



#### **DNA – What is it?**

Only slightly over half of Americans (60%) know that DNA is the genetic code for living cells. One out of ten Americans (11%) had no idea at all what DNA is.

Based on everything you know, what is DNA? Would it be:

Unaided



A virus

An organization

Other

Don't know

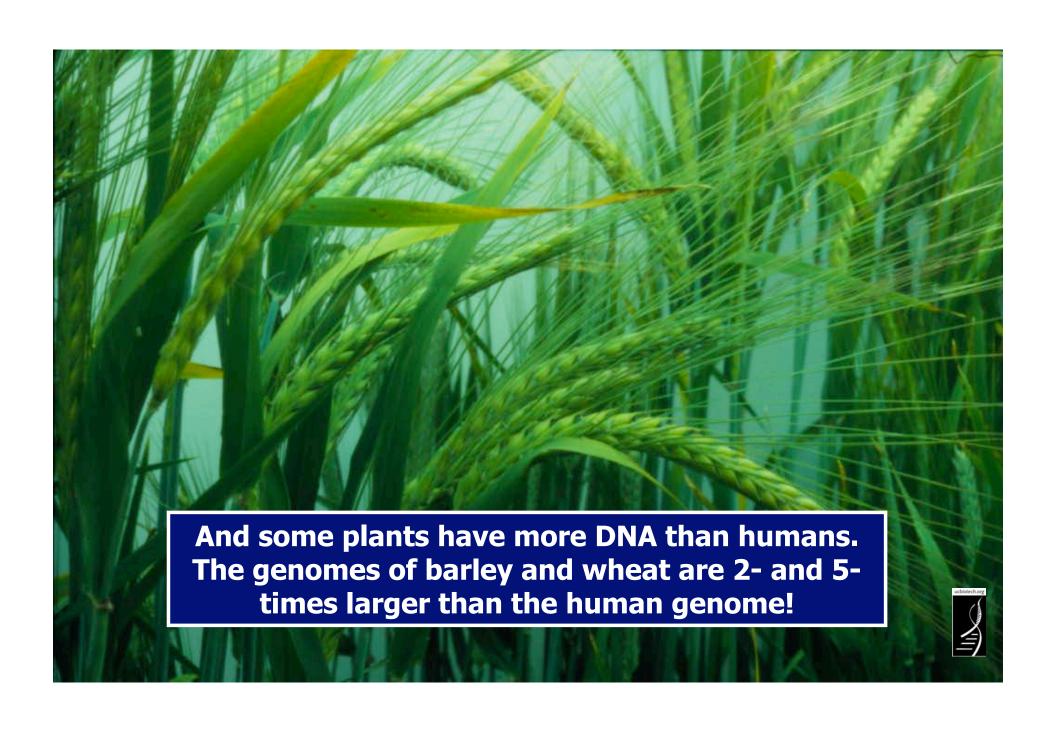


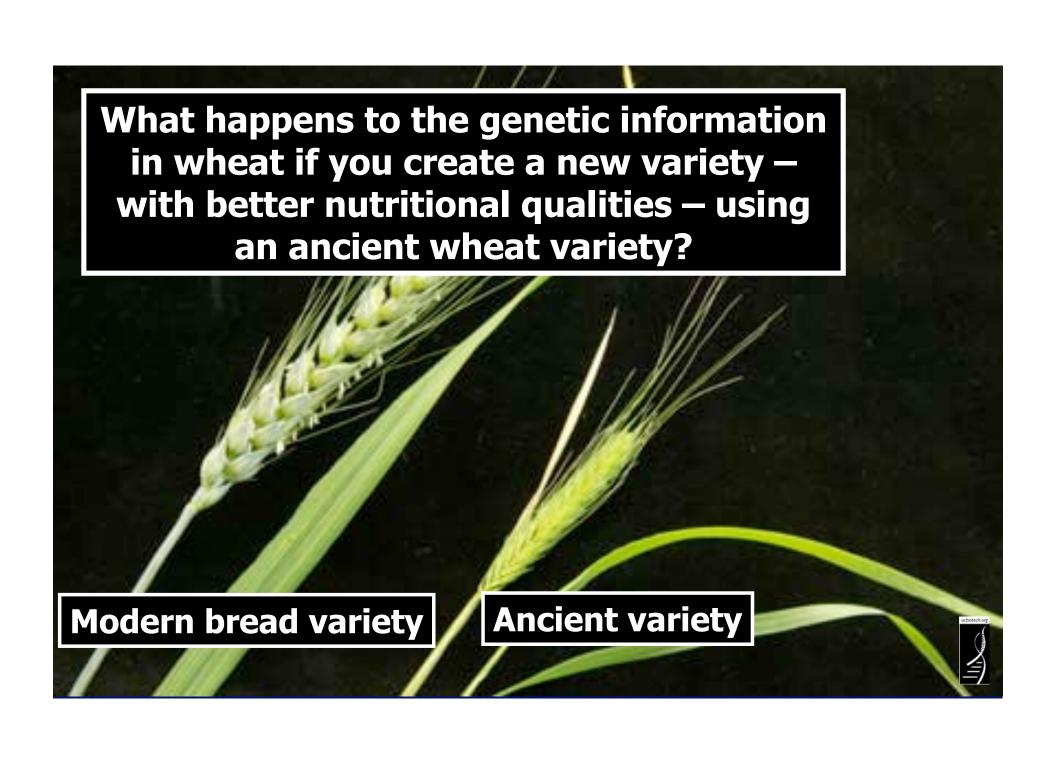
<sup>0%</sup> 0% 29%

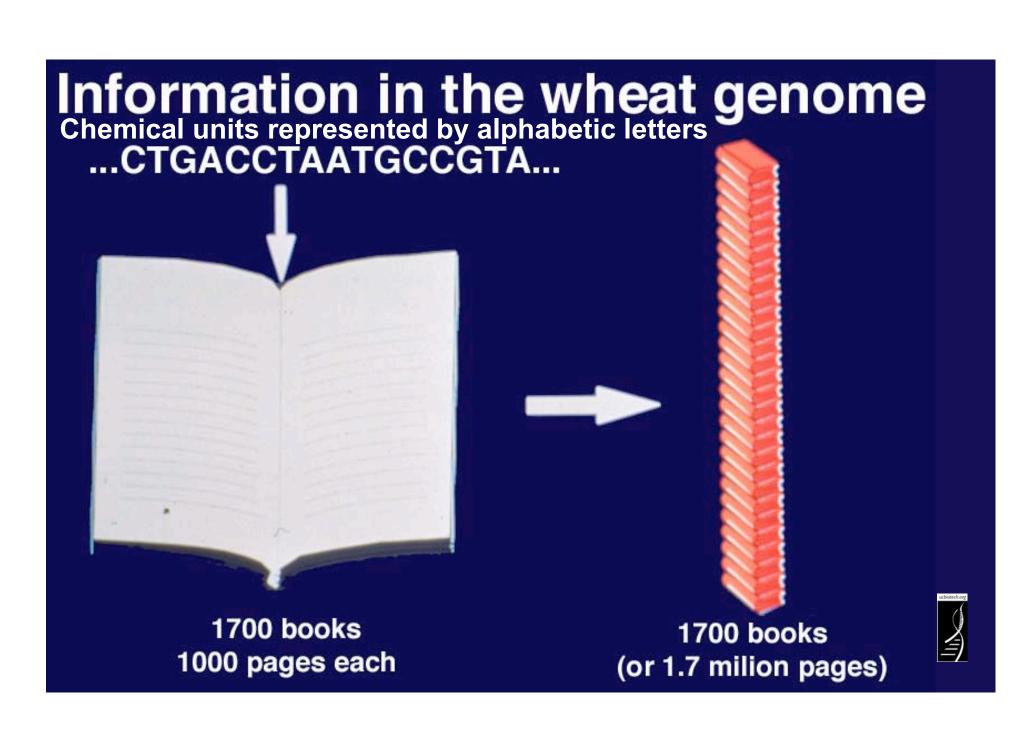
