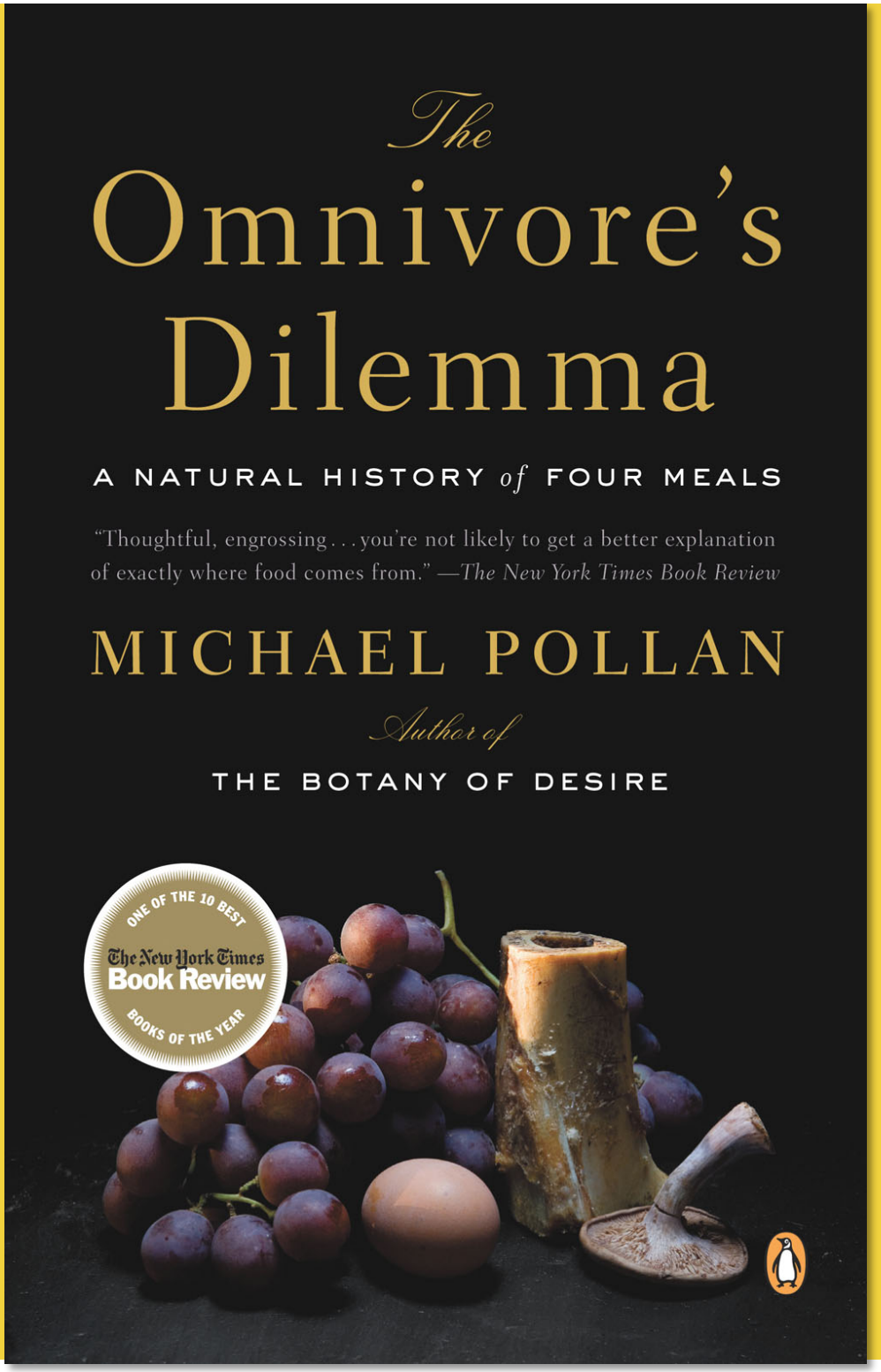
Can Biotechnology Help Solve "Omnivore's Dilemma"?

Peggy G. Lemaux
Dept Plant and Microbial Biology
UC Berkeley



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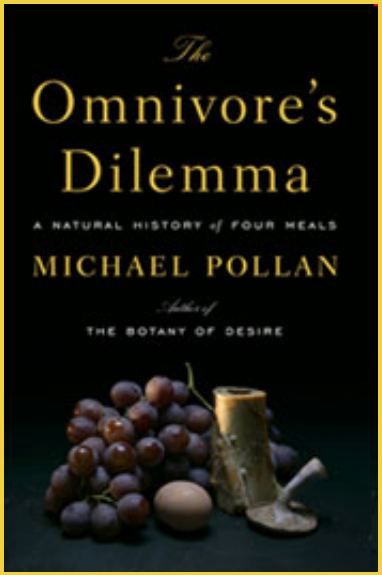

What is "Omnivore's Dilemma"?

"If humankind has evolved beyond the point of subsistence eating, then we should also be smart enough to make healthy, sustainable choices with our food." (http://fooddestination.blogspot.com/)

Pollan: The way we eat represents our most profound engagement with the natural world. He is …appalled by modern industrial food production, and how it separates us from the sources of our food.

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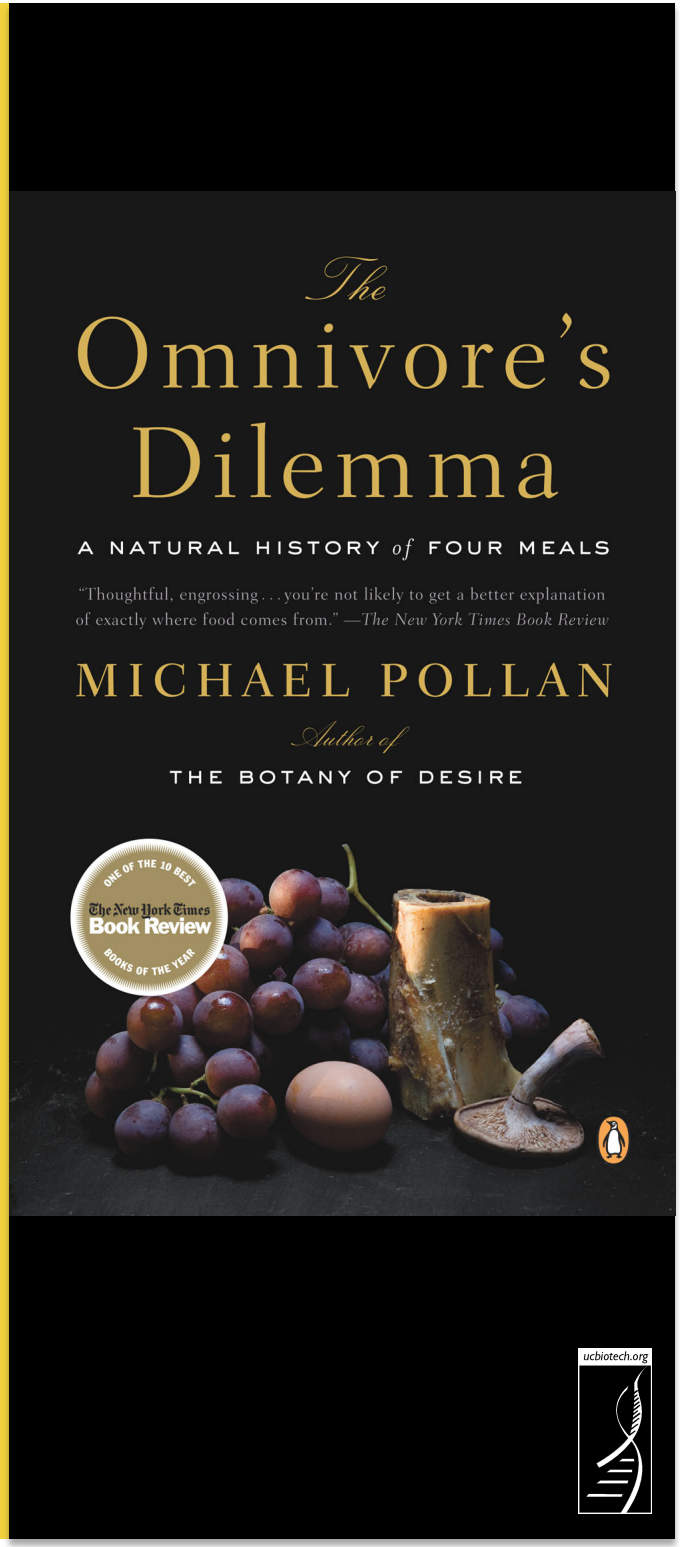
Some Important Messages:

- Eat less meat
- Support farmer's markets
- Cook at home
- Eat less processed foods
- Get junk food out of school lunch programs
- Read labels on your foods
- Subsidies for corn have impact on foods people eat

Some Questionable Messages:

- Organic farming would result in dramatic improvements in farming
- GE crops and foods should be avoided in effort to improve food production



Capital Press
Agriculture Newspaper

Consumers caught between pull of Green Revolution, organic practices

By CARL SAMPSON December 9, 2009

As the world population spirals toward 9 billion… a question weighs heavily on the leadership at the United Nations and elsewhere: **How will we feed all of those hungry mouths?** Already an

On one side, disciples of Norman Borlaug, who died earlier this year, maintain the only way to feed the world is to use the latest technology. That means developing drought- and pest-resistant, genetically modified seeds and growing them using the latest high-efficiency practices...

Then came the Green Revolution. Spearheaded by Norman Borlaug, who helped develop high-

At the other end of the spectrum are people like author Michael Pollan. As a proponent of the organic movement, Pollan believes modern agriculture is a dead-end street. He describes it as "unsustainable" and believes that only by reverting to older methods and sending "10, 20, 30 million" more Americans to work on farms can we hope to feed ourselves the right way -- that is, without the use of genetically modified seed and chemical fertilizers.

that is, without the use of genetically modified seed and chemical fertilizers.

SOURCE: Capital Press, December 10 2009

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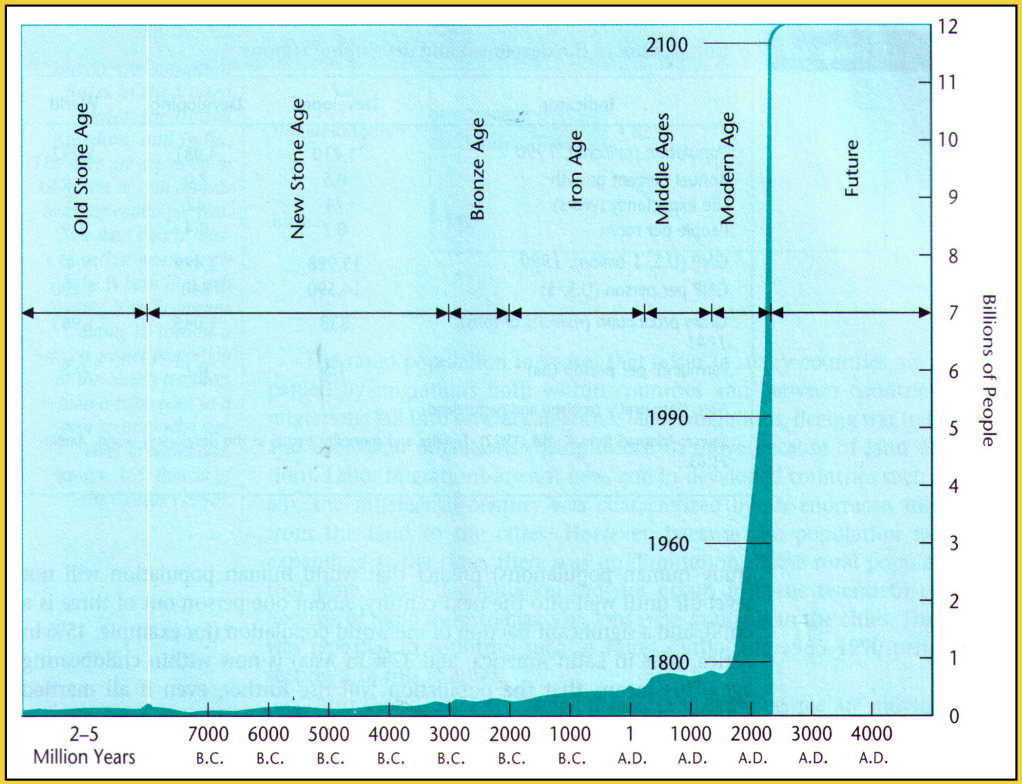
These points bring up issues of population explosion and how our food production system evolved and why.

History of Population Growth

2,000 years ago- there were 300 million people in the entire world – approximately same number as in the U.S. today!



Now ~ 6.5 billion, which means that in 0.1% of human history (2000 yrs), population increased 20-fold

2000 years ago, 500 people were added to world each day. Today it is 200,000!

SOURCE: "Plants, Genes, and Agriculture", Chrispeels, M.J. and Sadava, D.E. (editors) 1994.

