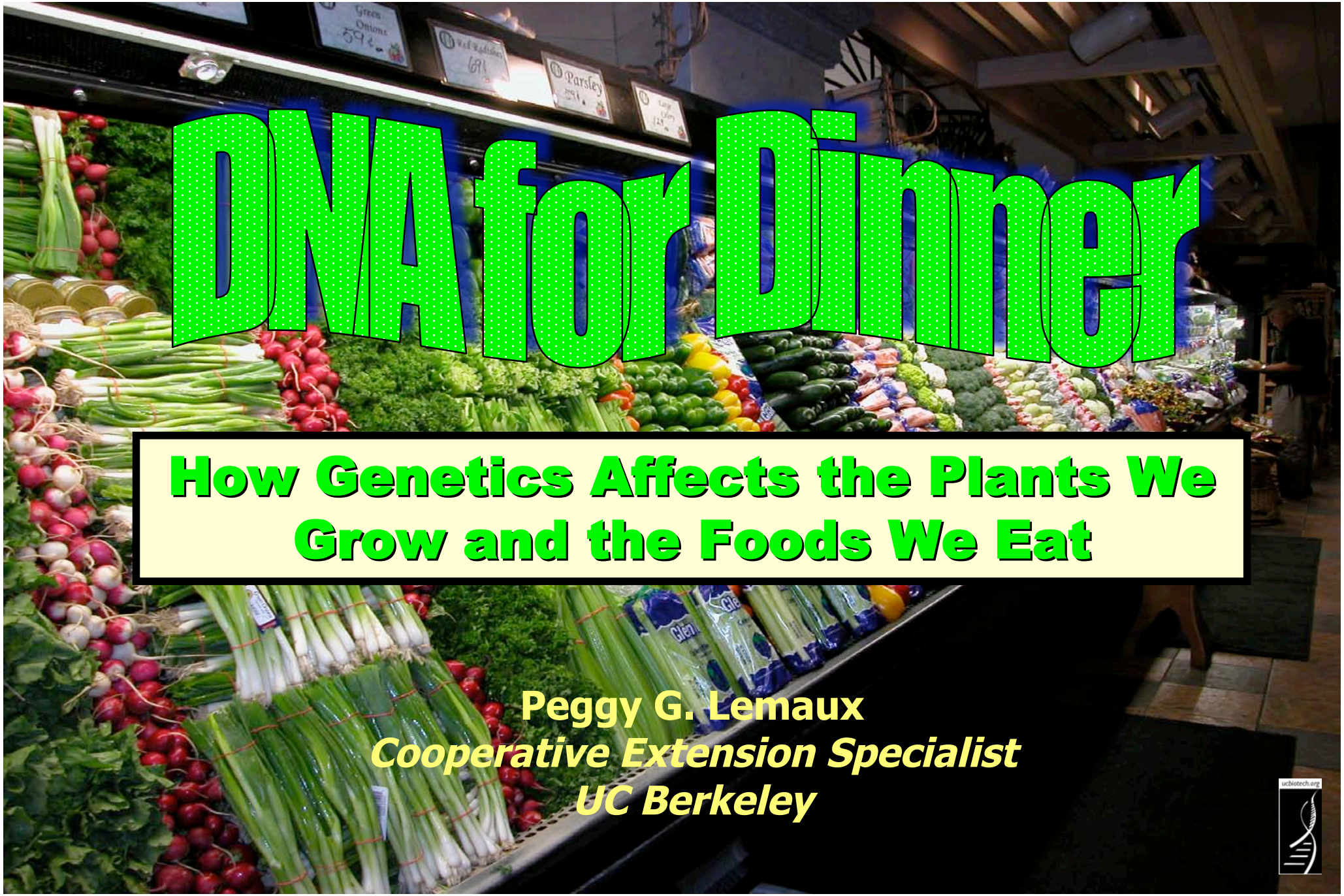
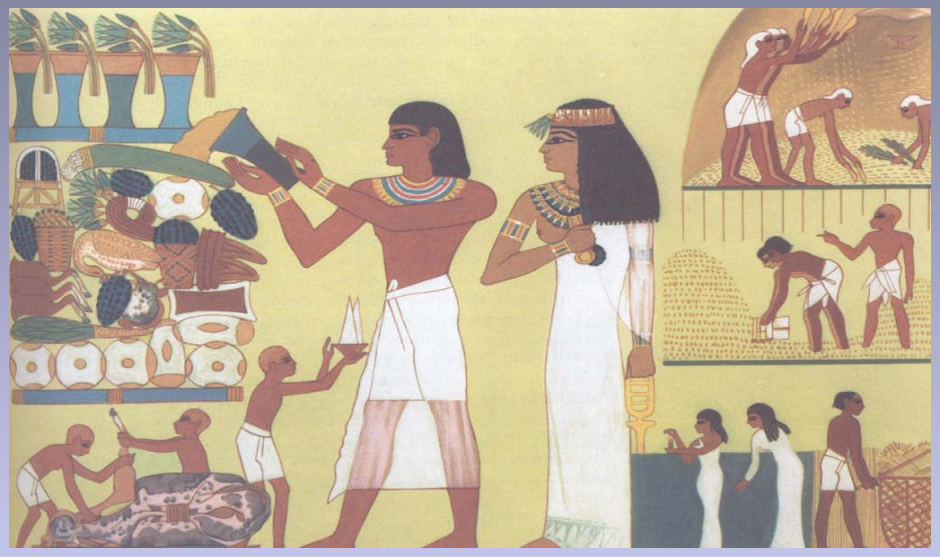

DNA for Dinner
How Genetics Affects the Plants We Grow and the Foods We Eat
Peggy G. Lemaux
Cooperative Extension Specialist
UC Berkeley
ucbiotech.org

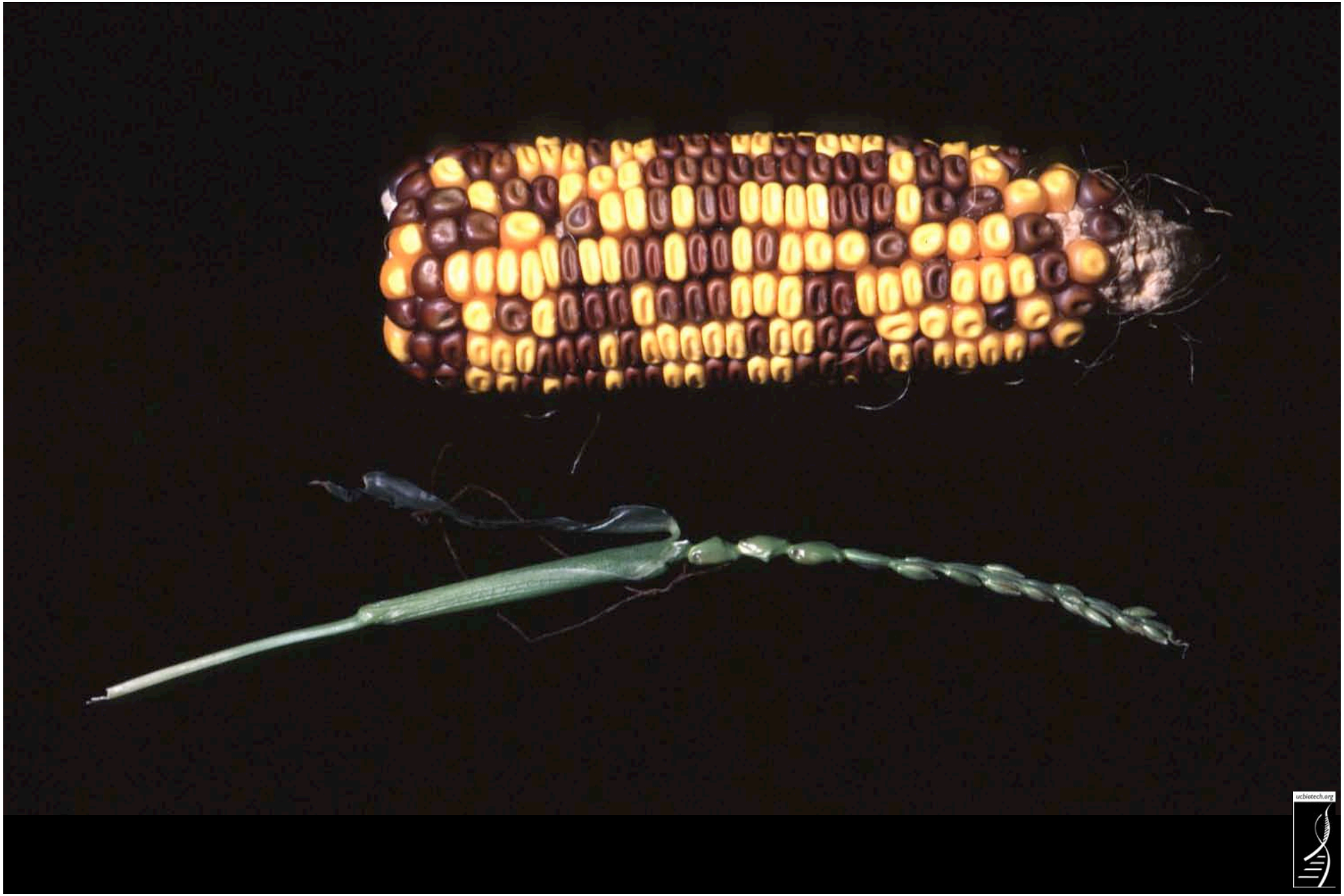
Agriculture was the Driving Force in Development of Civilization



Egyptian tomb mural ~ 4200 BP

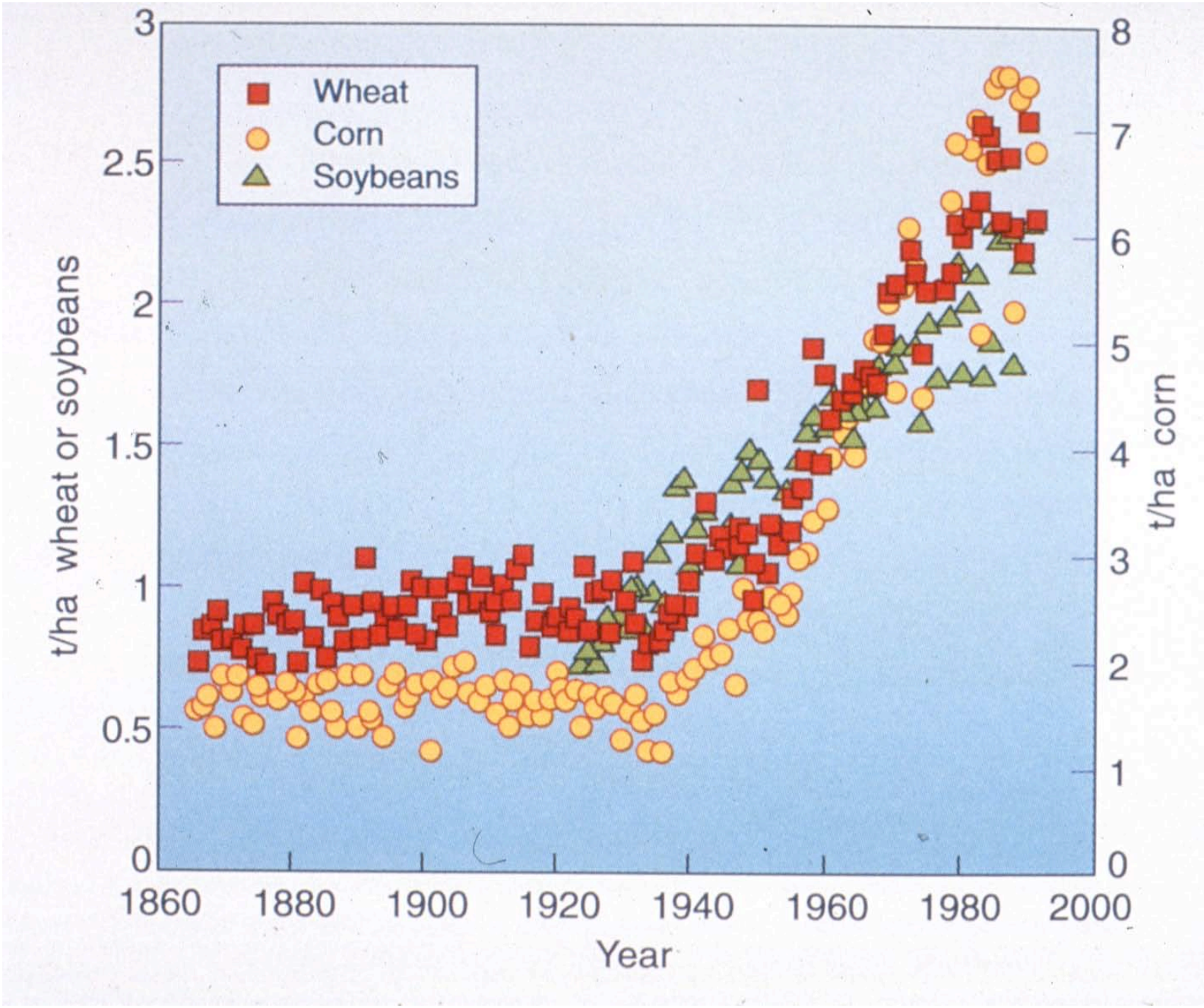
Indians cultivating maize

Changing Man From a Forager to a More Sedentary Life Style

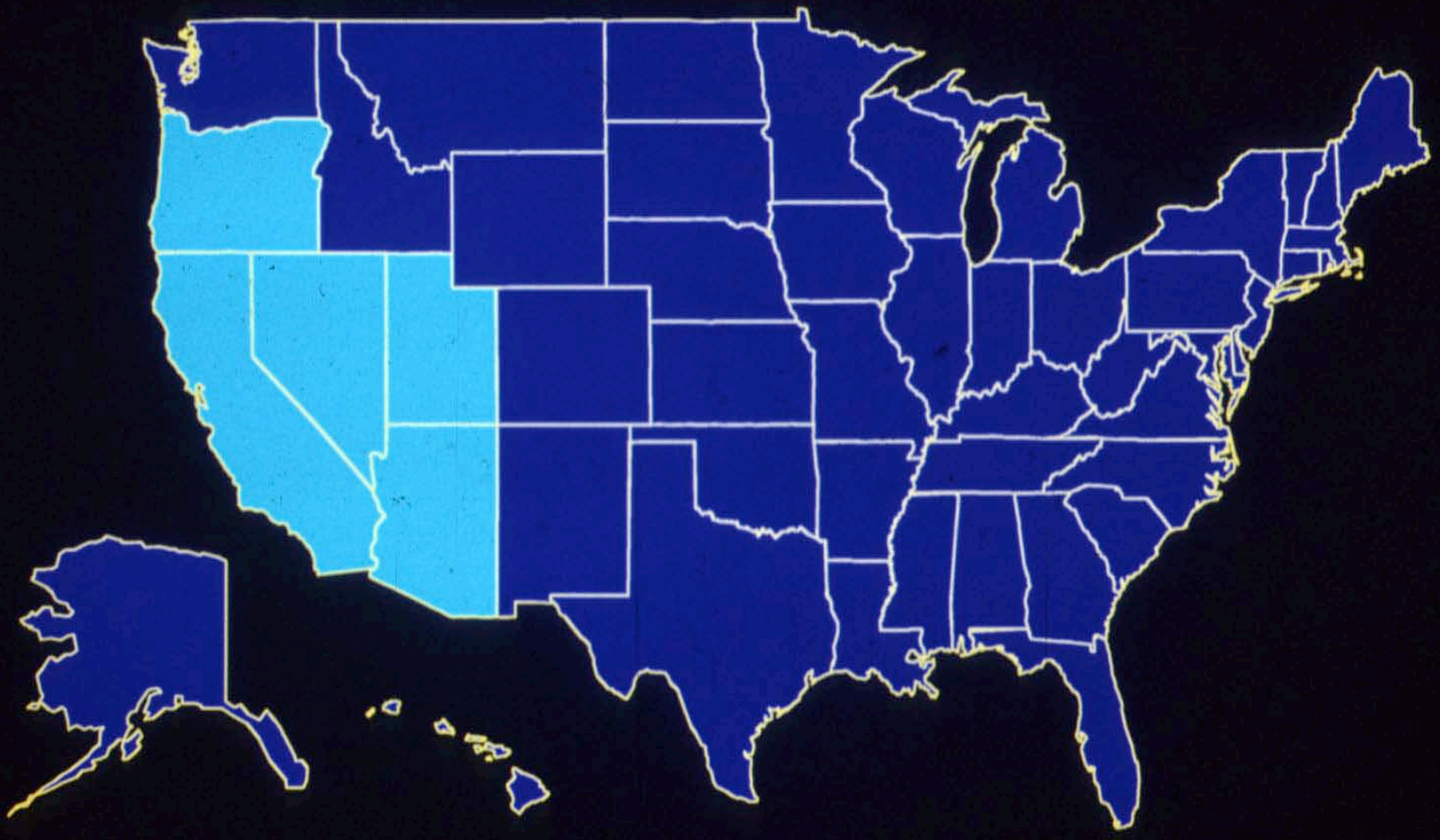

ucbiotech.org

From small farms to…


…large farms with higher yields!