<sup>\*</sup> Correct response

- 43% falsely asserted that ordinary tomatoes don't contain genes, only those that are genetically modified have genes
- 40% of respondents falsely thought that tomatoes genetically modified with genes from catfish would taste "fishy";
- 52% wrongly thought that genetically modified foods are created using radiation to create genetic mutations;
- 31% mistakenly believed that eating genetically modified fruit could modify a person's genes;

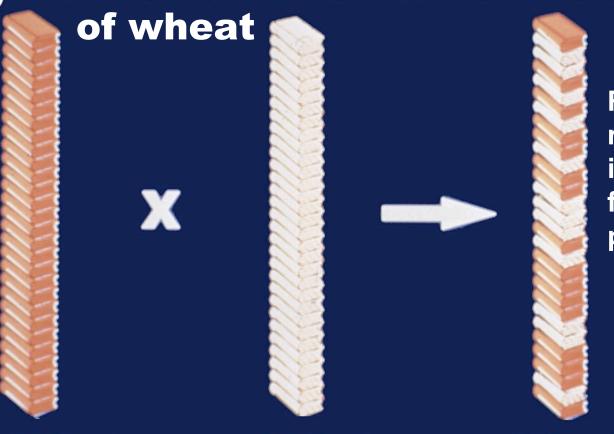








#### Hybridization or cross breeding



Random retention of information from each parent

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





#### Table of contents for genes in wheat



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

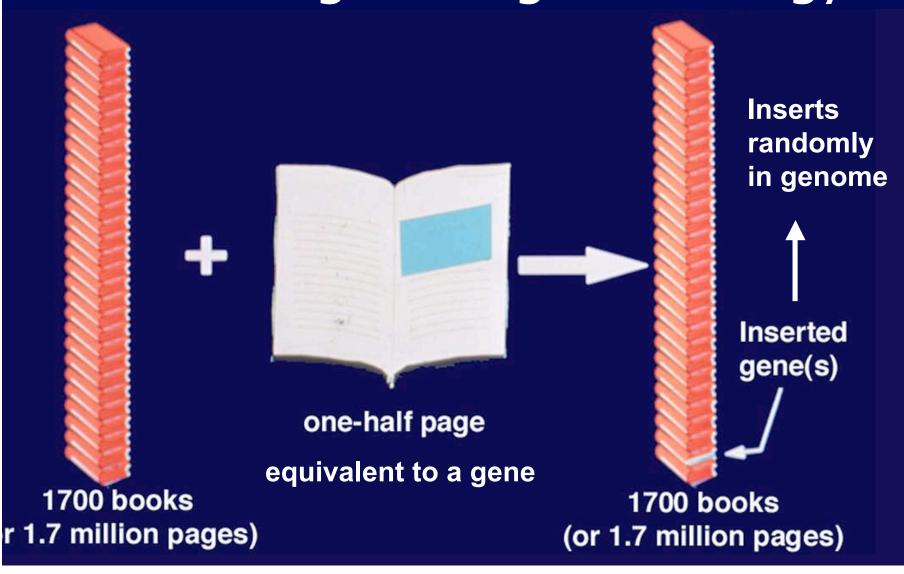
**Genomics** 

1700 books (or 1.7 million pages)





