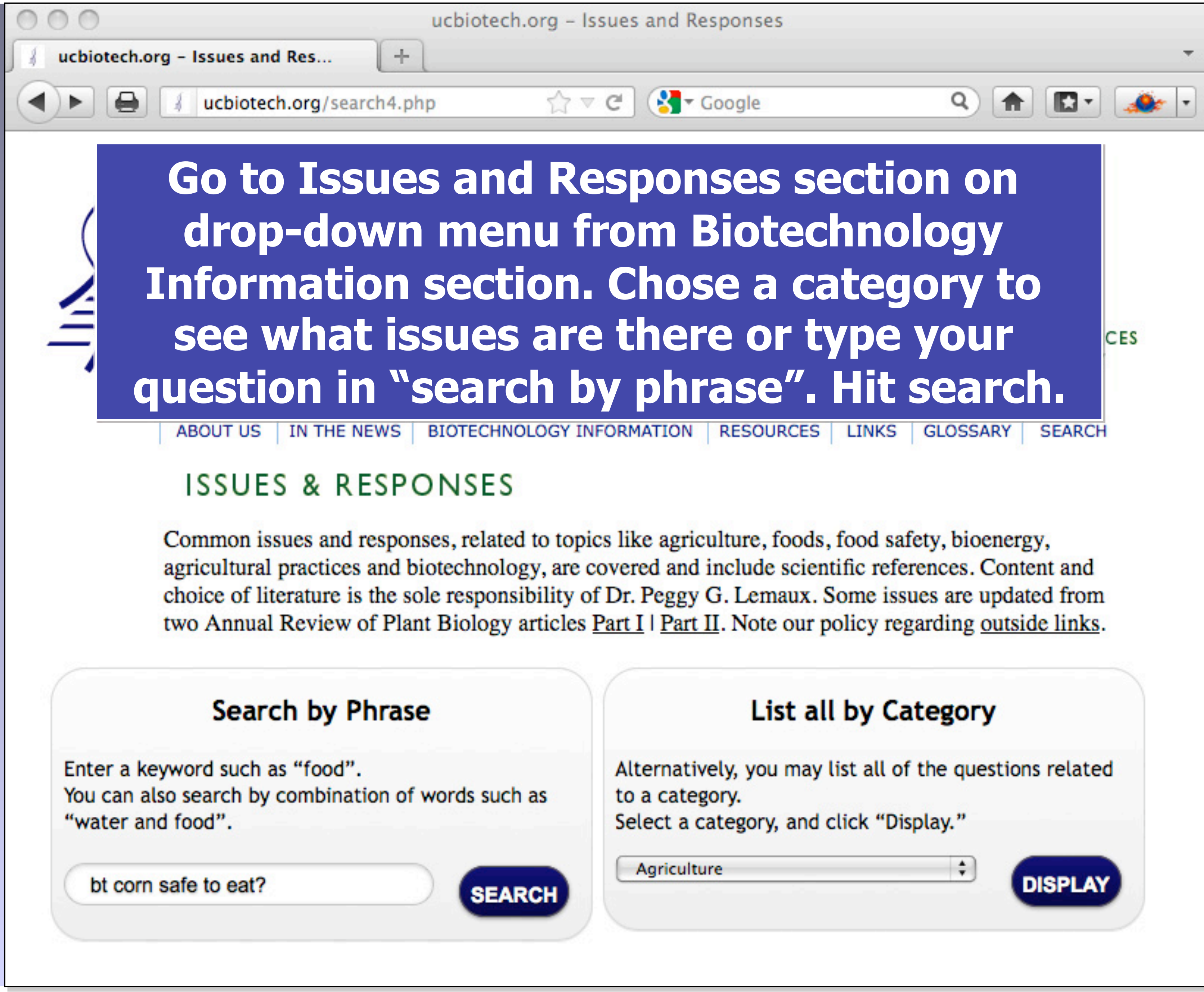
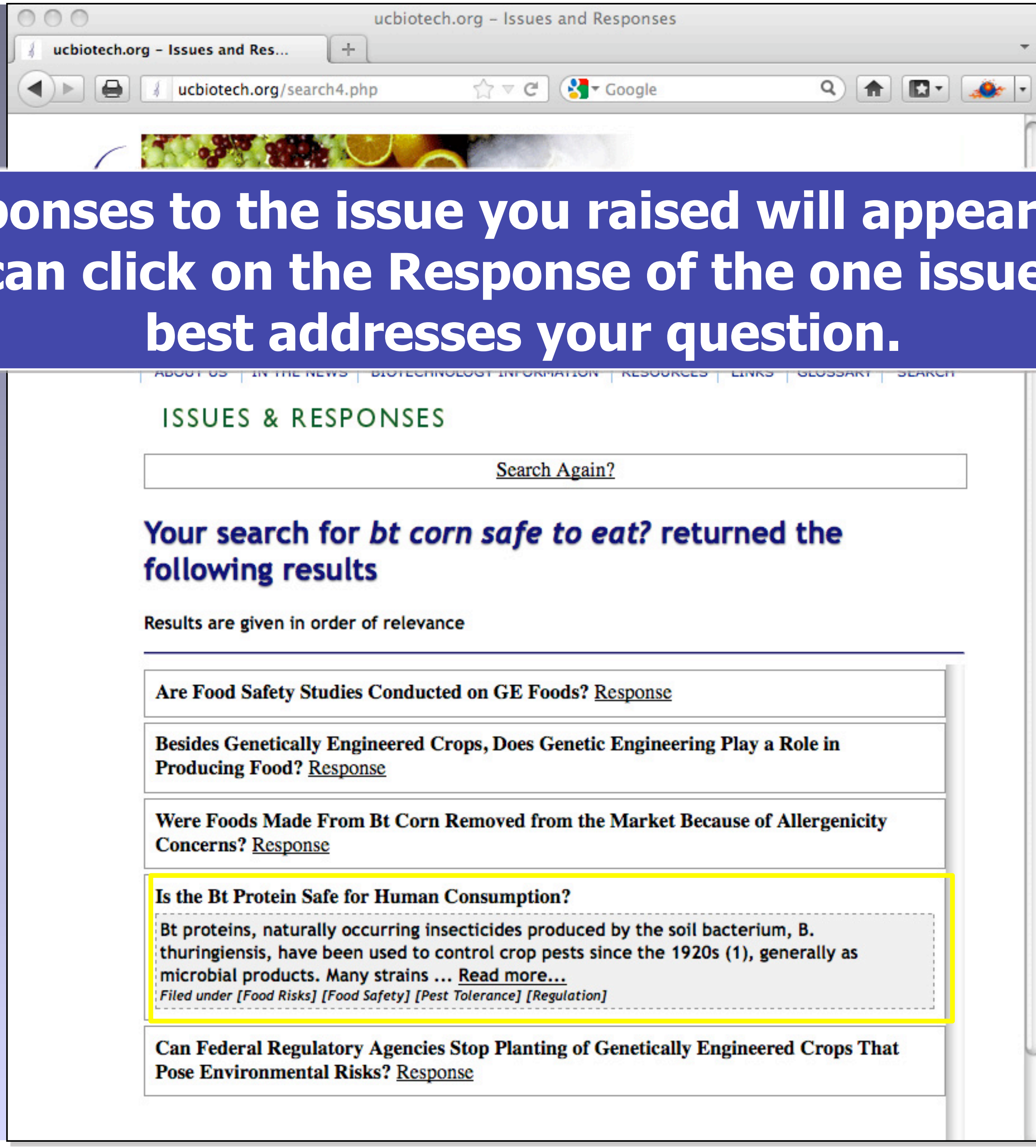
Want to ask questions? Follow these easy steps in Biotech information section of ucbiotech.org

Go to Issues and Responses section on drop-down menu from Biotechnology Information section. Chose a category to see what issues are there or type your question in "search by phrase". Hit search.



Responses to the issue you raised will appear and you can click on the Response of the one issue that best addresses your question.



Response to the issue you raised will appear with links to the scientific literature. If that doesn't answer your question, go back to the responses and choose another.

Is the Bt Protein Safe for Human Consumption?

Is the Bt Protein Safe for Human...

ucbiotech.org/answer.php?question=3

Google

Is the Bt Protein Safe for Human Consumption?

Response:

Bt proteins, naturally occurring insecticides produced by the soil bacterium, *B. thuringiensis*, have been used to control crop pests since the 1920s (1), generally as microbial products. Many strains of *B. thuringiensis* exist that produce different Bt proteins varying in the insects they target, e.g., larvae of butterflies and moths, beetles, and mosquitoes. The insecticidal Bt proteins form crystalline protein bodies inside the bacterium, hence the name Cry proteins. Full-sized Cry proteins are inactive until eaten by target insect larva, and inside the midgut they are cleaved and become active. The smaller, active peptides bind to specialized receptors, creating holes in the gut membrane that cause contents to leak and kill the larvae. The precision of different Bt proteins for their targets resides in the specificity of their tight binding to companion receptors in the insect gut (2).

Bt microbial products have a long history of safe use (~40 years) with only two reports prior to 1995 of possible adverse human effects, neither of which was due to exposure to Cry proteins (3). In a 1991 study that focused on exposure via inhalation of Bt sprays, results showed immune responses and skin sensitization to Bt in 2 of 123 farm workers (4). In a 2006 article, the Organic Consumers Association linked this observation to possible impacts of Bt in GE foods, warning that "Bt crops threaten public health" (5). But the respiratory sensitization observed in the farm workers does not provide validation that oral exposure to Bt would result in allergic responses.

In recent years a variety of safety studies were conducted specifically on native Bt proteins to show that they do not have characteristics of food allergens or toxins (See 6, 2, and 7 for reviews). In its review of Bt proteins, the EPA stated that, "several types of data are required for Bt plant pesticides to provide a reasonable certainty that no harm will result from the aggregate exposure of these proteins." The data must show that Bt proteins "behave as would be expected of a dietary protein, are not structurally related to any known food allergen or protein toxin, and do not display any oral toxicity when administered at high doses" (6).

The EPA does not require long-term studies because the protein's instability in digestive fluids makes such studies meaningless in terms of consumer health (8). In vitro digestion assays were used to confirm degradation characteristics of Bt proteins, whereas murine feeding studies were used to assess acute oral

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Are Food Safety Studies Conducted on GE Foods?

ucbiotech.org/answer.php?question=2

consume large amounts of food to obtain sufficient quantities of theGEingredient. Compositional analyses and toxicity testing of individual components are actually more sensitive and accurate in assessing safety (15). Therefore, in addition to whole foods, safety tests are conducted on individual products of introduced genes, both target and selectable marker genes, on the basis of the food additive provision (Section 409) of the 1992

Literature cited will appear with links when possible to the articles so that you can see them yourselves.