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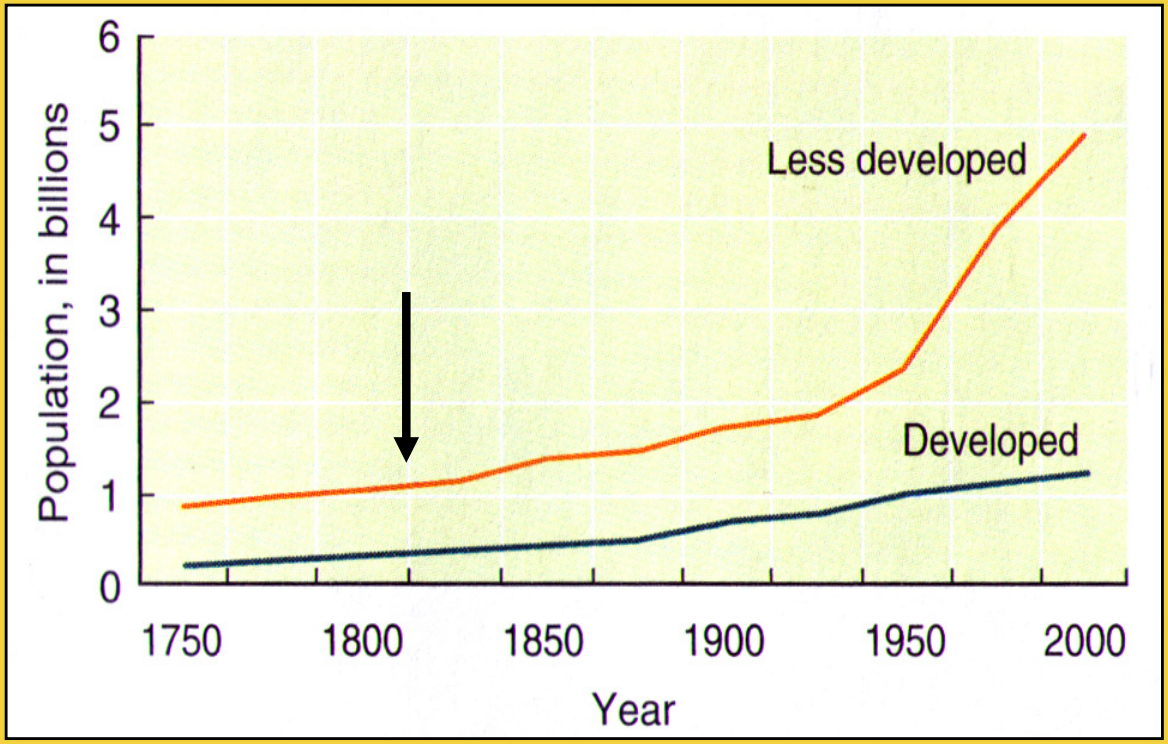
In early years, during the hunting/gathering era, there were moderately high birth and death rates

~10,000 years ago, agriculture began to replace hunting/gathering



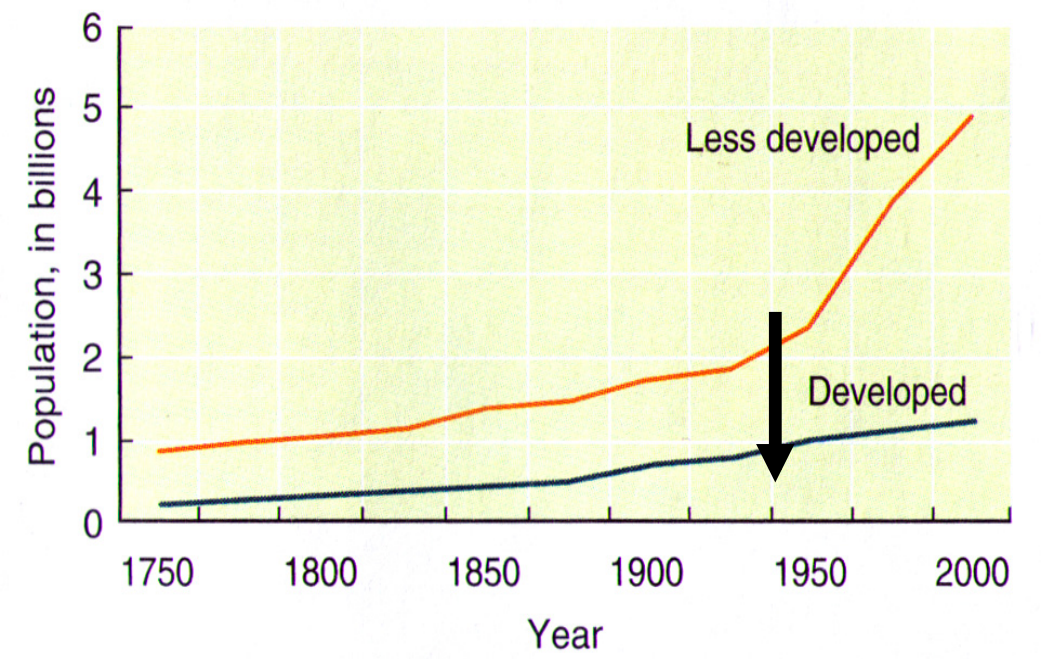
A reliable food supply led to dramatic birth rate increase and death rate decrease

From A.D.1 – 1800: high birth rate compensated by famine, war, disease keeping population down

SOURCE: "Plants, Genes, and Crop Biotechnology", Chrispeels, M.J. and Sadava, D.E. (editors), 2003

In last 80 years dramatic increase in population

WHY?



Food production more dependable; improved transportation

Rising income meant more people could buy food

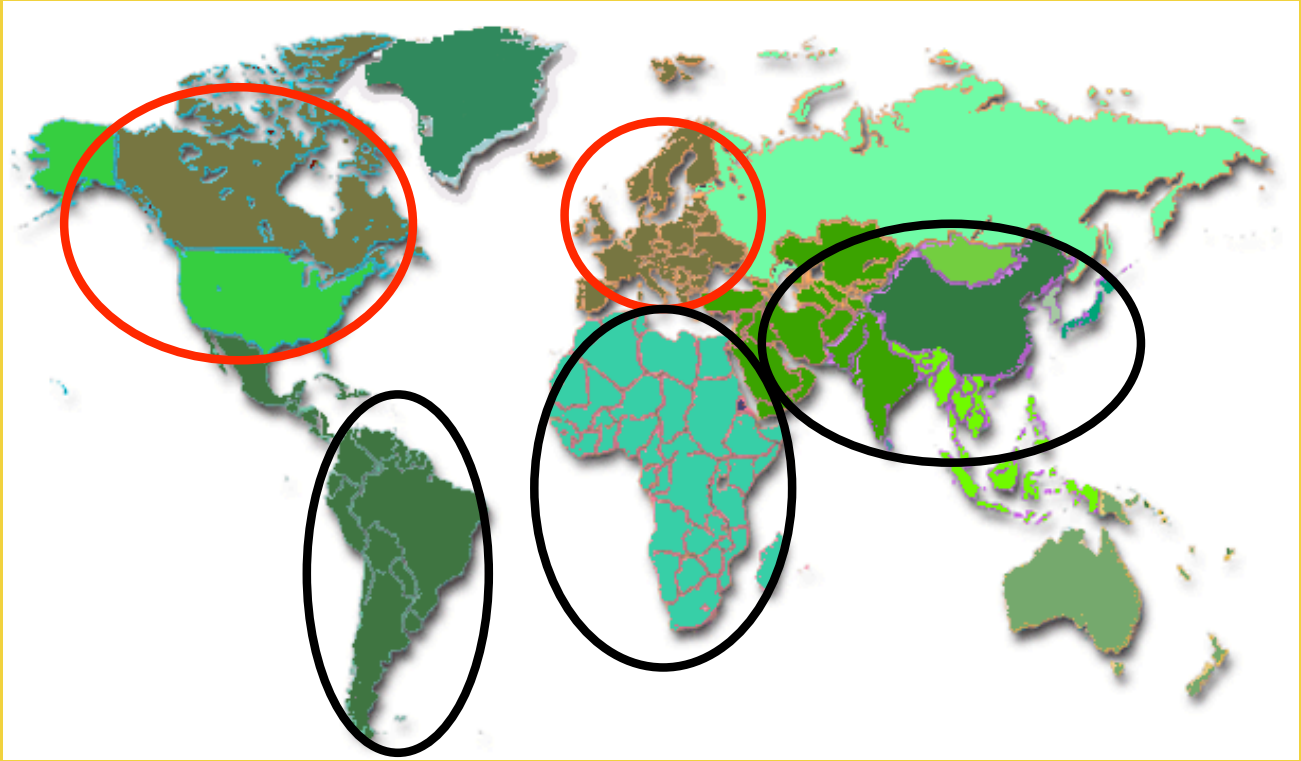
Improved housing/ public hygiene led to decrease in infectious disease

Medical advances: disease agent identification and treatments to control diseases

SOURCE: "Plants, Genes, and Crop Biotechnology", Chrispeels, M.J. and Sadava, D.E. (editors), 2003

In Europe and North America, industrialization occurred over several hundred years, giving food production time to adjust.

In Asia, Africa, Latin America, improvements occurred "overnight", in some cases during the last 50 years. so populations grew extremely rapidly, causing problems with agricultural production.



Comparison of developed and less developed regions

Indicator	Developed	Less Developed	World	
Population (millions), 2002	1,193	4,944	6,137	4X
Annual percent growth	0.1	1.6	1.3	16X
Life expectancy, years	75	64	67	
People per room	0.7	2.4	1.9	
Mortality under 5, per 100 births	0.8	6.1	5.6	7.6X
GNP per person, US$	20,520	3,300	6,650	
Grain production, millions of tons	810	1,259	2,069	1.5X
Farmland/person, hectares	1.5	0.6	0.7	

Population growth higher in less developed countries, but mortality is higher so population increases

Total grain production higher in less developed but per person production decreases with less food per person

SOURCE: "Plants, Genes, and Crop Biotechnology", Chrispeels, M.J. and Sadava, D.E. (editors), 2003

Not only is there pressure to produce a lot of food but the types of foods people want also affect agricultural production.

Comparison of the diets in India and United States

Food	Source of calories		Source of protein	
	India	United States	India	United States
Cereals, starchy foods	65%	25%	64%	21%
Sugars	6	12	—	—
Beans, lentils	10	4	18	3
Fruits, vegetables	2	6	1	4
Fats, oils	4	19	—	—
Milk, milk products	7	14	11	26
Meat, poultry, eggs, fish	6	20	6	46

Sources: Data from Food and Agriculture Organization and U.S. Department of Agriculture.

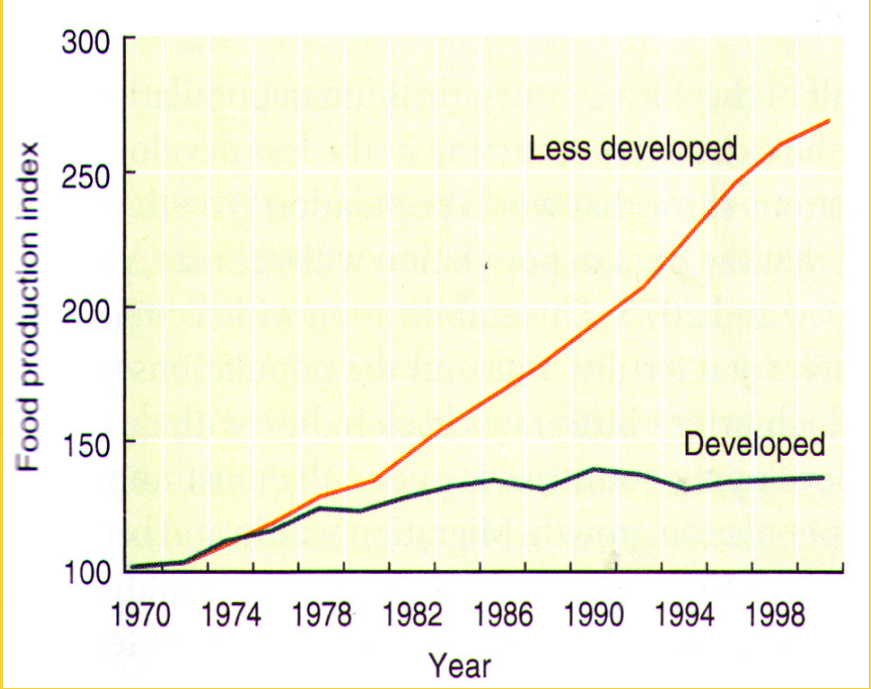
In developing countries, protein needs have historically been met with cereals and beans but now they shift to milk and meat - which affects agricultural production because….

Energy transfer efficiency from plant to humans via the cow is ~1%.

SOURCE: "Plants, Genes, and Agriculture", Chrispeels, M.J. and Sadava, D.E. (editors) 1994.

Increases in population have been matched with increases in the food supply. How has this happened?

Overall food production in developing and developed countries



Increase in land area used for food production from 1860 to 1978 but since 1978 amount cultivated has remained steady.