Wheat
Corn
Soybeans
t/ha wheat or soybeans
t/ha corn
Year
0
0.5
1
1.5
2
2.5
3
0
1
2
3
4
5
6
7
8
1860
1880
1900
1920
1940
1960
1980
2000

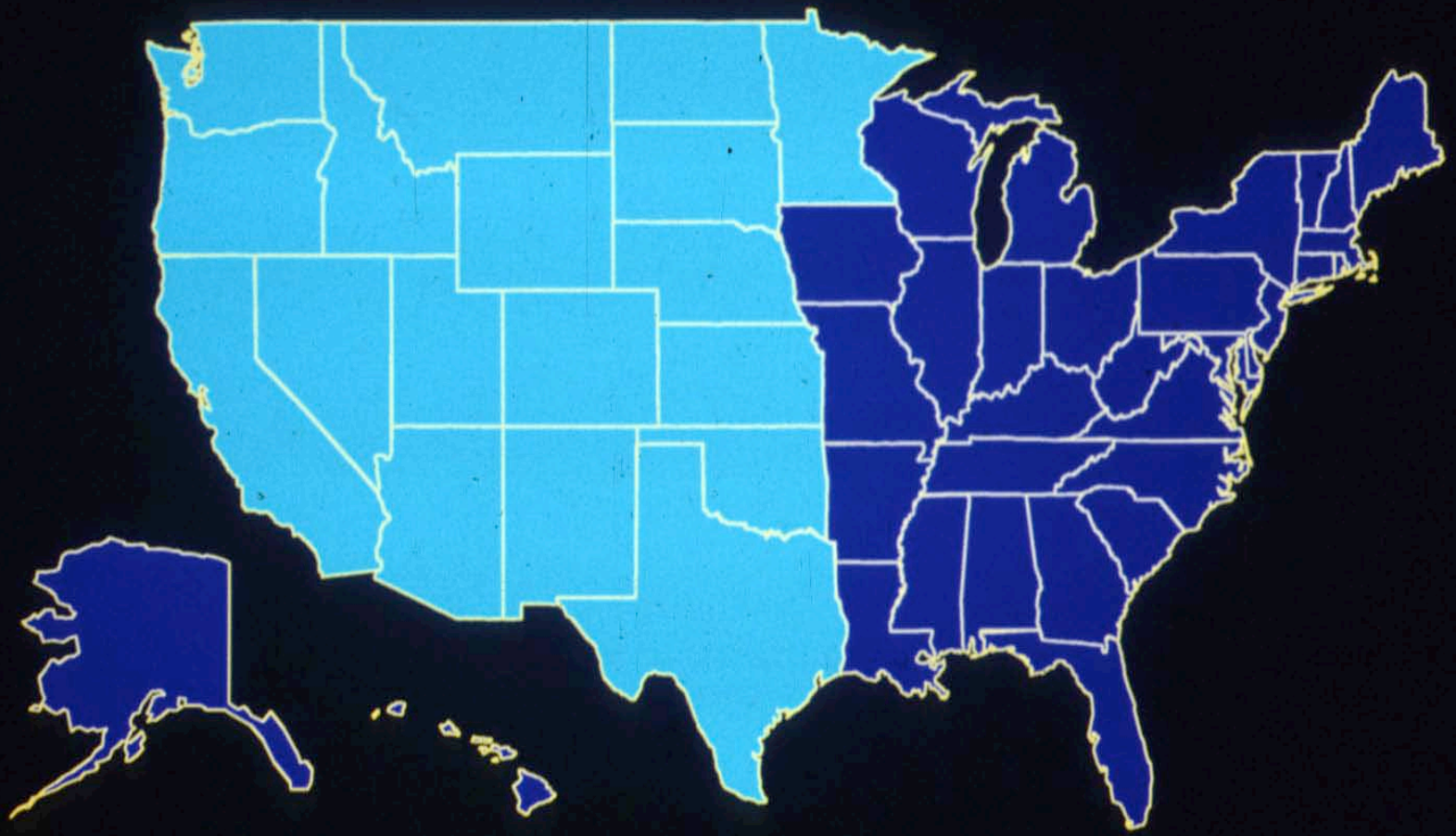
U.S. Cultivated Land



1987 Acreage

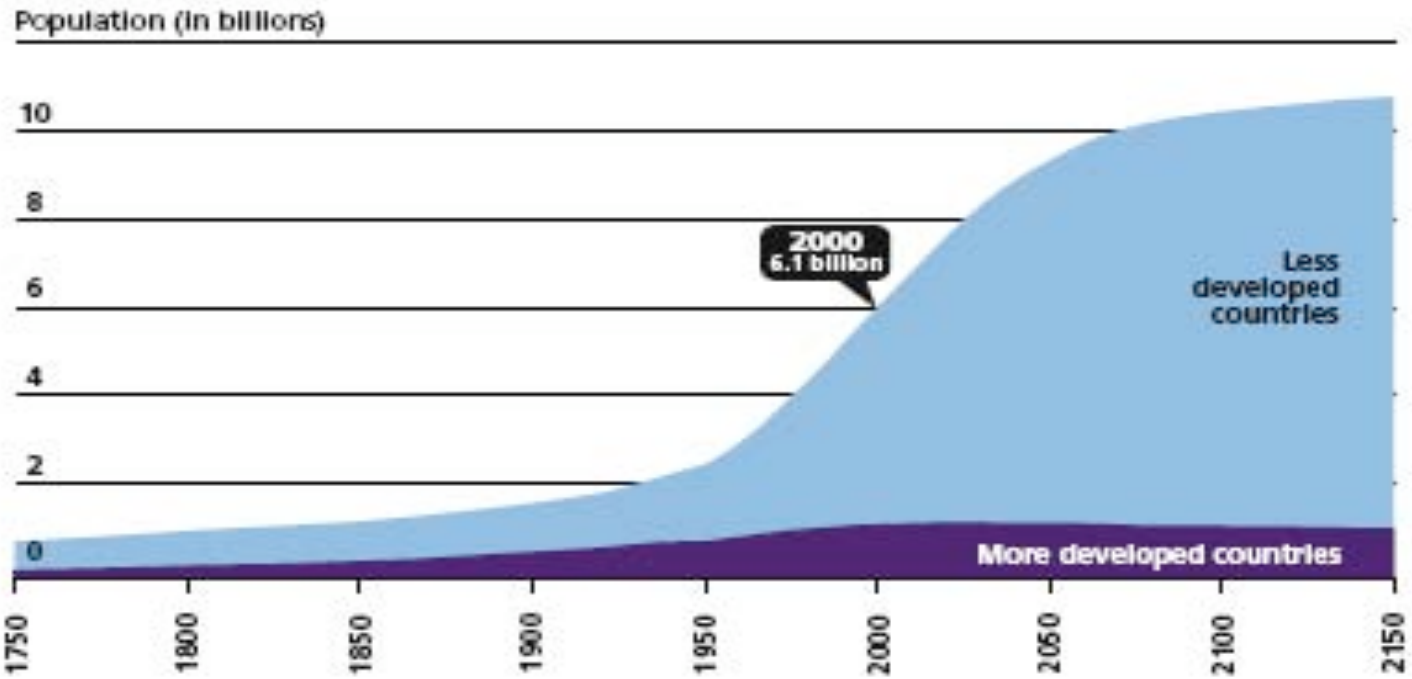
ucbiotech.org

U.S. Cultivated Land



Acreage Needed at 1929 Production Levels

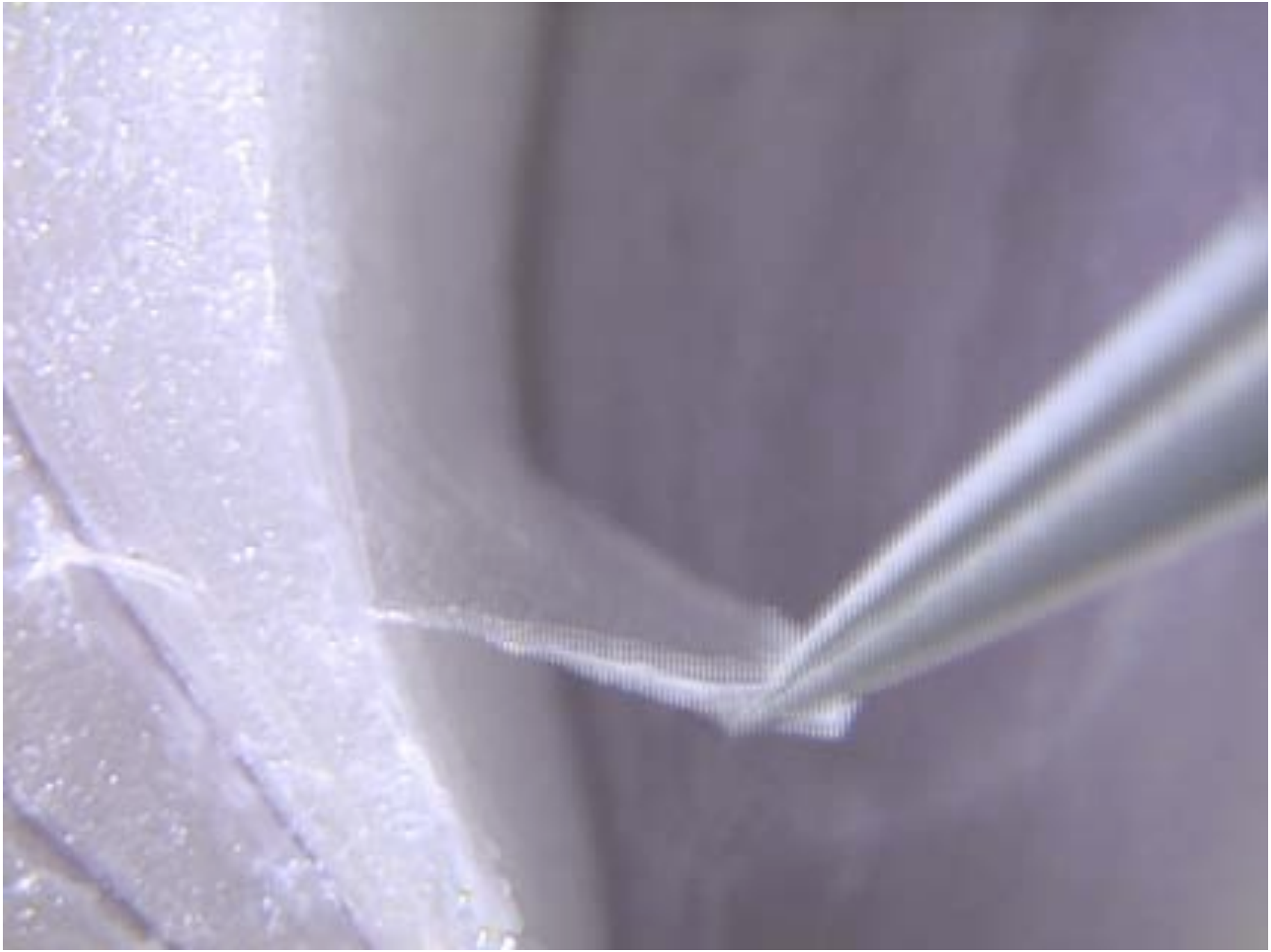
World population growth, 1750-2150

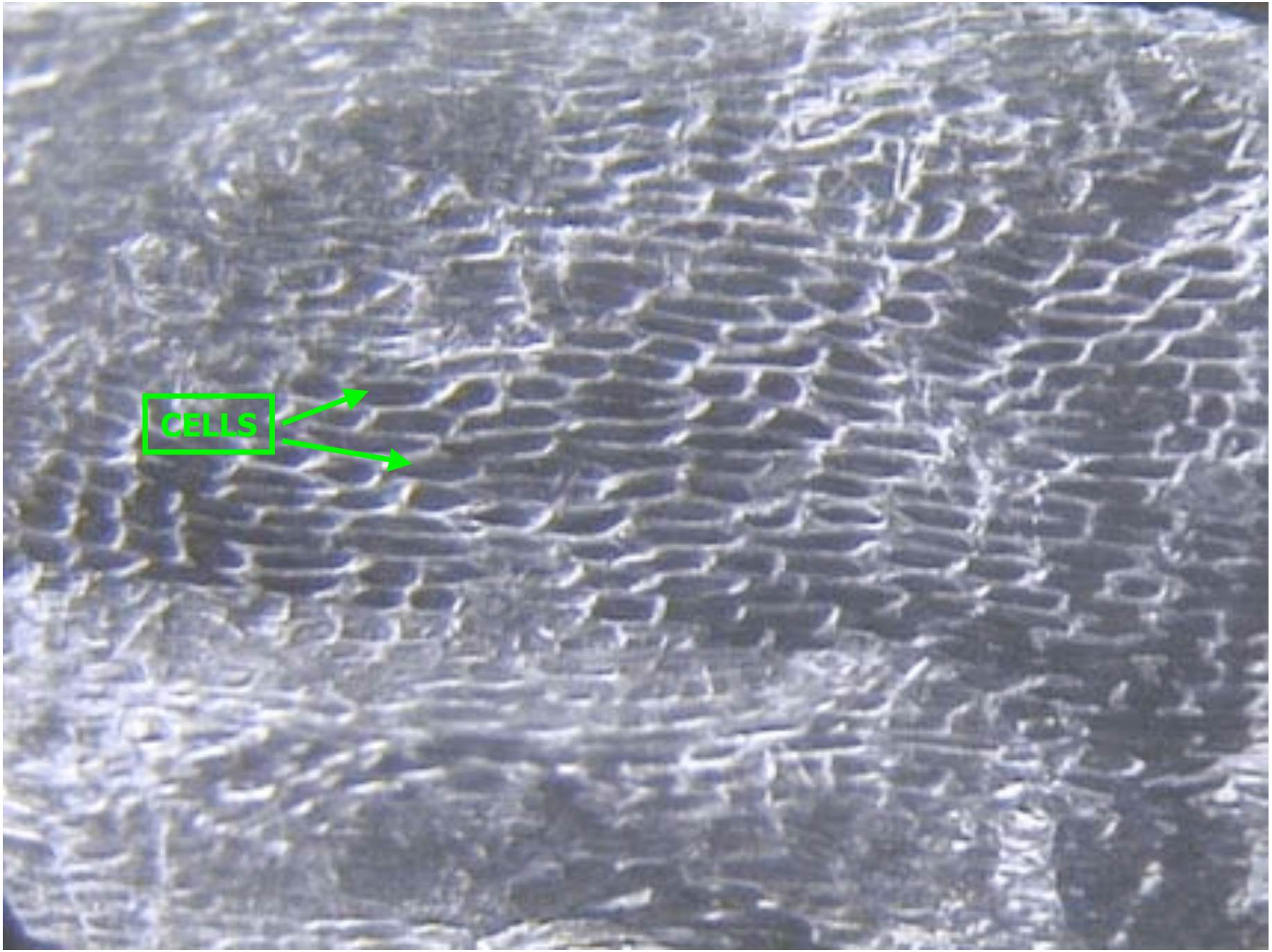


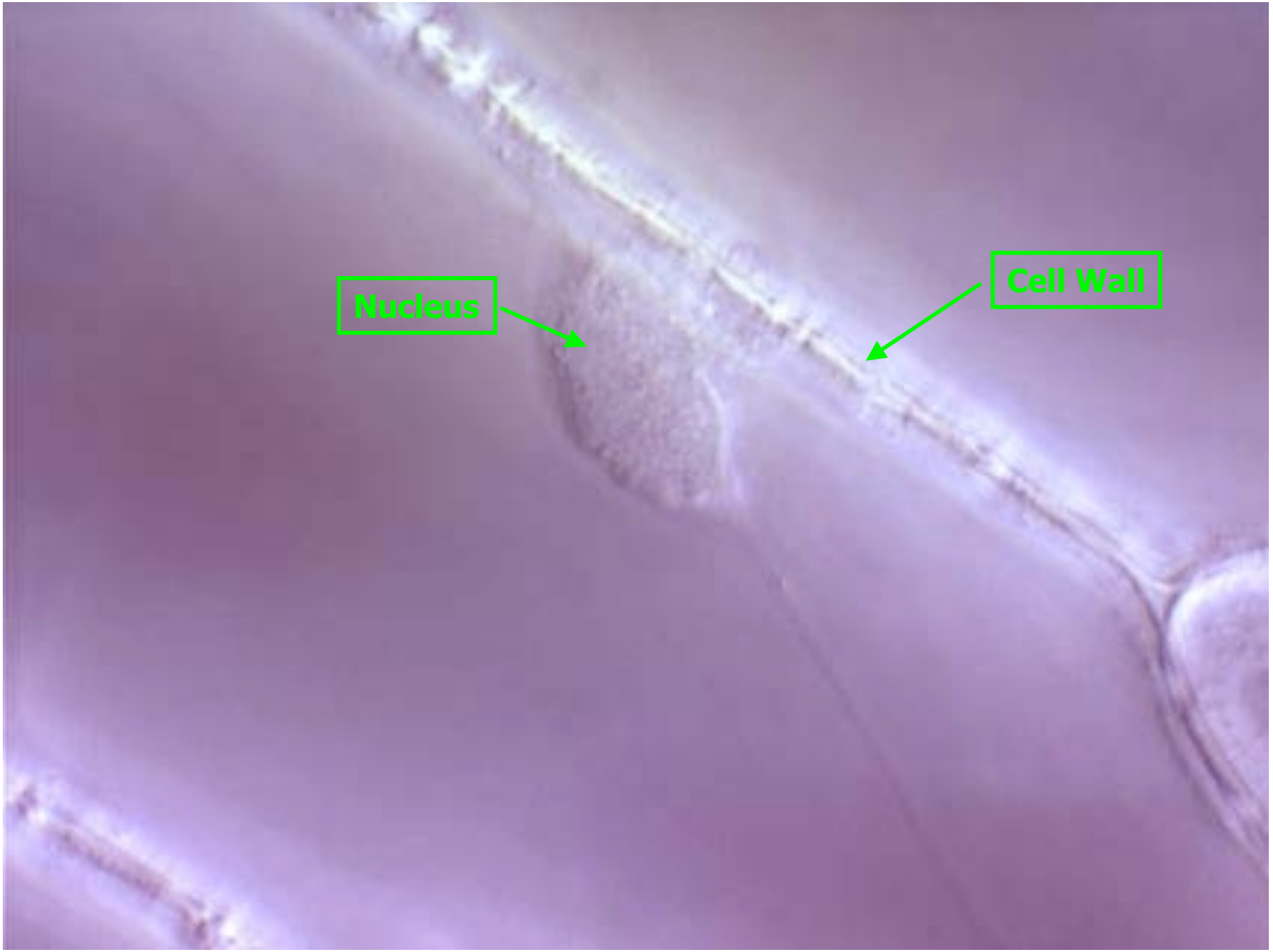
Source: United Nations, *World Population Prospects, The 1998 Revision* (New York: UN, 1998); and estimates by the Population Reference Bureau.