References:

1. Food Drug Adm. (FDA). 2005. Guidance for industry: Pharmacogenomic data submissions. http://www.fda.gov/downloads/.../Guidances/ucm126957.pdf Last accessed 2011-11-26. PDF

Now on to the topic at hand…

http://www.epa.gov/scipoly/biotech/pubs/framework.htm. Last accessed 2011-12-8. PDF

4. Kuiper HA, Kleter GA, Noteborn HPJM, Kok EJ. 2001. Assessment of the food safety issues related to genetically modified foods. *Plant J.* 27:503-28

5. Kessler DA, Taylor MR, Maryanski JH, Flamm EL, Kahl LS. 1992. The safety of foods developed by biotechnology. *Science* 256:1747-49

6. Berberich SA, Ream JE, Jackson TL,Wood R, Stipanovic R, et al. 1996. The composition of insect-protected cottonseed is equivalent to that of conventional cottonseed. *J. Agric. Food Chem.* 44:365-71

7. Sidhu RS, Hammond BG, Fuchs RL, Mutz J-N, Holden LR, et al. 2000. Glyphosatetolerant corn: The composition and feeding value of grain from glyphosate-tolerant corn is equivalent to that of conventional corn (*Zea mays* L.). *J. Agric. Food Chem.* 48:2305-12

8. Taylor NB, Fuchs RL, MacDonald J, Shariff AR, Padgette SR. 1999. Compositional analysis of glyphosate-tolerant soybeans treated with glyphosate. *J. Agric. Food Chem.* 47:4469-73

9. Kahle K, Kraus M, Richling E. 2005. Polyphenol profiles of apple juices. *Mol. Nutr. Food Res.* 49:797-806

10. Chassy B, Hlywka JJ, Kleter GA, Kok EJ, Kuiper HA, et al. 2004. Nutritional and safety assessments of foods and feeds nutritionally improved through biotechnology: An executive summary. *Compr. Rev. Food Sci. Food Saf.* 3:25–104
Provides scientific information and recommendations on safety and nutritional aspects of crops with improved nutritional qualities.

11. Flachowsky G, Aulrich K, Böhme H, Halle I. 2007. Studies on feeds from genetically modified plants (GMP)—Contributions to nutritional and safety assessment; Table 3. *Anim. Feed Sci. Technol.* 133:2-30

12. Konig A, Cockburn A, Crevel RWR, Debruyne E, Grafstroem R, et al. 2004.

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What will be covered?

1. Background on genes, genetics, genetic engineering
2. What GE crops are commercialized? In the pipeline?
3. What is the regulatory structure for GE crops?
4. What are food safety issues with GE foods?
5. What are environmental issues with GE crops?