Since population increased by 1.7 billion, amount of cultivated land per person has dropped 25%

SOURCE: "Plants, Genes, and Crop Biotechnology", Chrispeels, M.J. and Sadava, D.E. (editors), 2003

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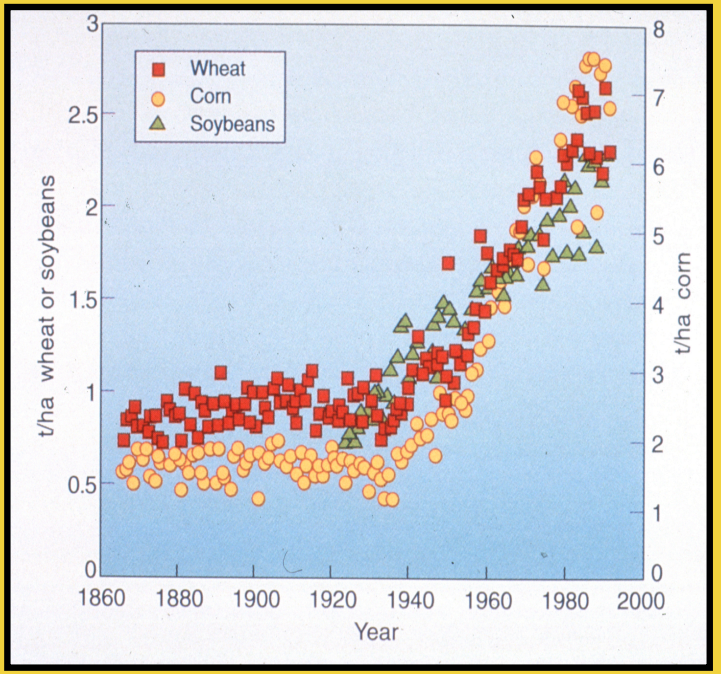
How was it possible to feed more people with less land?

Productivity per land unit improved significantly - otherwise Malthus would have been right and massive starvation would have occurred.

There are 300 different plants grown for food worldwide, but 24 supply nearly all of our food; 8 supply 85% and 3 (corn, wheat, rice) supply 50%.



Acreage used for these crops has not risen in 50 years, but total food productivity rose dramatically, particularly in developed countries.

SOURCE: "Plants, Genes, and Crop Biotechnology", Chrispeels, M.J. and Sadava, D.E. (editors), 2003

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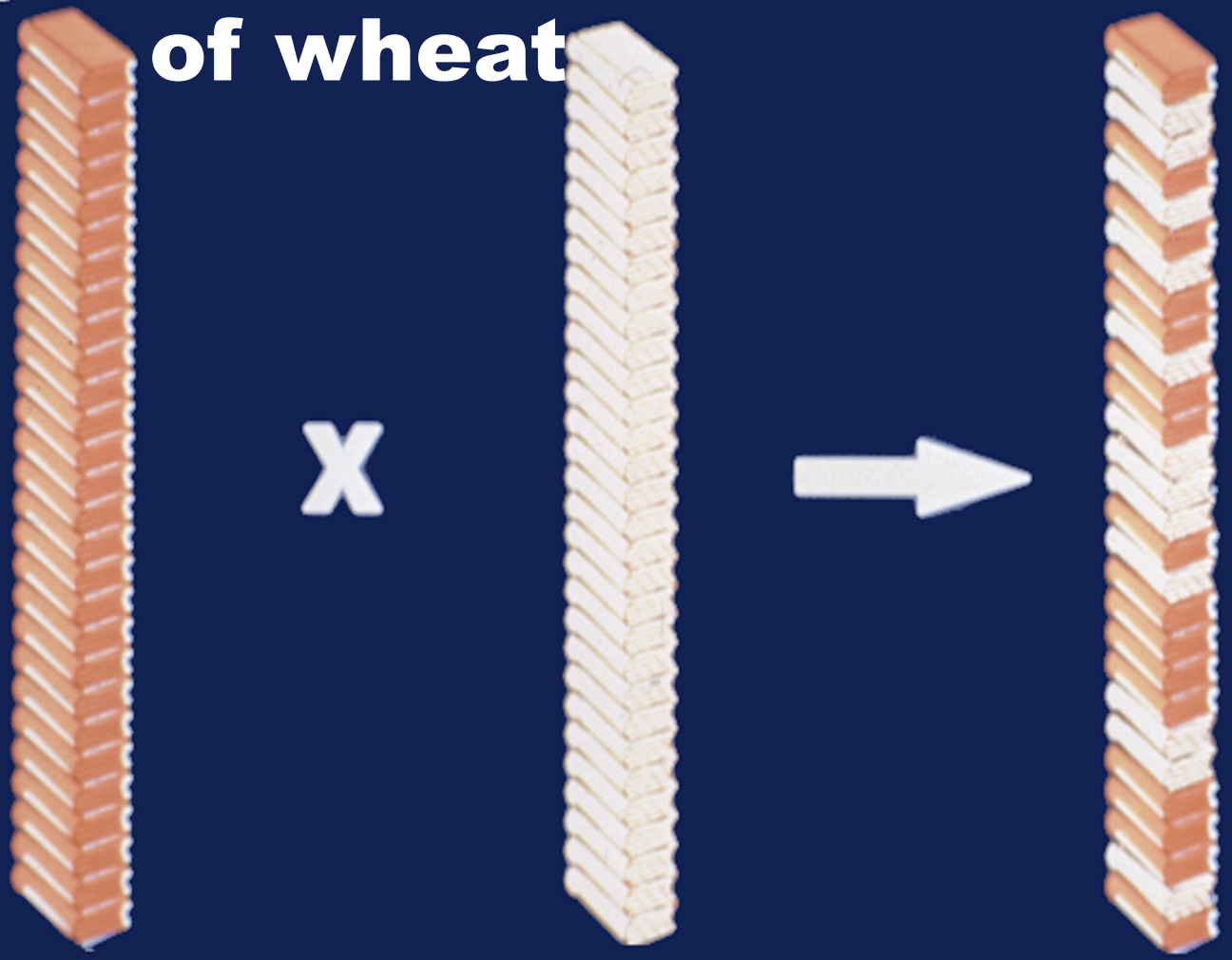
How has food productivity increased?

Improved farming methods and…

Using genetics to improve crop productivity

One way to use genetic is crossing different varieties – each with different desirable characteristics – to create a new variety with the best traits of both varieties

Hybridization or cross breeding of wheat



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

Random retention of information from each parent

1700 books (or 1.7 million pages)

This is what is termed “classical breeding”

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	1930	2009
% of people involved in farming:	21%	~0.7%
Number of farms:	6,295,000	2,200,000
Average acreage per farm:	157	418

Productivity of average U.S. farmer…

In 1930 fed 10
In 1960 24
In 1990 100
In 2009 155

Breeding improved varieties along with more efficient farming practices helped American farmers increase productivity

http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_1_US/st99_1_063_063.pdf

http://prb.org/Datafinder/Geography/Data.aspx?category=6&region=72&region_type=3

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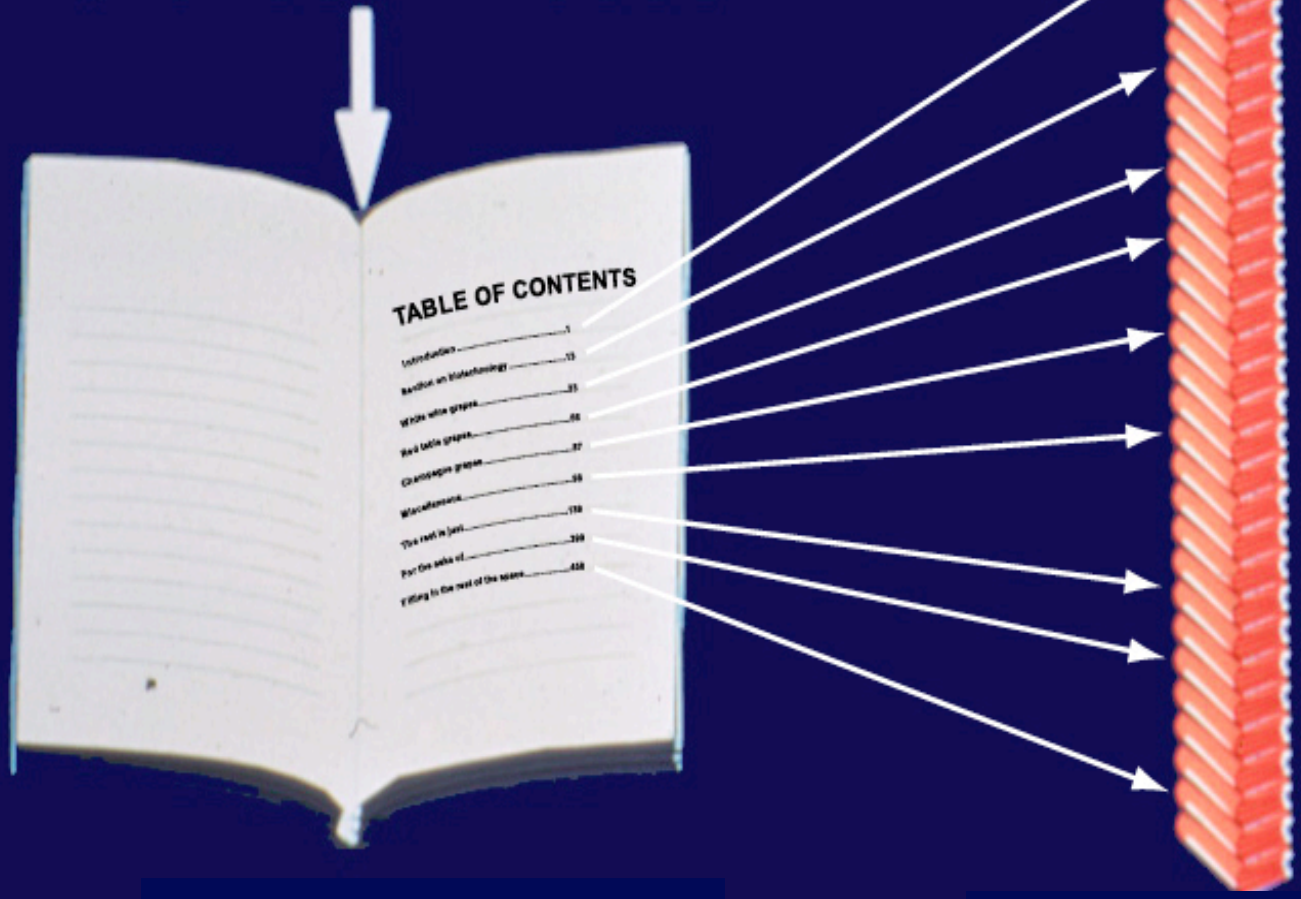
Another tool involves using genomic information for crops

Table of contents for genes in wheat

...CTGACCTAATGCCGTA...



By "reading" entire genome, information can be used for what is termed, "Marker-Assisted Breeding"

Genomics

1700 books (or 1.7 million pages)

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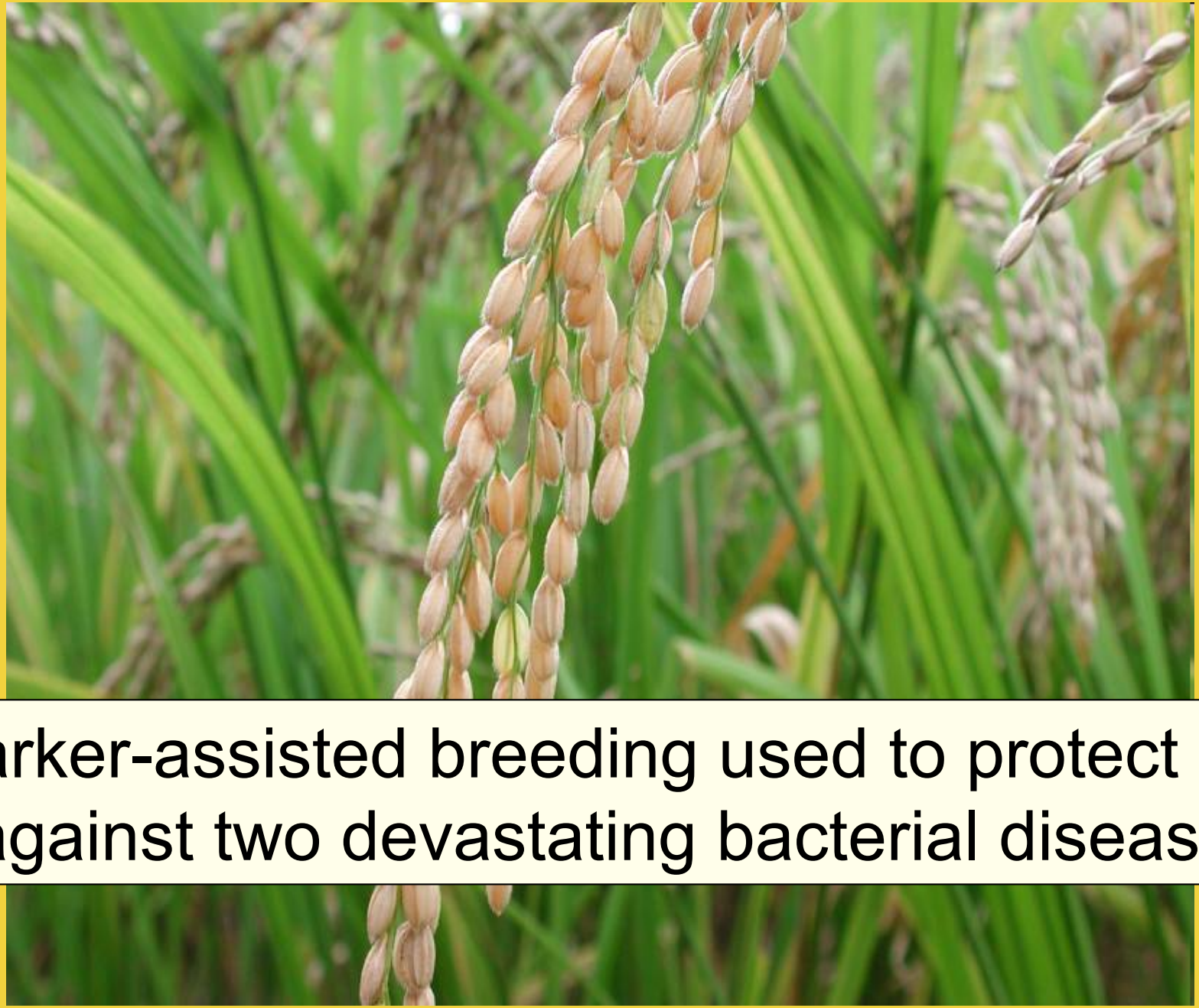