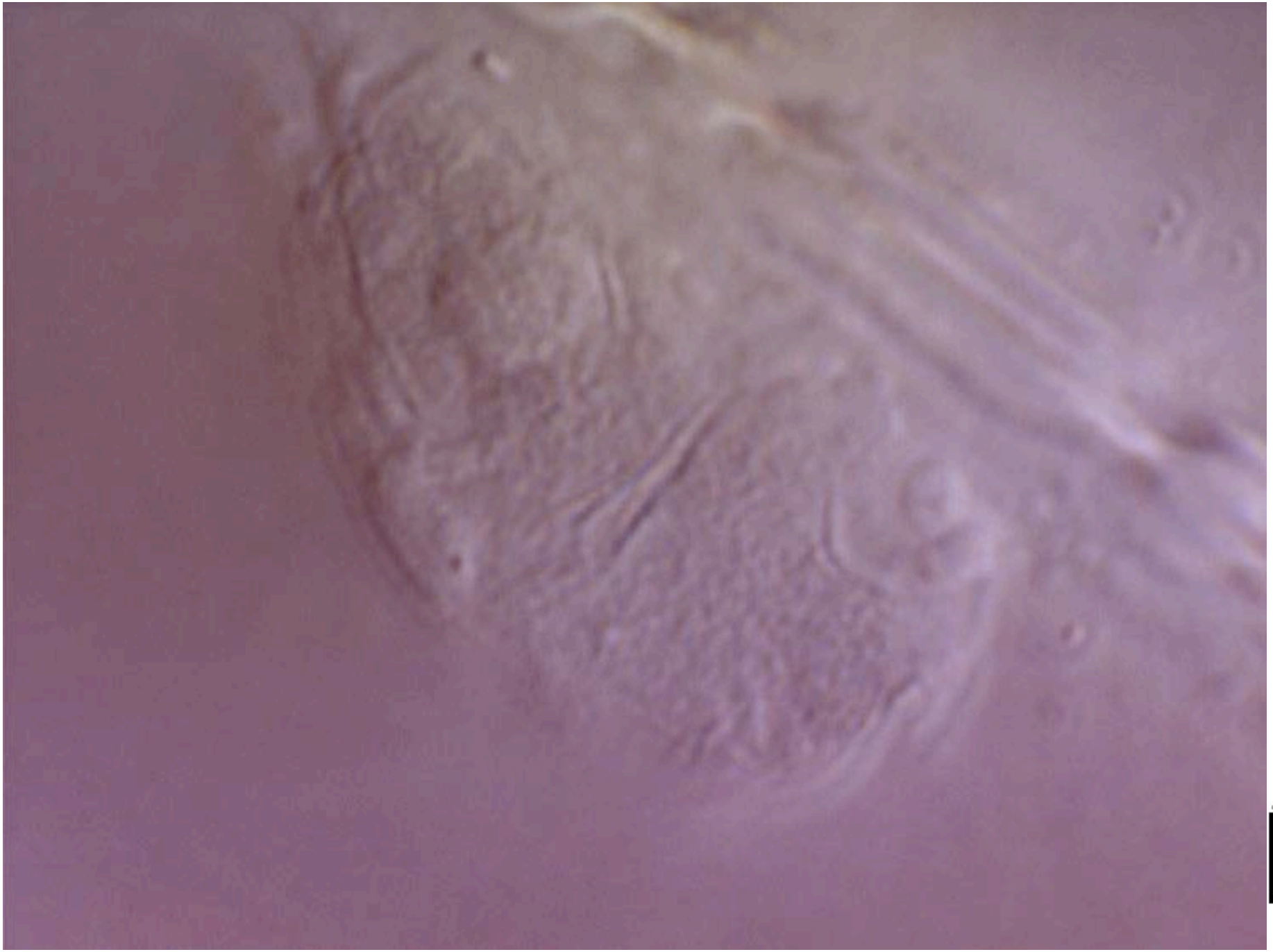
Tour d'Onion

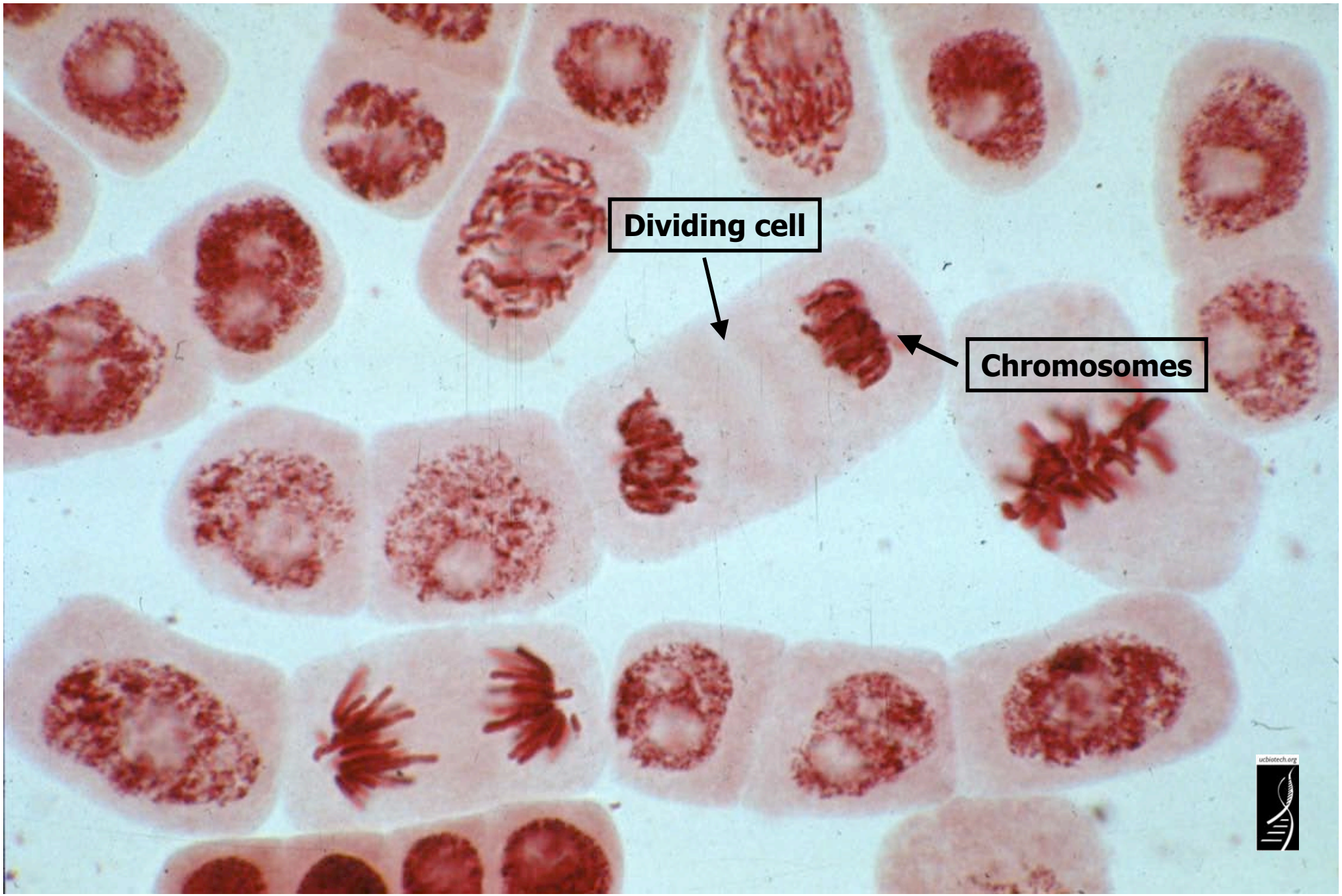

ucbiotech.org

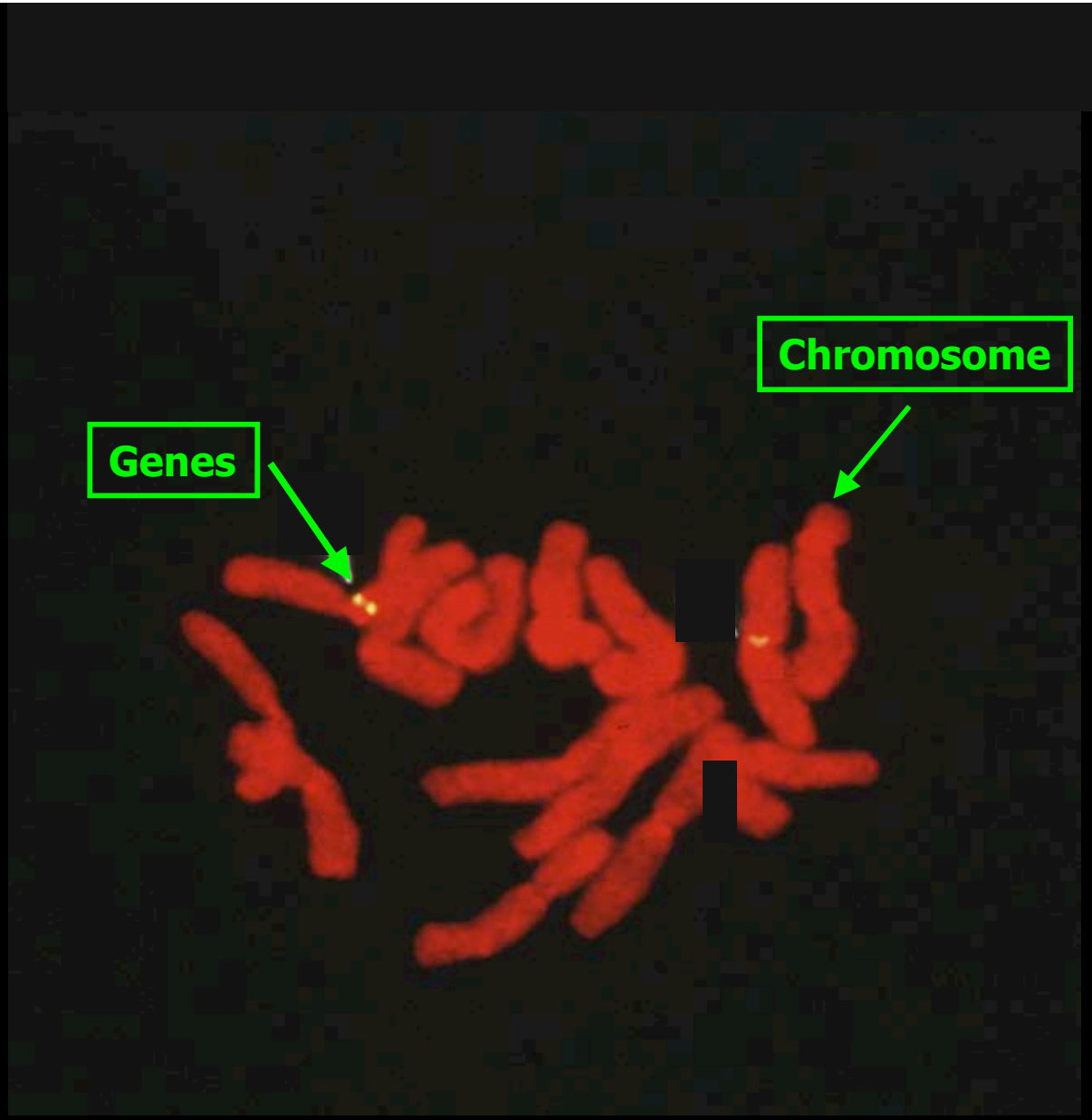



CELLS


Nucleus
Cell Wall




Dividing cell
Chromosomes
ucbiotech.org


Chromosome
Genes

How is a new wheat variety created by classical breeding?

Triticum aestivum

Modern bread variety

Triticum monococcum

Ancient variety

Information in the wheat genome

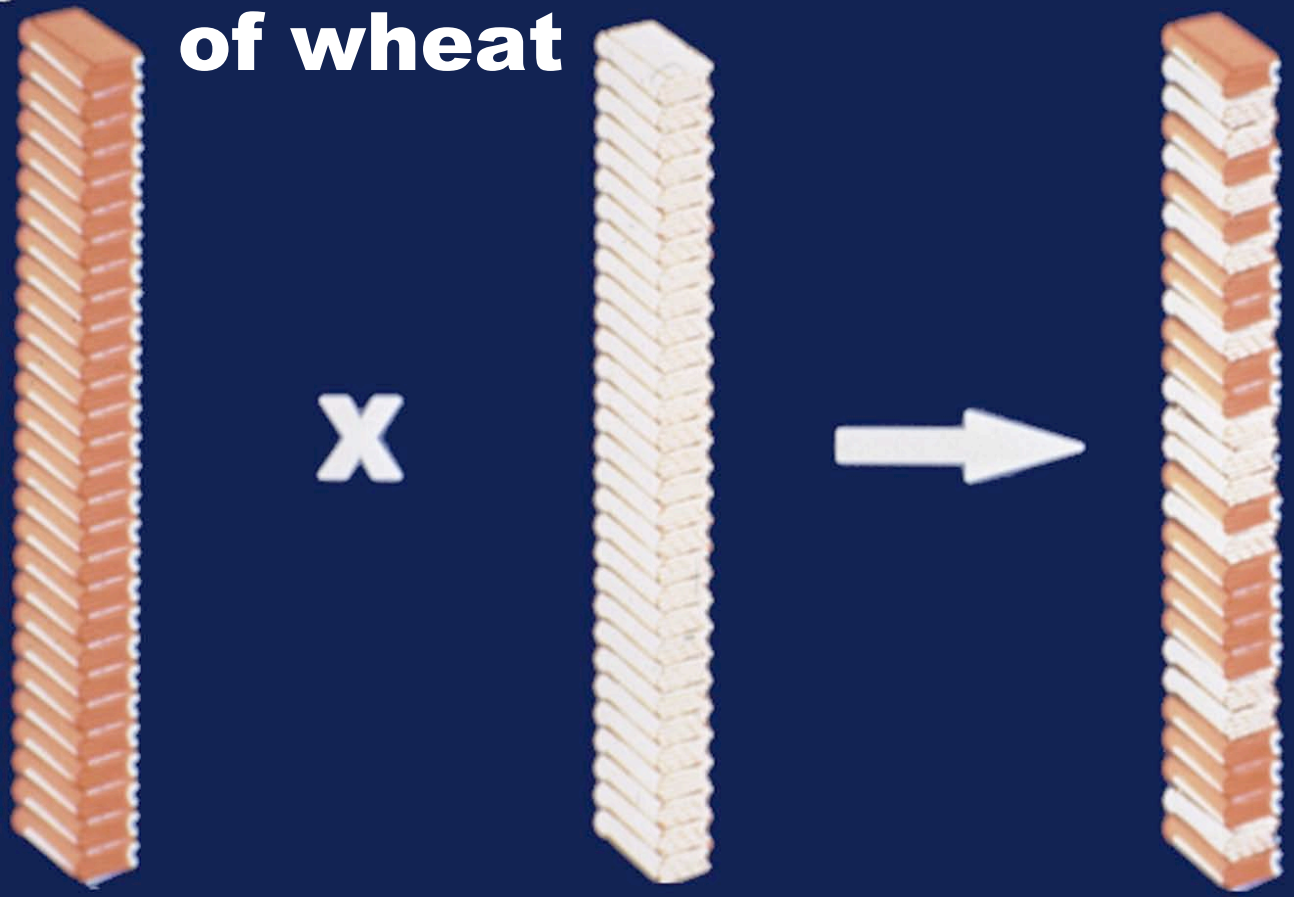
Chemical units represented by alphabetic letters

...CTGACCTAATGCCGTA...