Tour d'Onion
Or what makes an onion, an onion?
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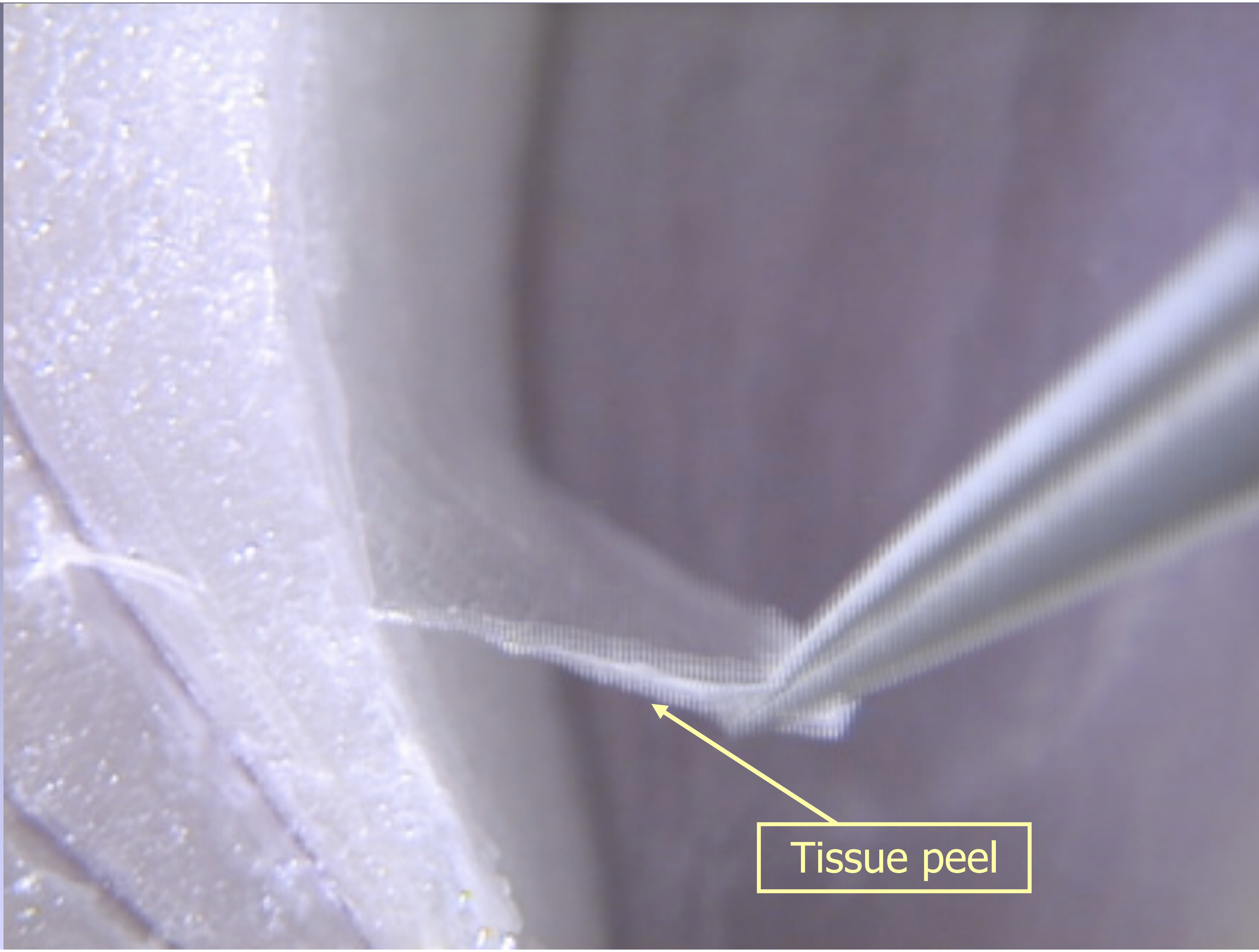
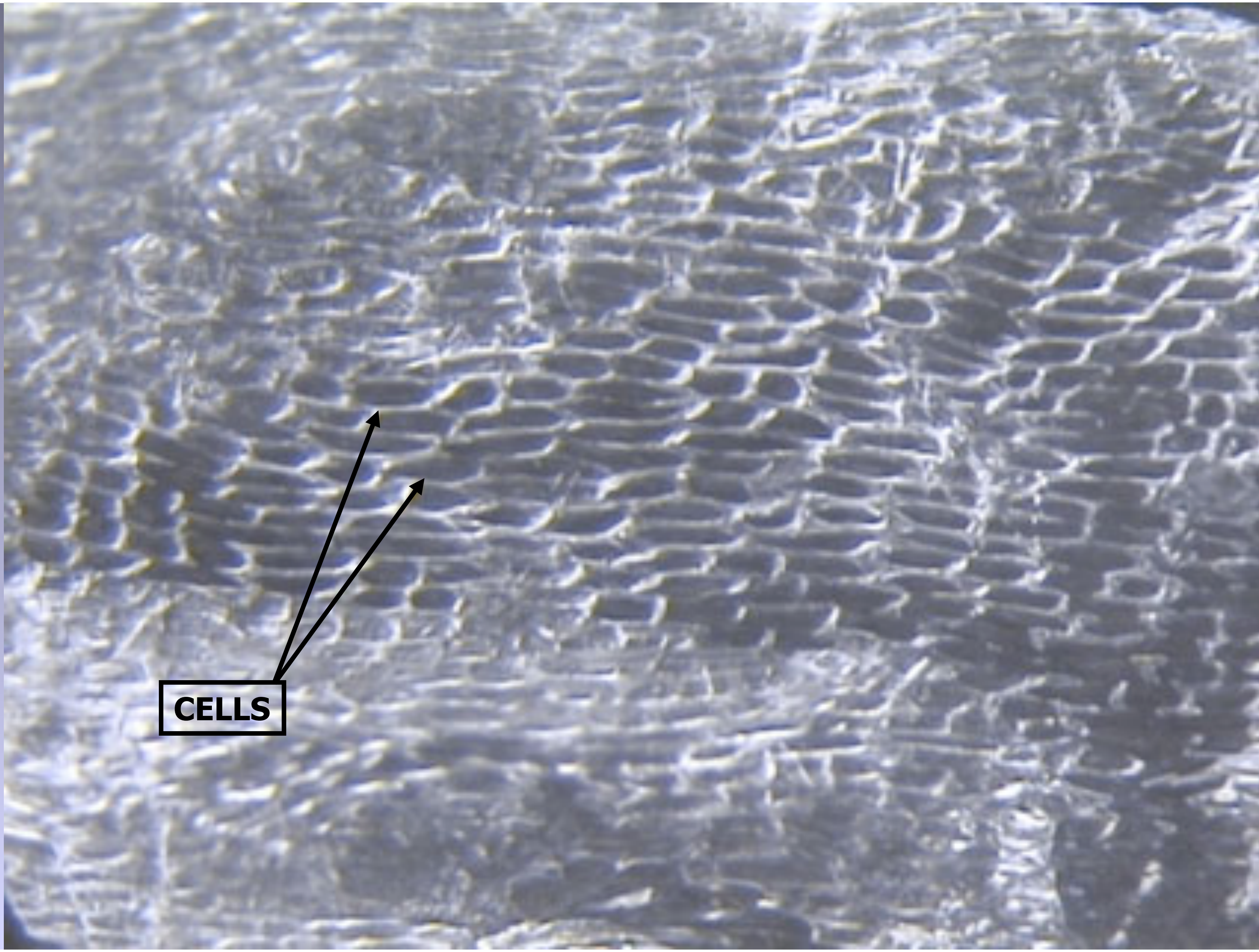
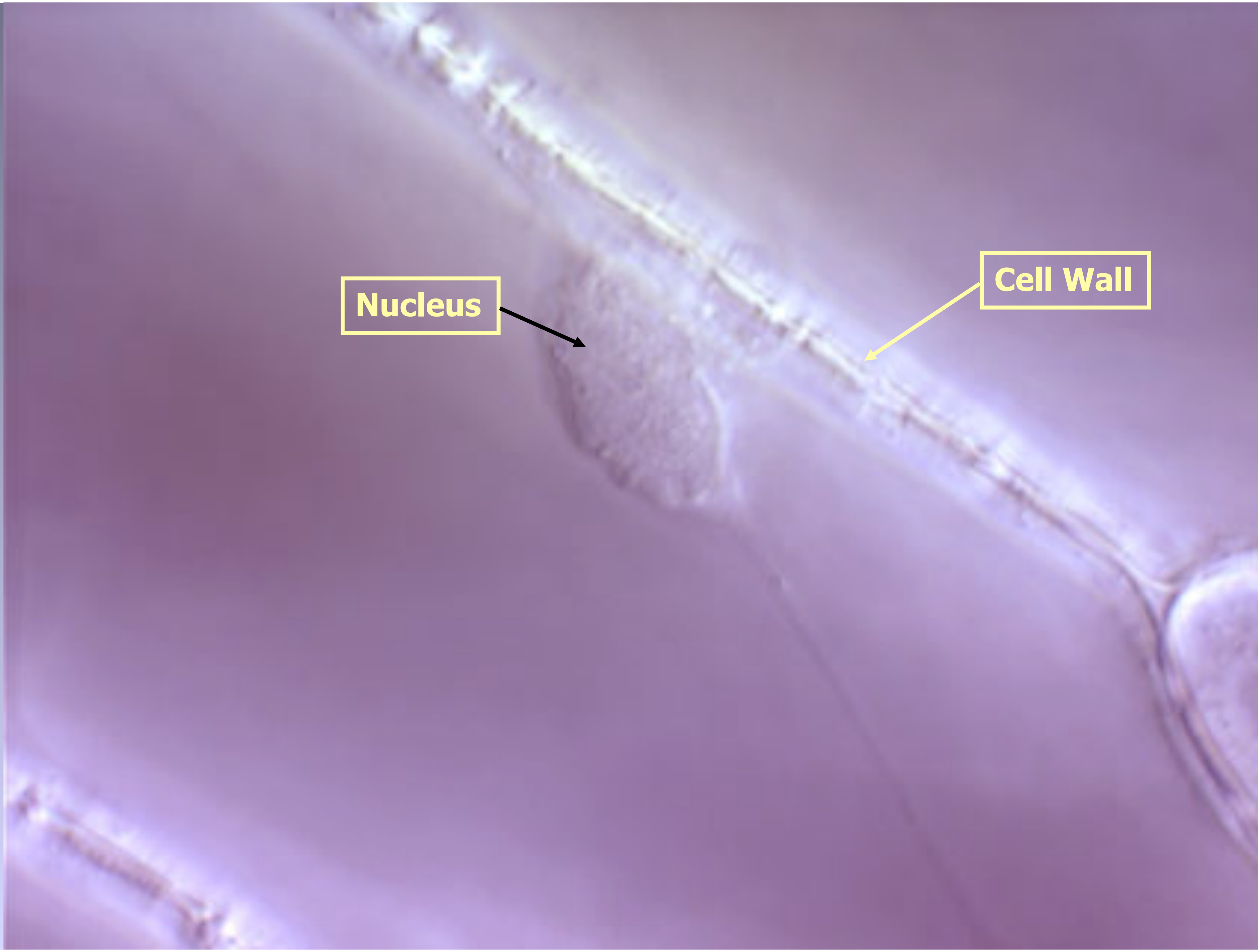
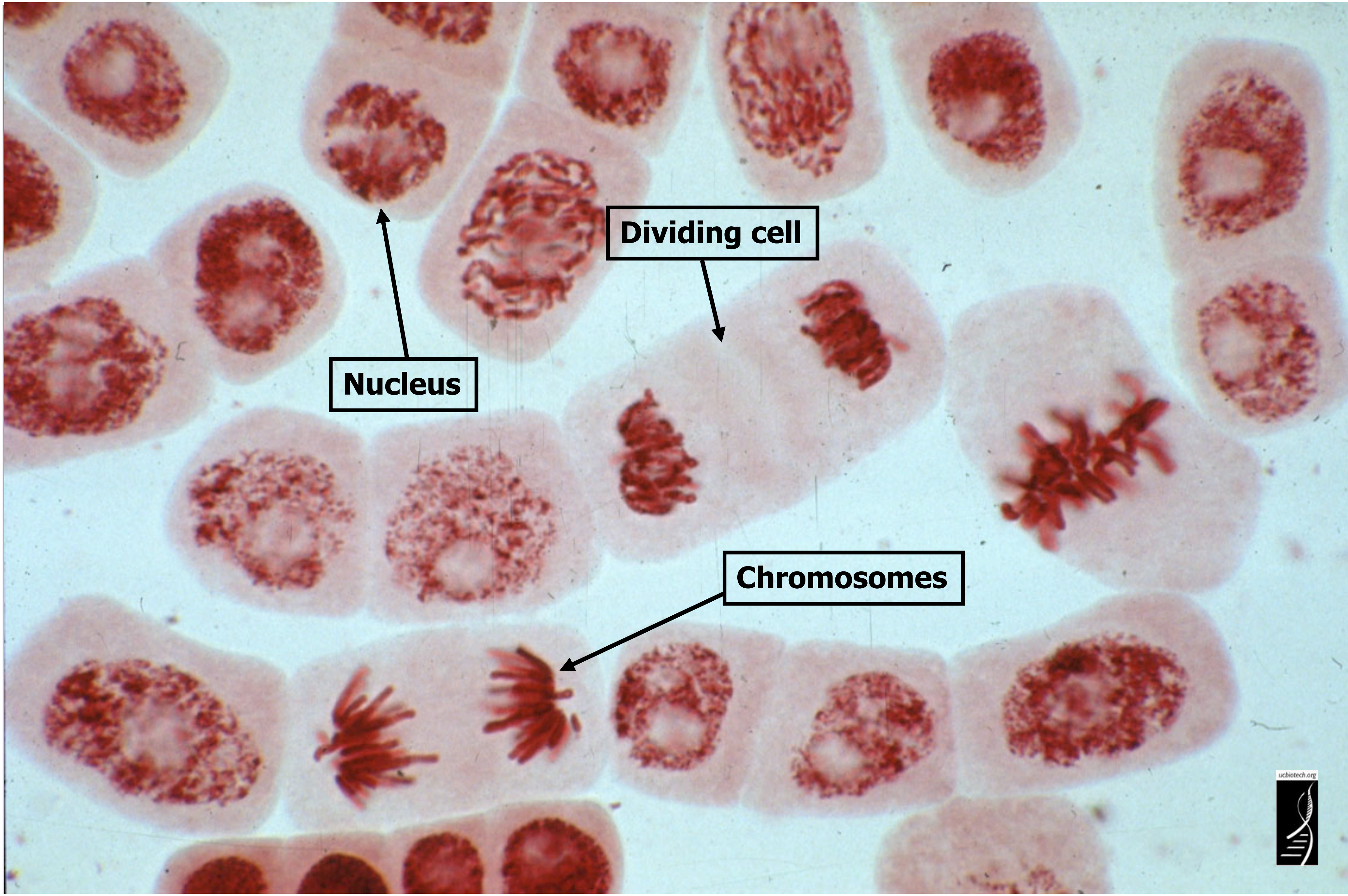
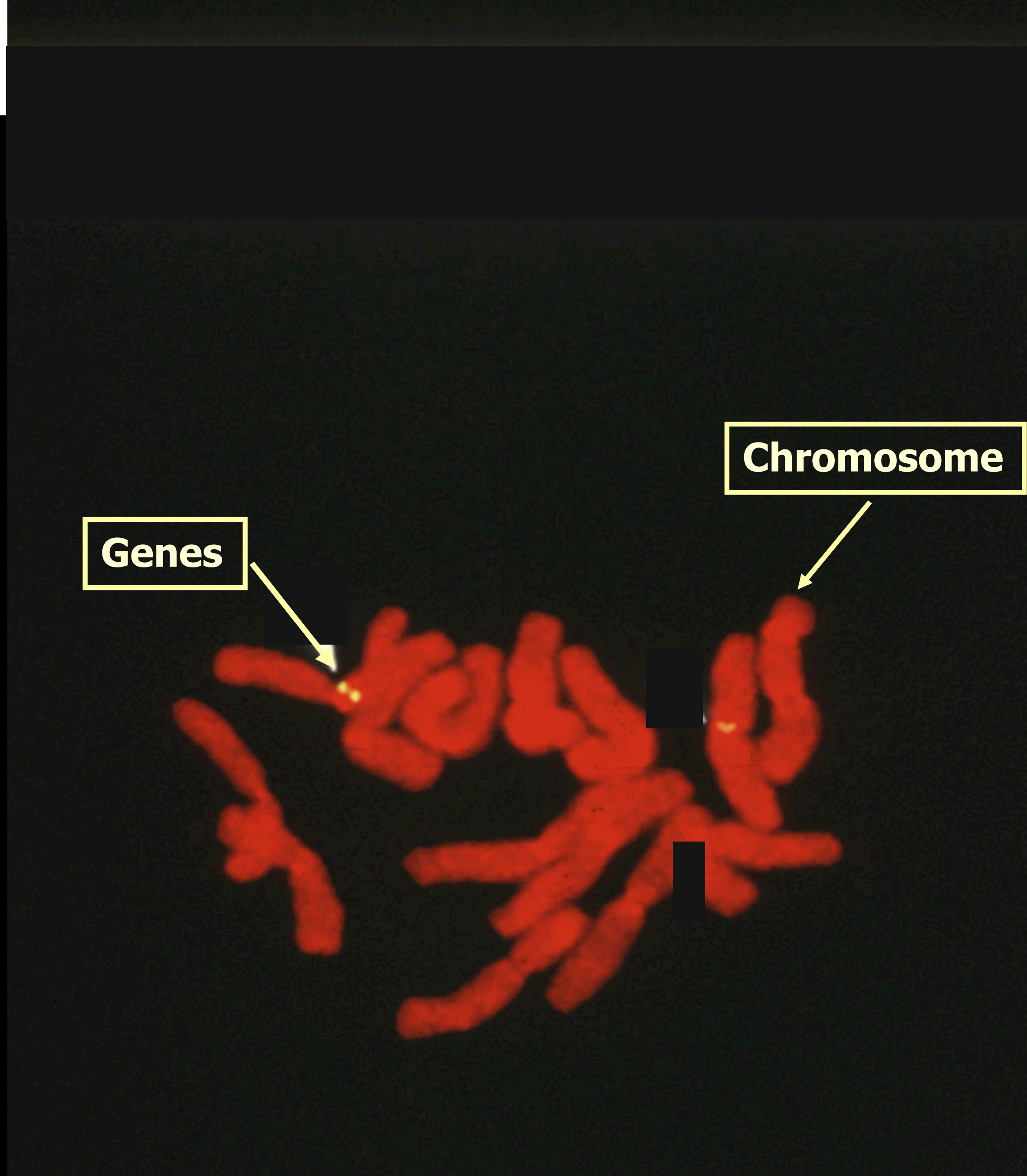