Marker-assisted breeding used to protect rice against two devastating bacterial diseases

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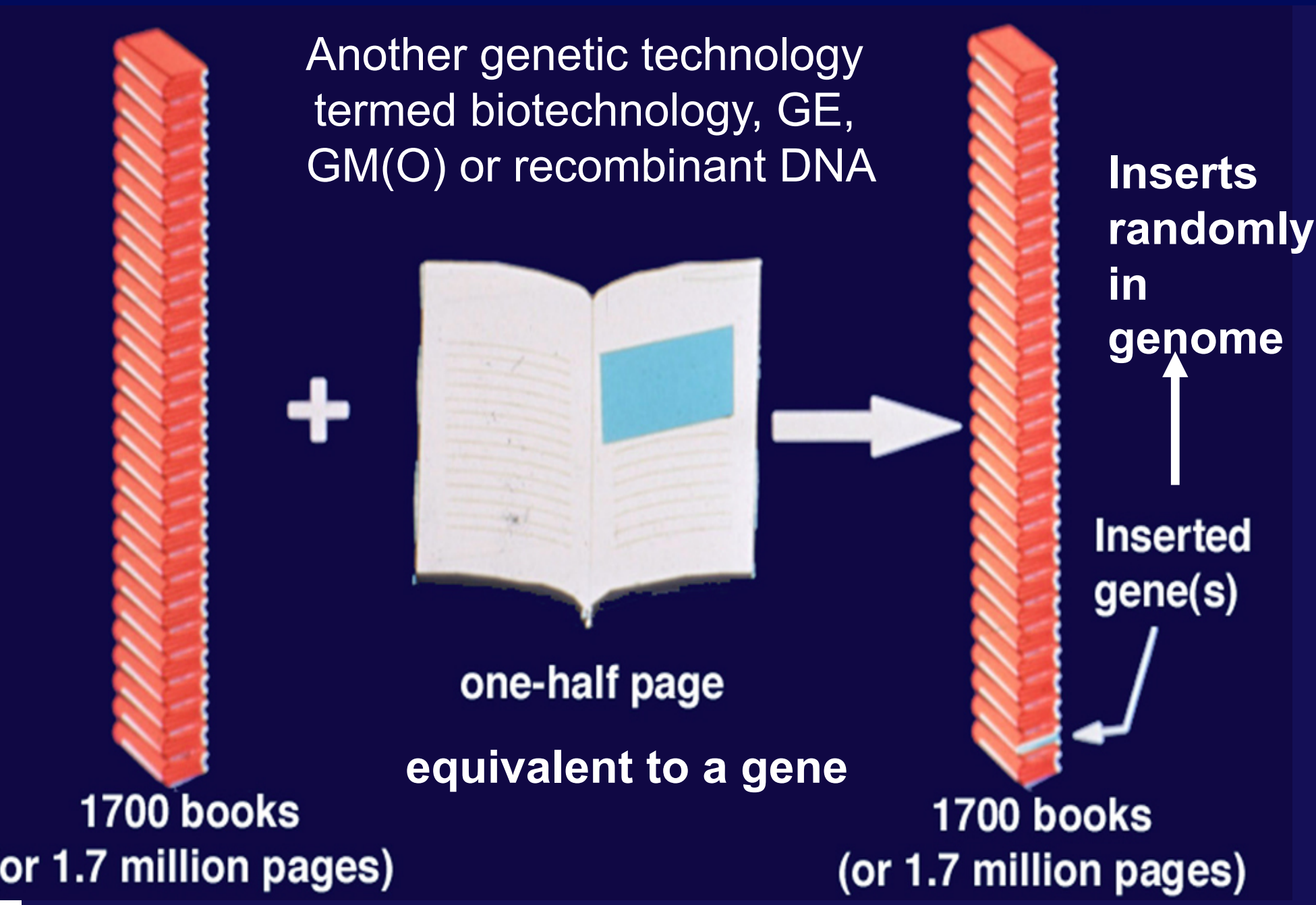
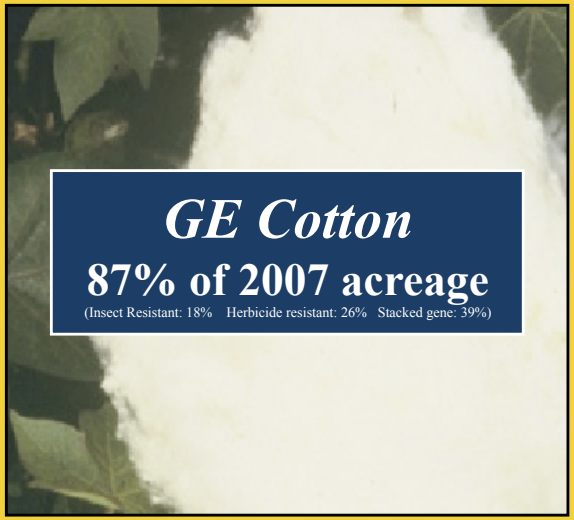
Genetic Engineering Technology

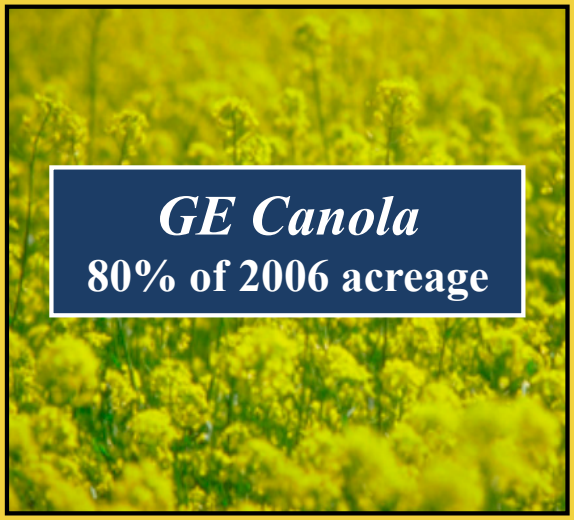


GE Soybean
91% of 2007 acreage
(Herbicide resistant: 89%)

What's in the commercial field in the U.S.?

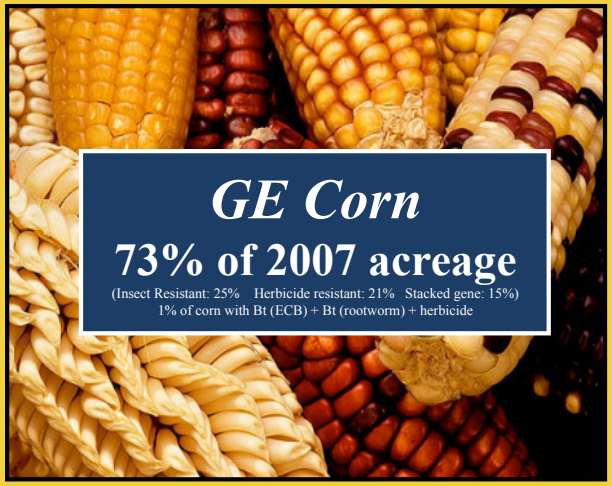


GE Cotton
87% of 2007 acreage
(Insect Resistant: 18% Herbicide resistant: 26% Stacked gene: 39%)



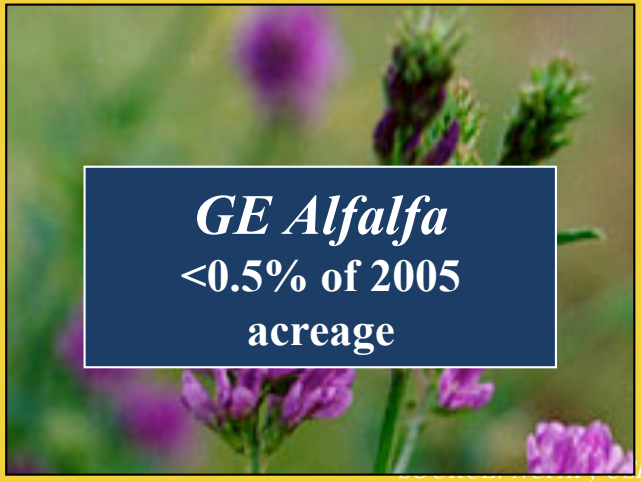
GE Canola
80% of 2006 acreage

But only a few traits



GE Corn
73% of 2007 acreage
(Insect Resistant: 25% Herbicide resistant: 21% Stacked gene: 15%)
1% of corn with Bt (ECB) + Bt (rootworm) + herbicide

GE Sugar beet
95% of 2009 acreage
(Source: Capital Press, 2/8/10)



GE Alfalfa
<0.5% of 2005 acreage

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USDA ERS


Bollgard Cotton™
Engineered for insect resistance using gene from naturally occurring bacterium
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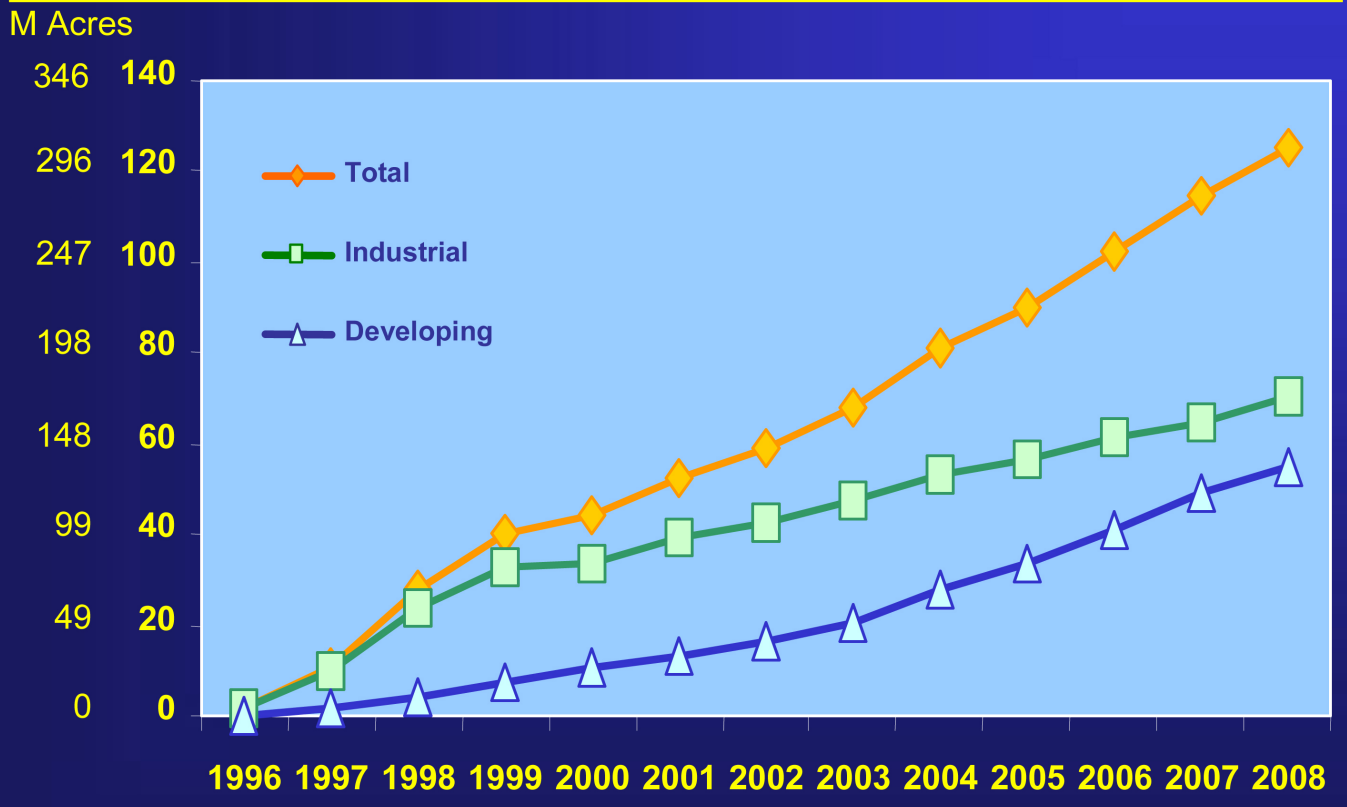
Roundup Ready ™

Engineered with bacterial gene to tolerate herbicide

Are GE crops being grown in other countries?