1700 books
1000 pages each

1700 books
(or 1.7 milion pages)

Hybridization or cross breeding of wheat



1700 books (or 1.7 million pages)

1700 books (or 1.7 million pages)

1700 books (or 1.7 million pages)

Random retention of information from each parent

Table of contents for genes in wheat

...CTGACCTAATGCCGTA...

Used for Marker-Assisted Breeding

Genomics

1700 books
(or 1.7 million pages)

MAS For Quality Traits In Wheat

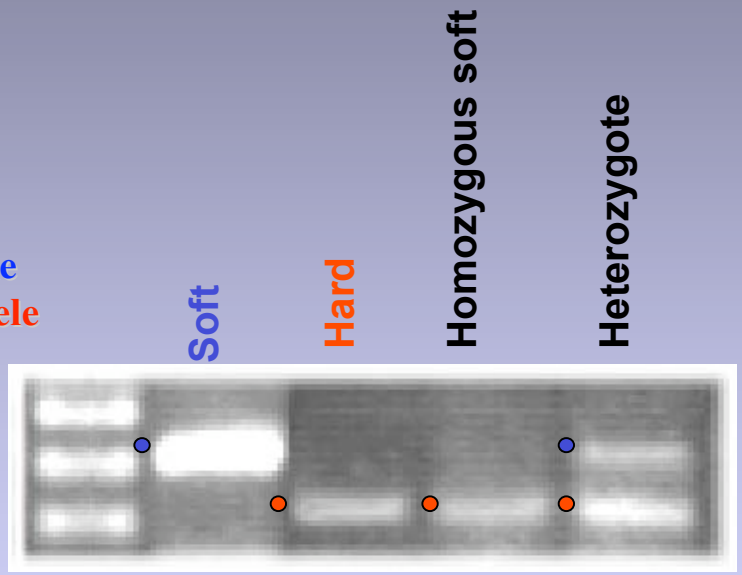
Selection of Hard and Soft Wheat

```
5' A AAC AAC ATT GAA AAC ATG AAG ACC TTA TTC CTC CTA GCT
 CTC CTT GCT CTT GTA GCG AGC ACA ACC TTC GCG CAA TAC TCA
 GAA GTT GGC GGC TGG TAC AAT GAA GTT GGC GGA GGA GGT GGT
 TCT CAA CAA TGT CCG CAG GAG CGG CCG AAG CTA AGC TCT TGC
 AAG GAT TAC GTG ATG GAG CGA TGT TTC ACA ATG AAG GAT TTT

                                        Gly
 CCA GTC ACC TGG CCC ACA AAA TGG TGG AAG GGC GGC TGT GAG  Soft allele
                                        AGC              Hard allele
                                        Ser

 CAT GAG GTT CGG GAG AAG TGC TGC AAG CAG CTG AGC CAG ATA
 GCA CCA CAA TGT CGC TGT GAT TCT ATC CGG CGA GTG ATC CAA
 GGC AGG CTC GGT GGC TTC TTG GGC ATT TGG CGA GGT GAG GTA
 TTC AAA CAA CTT CAG AGG GCC CAG AGC CTC CCC TCA AAG TGC
 AAC ATG GGC GCC GAC TGC AAG TTC CCT AGT GGC TAT TAC TGG TGA

 TGA TAT AGC CTC TAT TCG TGC CAA TAA AAT GTC ACA TAT CAT
 AGC AAG TGG CAA ATA AGA GTG CTG AGT GAT GAT CTA TGA ATA
 AAA TCA CCC TTG TAT ATT GAT CTG TGT TCG AGA AAA AAA AAA
 AAA AAA AAA 3'
```



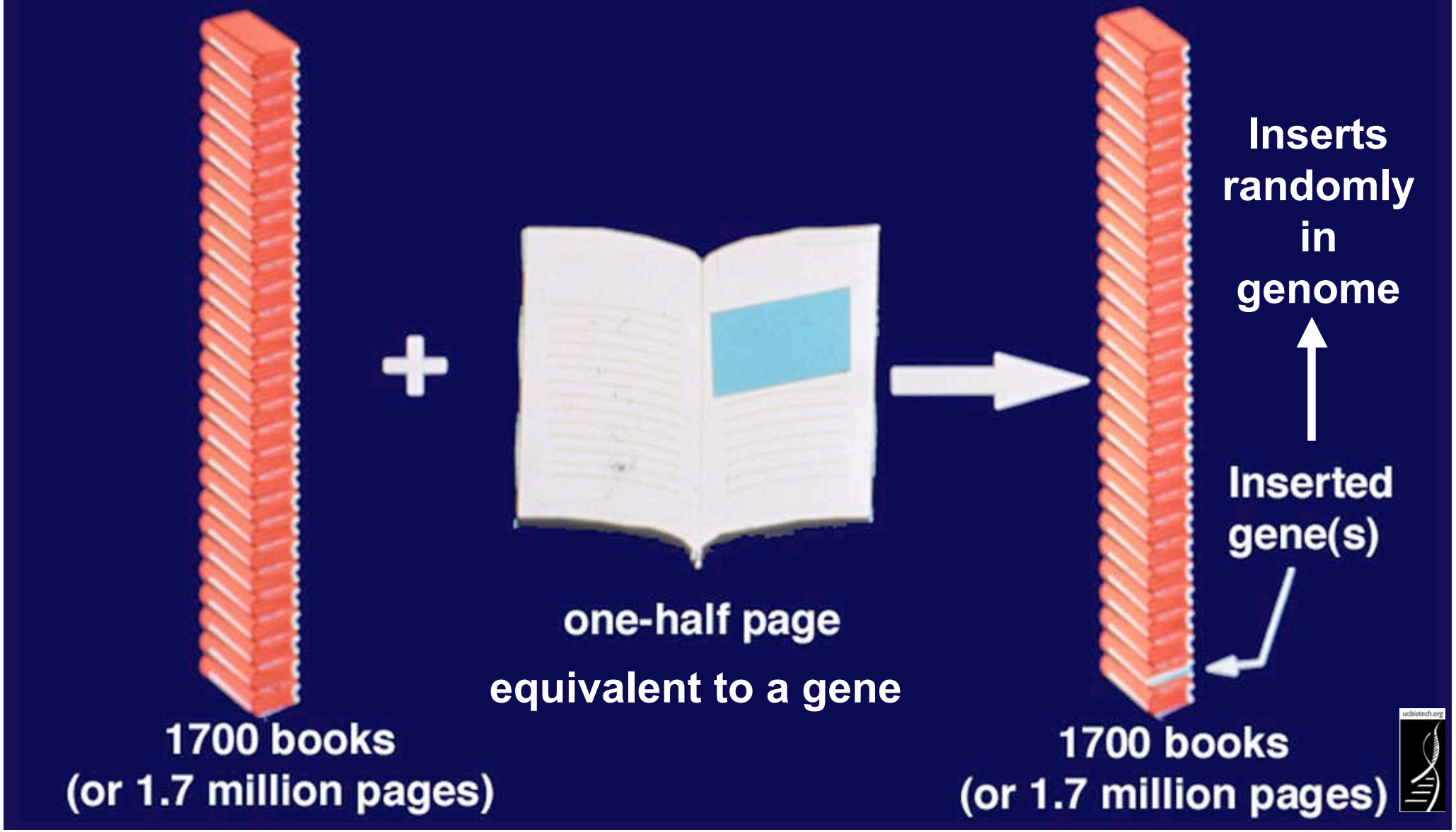
- PCR amplification of puroindoline b
- \+
- Digestion with *Bsr*-BI

Hard allele: cut **Soft** allele: uncut

GAG CGG: *Bsr*-BI restriction site.

Adapted and modified from http://maswheat.ucdavis.edu/

Genetic Engineering Methods



TERMS USED

GMO

Genetically Modified Organism

GEO

Genetically Engineered Organism

LMO

Living Modified Organism

rDNA

Recombinant DNA

Biotechnology

What Does the Introduced, Recombinant DNA Construct Look Like?

On switch

Gene of interest: herbicide, stress or disease tolerance

Off switch

On switch

Marker gene: antibiotic or herbicide resistance

Off switch

Process of Genetic Engineering of Plants

- Create rDNA with gene from same or different organism
- Transfer DNA to plant cell; plant cells divide under selection
- Cue cells to reform plant – every cell will have new DNA
- Confirm introduced DNA and expression of foreign protein in plants

Source of gene

rDNA

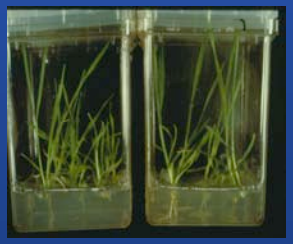
Introduce DNA

Selection

Cells dividing

Hormones

Remove hormones

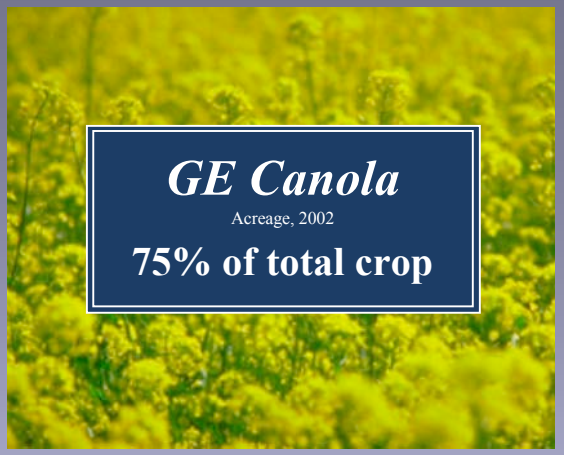


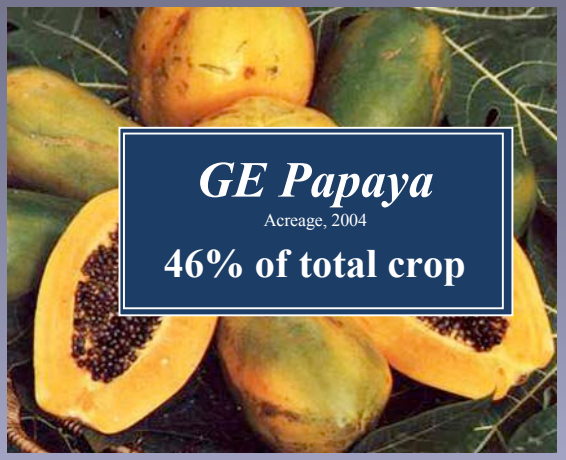
Put in soil

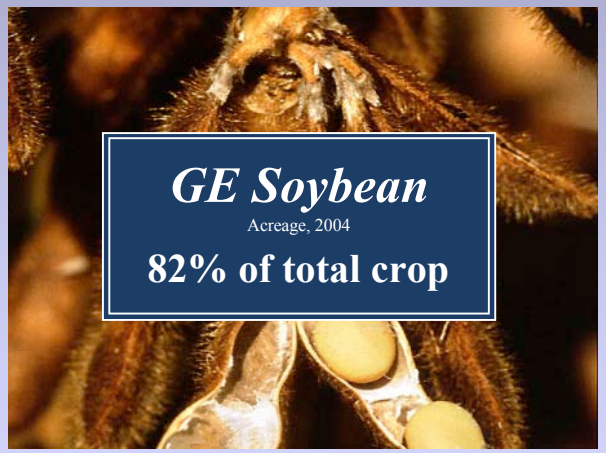
Check for introduced trait

Classical Breeding compared to *Genetic Engineering*

Classical Breeding	*Genetic Engineering*
Uses plant machinery in plant	Uses plant machinery in laboratory
Gene exchange is random involving entire genome	Gene exchange is specific, single or a few genes
When/where genes expressed not controlled by breeder	When/where gene expressed can be controlled precisely
Only between closely related or within species	Source of gene from any organism





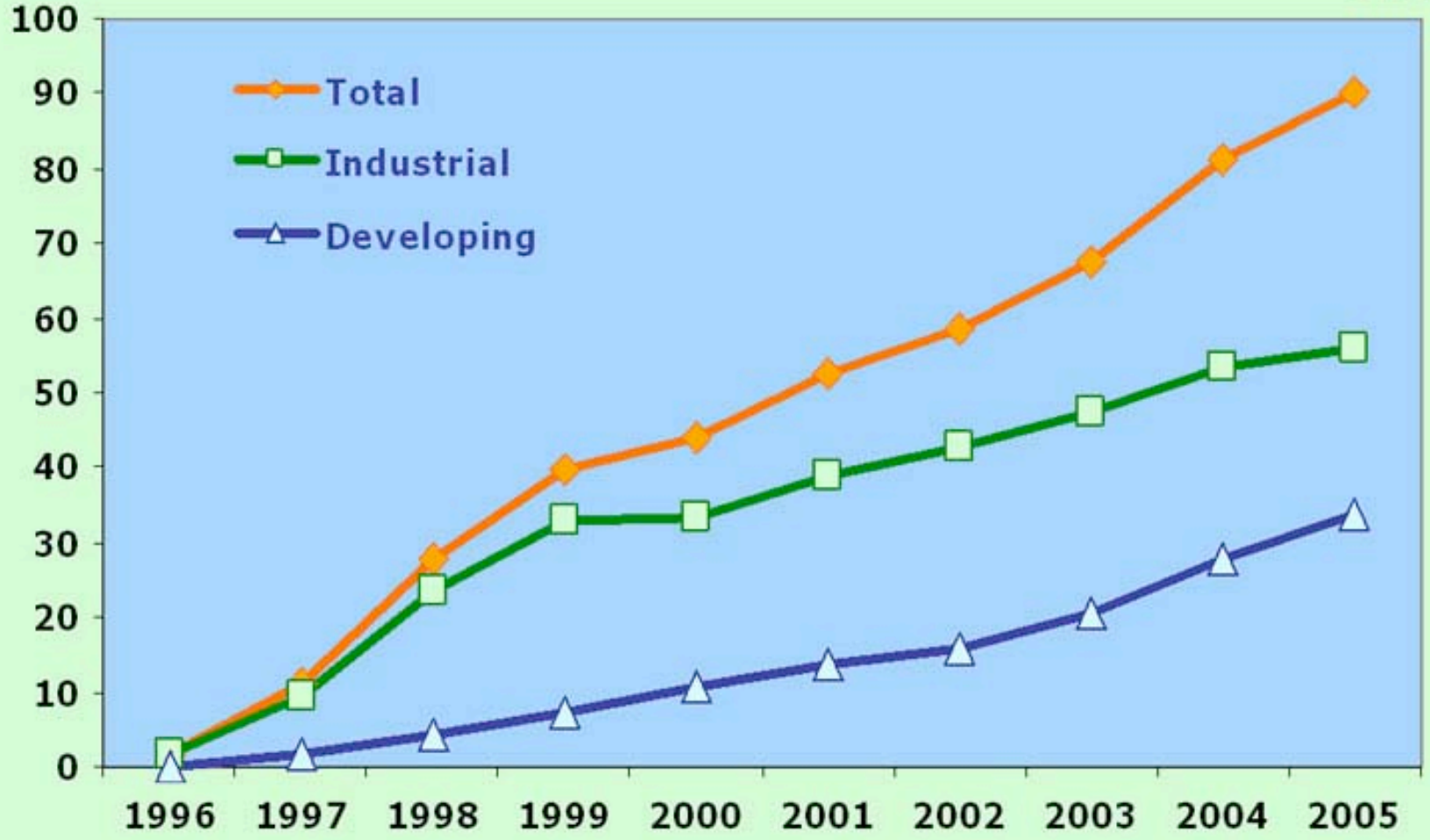


SOURCE: NCFAP; USDA, USA Today

ucbiotech.org

GLOBAL AREA OF BIOTECH CROPS

Million Hectares (1996 to 2005)



Increase of 11%, 9.0 million hectares or 22 million acres, between 2004 and 2005.