Tissue peel


CELLS


Nucleus
Cell Wall



Dividing cell
Nucleus
Chromosomes


Genes
Chromosome

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

Triticum monococcum

Ancient variety

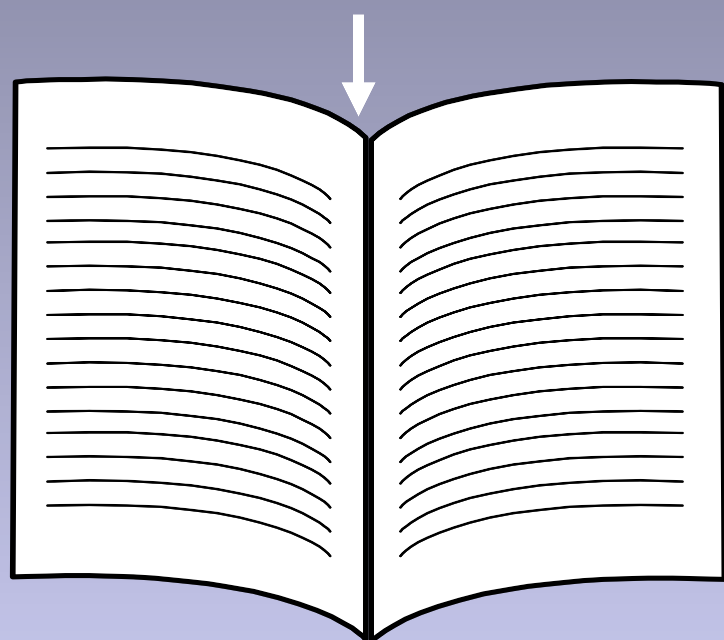
Triticum aestivum

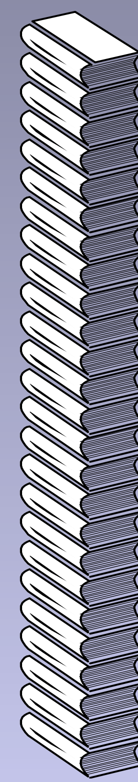
Modern bread variety

Information in the wheat genome

Chemical units represented by alphabetic letters

...CTGACCTAATGCCGTA...

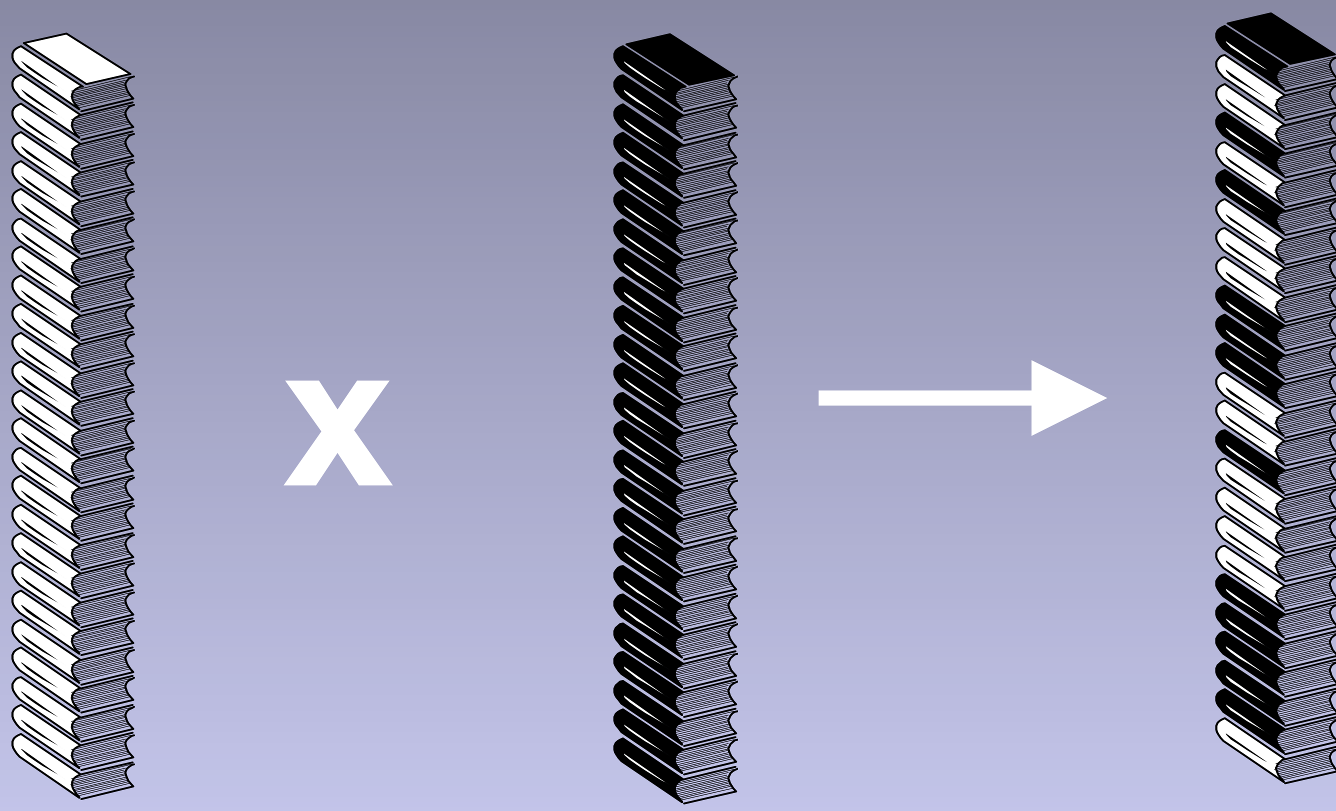




1700 books
1000 pages each

1700 books
(or 1.7 million pages)

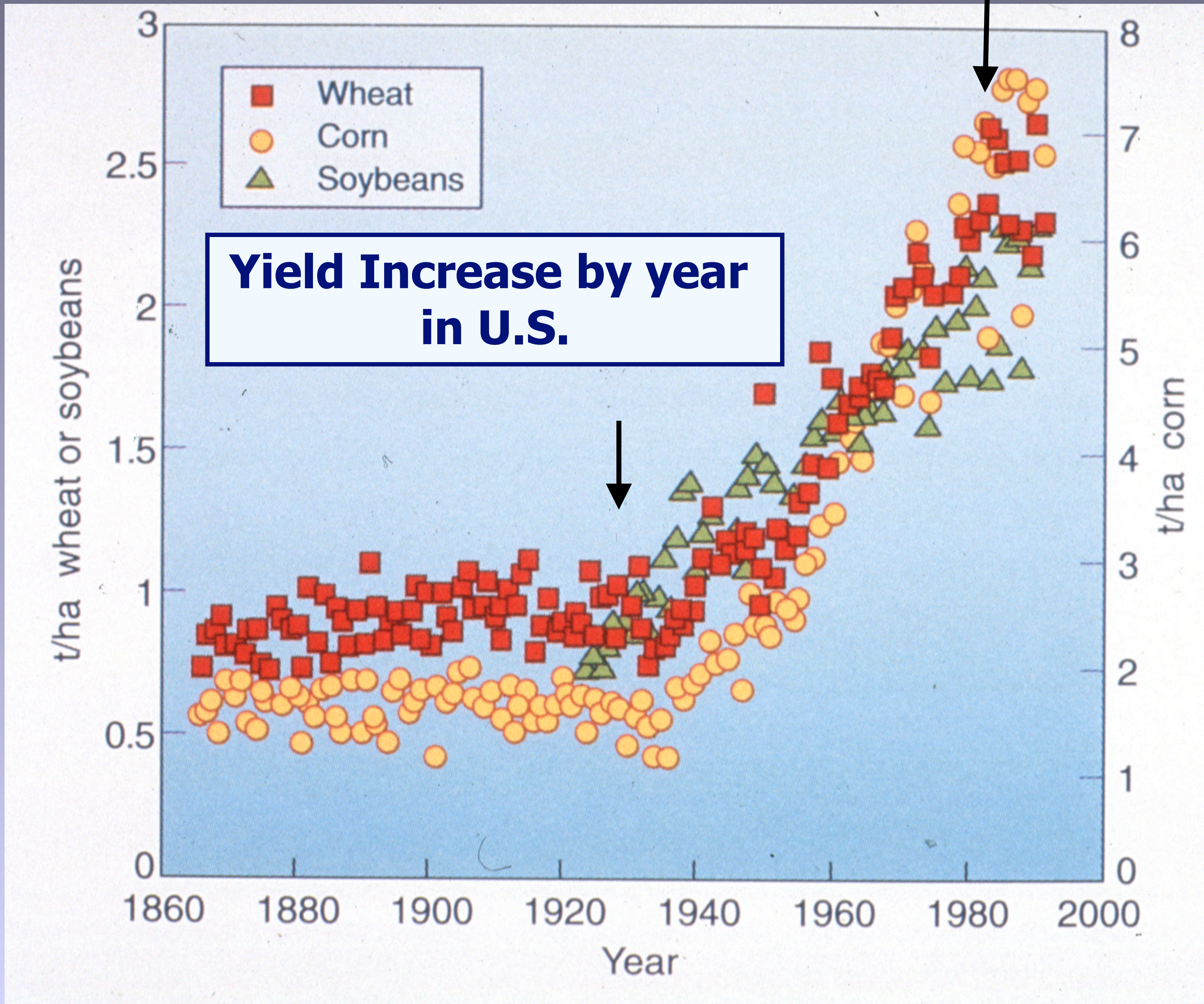
Hybridization or cross breeding of wheat