Global Area of Biotech Crops, 1996 to 2008: Industrial and Developing Countries (M Has, M Acres)



Source: Clive James, 2009

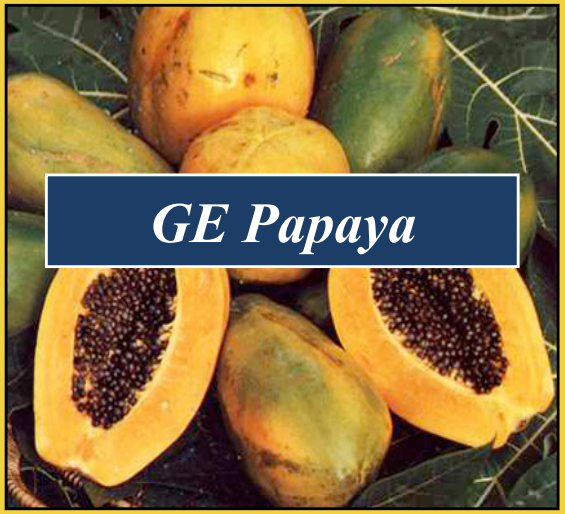
482,812 square miles worldwide in 2008 (equal to combined areas of CA, TX and NY) in 25 industrial and developing countries

But the variety of GE crops is limited.

25 industrial and developing countries in order of acreage:

United States, Brazil, Argentina, India, Canada, China, Paraguay, South Africa, Uruguay, Bolivia, Philippines, Australia, Burkina Faso, Spain, Mexico, Chile, Colombia, Honduras, Czech Republic, Portugal, Romania, Poland, Costa Rica, Egypt, Slovakia.

Only a few whole GE foods are on the market in the U.S.



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Why Do Farmers Adopt GE Crops in Developed Countries?

Expected profitability plays big role in farmers' decisions to adopt new innovations and GE varieties have had positive economic impacts.

Although current GE crops are not engineered for higher yield *per se*, increased yields have occurred due to protection from biotic and abiotic stresses.

Improves ease of farming – more options for disease and weed control.

Why Do Farmers Adopt GE Crops in Less Developed Countries?

"Economic evidence does not support misconception that transgenic crops only benefit large farms; evidence indicates technology might actually be 'pro-poor."

(Ruttan VW 2004. *Intl J Biotechnol 643-54*)

What does "pro-poor" mean?

How can this technology be pro-poor?

Evidence for Bt Cotton Gains

Bt cotton in:

- **United States yield increase 0 – 15%**
- **China yield increase 10%**
- **South Africa yield increase 20%-40%**
- **India yield increase 60 – 80 %**

Ref: : Qaim M and Zilberman D. 2003. **Science 299:900-902**

Another study, using data collected by researchers on field trials of 9000 farming families in India, found a 45-63% higher yield with Bt vs. nonBt cotton.

Ref: Bennett *et al*., 2006. *Rev Agric Econ* 28: 59-71

Reason for difference: Small-scale farmers suffer bigger pest-related yield losses due to technical and economic constraints

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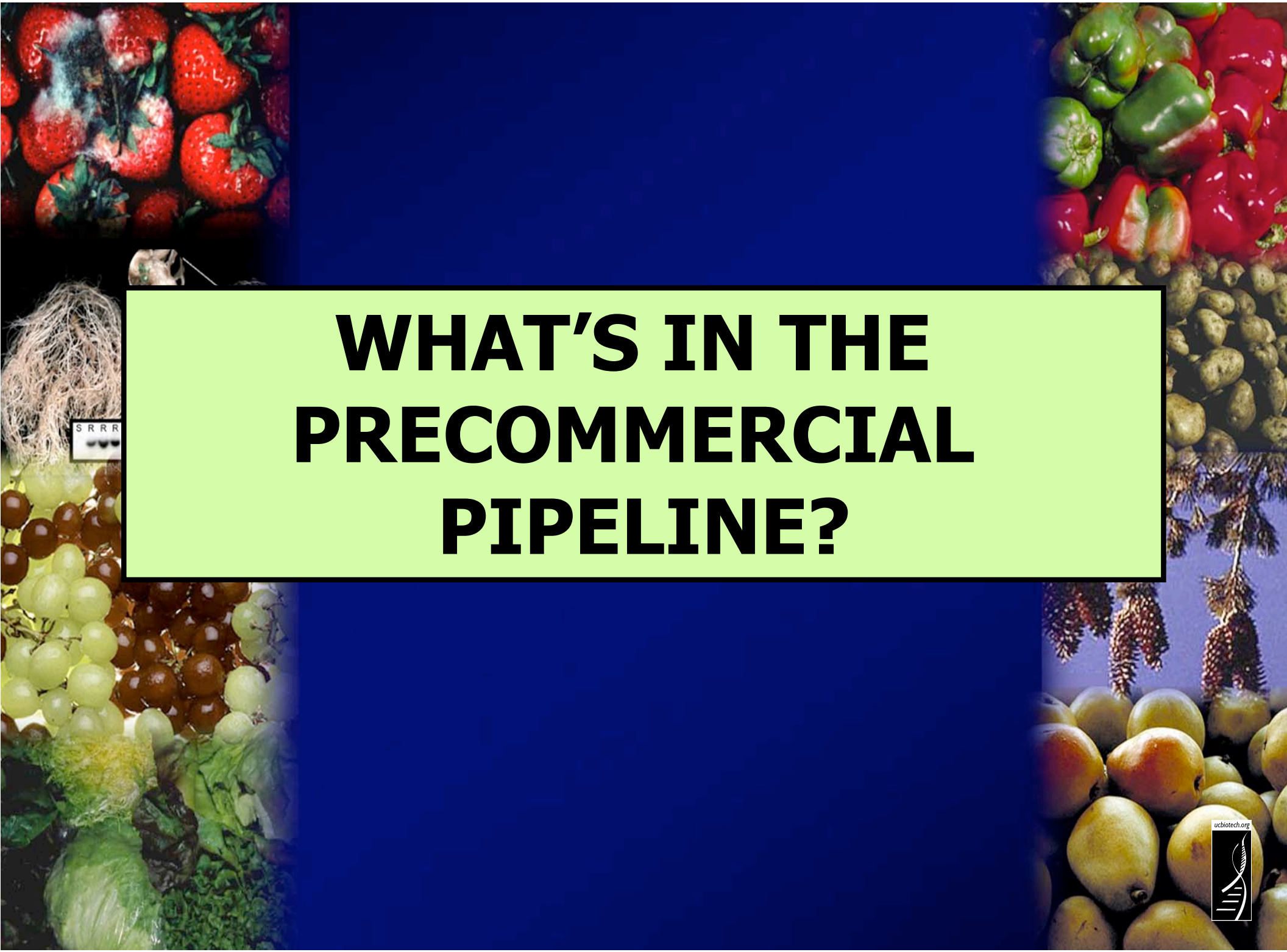
WHAT'S IN THE PRECOMMERCIAL PIPELINE?
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GE grape root stocks engineered for protection against fanleaf virus:
field tested in northern France

SOURCE: USDA Foreign Agricultural Service. 2005. EU-25: GMO trials on grape wine given go-ahead in France. Report E35183

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Plum trees genetically engineered for resistance to plum pox

SOURCE: Information Systems for Biotechnology, June 2006. APHIS petition (http://www.aphis.usda.gov/brs/aphisdocs/04_26401p.pdf); image courtesy of http://www.forestryimages.org

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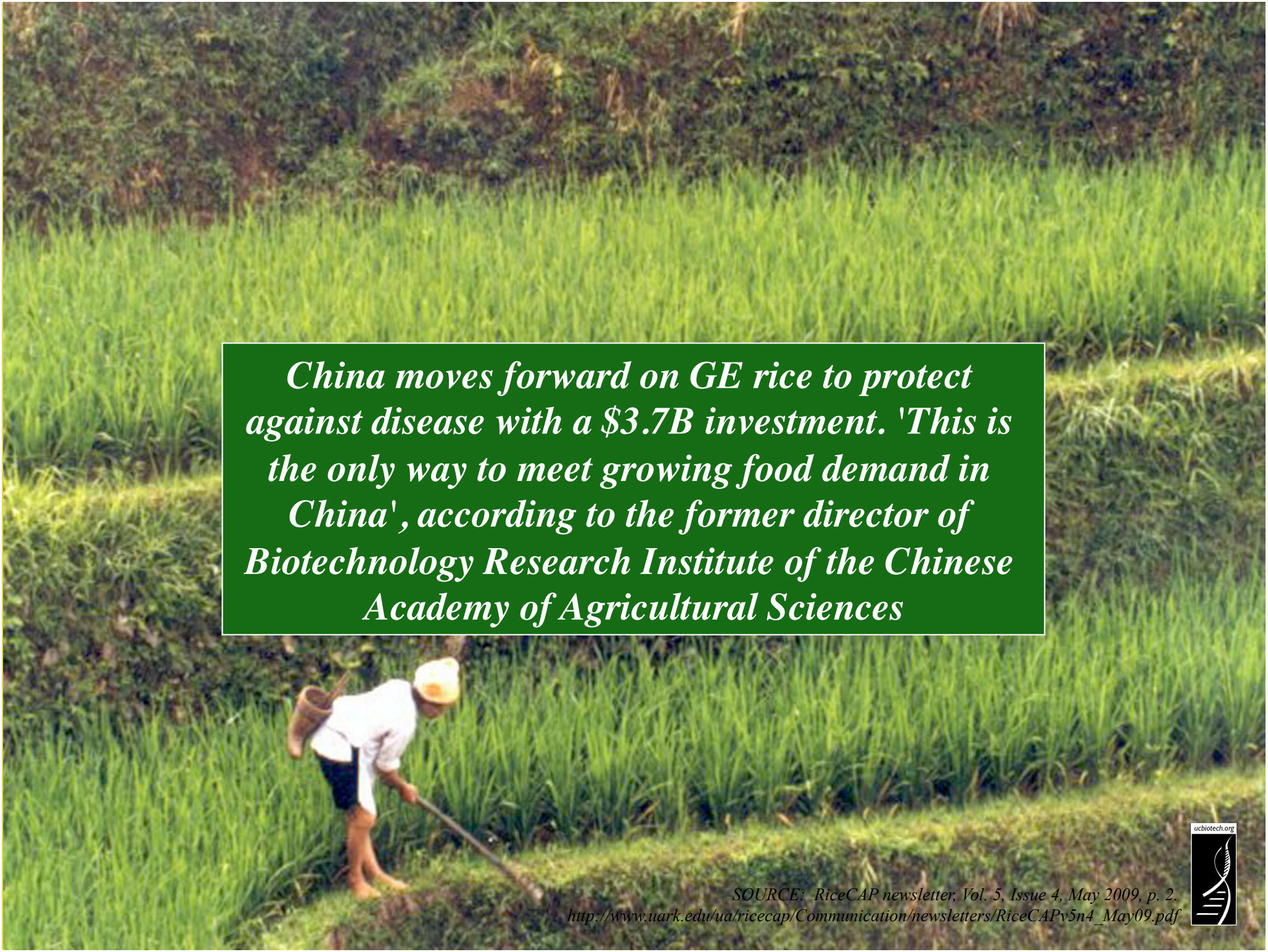

SOURCE: RiceCAP newsletter, Vol. 5, Issue 4, May 2009, p. 2.
http://www.uark.edu/ua/ricecap/Communication/newsletters/RiceCAPv5n4_May09.pdf