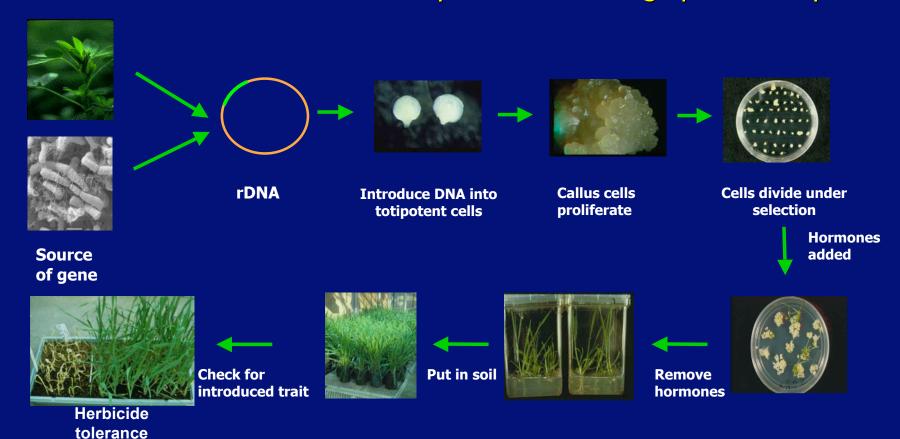
### Genetic Engineering Technology

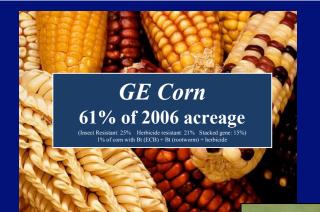




#### **Genetic Engineering**

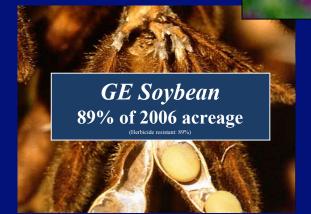
- Create rDNA with gene from same or different organism
  Transfer DNA to plant cell; allow plant cells to divide under selection
- •Cue cells to reform plant every cell will have new DNA
- •Confirm introduced DNA and expression of foreign protein in plants





*GE Canola* 75% of 2004 acreage

GE Alfalfa <0.5% of 2005 acreage

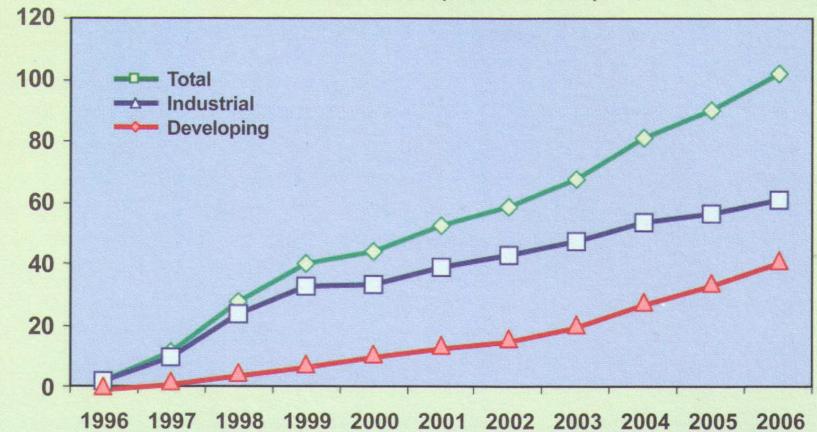






#### **GLOBAL AREA OF BIOTECH CROPS**

Million Hectares (1996 to 2006)



Increase of 13%, 12 million hectares (30 million acres) between 2005 and 2006.