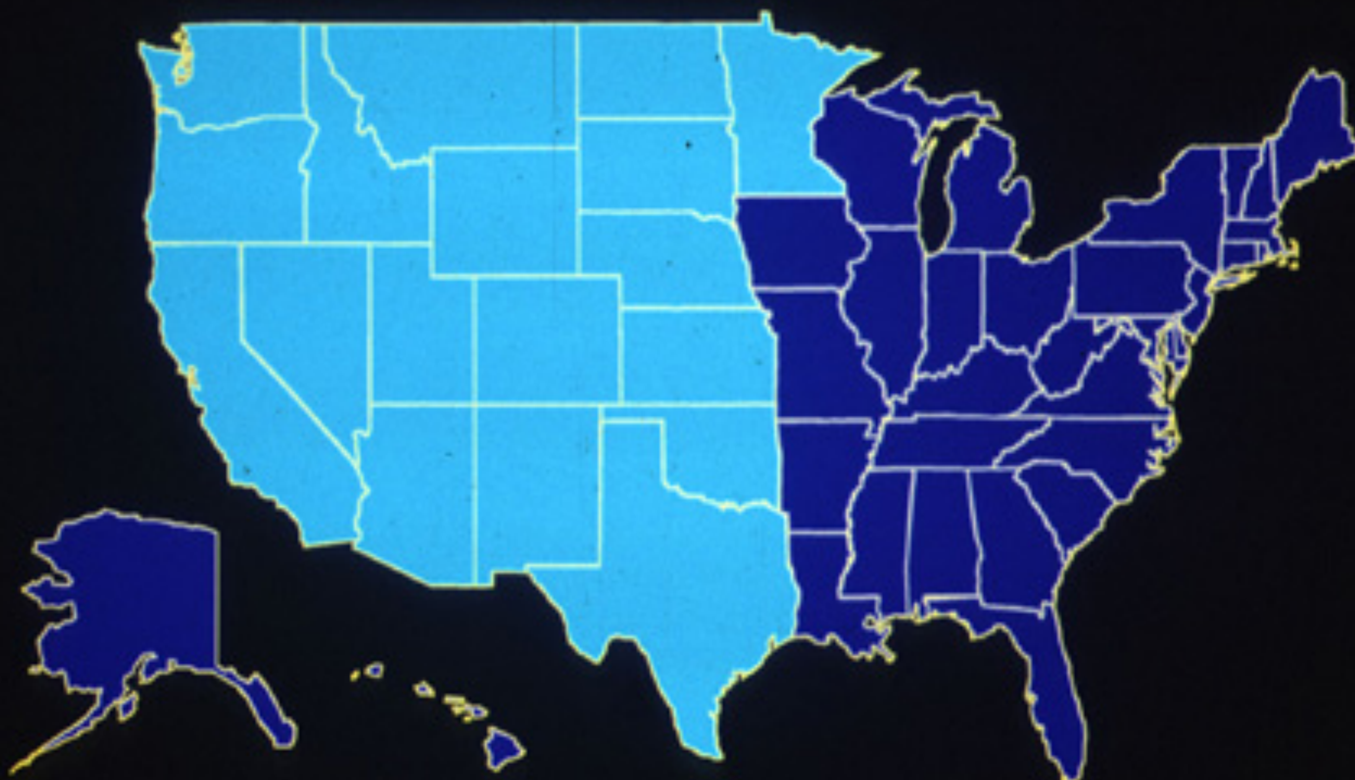
Random retention of information from each parent

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

Yield Increase by year in U.S.



U.S. Cultivated Land



Acreage Needed at 1929 Production Levels

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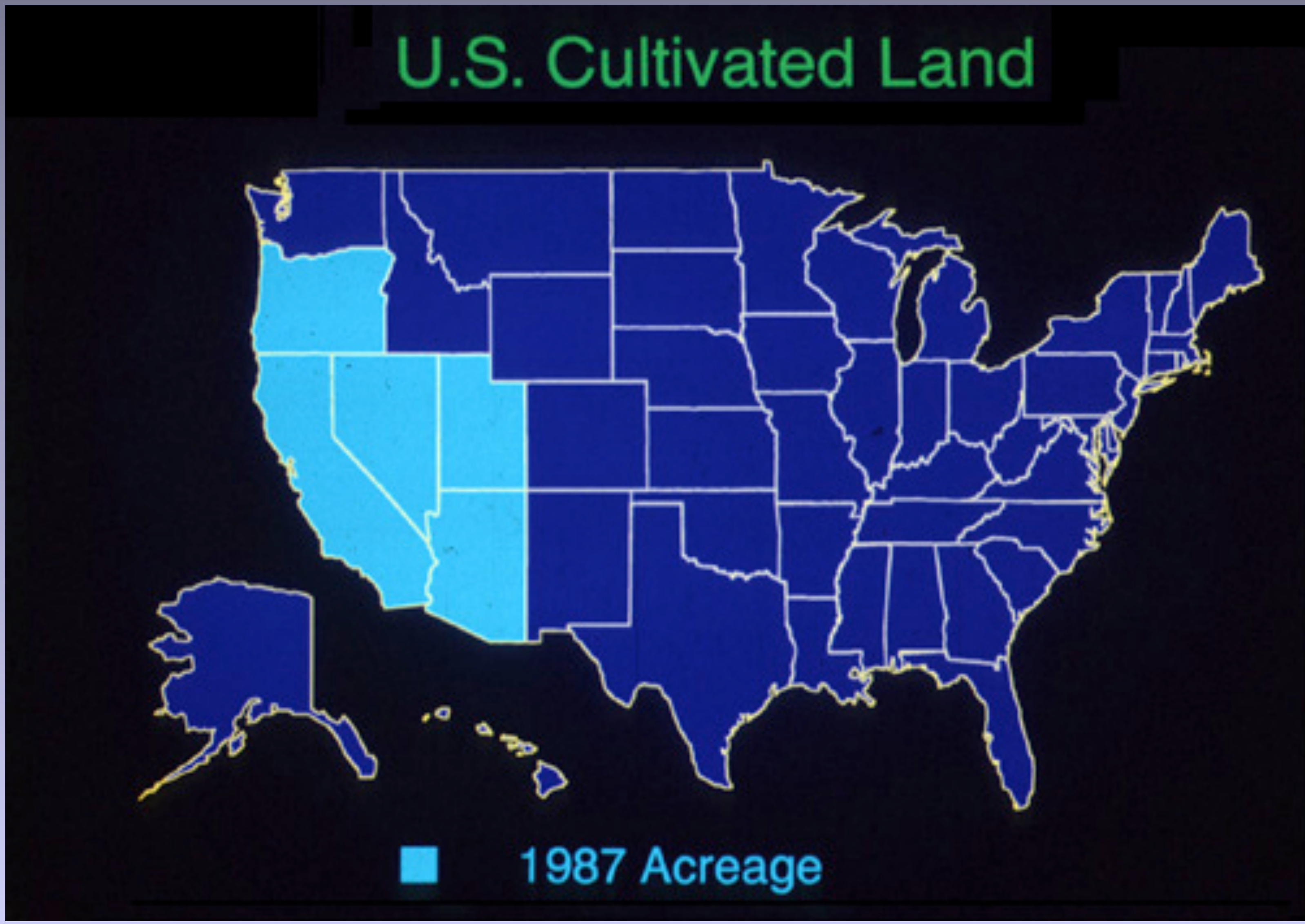
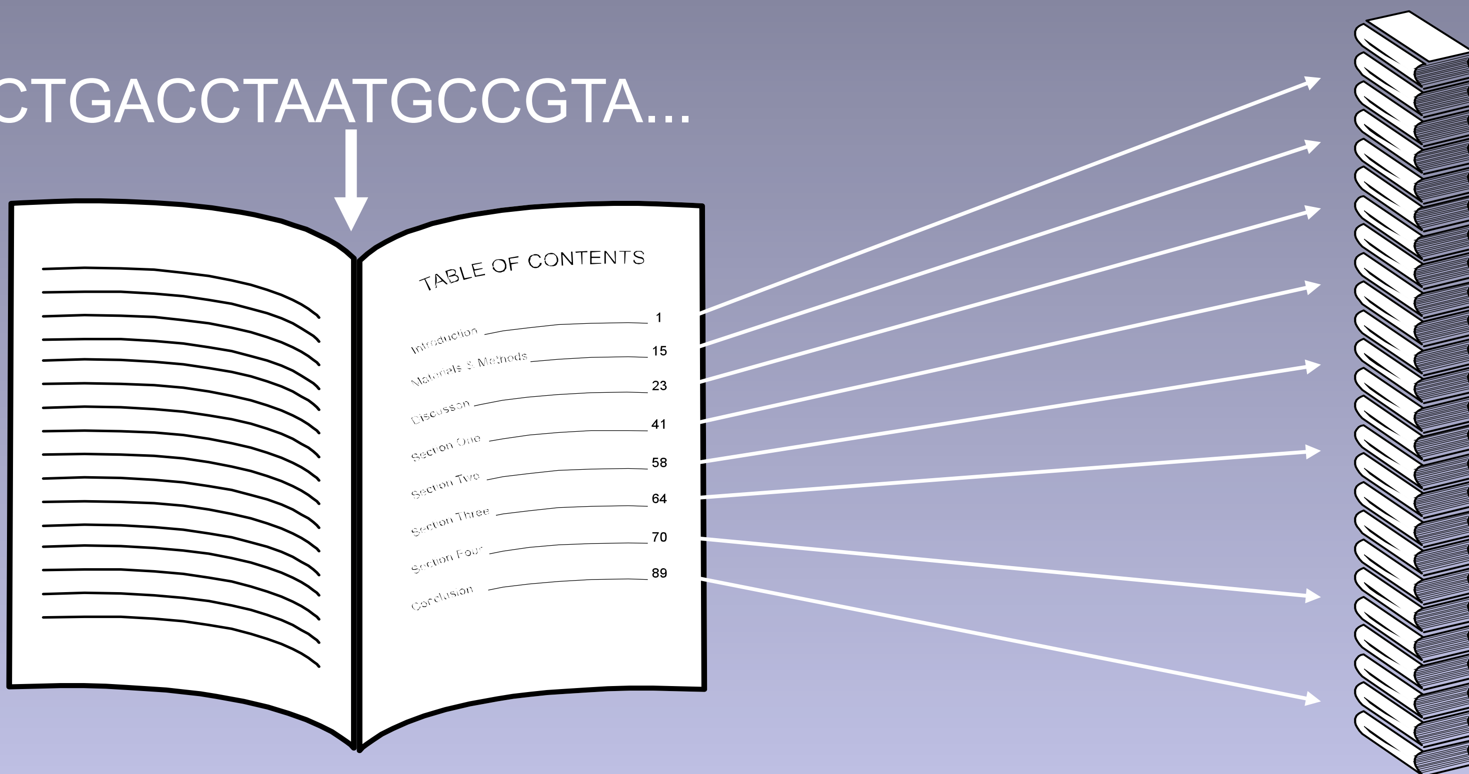

U.S. Cultivated Land
1987 Acreage

Table of contents for genes in wheat

...CTGACCTAATGCCGTA...