Source: Clive James, 2005

Estimated 75% of Processed Foods Have GE Ingredients

Insect-Resistant Cotton (Bt)

+ Increases yields; profits variable

+ Decreased pesticide use

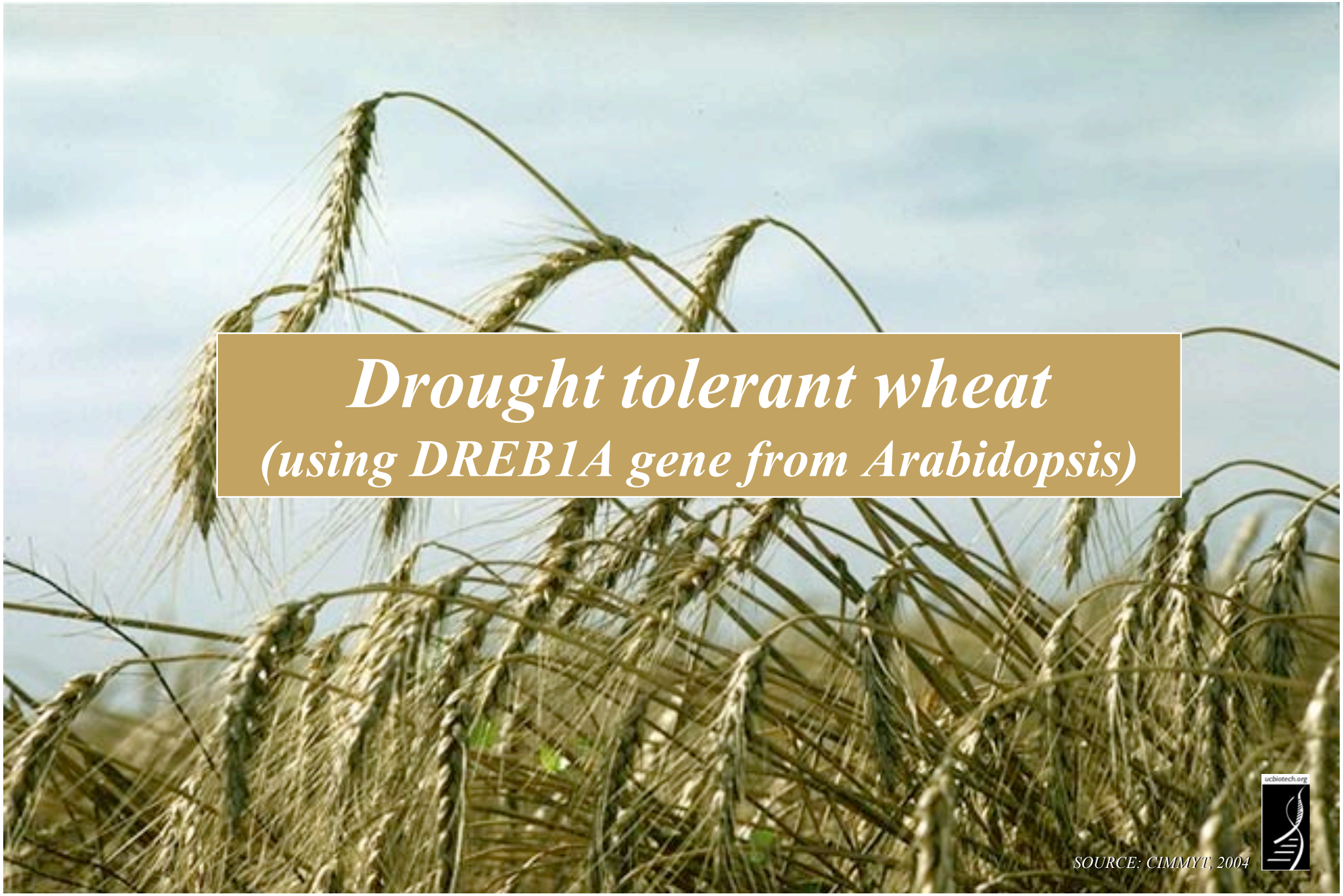
+ Reduced tillage

- Can result in Bt-resistant insects

- Produces insect toxin throughout plant

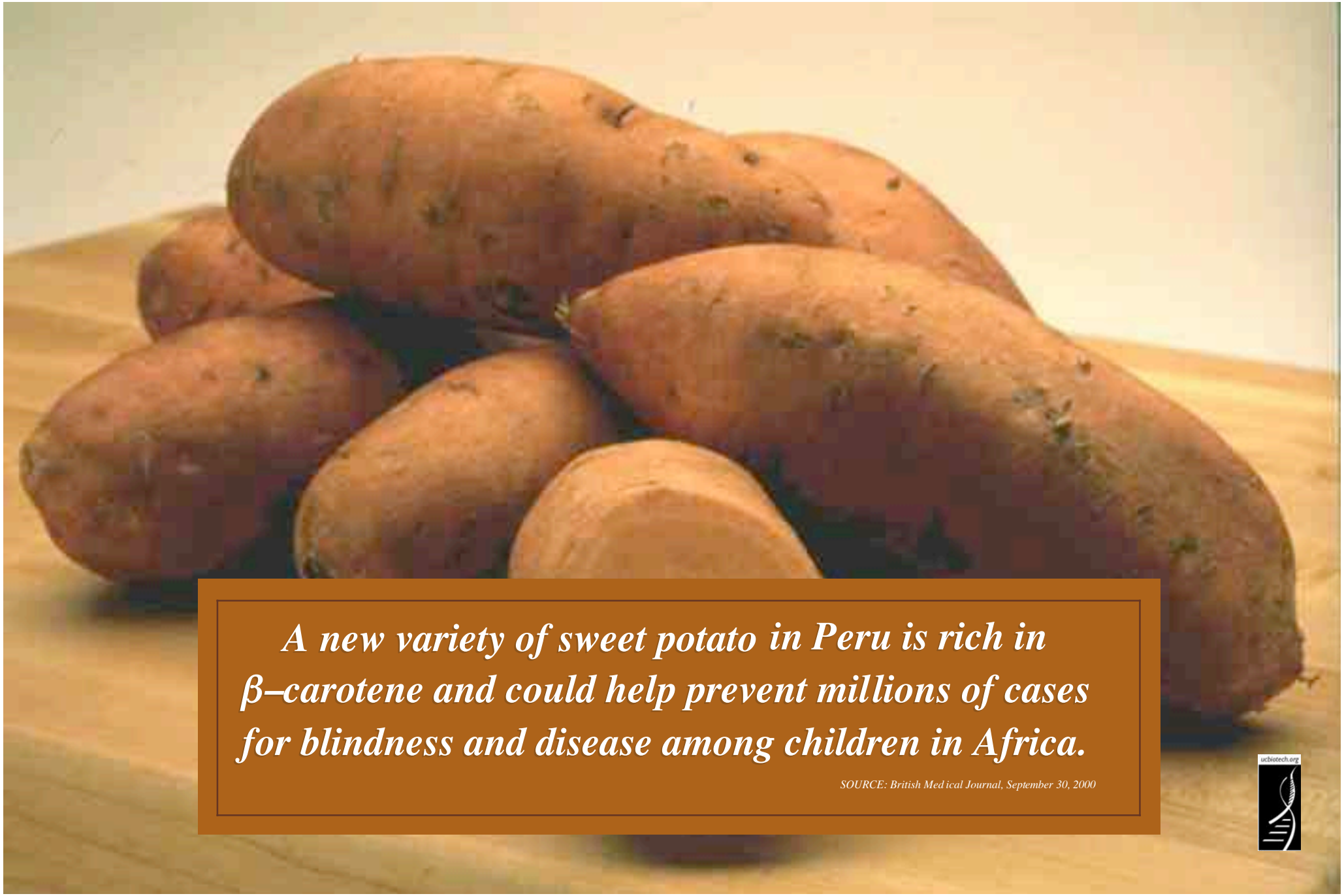
- Can transfer Bt gene to wild relatives

WHAT'S IN THE PIPELINE?


Drought tolerant wheat
(using DREB1A gene from Arabidopsis)
SOURCE: CIMMYT, 2004
ucbiotech.org


GE Grape Root Stocks Field Tested in Northern France for Fanleaf Virus Protection that Can Reduce Yields by 80%
SOURCE: USDA Foreign Agricultural Service. 2005. EU-25: GMO trials on grape wine given go-ahead in France. Report E35183
ucbiotech.org


Mitigating food allergies
through genetic engineering
ucbiotech.org


A new variety of sweet potato in Peru is rich in β–carotene and could help prevent millions of cases for blindness and disease among children in Africa.
SOURCE: British Medical Journal, September 30, 2000
ucbiotech.org

Production of Omega-3 and Omega-6 Oils in Plants

SOURCE: "Transgenic plants produce omega-3 and omega-6 fatty acids", Baoxiu Qi, ISB News Report July 2004
http://www.isb.vt.edu/news/2004/news04.jul.html#jul0403

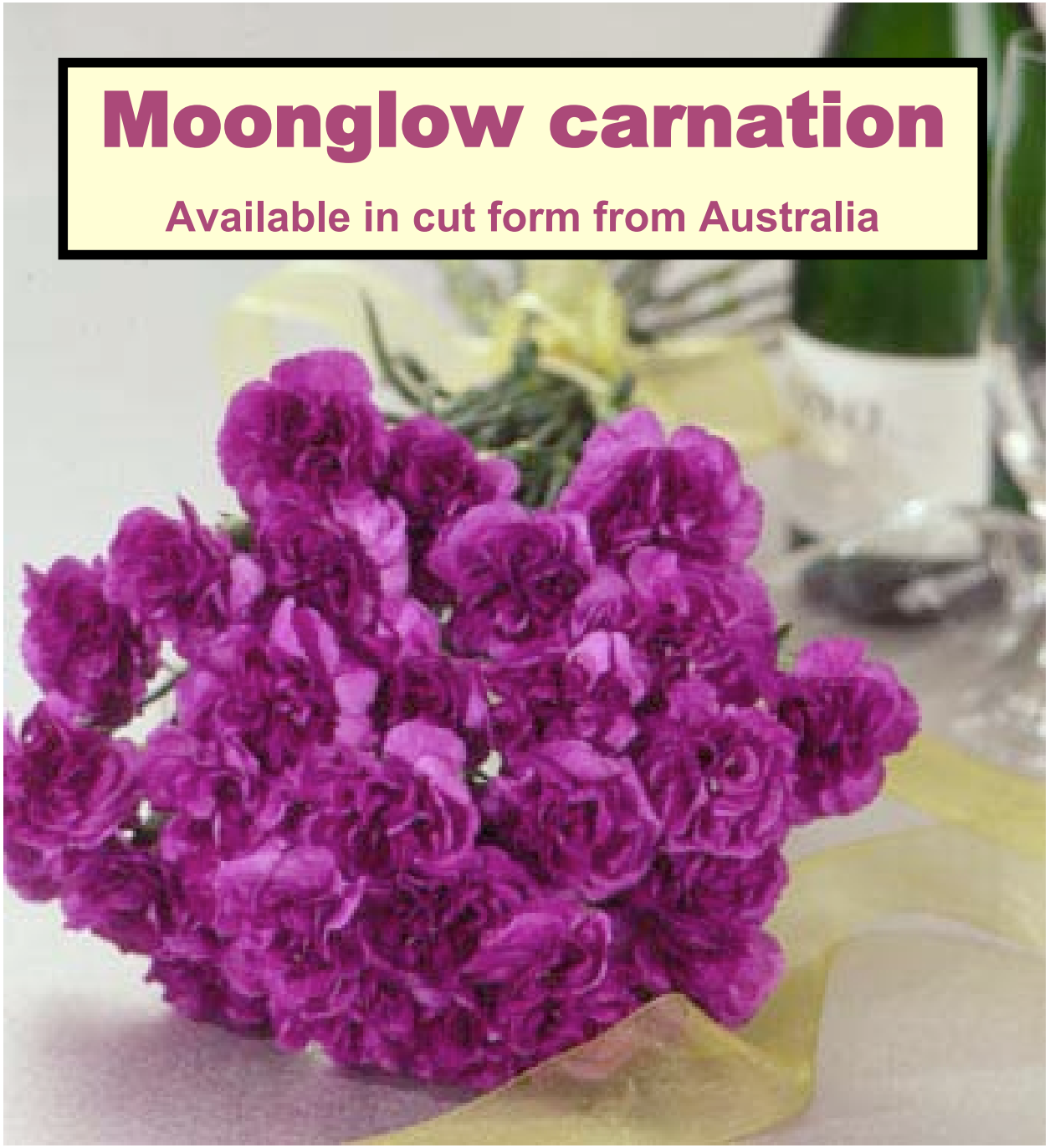
ucbiotech.org

Japanese scientists create blue rose from blue pigments in pansies

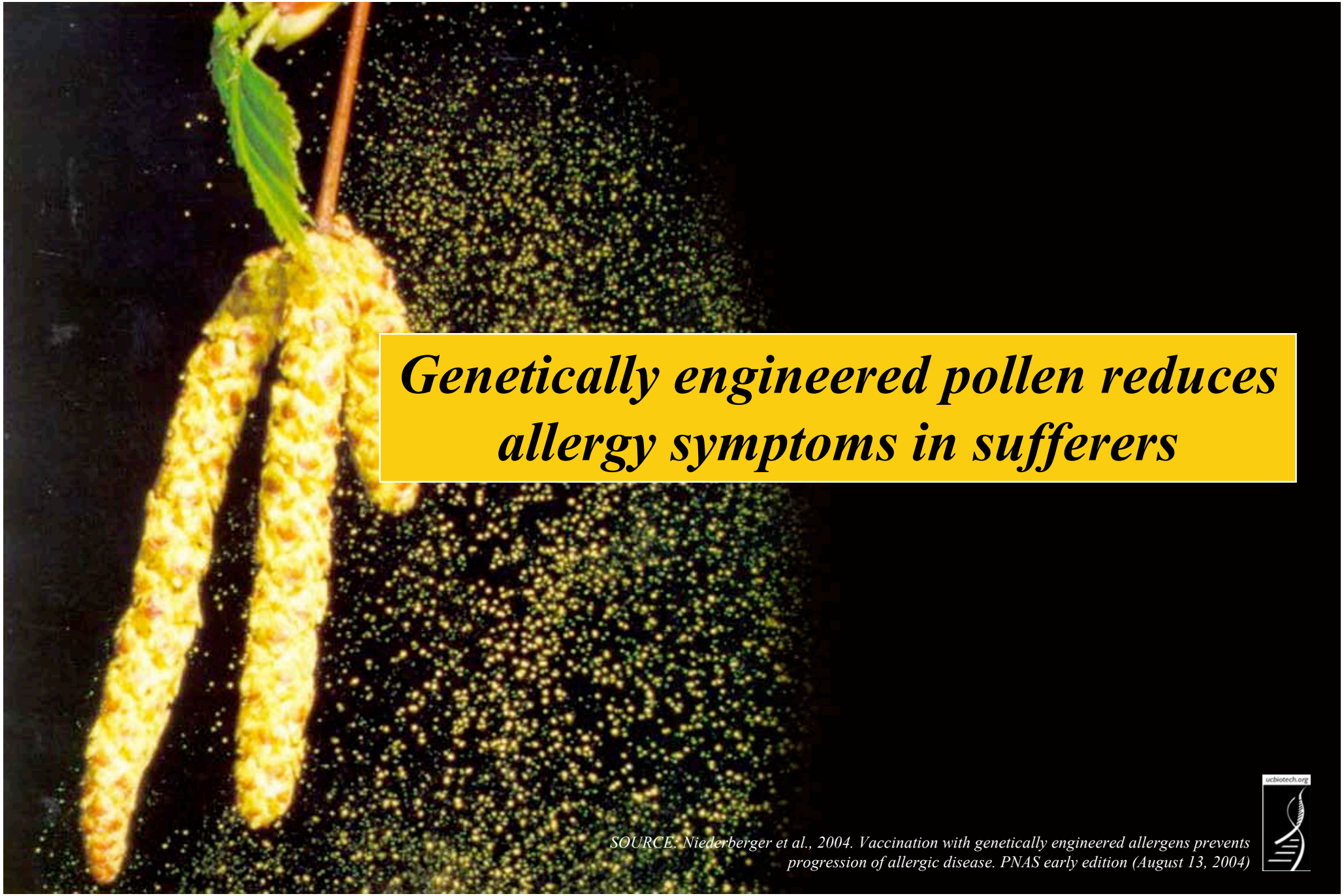
SOURCE: http://www.japantimes.co.jp/cgi-bin/getarticle.pl5?nn20040701a2.htm

Moonglow carnation

Available in cut form from Australia




Slow grow grass
ucbiotech.org


Genetically engineered pollen reduces allergy symptoms in sufferers
SOURCE: Niederberger et al., 2004. Vaccination with genetically engineered allergens prevents progression of allergic disease. PNAS early edition (August 13, 2004)
ucbiotech.org

"Production of specific vaccines for lymphoma in tobacco"

SOURCE: PNAS 96:70 3-708, McCormick,et al.