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Maize photosynthesis gene introduced in rice boosts yields by 35%
SOURCE: Los Banos Philippines, April 2, 2000 A.F.P.
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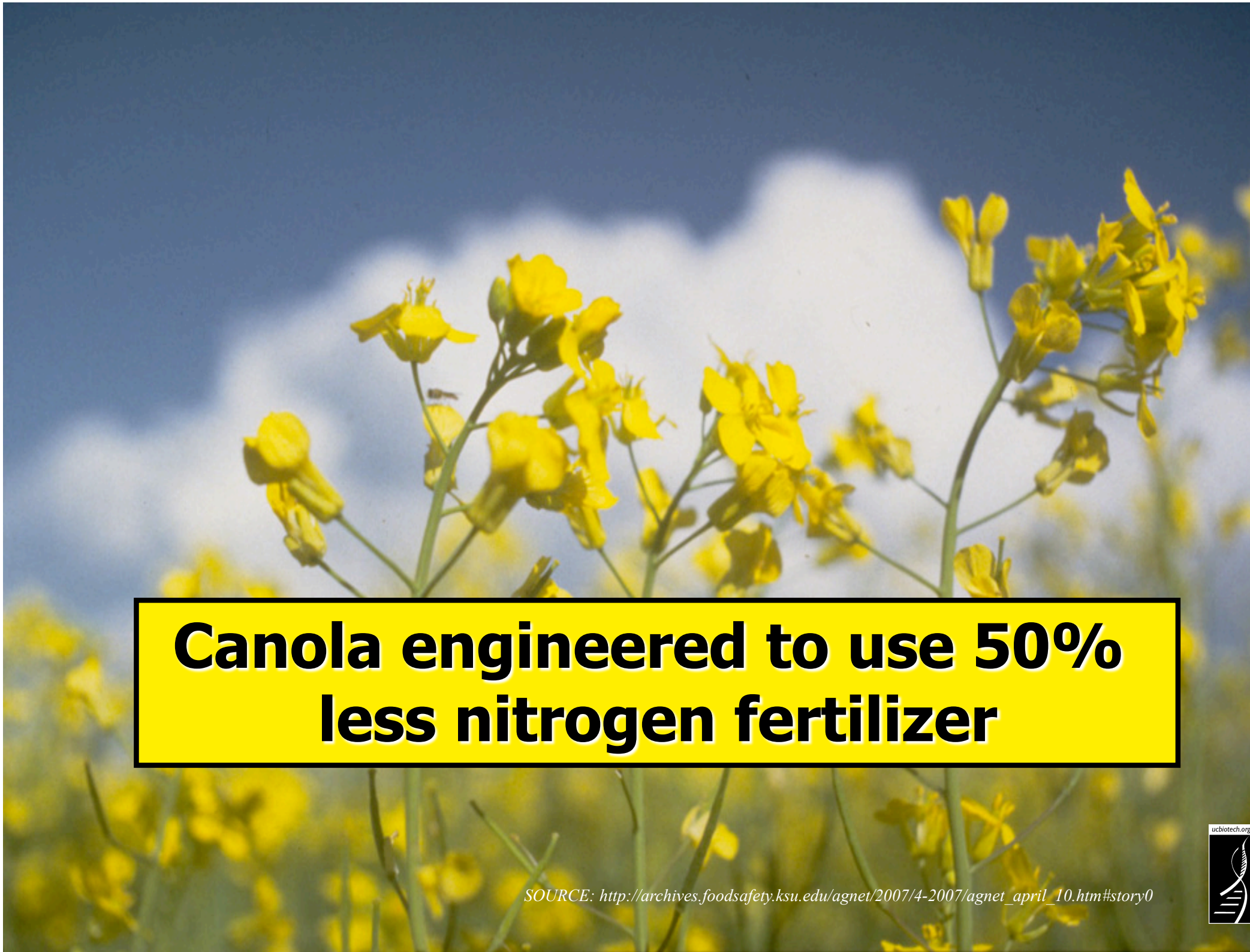
Canola engineered to use 50% less nitrogen fertilizer
SOURCE: http://archives.foodsafety.ksu.edu/agnet/2007/4-2007/agnet_april_10.htm#story0
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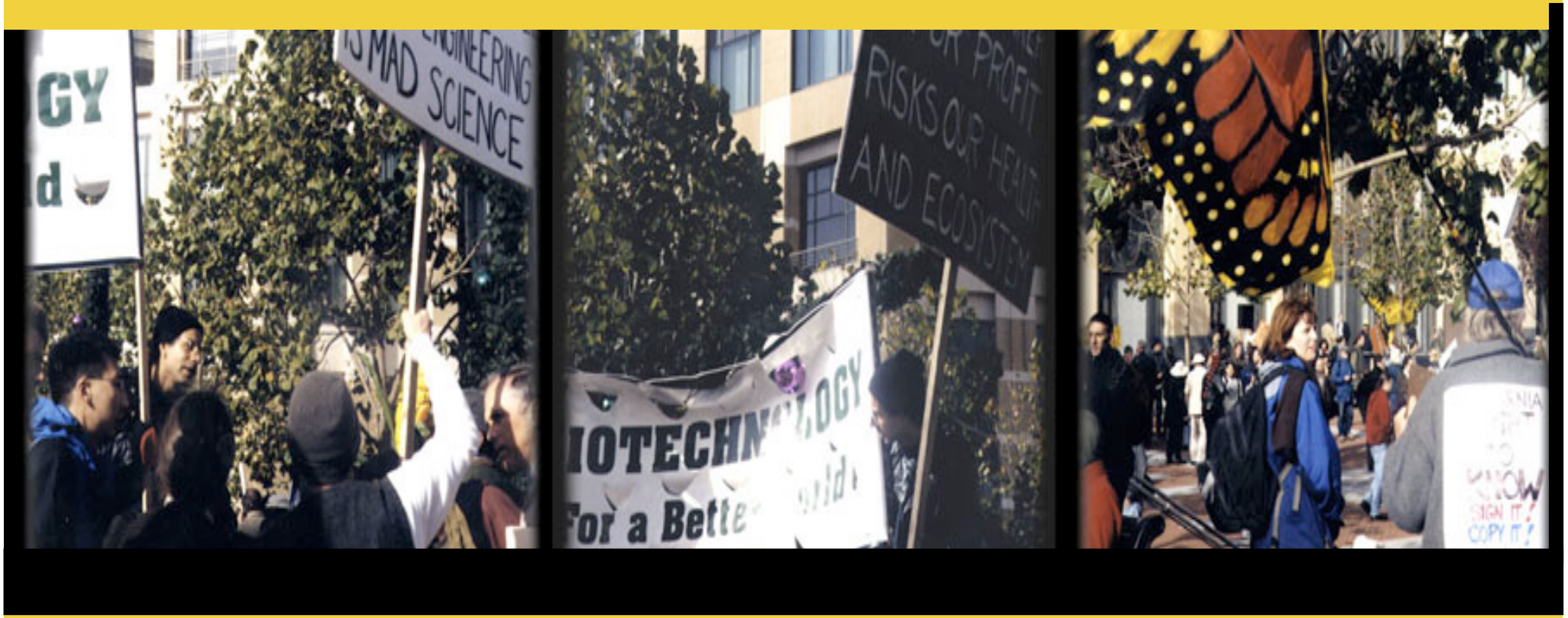
Given What We Have Seen, Can Biotechnology Help Solve Some Issues Raised in Omnivore's Dilemma?



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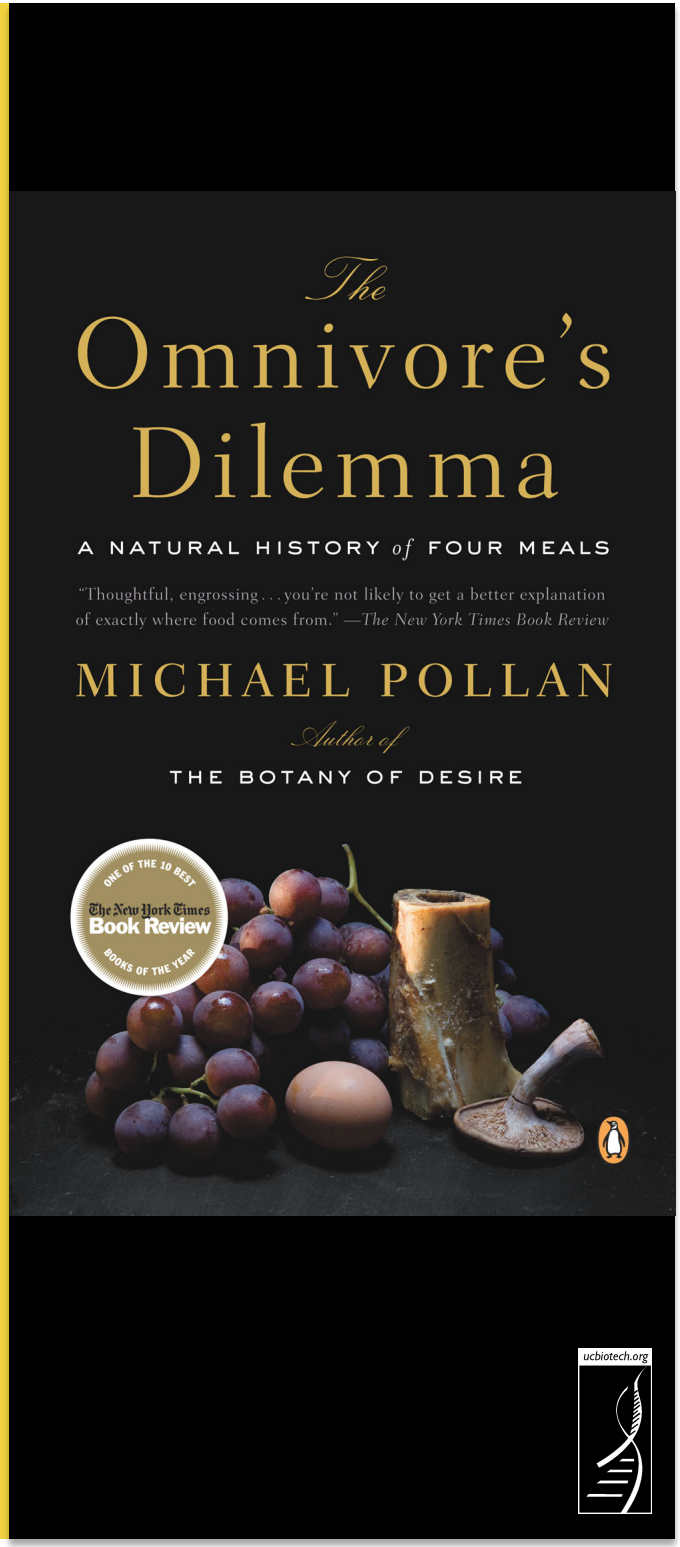

Organic Agriculture

Often seen as either/or…"big ag" vs. "little ag"

SOURCE: "Farmers must define true sustainability", Capital Press, January 29, 2009. http://capitalpress.info/main.asp?SectionID=75&SubSectionID=767&ArticleID=48313

What Exactly Is Organic Agriculture? It is a production system that…

- Places a priority on health of crops, animals, farmers, environment, and consumers
- Focuses on improving soil fertility through use of organic matter and cover crops
- Supports and enhances an abundance of beneficial insects
- Doesn't use synthetic pesticides, or fertilizers
- GE crops can't knowingly be cultivated in organic farming
- Must have 3 years with no prohibited material and be inspected on an annual basis by a USDA accredited certifier to be certified organic

P. Ronald UC Davis

From NOP preamble…

- **Organic Production is a <u>PROCESS</u> certification NOT a <u>PRODUCT</u> certification – it allows for Adventitious Presence (AP) of certain excluded methods.**

So, can't organic, conventional and GE cropping systems co-exist?

Theoretically, yes but…

"…make zero presence of experimental GE crops in food and feed your management goal, and gear your implementing regulations to achieve it as fully as possible."

- Excerpt from Californians for GE Agriculture Newsletter regarding APHIS call for comments on proposed GE rules

SOURCE: Californians for GE-Free Agriculture Newsletter, November 22, 2008

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European Commission has mandated E.U. countries developing a plan to allow co-existence of GE and non-GE crops

This is possible provided zero tolerance is not mandated

SOURCE: "Co-existence project kicked-off", European Biotechnology News, Vol. 4, 2005