Used for Marker-Assisted Selection

Genomics

1700 books
(or 1.7 million pages)

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

Marker-assisted selection used to protect potatoes against wireworms, but…

Protection limited to diversity in crop and compatible relatives

SOURCE: "New Potatoes Withstand Destructive Wireworms", Agricultural Research Service, 9/20/11. http://www.ars.usda.gov/is/AR/archive/sep11/wireworms0911.htm

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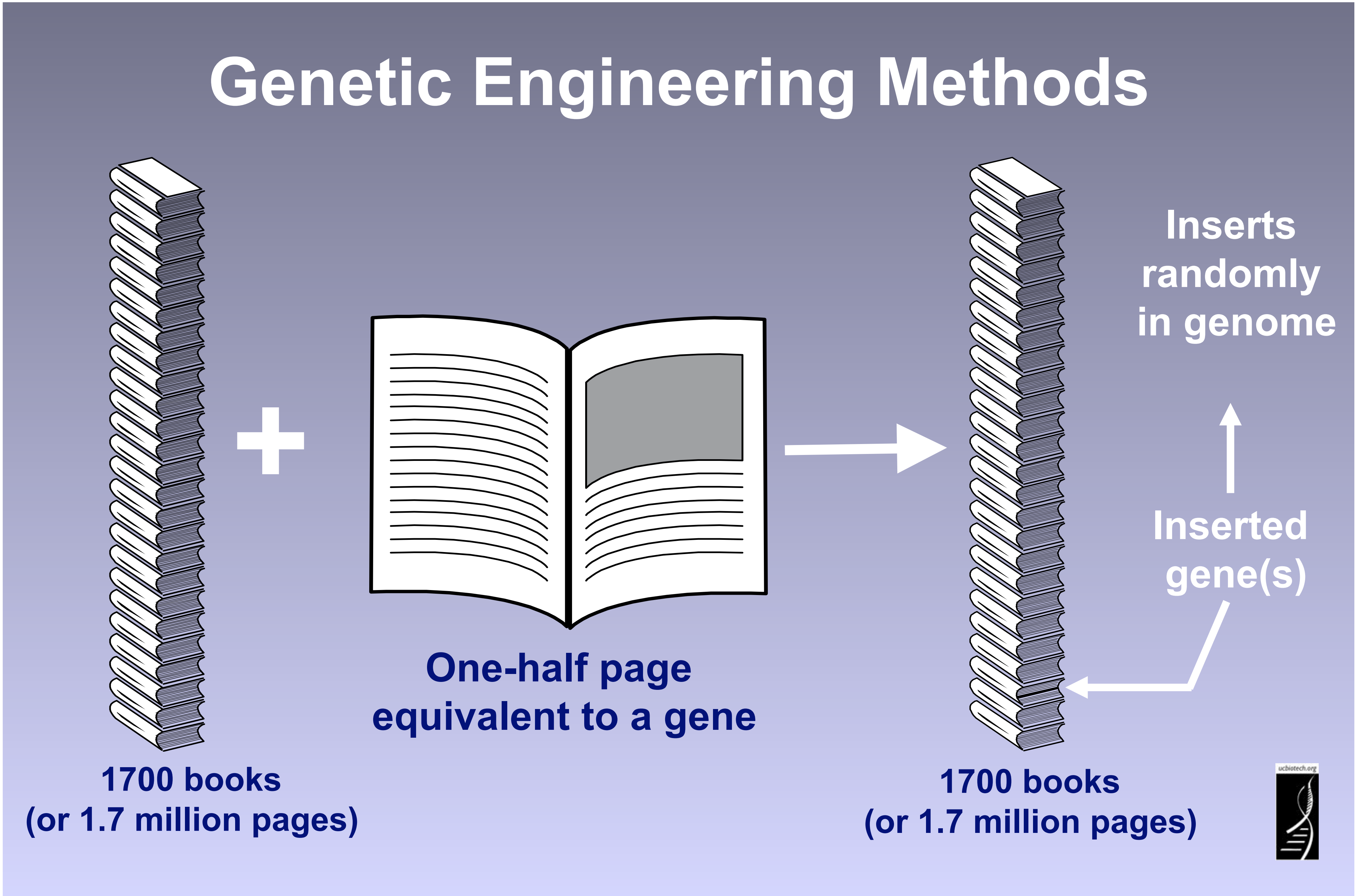
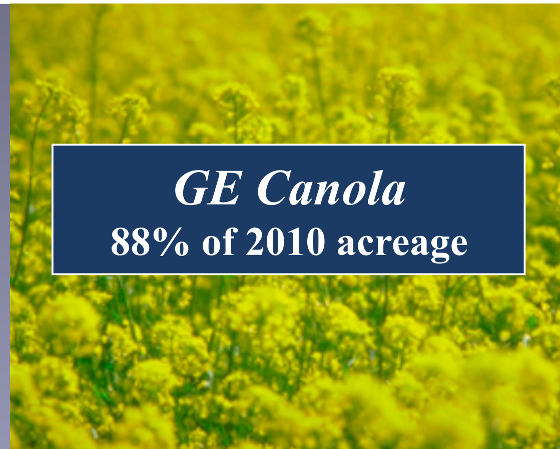
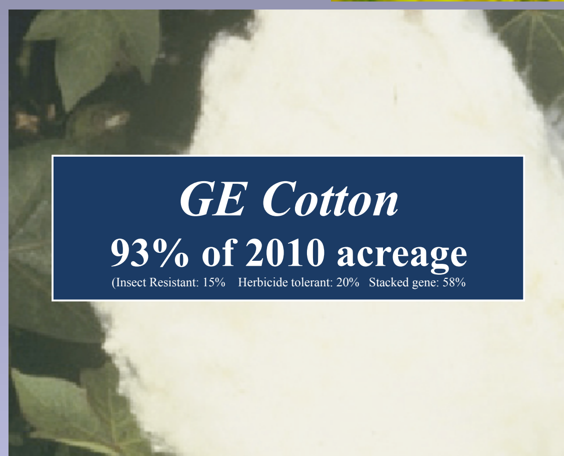
But there are other ways to create new varieties using the modern tools of genetics

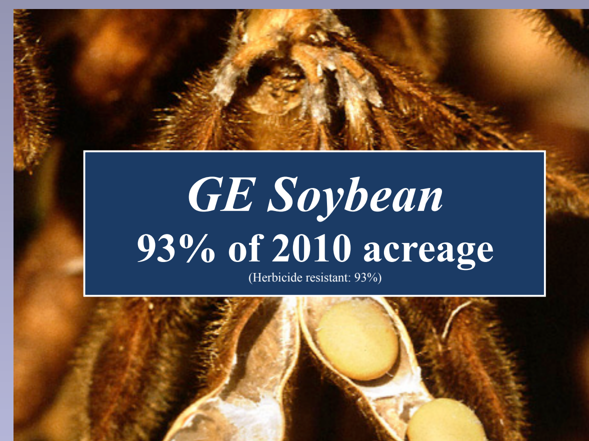

Genetic Engineering Methods
Inserts randomly in genome
Inserted gene(s)
One-half page equivalent to a gene
1700 books (or 1.7 million pages)
1700 books (or 1.7 million pages)

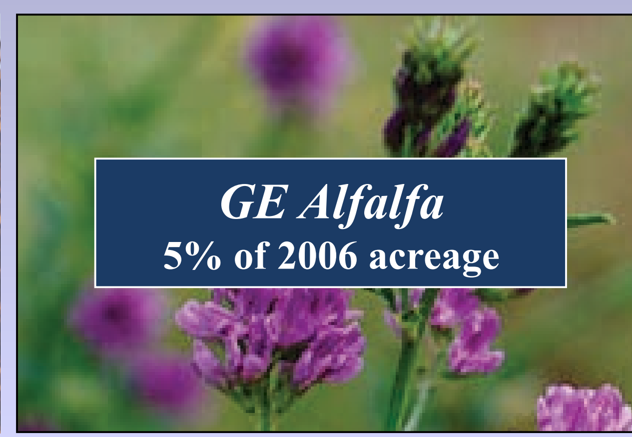
Classical Breeding	**compared to**	***Genetic Engineering***
Uses plant machinery in plant		Uses plant machinery in laboratory
Gene exchange is random involving whole genome		Gene exchange is specific involving single or few genes
When/where gene expressed not controlled by breeder		When/where gene expressed controlled precisely
Source of gene primarily within genera – not between kingdoms like plants & bacteria		Source of gene from any organism

Number of different commercially available GE crops is limited









SOURCE: NCFAP; USDA ERS

Types of GE Crops Leads To Estimates that 75% of Processed Foods in U.S. Have GE Ingredients