After eating potato-based vaccine for Hepatitis B, 60% of humans show immunological response
SOURCE: Thanavala, Y., Mahoney, M., Pal, S., Scott, A., Richter, L., Natarajan, N., Goodwin, P., Arntzen, C.J. and Mason, H.S. 2005. Immunogenicity in humans of an edible vaccine for hepatitis B. Proceedings of the National Academy of Sciences USA, Online First (DOI 10.1073/pnas.0409899102).
ucbiotech.org

Green glowing pigs used to study human disease

SOURCE: http://news.yahoo.com/s/nm/20060112/od_nm/taiwan_pig1_dc;_ylt=AiXxJyE6jj1ZXwue0kX2JfkSH9EA;_ylu=X3oDMTBiMW04NW9mBHNlYwMlJVRPUCUl

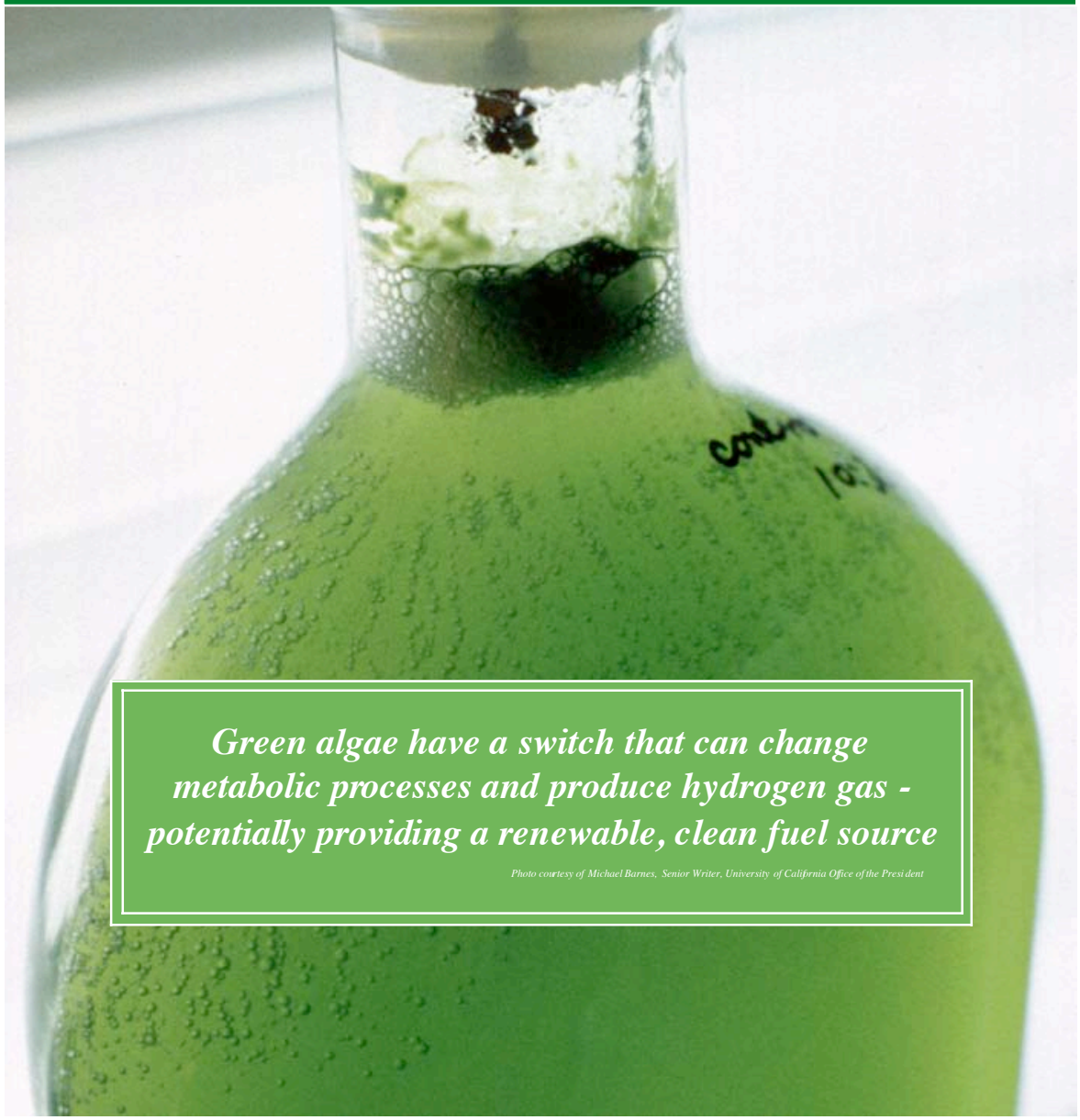
SOURCE: "Nicotine-reduced cigarettes reach market", January 27, 2003, Associated Press

Genetic engineering used to improve breakdown of global wastepaper glut

SOURCE: Fierobe et al. 2005. Action of Designer Cellulosomes on Homogeneous Versus Complex Substrates: CONTROLLED INCORPORATION OF THREE DISTINCT ENZYMES INTO A DEFINED TRIFUNCTIONAL SCAFFOLDIN. J. Biol. Chem. 280:16325-16334.


Yellow poplar bioremediation
ucbiotech.org

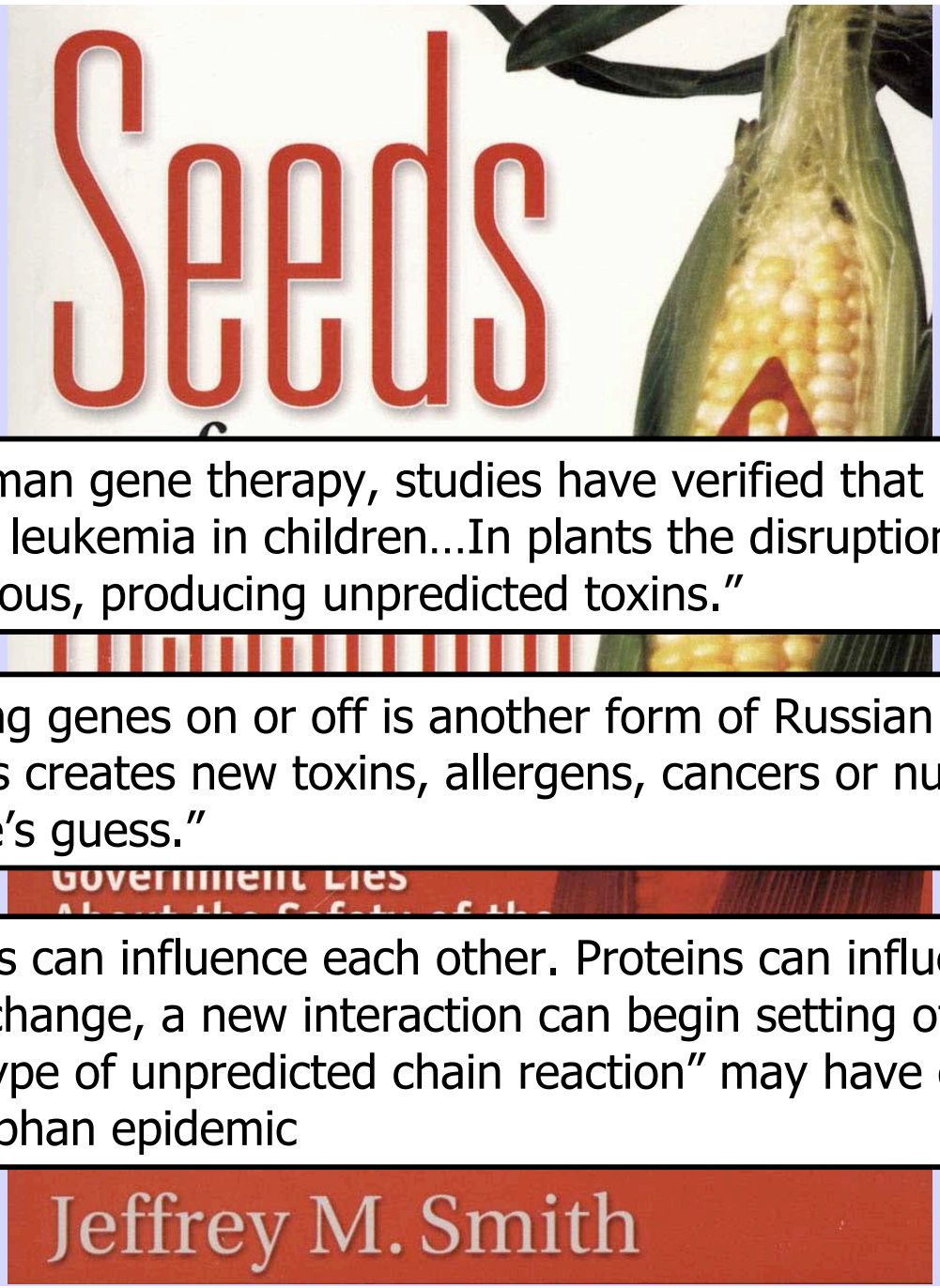
ENERGY FARMS



Green algae have a switch that can change metabolic processes and produce hydrogen gas - potentially providing a renewable, clean fuel source

Photo courtesy of Michael Barnes, Senior Writer, University of California Office of the President


The HORROR of Genetically Engineered Food
IT Came from the Grocery Store
You Can't Avoid It Because It's NOT LABELED!
GREENPEACE
From the LABS of Monsanto to YOUR TABLE!
A NEW LIFE FORM Released into the World!



"In human gene therapy, studies have verified that insertion mutation can lead to leukemia in children…In plants the disruptions may be similarly dangerous, producing unpredicted toxins."

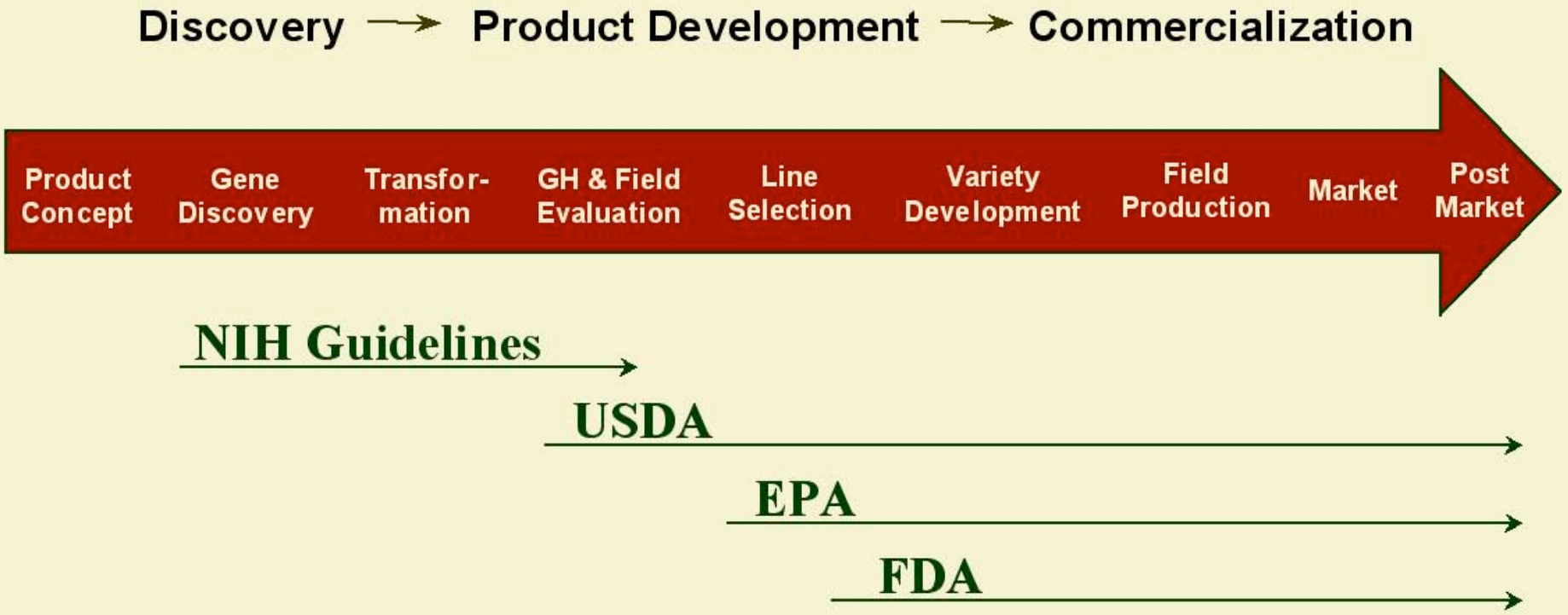
"Turning genes on or off is another form of Russian roulette. Whether the process creates new toxins, allergens, cancers or nutritional changes is anyone's guess."

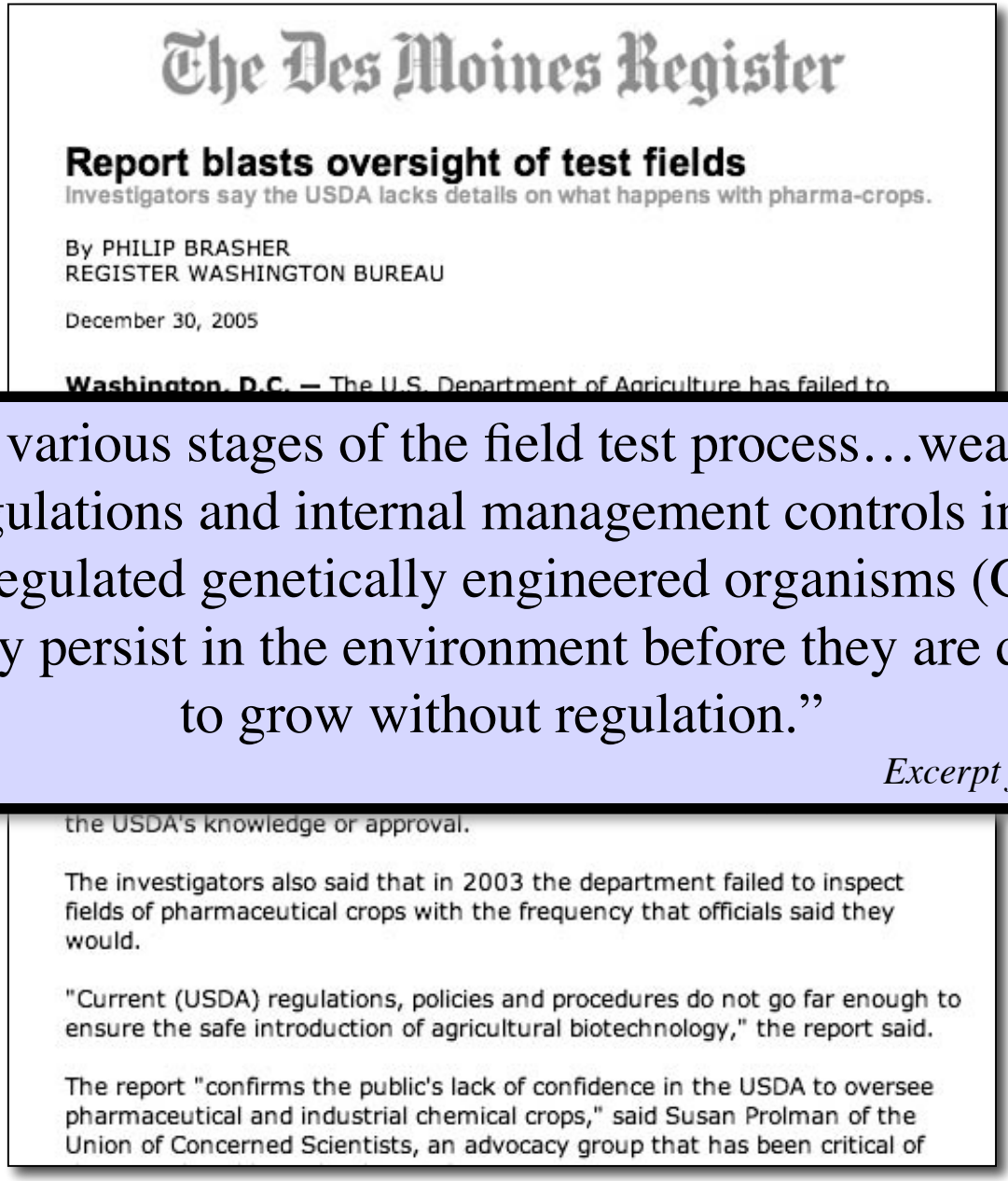
"Genes can influence each other. Proteins can influence each other. With each change, a new interaction can begin setting off yet more changes. This type of unpredicted chain reaction" may have caused the 'deadly' tryptophan epidemic

Some food safety concerns with genetically engineered foods

- Adverse change/improvement in nutritional content
- Creation/removal of allergen
- Activation/removal of toxin
- Horizontal gene flow from food to intestinal flora
- Increase in antibiotic resistance
- Labeling

Plant Biotech Products Have Continuous Regulatory Oversight





The Des Moines Register

Report blasts oversight of test fields

Investigators say the USDA lacks details on what happens with pharma-crops.