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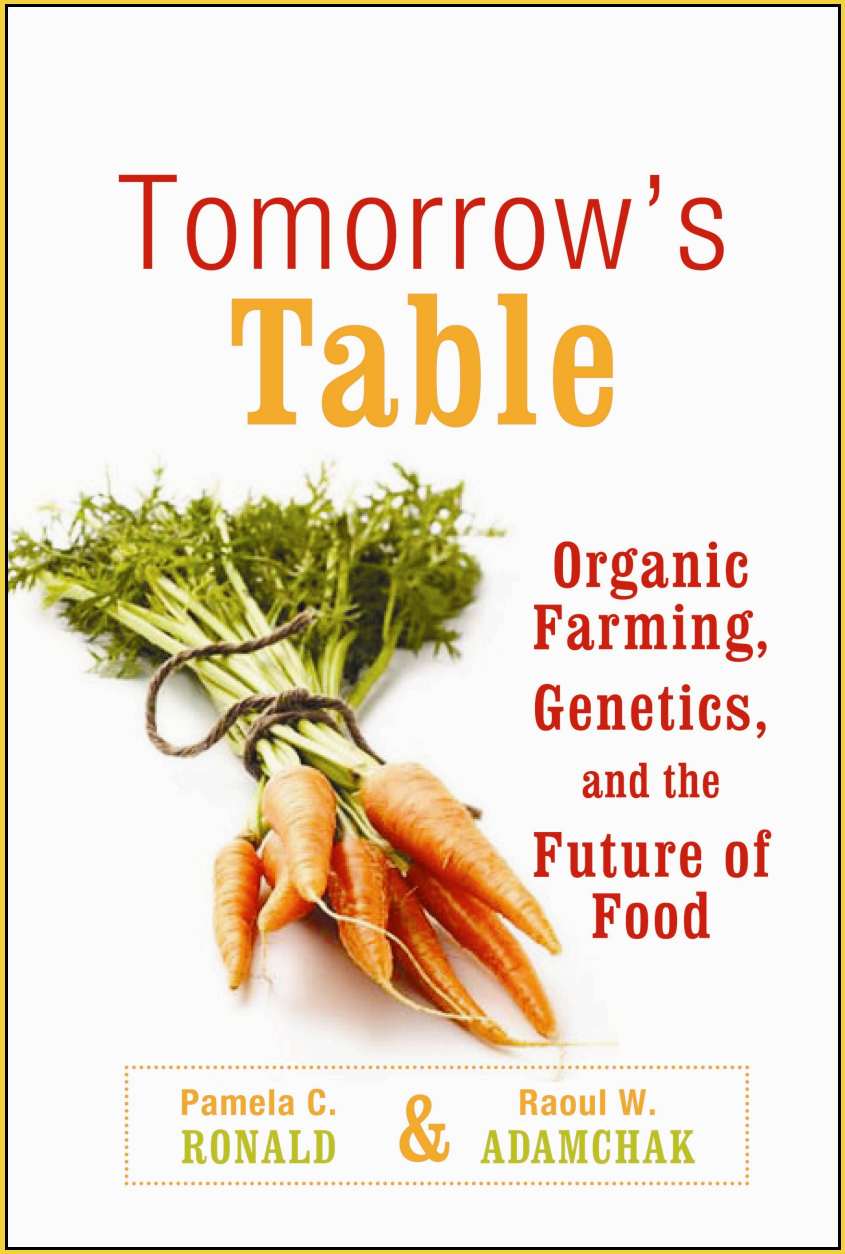
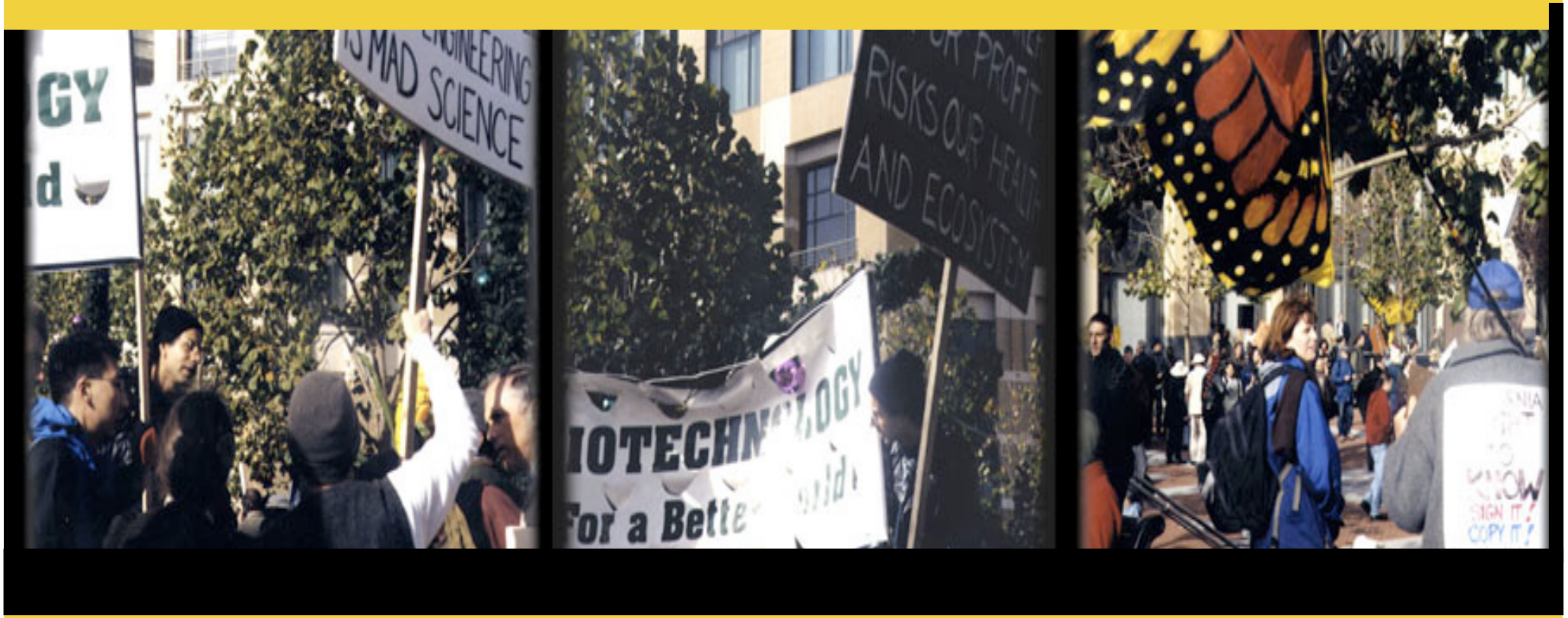


Written by:

Faculty member, Pam Ronald, in plant sciences at UC Davis, who does genetic engineering of rice for developing countries, and her husband, Raoul Adamchak, who manages the *student*-run organic farm on campus

www.oup.com/us
www.amazon.com

What Are Some of the Other Issues?



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Capital Press
Agriculture Newspaper

Judge rejects Roundup Ready alfalfa approval

Court says USDA should have done Environmental Impact Statement

By PEGGY STEWARD
Capital Press Staff Writer

A U.S. District Court Judge ruled Feb. 13 that the U.S. Department of Agriculture erred when it approved Roundup Ready alfalfa without adequately considering the environmental impacts of genetically engineered crops.

Courts are entering into the assessment of the environmental impacts of GE crops that were deregulated by USDA APHIS.

ern District of California said that, while the USDA's Animal and Plant Health Inspection Service conducted an Environmental Assessment, the agency should have gone further and conducted a full EIS before granting Monsanto's

without direct USDA regulation.

Breyer said a lawsuit filed last year by farmers and environmental groups raised substantial questions about the impact of the genetically engineered crop. He said APHIS

Questions include whether allowing the genetically engineered crop without geographic restrictions could lead to transmission of the engineered gene to organic and conventionally grown alfalfa, and the possible extent of that transmission

by bees and other insects. Farmers were left with the burden to determine their own buffers to protect their crops, the judge said. Questions also were raised about the possibility of weeds acquiring the engineered gene.

APHIS' next step is unclear, said Andrea McNally, agency spokeswoman in Washington, D.C. The ruling is still being evaluated, and the agency hasn't yet decided if it will appeal, she said.

on the USDA process only and that it was unclear if the court reviewed the extensive documentation the company provided to regulators about the technology and its safety testing.

Monsanto continues to work

Information

www.cand.uscourts.gov — The case is Geertson Seed Farms v. Mike Johanns, case number CV c-06-01075.

with seed companies and farmers who want to use the Roundup Ready alfalfa, Burchett said. He said the technology has been shown to increase hay quality and yields. He declined

County, Wash., alfalfa grower and a past president of the Washington State Hay Growers Association, hailed the ruling and said it would give the industry some breathing room to sort out concerns. Gauntt, who exports a significant amount of

his hay crop to Japan, said that while the Japanese government has approved Roundup Ready alfalfa imports, Japanese buyers have been reluctant to accept it. Gauntt said he has had to go to extreme measures, including requiring seed tests, to protect his crop.

Philip Bowles, a Los Banos, Calif., alfalfa grower and chairman of the California Alfalfa and Forage Association, said the ruling raises uncertainties.

cally engineered alfalfa has advantages for growers and for the environment.

Peggy Steward is based in Ellensburg, Wash. Her e-mail address is psteward@capitalpress.com.

2005 IRRI Field Trail - Recovery after 17 d submergence

SOURCE: Capital Press, February 23, 2007.

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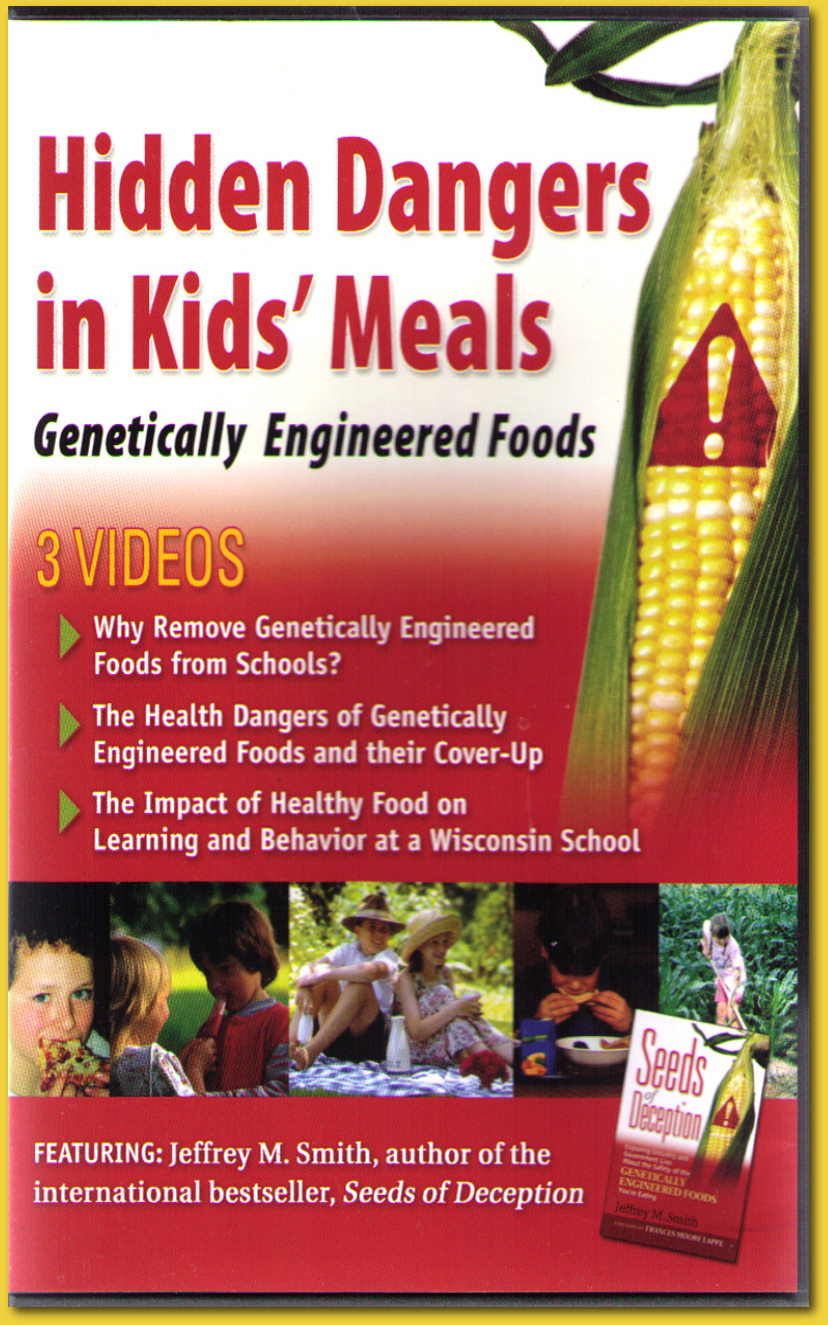
Numerous books, films, journal articles that demonize genetically engineered crops and foods



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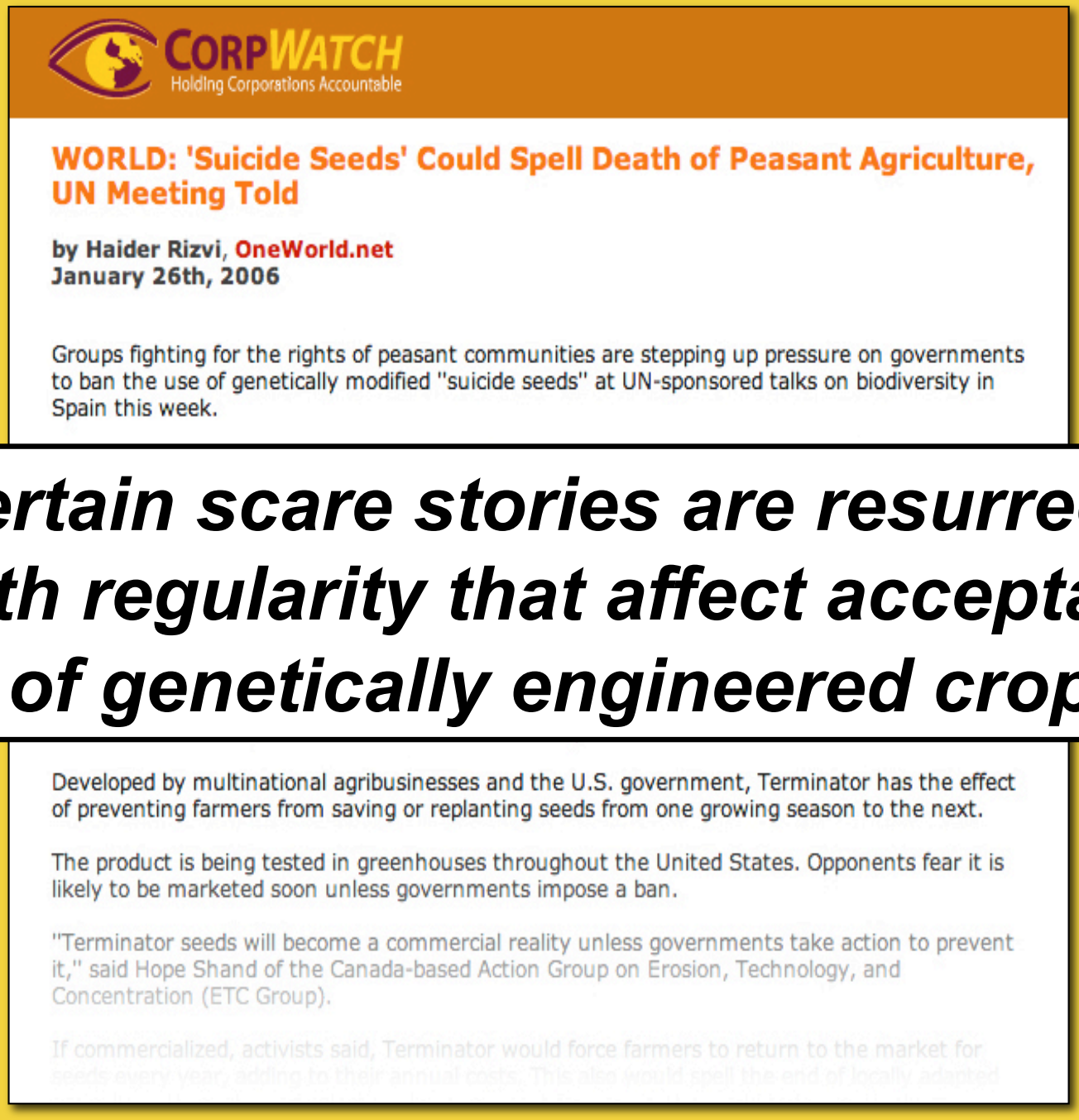

CORPWATCH
Holding Corporations Accountable

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.