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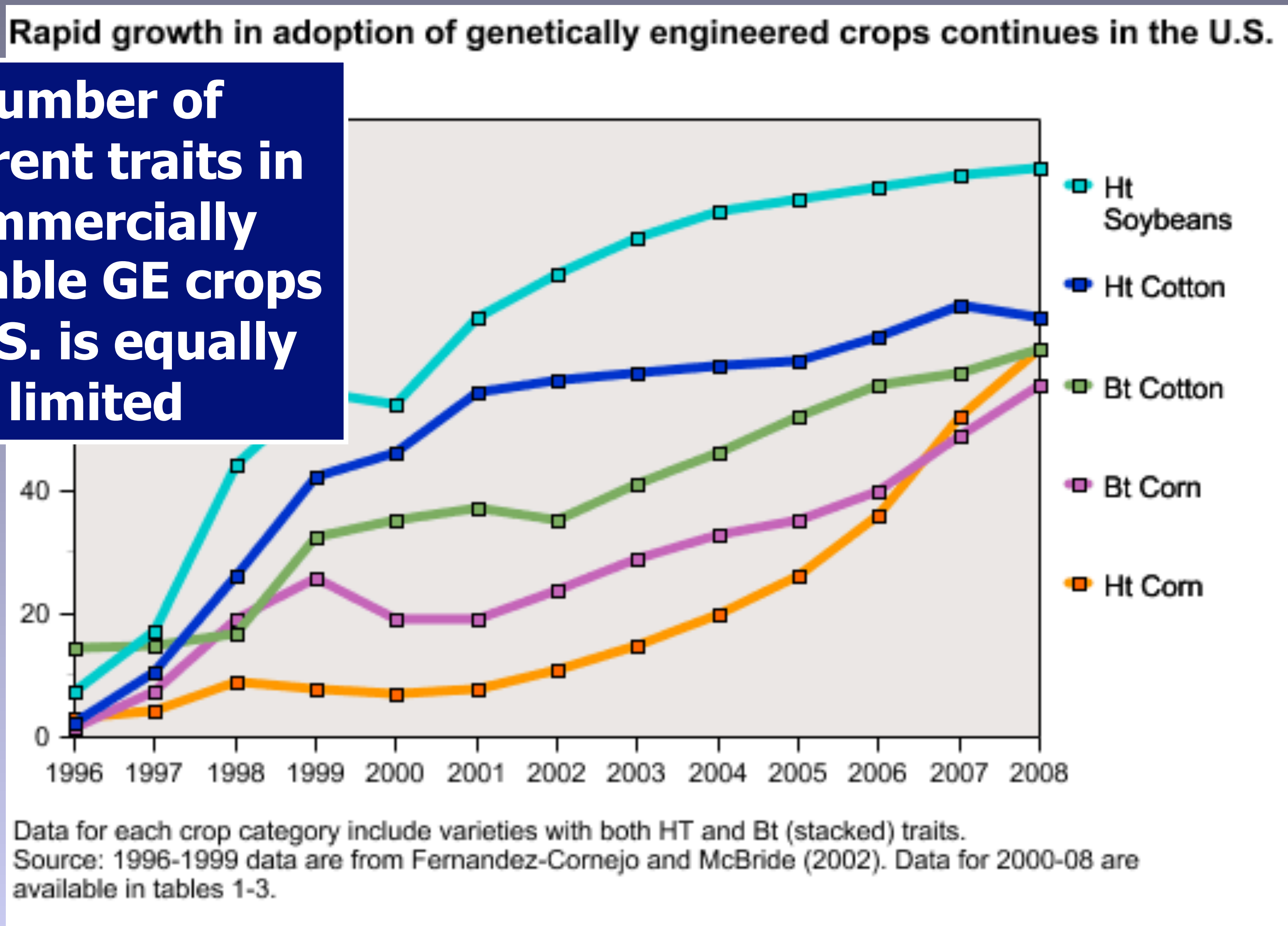
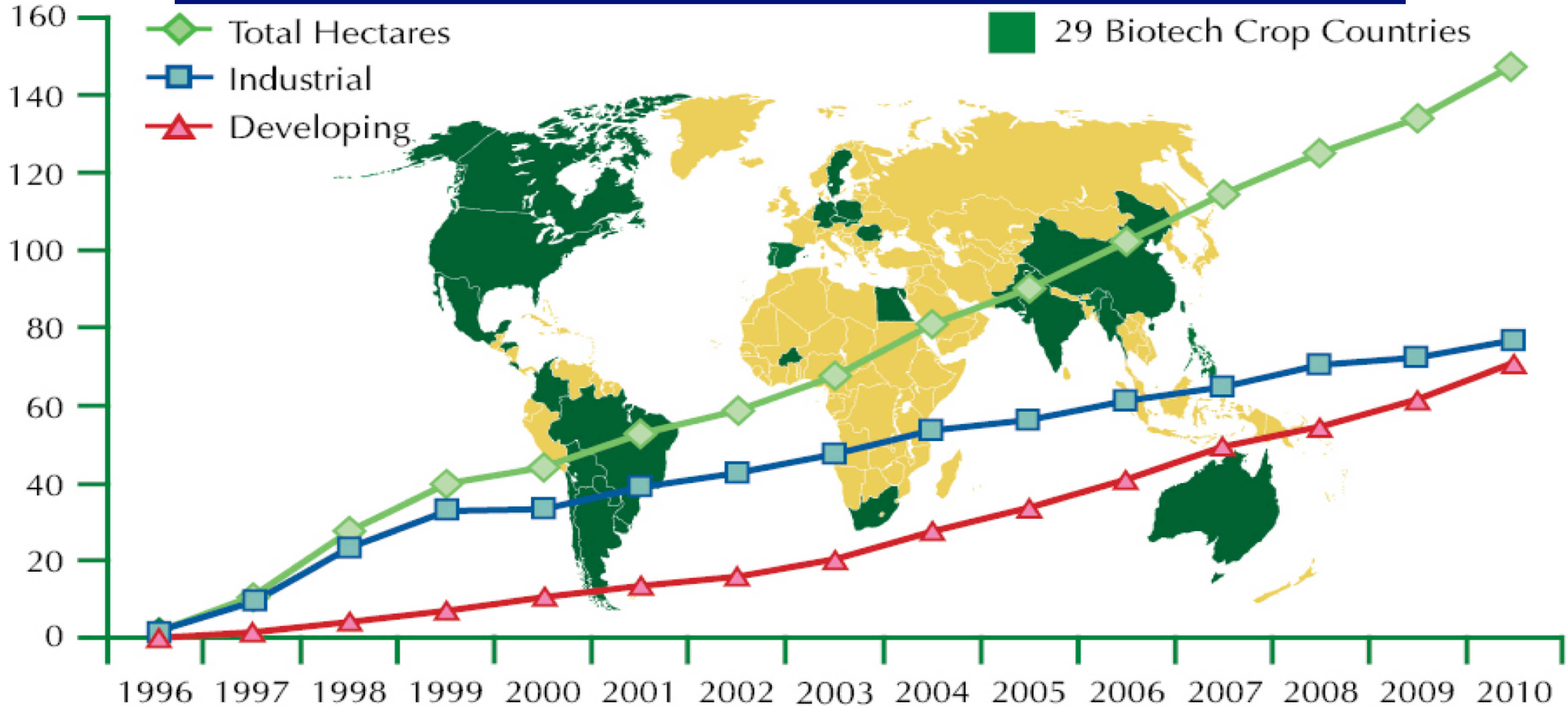
Number of different traits in commercially available GE crops in U.S. is equally limited



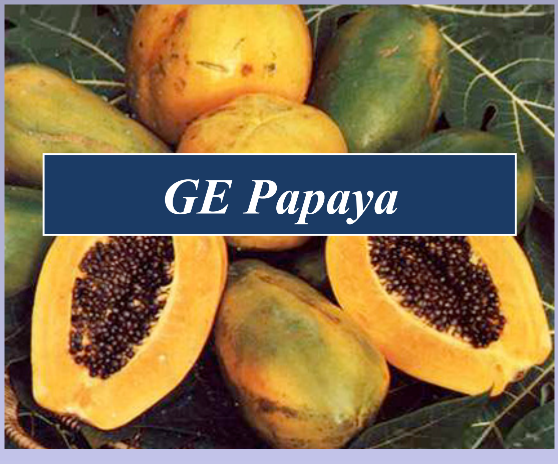
SOURCE: http://www.ers.usda.gov/Data/BiotechCrops/

Despite limited crop and trait types, worldwide acreage is increasing



Total worldwide area cultivated = Areas of Texas + California + Colorado + South Carolina

There are a few whole, genetically engineered foods in the U.S market



WHAT'S IN THE PIPELINE?

Field Trials Conducted 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


Australian researchers identify grape genes that provide resistance to powdery mildew
SOURCE: Western Farm Press, volume 26, number 16
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Arcadia Biosciences develops canola
that uses 50% less nitrogen fertilizer
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SOURCE: http://archives.foodsafety.ksu.edu/agnet/2007/4-2007/agnet_april_10.htm#story0

Yields in rice and maize increase under water-limiting conditions

SOURCE: Castiglioni, P. et al. 2008. Bacterial RNA Chaperones Confer Abiotic Stress Tolerance in Plants and Improved Grain Yield in Maize under Water-Limited Conditions. Plant Physiology 147: 446-455.

Salt-tolerant Tomatoes

Engineered ***Control***

SOURCE: Zeraim Gedera L.T.D., Israel

"In a globalized economy, the control of fruit ripening is of strategic importance because excessive softening limits shelf life."

Engineered tomatoes have ~30 day extension of shelf life

SOURCE: Meli, V.S., Ghosh, S., Prabha, T.N., Chakraborty, N., Chakraborty, S., and Datta, A. 2010. Enhancement of fruit shelf life by suppressing N-glycan processing enzymes. Proceedings of the National Academy of Sciences USA, doi/10.1073/pnas.0909329107.