By PHILIP BRASHER
REGISTER WASHINGTON BUREAU

December 30, 2005

Washington, D.C. — The U.S. Department of Agriculture has failed to

the USDA's knowledge or approval.

The investigators also said that in 2003 the department failed to inspect fields of pharmaceutical crops with the frequency that officials said they would.

"Current (USDA) regulations, policies and procedures do not go far enough to ensure the safe introduction of agricultural biotechnology," the report said.

The report "confirms the public's lack of confidence in the USDA to oversee pharmaceutical and industrial chemical crops," said Susan Prolman of the Union of Concerned Scientists, an advocacy group that has been critical of

"In fact at various stages of the field test process…weaknesses in APHIS regulations and internal management controls increase the risk that regulated genetically engineered organisms (GEO) will inadvertently persist in the environment before they are deemed safe to grow without regulation."

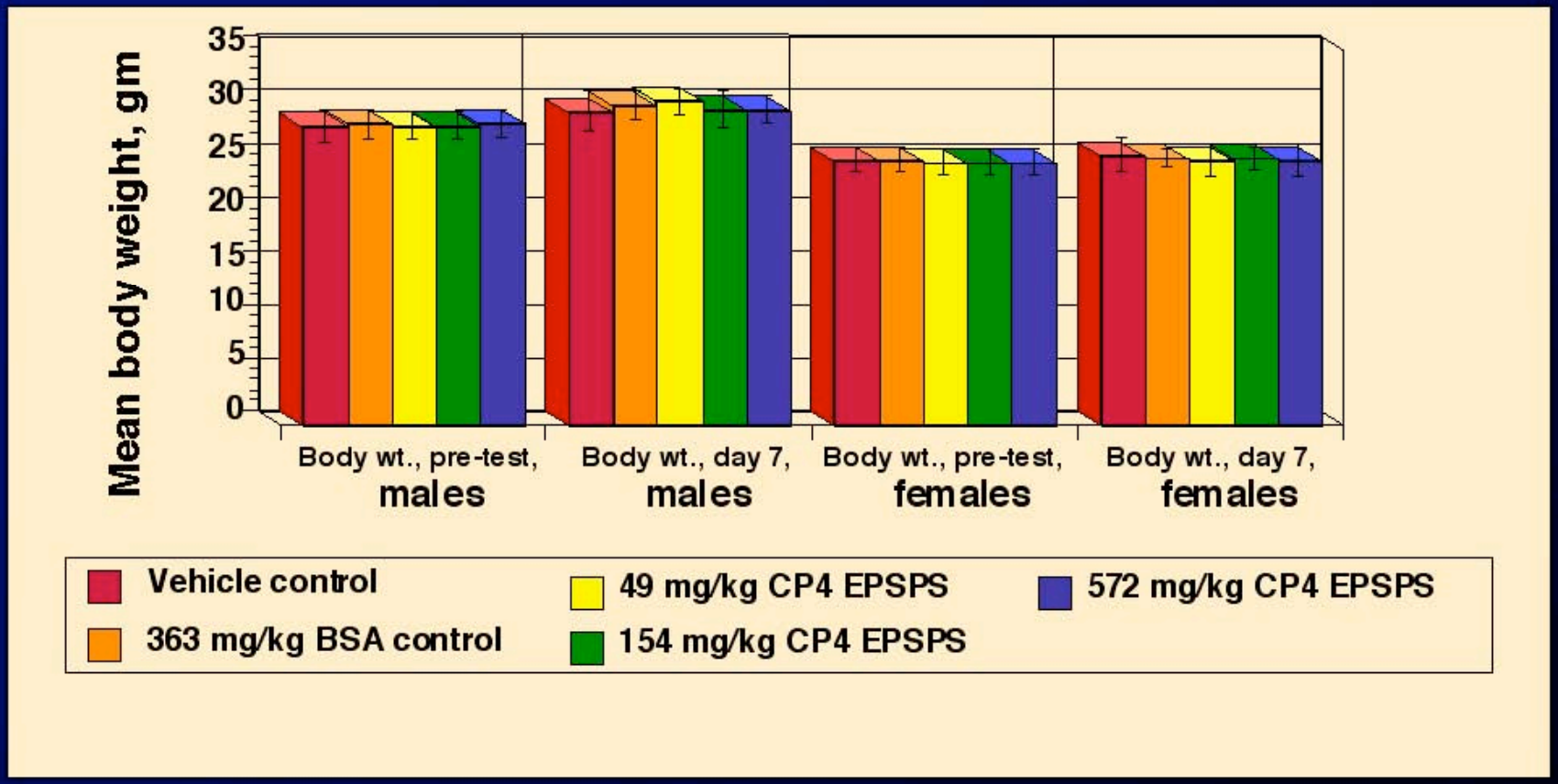
Excerpt from USDA Audit

SOURCE: http://www.desmoinesregister.com/apps/pbcs.dll/article?AID=/20051230/BUSINESS01/512300334&SearchID=73231131107800

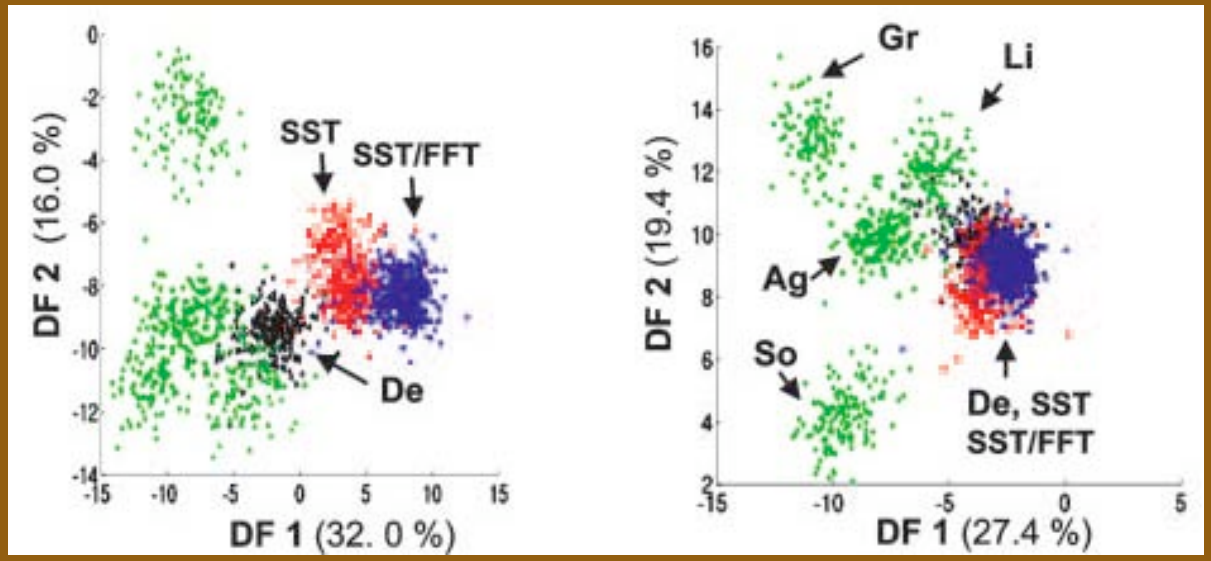
ucbiotech.org

Toxicity Assessment: Roundup Ready/CP4 EPSPS protein

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



Hierarchical metabolomics demonstrates substantial compositional similarity between genetically modified and conventional potato crops



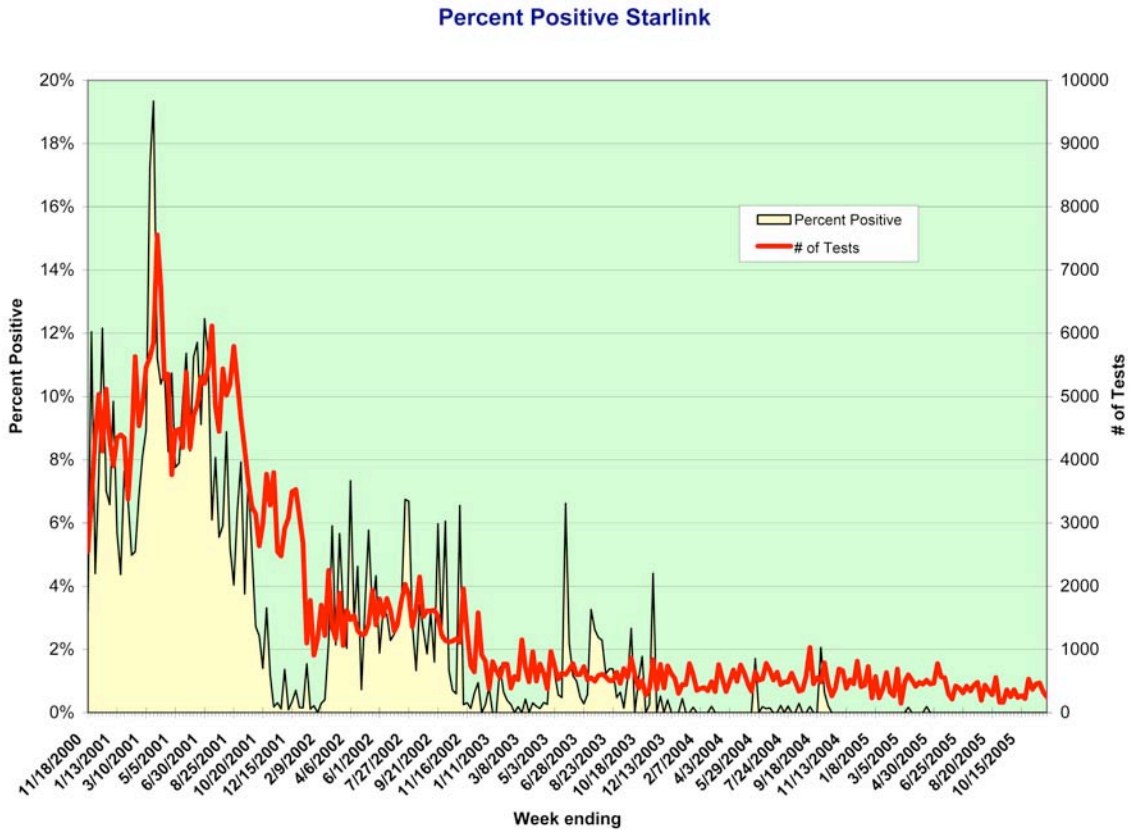
"…apart from targeted changes, these GM potatoes in this study appear substantially equivalent to traditional cultivars."

SOURCE: Catchpole et al. 2005. Hierarchical metabolomics demonstrates substantial compositional similarity between genetically modified and conventional potato crops. Proceedings of the National Academy of Sciences USA 105: 14458-14462.

ucbiotech.org

Kraft Food recalls all taco shells sold nationwide under Taco Bell Brand

SOURCE: Washington Post, September 19, 2000



Percentage of Positive Starlink Tests
Week ending:

November 25, 2000	12.05%
November 30, 2002	1.19%
November 1, 2003	0.26%
November 27, 2004	0.00%
April 16, 2005	0.19%
May, 2005	0.00%
June, 2005	0.00%
July, 2005	0.00%
August, 2005	0.00%
October, 2005	0.00%
November, 2005	0.00%
December, 2005	0.00%


Kiwi Allergies

Some environmental concerns with genetically engineered crops

- Transgene movement via pollen flow
- Transfer of transgenes to non-GMO / organic crops
- Generation of "superweeds" (transfer of herbicide-tolerance to wild/weedy species)
- Spread of pharmaceutical genes to edible crops
- Loss of genetic diversity
- Property rights (gene patents)

Movement of genes between crop species and wild relatives

Charlock

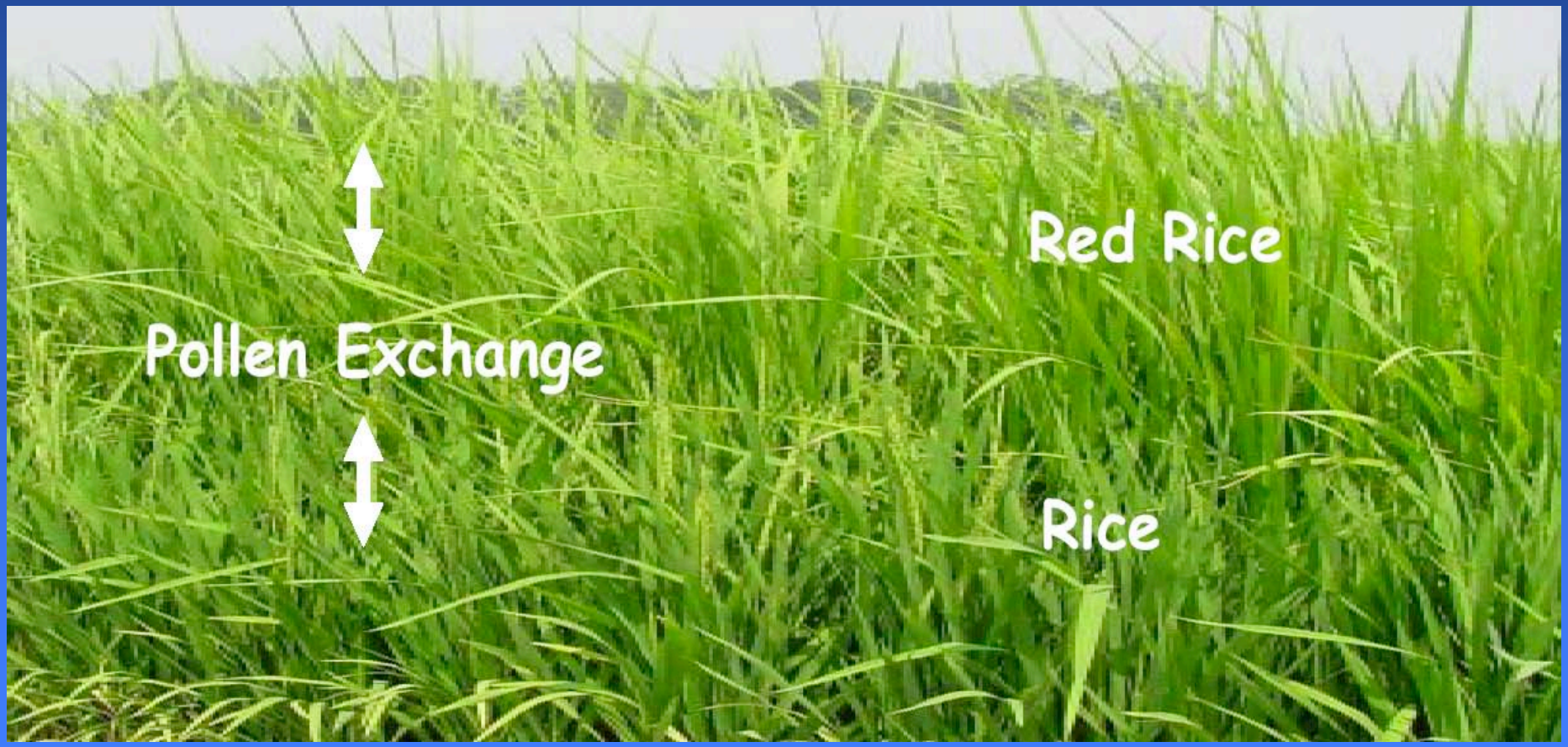
Canola

Wild radish

Buchan weed

Brassica tournefortii

Example - Gene flow from rice to weedy red rice



CORPWATCH
Holding Corporations Accountable

WORLD: 'Suicide Seeds' Could Spell Death of Peasant Agriculture, UN Meeting Told

by Haider Rizvi, OneWorld.net
January 26th, 2006

Groups fighting for the rights of peasant communities are stepping up pressure on governments to ban the use of genetically modified "suicide seeds" at UN-sponsored talks on biodiversity in Spain this week.

Genetically modified crops offer the promise of fat profits for their developers, marketers, and political supporters while threatening farmers with lean times and consumers with ill-health.

"This technology is an assault on the traditional knowledge, innovation, and practices of local and indigenous communities," said Debra Harry, executive director of the U.S.-based Indigenous Peoples Council on Biocolonialism.

The group is among organizations urging United Nations experts to recommend that governments adopt tough laws against field testing and selling Terminator technology, which refers to plants that have had their genes altered so that they render sterile seeds at harvest. Because of this trait, some activists call Terminator products "suicide seeds."

Developed by multinational agribusinesses and the U.S. government, Terminator has the effect of preventing farmers from saving or replanting seeds from one growing season to the next.

The product is being tested in greenhouses throughout the United States. Opponents fear it is likely to be marketed soon unless governments impose a ban.

"Terminator seeds will become a commercial reality unless governments take action to prevent it," said Hope Shand of the Canada-based Action Group on Erosion, Technology, and Concentration (ETC Group).