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 seeds every year, adding to their annual costs. This also would spell the end of locally adapted

Certain scare stories are resurrected with regularity that affect acceptance of genetically engineered crops

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

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Capital Press
Agriculture Newspaper

Investigative report

Monsanto's practices weed out competition

Licensing pacts, science

Large agrichemical companies are in control of the tools that are needed to create genetically engineered crops

veloper is squeezing competitors, controlling smaller seed companies and protecting its dominance over the multibillion-dollar market for genetically altered crops, an Associated Press investigation has found.

With Monsanto's patented genes being inserted into roughly 95 percent 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

Dan Gill/Associated Press

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.

SOURCE: Capital Press, December 18, 2009

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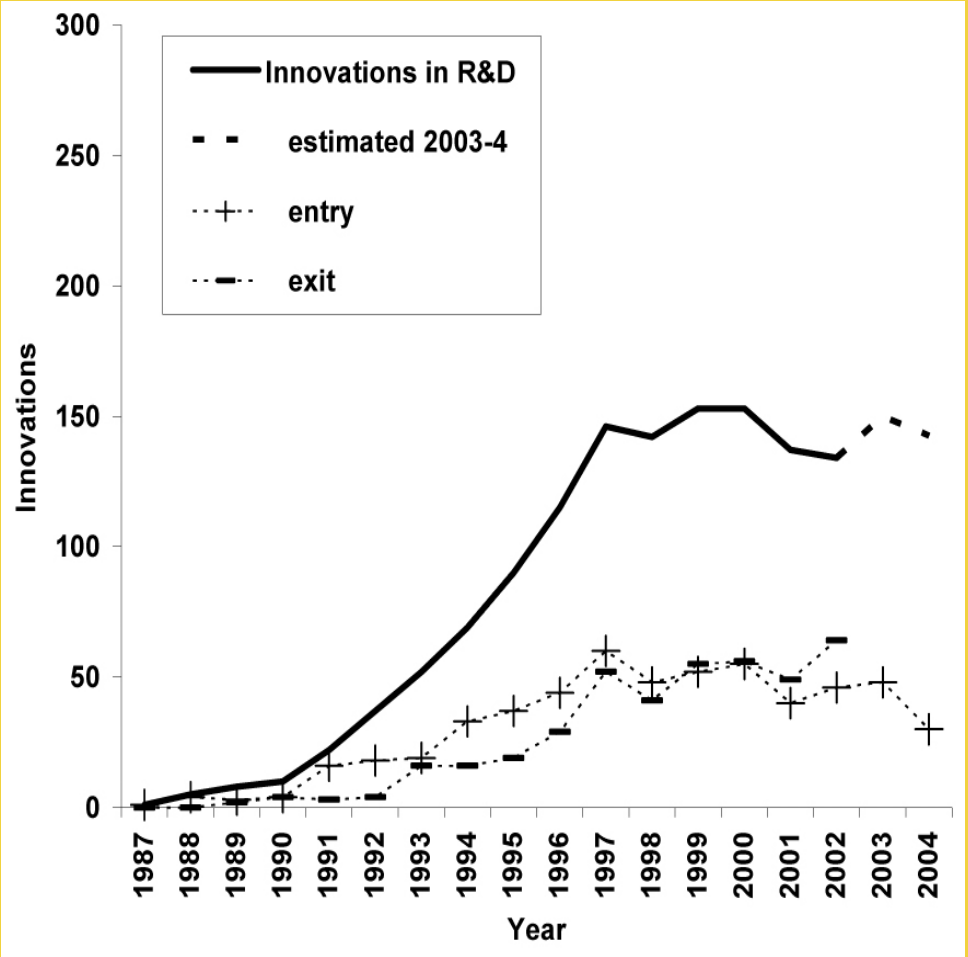
This Consolidation Has Led to a Contraction of Product Innovation in Agricultural Biotechnology



SOURCE: Graff, G.D., Zilberman, D. and Bennett, A.B. 2009. The contraction of agbiotech product quality innovation in agricultural biotechnology. Nature Biotechnology, in press (August, 2009).

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"Another development in the R&D of GM crops is the emergence of more players. While currently it is private companies from the USA or Europe that develop most of the GM events and crops (which are generally first authorized and cultivated in North America), over the next years more GM crops will be supplied by private and public entities from Asia, in particular from China and India."

Events in commercial GM crops and in pipelines worldwide, by region of origin

"But in Asia, 'for the most part, it's not companies that are doing it. It's coming out of the public sector, and that's really going to change the landscape,' says Peggy Lemaux, at the University of California-Berkeley, who is involved in genetic engineering of crops suitable for developing countries."

"Genetically modified foods get U.S. traction, global debate"

Elisabeth Weise USA Today, March 18, 2010

SOURCE: Stein, A.J. and Rodríguez-Cerezo, E. 2009. The global pipeline of new GM crops: implications of asynchronous approval for international trade. JRC Scientific and Technical Report EUR Number: 23846 EN.
http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=2420

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Greenpeace activists vandalize field of Monsanto GE Maize in France July 2008

Europe has been slow to accept GE crops and foods and have influenced a large part of the developing world to reject them

SOURCE: http://www.greenpeace.org/international/news/austria-bans-monsanto-maize250708

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The precautionary principle is used in the E.U. to reject GE crops and foods. This is not the first time this principle was raised in the face of new technology

Locomotive Act

The Locomotive Act (also known as the Red Flag Act) is a reference to the Locomotives Act 1865 introduced by the British parliament as one of a series of measures to control the use of mechanically propelled vehicles on British public highways during the latter part of the 19th century. This act required any motorised vehicle to be preceded by a man with a red flag.

In the 1860s, there was concern that the widespread use of traction engines, such as road locomotives and agricultural engines, would endanger the safety of the public. It was believed that engines and their trailers might cause fatal accidents, scare horses, block narrow lanes, and disturb the locals by operating at night. The financial burden of maintaining the roads was already shifting from tolls onto local rate-payers, and these new types of vehicle, possibly up to 9 feet (2.7 m) wide and 14 tons, could allegedly damage the highway while they were being propelled at "high speeds" of up to 10 miles per hour (16 km/h). However, there is evidence that the steam carriages' better brakes (which did not lock and drag), their wide tyres, and the absence of horses' hooves striking the road allowed them to cause less damage to the roads than horse-drawn carriages.

Intended to protect railroad interests, an unintended consequence of these Acts was the slowdown of technological progress and diminished opportunities for industry in Britain.

SOURCE: http://en.wikipedia.org/wiki/Locomotive_Act

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“Because the technology involves introducing genes from one plant or bacteria into another in combinations not found in nature, many believe it can never be proven entirely safe. They think science should operate on the ‘precautionary principle’ that if something can't be proven to be 100% safe long term, it shouldn't be used. And they feel long-term research hasn't been done.”

Doug Gurian-Sherman, Union of Concerned Scientists
in USA Today, March 18, 2010

Capital Press
Agriculture Newspaper

It's time for farmers to tell ag's story

Editorial

During a three-hour speech in the campaign of 1890, populist rabble rouser Mary Lease reportedly told her audience in Halstead, Kan., "What you farmers need to do is raise less corn and more hell."

Whether Lease ever uttered the phrase is unclear, but most agree it reflected her sentiment. In speeches across the Western plains she challenged farm families to fight for their own self interest.

It was with equal force, but greater deference to the occasion, that American Farm Bureau Federation president Bob Stallman told the group's national convention in Seattle last week that ag interests must take off the gloves and aggressively challenge industry critics and those who, through litigation,

years later, the survivors of that age are painted in the popular press as "corporate farmers" who use "factory" methods to produce unhealthy, unsafe food stuffs at the expense of the environment, all for the sake of profit.

American agriculture has a powerful story to tell. Never have fewer people produced so much food in so great a variety. Neither quaint portraits of rural characters nor exposes on the few bad actors within the farming community tell the story.

Several ag organizations have adopted programs to take that story into the classrooms and other venues. Others are using social networking to reach out beyond the farm. We applaud these efforts, and encourage every farmer and rancher to reach out to their non-farm

Bottom Line: Pollan has some valid points but, feeding the 9 billion people expected by 2050, will be a challenge and using wisely the best of all agricultural technologies will be necessary in both the developed and less developed world

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Where to get more information on the issues?

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SCIENCE-BASED INFORMATION & RESOURCES ON AGRICULTURAL BIOTECHNOLOGY

HOME | IN THE NEWS | BIOTECHNOLOGY INFORMATION | SCIENTIFIC DATABASE | RESOURCES | LINKS | GLOSSARY | CONTACTS

know GMOS

This website, developed for the University of California Division of Agricultural and Natural Resources Statewide Biotechnology Workgroup, 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.

BIOTECHNOLOGY INFORMATION

ANNUAL REVIEWS

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

Issues and Responses: Searchable list of issues related to agriculture, foods, technologies linked to responses.

RESOURCES FOR OUTREACH & EXTENSION, RESEARCHERS & TEACHERS

Slide Archive: Extensive collection of PP slides on agriculture & biotechnology.

Available on loan:

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.

Tic Tac Grow: Educational game to teach what foods come from what crops.

HELPFUL SITES

Seed Biotechnology Center
Mobilizes research, education & outreach efforts in partnership with seed & biotechnology industries.

Animal Genomics & Biotechnology Cooperative Extension Program, UC Davis
Provides education on use of animal genomics & biotechnology in livestock production.

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Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I)

Peggy G. Lemaux

Department of Plant and Microbial Biology, University of California, Berkeley, California 94720; email: lemauxpg@nature.berkeley.edu

Annu. Rev. Plant Biol. 2008. 59:771–812

First published online as a Review in Advance on February 19, 2008

The *Annual Review of Plant Biology* is online at plant.annualreviews.org

This article's doi: 10.1146/annurev.arplant.58.032806.103840

1543-5008/08/0602-0771$20.00

Key Words

benefits, biotechnology, crops, food safety, genetic engineering risks

Abstract

Through the use of the new tools of genetic engineering, ge be introduced into the same plant or animal species or into p animals that are not sexually compatible—the latter is a di with classical breeding. This technology has led to the co production of genetically engineered (GE) crops on appr 250 million acres worldwide. These crops generally are and pest tolerant, but other GE crops in the pipeline foc traits. For some farmers and consumers, planting and from these crops are acceptable; for others they raise iss the environment. In Part I of th

Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part II)

Peggy G. Lemaux

Department of Plant and Microbial Biology, University of California, Berkeley, California 94720; email: lemauxpg@nature.berkeley.edu

Annu. Rev. Plant Biol. 2009. 60:511–59

The *Annual Review of Plant Biology* is online at plant.annualreviews.org

This article's doi: 10.1146/annurev.arplant.043008.092013

1543-5008/09/0602-0511$20.00

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Abstract

Genetic engineering provides a means to introduce genes into plants via mechanisms that are different in some respects from classical breeding. A number of commercialized, genetically engineered (GE) varieties, most notably canola, cotton, maize and soybean, were created using this technology, and at present the traits introduced are herbicide and/or pest tolerance. In 2007 these GE crops were planted in developed and developing countries on more than 280 million acres (113 million hectares) worldwide, representing nearly 10% of rainfed cropland. Although the United States leads the world in acres planted with GE crops, the majority of this planting is on large acreage farms. In developing countries, adopters are mostly small and resource-poor farmers. For farmers and many consumers worldwide

Also in peer-reviewed articles:

Lemaux P.G. *Annual Review of Plant Biology*

2008 and 2009