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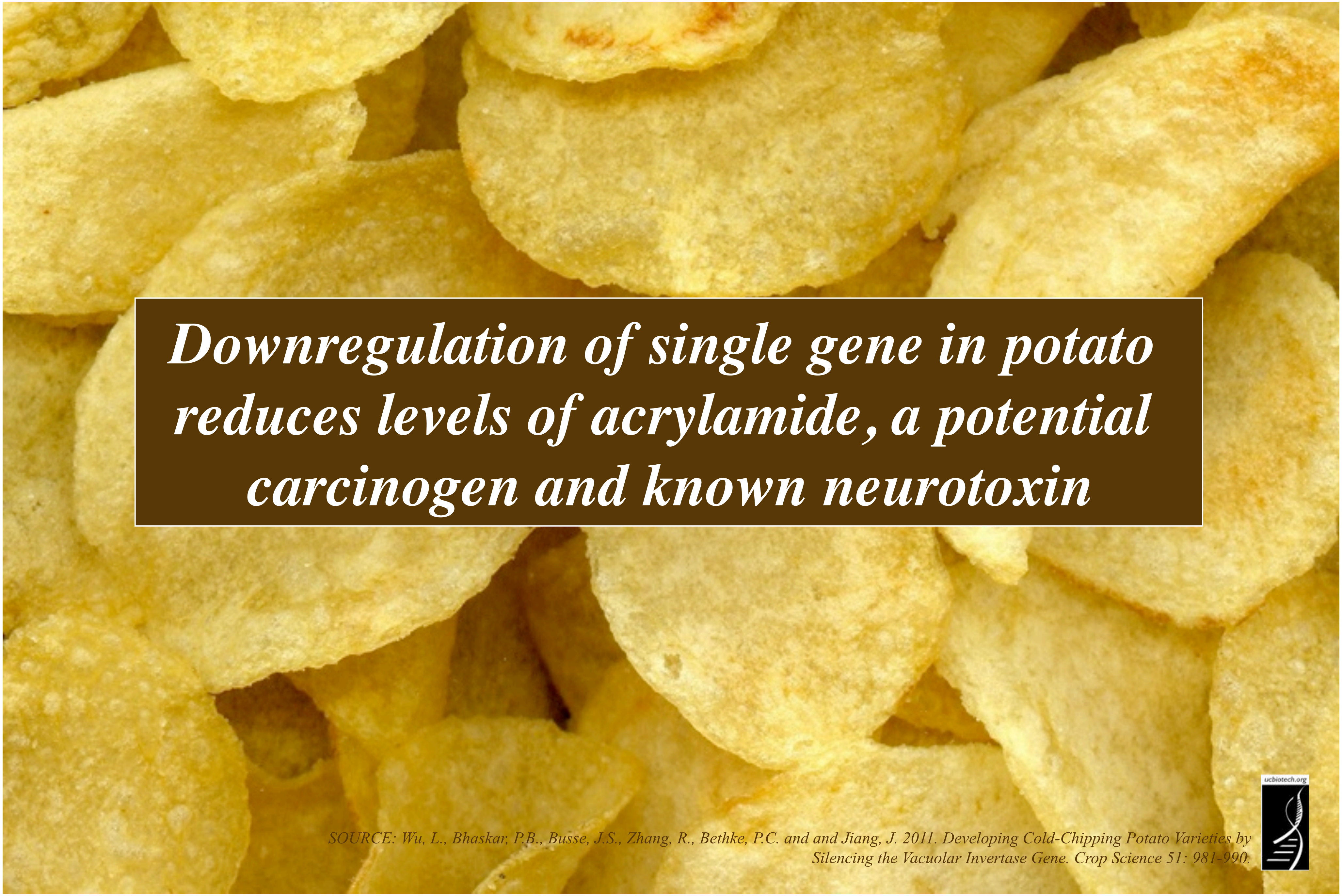
Downregulation of single gene in potato reduces levels of acrylamide, a potential carcinogen and known neurotoxin
SOURCE: Wu, L., Bhaskar, P.B., Busse, J.S., Zhang, R., Bethke, P.C. and and Jiang, J. 2011. Developing Cold-Chipping Potato Varieties by Silencing the Vacuolar Invertase Gene. Crop Science 51: 981-990.
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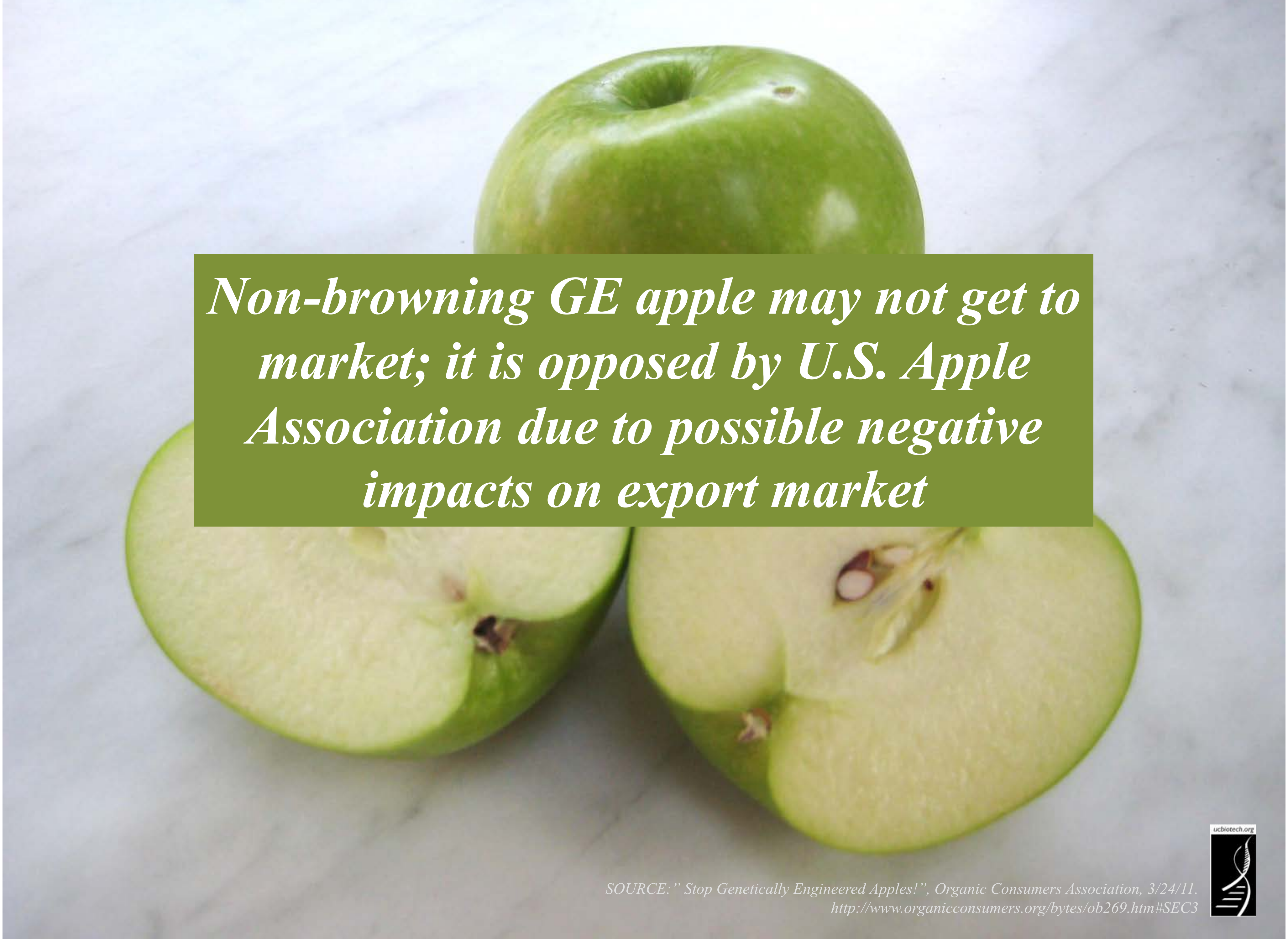

Non-browning GE apple may not get to market; it is opposed by U.S. Apple Association due to possible negative impacts on export market
SOURCE:" Stop Genetically Engineered Apples!", Organic Consumers Association, 3/24/11.
http://www.organicconsumers.org/bytes/ob269.htm#SEC3
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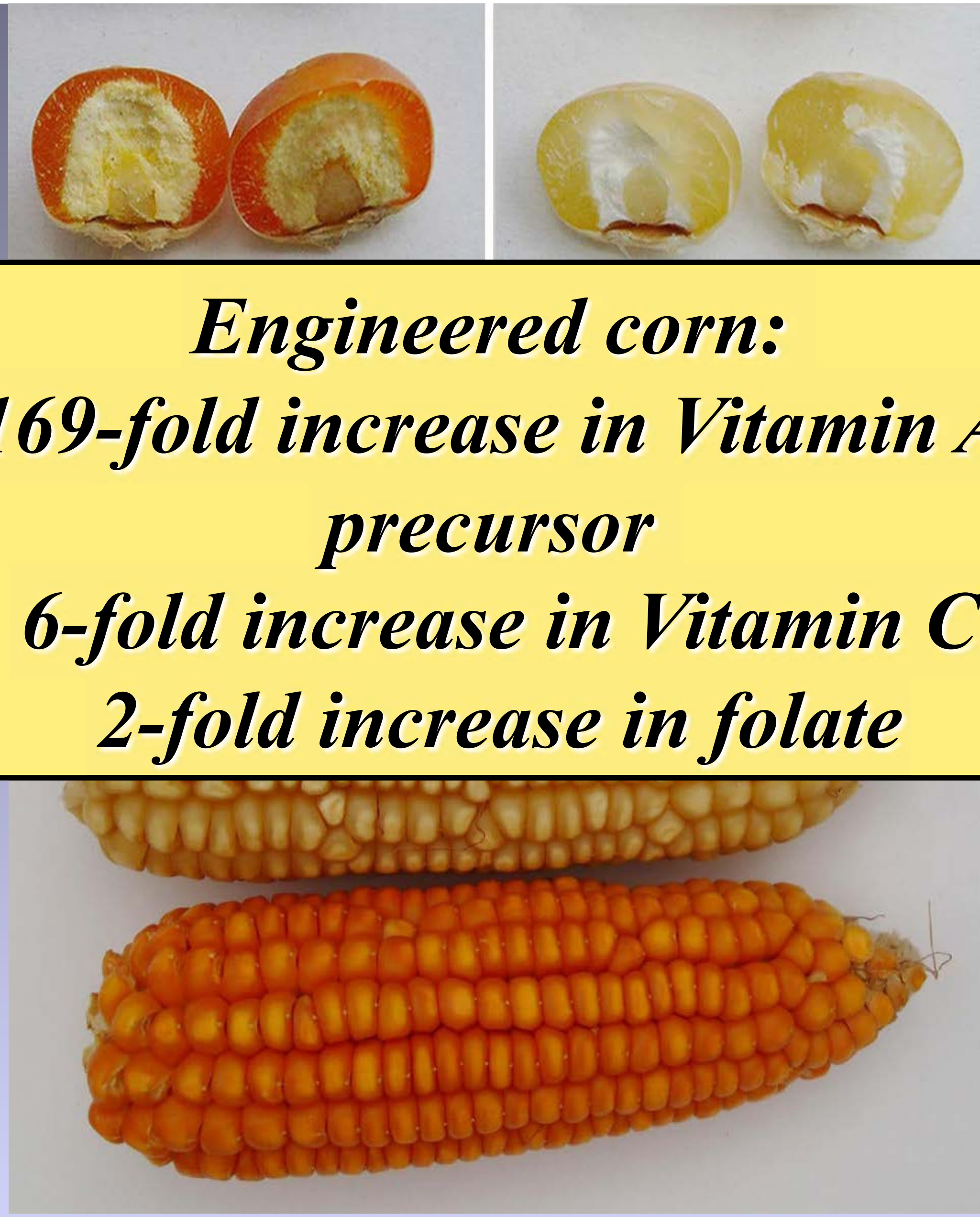
Tear-free onion developed by turning off tear-inducing enzyme

SOURCE: "Scientists create 'no tears' onions", Herald and Weekly Times, 2/1/08
http://www.checkbiotech.org/green_News_Genetics.aspx?Name=genetics&infoId=16834



Engineered corn:

169-fold increase in Vitamin A precursor

6-fold increase in Vitamin C

2-fold increase in folate

SOURCE: Naqvi et al. 2009. Transgenic multivitamin corn through biofortification of endosperm with three vitamins representing three distinct metabolic pathways. Proceedings of the National Academy of Sciences USA, doi: 10.1073/pnas.0901412106.

Engineered Pea Seeds Protect Chickens against Parasitic Coccidiosis

SOURCE: "Engineered pea seeds protect against parasites", BioMed Central, 9/10/09, http://www.eurekalert.org/pub_releases/2009-09/bc-eps090909.php
Zimmermann, J., Saalbach, I., Jahn, D., Giersberg, M., Haehnel, S., Wedel, J., Macek, J., Zoufal, K., Glunder, G., Falkenburg, D. and Kiprijanov, S.M. 2009. Antibody expressing pea seeds as fodder for prevention of gastrointestinal parasitic infections in chickens. BMC Biotechnology, in press.

Japanese scientists create blue rose with blue pigments from pansies

SOURCE: http://www.japantimes.co.jp/cgi-bin/getarticle.pl5?nn20040701a2.htm

Delayed senescence Moonshadow™ carnation

http://www.florigene.com/products/products.php?product_name=moonshadow

Slow-Mow grass addresses watering, maintenance and weed problems

SOURCE: "Engineering a mow-less lawn", New York Times, 4/22/06
http://www.nytimes.com/2006/04/22/business/22offline.html?_r=1&oref=slogin

What is the U.S. regulatory process that governs these engineered plants?

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U.S. Regulatory Agencies

USDA

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

Plant pest?

FDA

- Food safety
- Feed safety

Danger to people?

EPA

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

Risk to environment?

APHIS Determines Nonregulated Status – 75 granted

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

- Alfalfa – HT –removed/ reinstated
- ✓ Cotton - HT, IR
- ✓ Corn - HT, IR, AP
- ✓ Soybean - HT, PQ
- ❖ Potato - IR, VR
- ❖ Tomato - PQ
- Squash - VR
- ✓ Canola – HT
- Papaya - VR
- ❖ Rice - HT
- Rapeseed - HT, AP, PQ
- Sugar beet - HT
- ❖ Flax - HT
- Chicorium - AP
- Tobacco - PQ

✓Large-scale production
❖Not on market

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

Where to get more information on the issues?