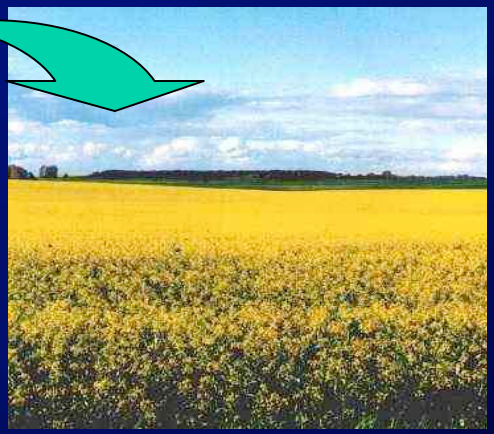
If commercialized, activists said, Terminator would force farmers to return to the market for

SOURCE: http://www.corpwatch.org/article.php?id=13178

ucbiotech.org

Consequences of gene flow from GE crops to organic crops in the field

GM canola



non-GM canola

Will an organic farmer automatically lose accreditation if his/her crop is found contaminated with a GE crop?

No.

"As long as an organic operation has not used excluded methods and takes reasonable steps to avoid contact with the products of excluded methods, as detailed in their approved organic system plan, the unintentional presence of the products of excluded methods should not affect the status of an organic product or operation."

SOURCE: AMS National Organic Program Q&A

ucbiotech.org

Capital Press, September 16, 2005

Communicate to avoid pesticide drift, winemaker says

By MATEUSZ PERKOWSKI
Freelance Writer

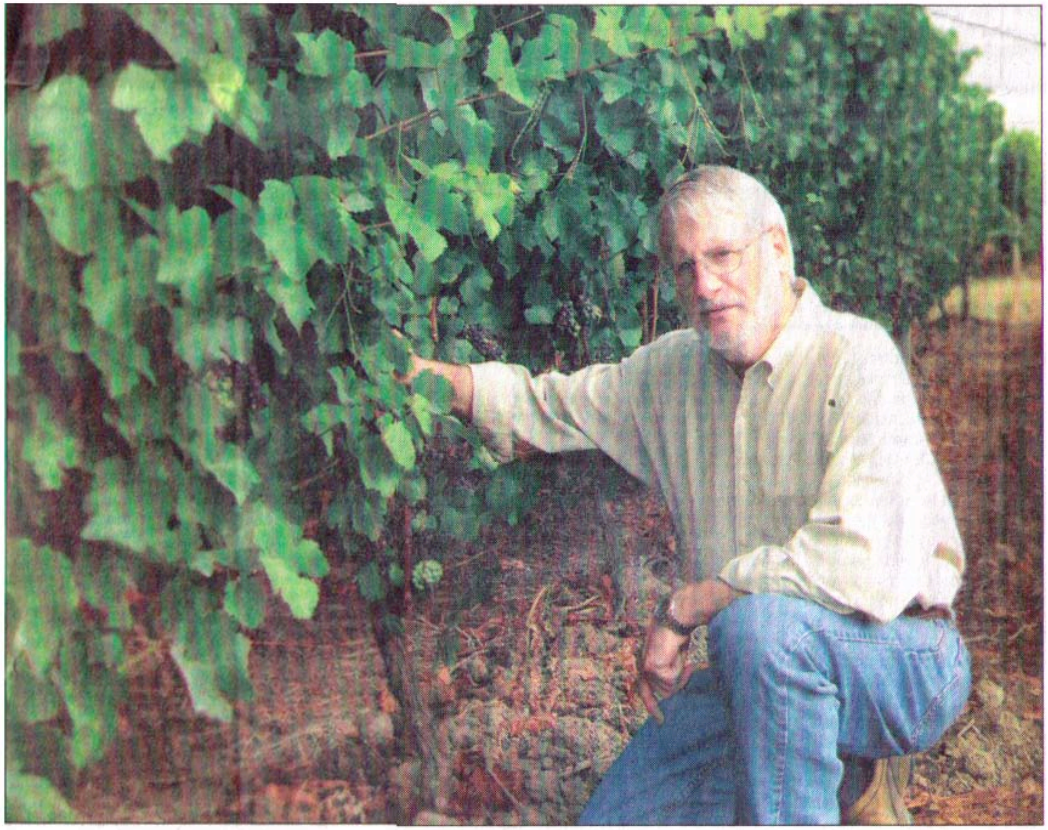
Fifteen years ago, David Adelsheim received some bad news. His vineyard manager had noticed that a section of his vineyard, located near Newberg, Ore., was producing vines with badly distorted leaves.

"Instead of being a full leaf shape, they might have been only half-a-leaf shape, or they were smaller and fanned together," said Adelsheim. All the symptoms pointed to one thing: the plants had been damaged by an herbicide.

As it turned out, a neighbor had sprayed half an acre of his land that was overgrown with blackberry bushes with a growth regulator herbicide containing 2,4-D. Aside from killing the blackberries, some of the herbicide had drifted onto the rows of grapevines growing only 15 feet away.

Roughly five acres were affected by the drift, which was about a third of Adelsheim Vineyards at the time. The first several rows were the most badly damaged, but even grapevines 30 rows down were showing some deformation. Because the neighbor had sprayed in mid-spring – after the grape bud break but prior to bloom – much of the year's crop had been aborted, and the remaining vines were too damaged to ripen any grapes.

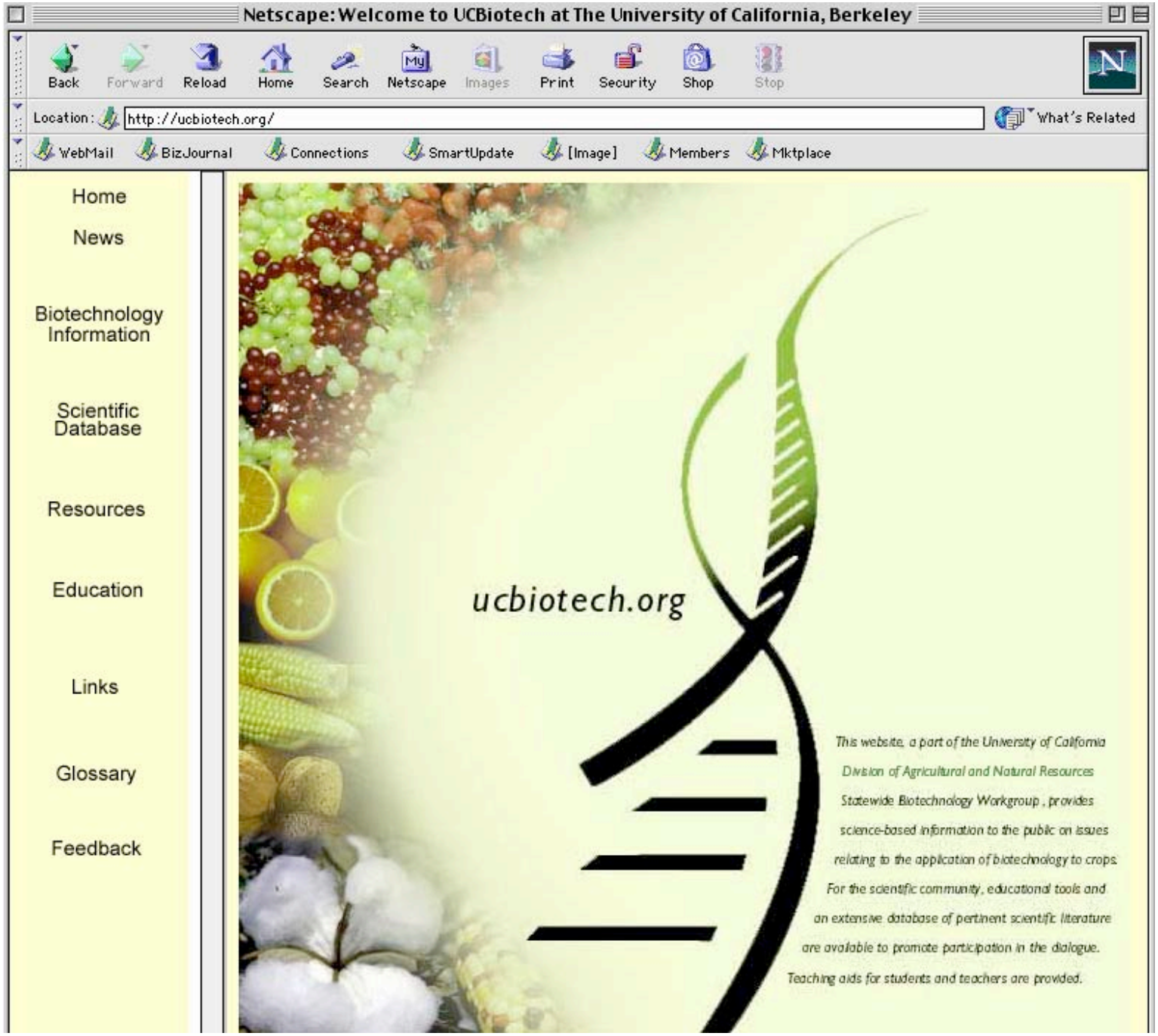
In the decade and a half since then, Adelsheim Vineyards has managed to overcome the injury caused by the incident – the company has expanded to 180 acres, and the five acres ravaged by the herbicide have largely recovered. Nonetheless, Adelsheim said the effects of the



MATEUSZ PERKOWSKI/For the Capital Press

David Adelseheim examines some grapes at his vineyards near Newberg, Ore. Fifteen years ago, herbicide drift damaged several acres of his grapevines, and Adelsheim said the affected plants have never fully recovered.

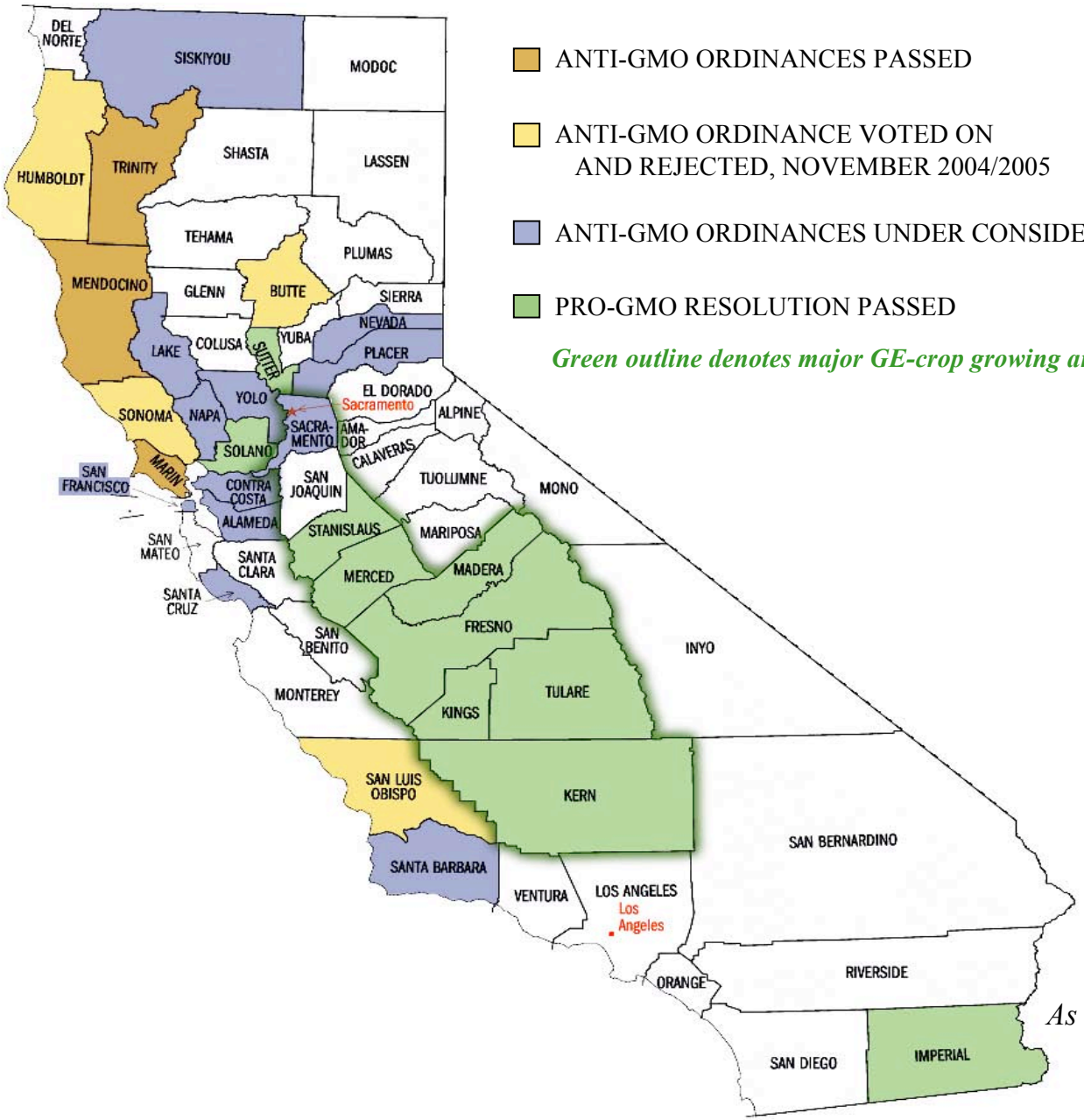

European Commission project aimed at co-existence of GE and non-GE crops
SOURCE: "Co-existence project kicked-off", European Biotechnology News, Vol. 4, 2005
ucbiotech.org


Netscape: Welcome to UCBiotech at The University of California, Berkeley
Back
Forward
Reload
Home
Search
Netscape
Images
Print
Security
Shop
Stop
Location:
http://ucbiotech.org/
What's Related
WebMail
BizJournal
Connections
SmartUpdate
[Image]
Members
Mktplace
Home
News
Biotechnology Information
Scientific Database
Resources
Education
Links
Glossary
Feedback
ucbiotech.org
This website, a part of the University of California Division of Agricultural and Natural Resources Statewide Biotechnology Workgroup, provides science-based information to the public on issues relating to the application of biotechnology to crops. For the scientific community, educational tools and an extensive database of pertinent scientific literature are available to promote participation in the dialogue. Teaching aids for students and teachers are provided.


ucbiotech.org

FOOD FIGHTS IN CALIFORNIA

County GMO Ordinances



ANTI-GMO ORDINANCES PASSED

ANTI-GMO ORDINANCE VOTED ON AND REJECTED, NOVEMBER 2004/2005

ANTI-GMO ORDINANCES UNDER CONSIDERATION

PRO-GMO RESOLUTION PASSED

Green outline denotes major GE-crop growing areas

As of 11/9/05

ucbiotech.org

March 2004 MENDOCINO
MEASURE H -2,579 signatures obtained

- "unlawful for any person, firm, or corporation to propagate, cultivate, raise, or grow genetically modified organisms in Mendocino County"

"unlawful for any person, firm, or corporation to propagate, cultivate, raise, or grow genetically modified organisms in Mendocino County"
(excludes microorganisms)

- The ban does not pertain to properties within city limits, or lands managed by State, Tribal and Federal agencies.

- At election time, no GE organisms were known to be in production in Mendocino County.

November 2004, Fresno

Passed: Board of Supervisors 5 For; 0 Against

- **Whereas, biotechnology has the potential to greatly improve the health, nutrition and**

County of Fresno affirms the right for farmers and ranchers to choose to utilize the widest range of technologies available to produce a safe, healthy, abundant and affordable food supply, and that the safe, federally regulated use of biotechnology is a promising component of progressive agricultural production.

and ranchers to choose to utilize the widest range of technologies available to produce a safe, healthy, abundant and affordable food supply, and that the safe, federally regulated use of biotechnology is a promising component of progressive agricultural production.

Nonexhaustive List of Issues with GMO Foods

Food Safety Issues

- Create new allergens
- Activate naturally occuring toxins or create new ones
- Removal of existing allergens and antinutritionals

- Adversely affect the nutritional quality of foods
- Enhance the nutritional quality of foods

- Vegetarian and religious issues with GMOs
- Labeling
- Increased antibiotic resistance in intestinal flora
- Horizontal transfer of DNA from plants to humans through foods
- Unknown, unanticipated risks from GMO consumption
- Trust in regulatory agencies

Nonexhaustive List of Issues with GMO Foods

Environmental Issues

- Unintended adverse consequences for beneficial insects
- Unintended beneficial consequences for beneficial insects

- Soil residuals of bio-engineered pesticides
- Soil residuals of nonengineered pesticides used in the absence of engineered varieties

- Degradation of the environment because of GMOs, *e.g.*, residuals, chemical dependence
- Degradation of the environment because of current agricultural practices, *e.g.*, tilling, fertilizers, pesticides
- Improved environmental situation with GMOs, *e.g.*, reduced phytic acid, phyto and bioremediation

- Herbicide-resistant weeds as a result of GMOs, "superweeds"
- Herbicide-resistant weeds from conventional practices in absence of GMOs