Source: Clive James, 2006. 103 million hectares = approximate size of TX + CA

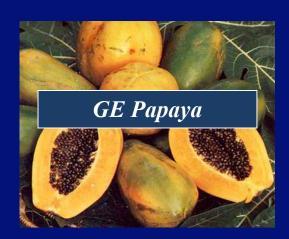




# Only a few whole foods on the market are genetically engineered

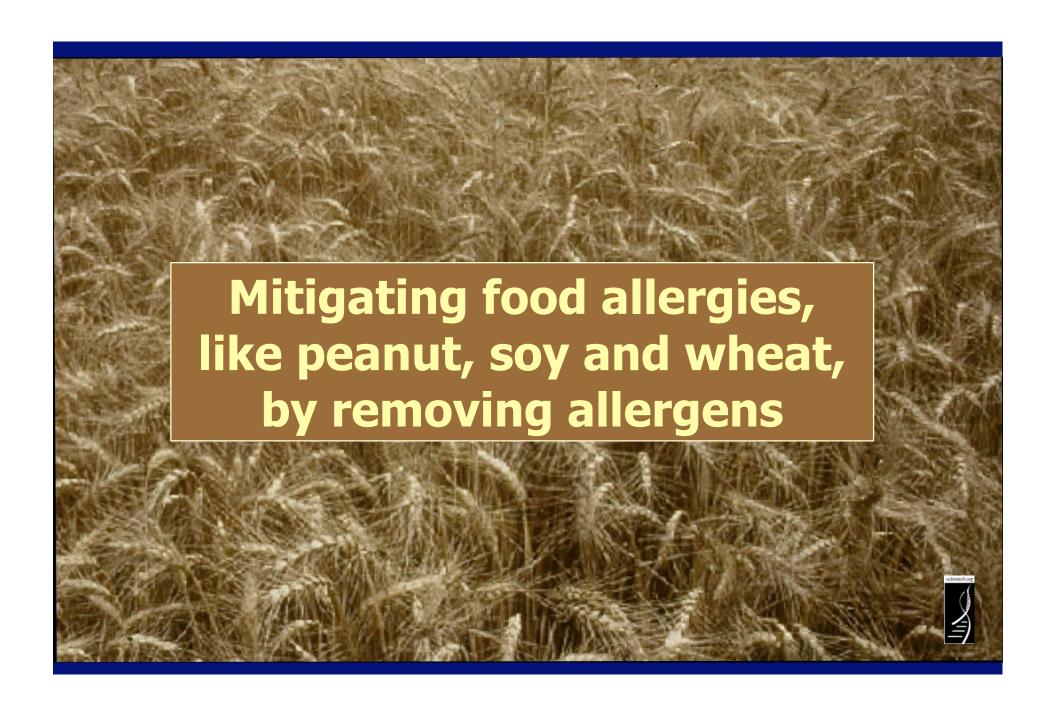














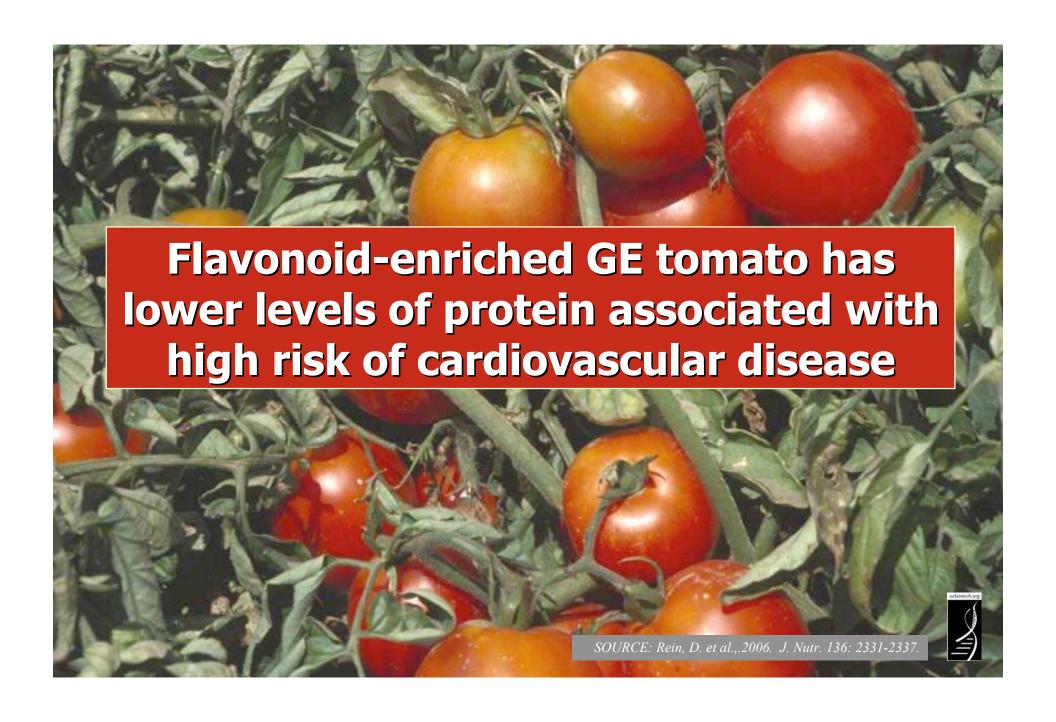


### Gene from wild wheat boosts protein, zinc, iron content of cultivated wheat

Transgenic Low GPC-1

Control
Normal GPC-1







### **B-carotene-enriched Golden Rice:** uses corn gene and bacterial gene







Improving nutritional quality of sorghum for Africa using plant genes







### Rice seed-based edible peptide vaccine for allergic diseases like







# Edible HIV vaccine in corn using surface protein from monkey form of HIV

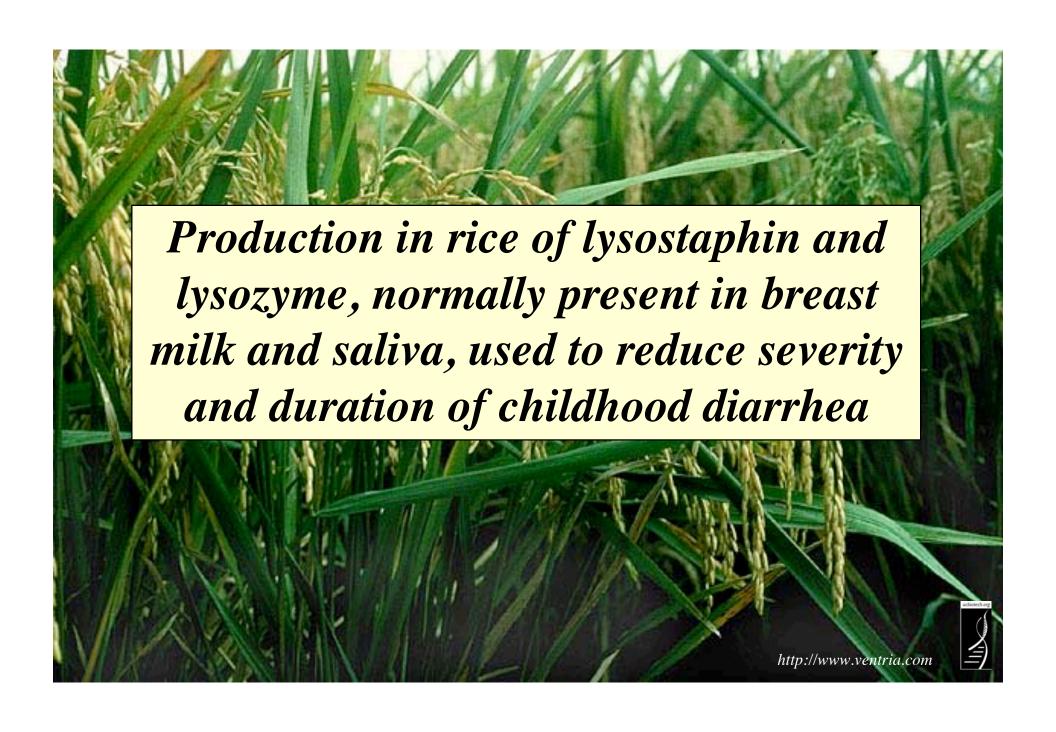


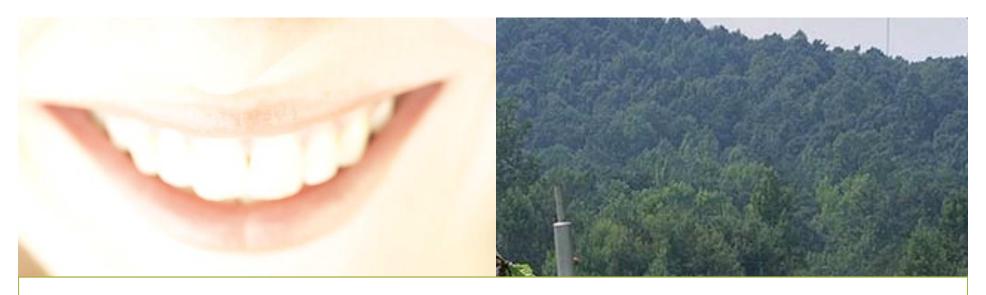




Expression of human immune protein, CD14, (pattern recognition receptor) in plants could prevent ocular infections in infants







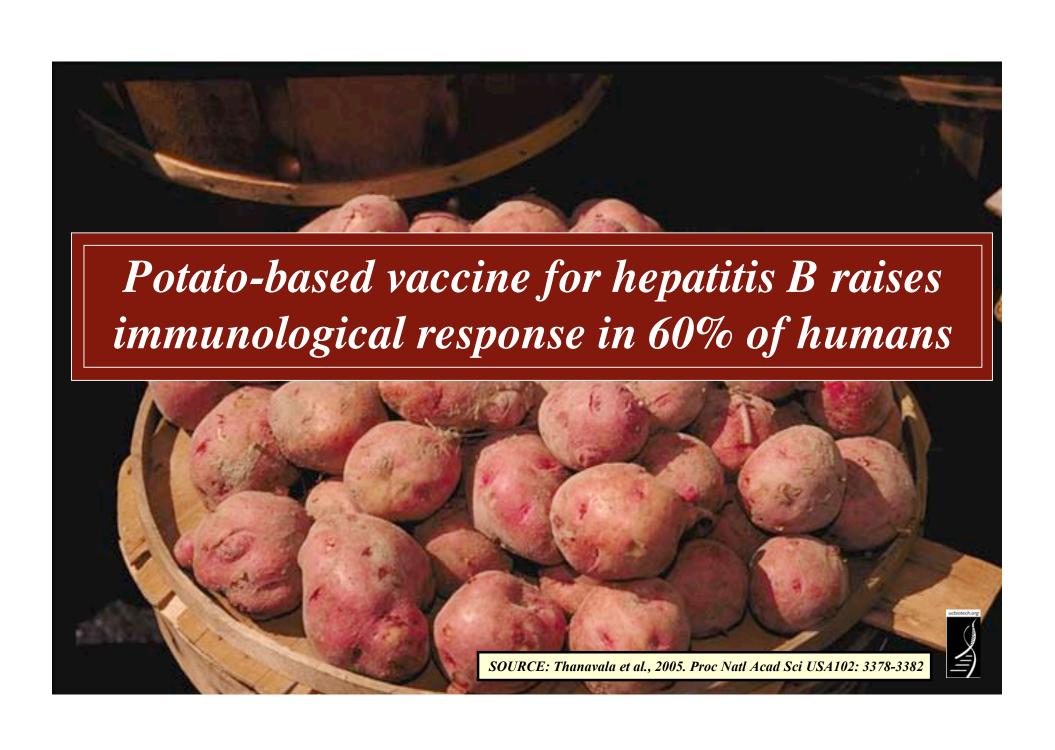
## Tobacco engineered with antimicrobial antibody to S. mutans fights tooth decay

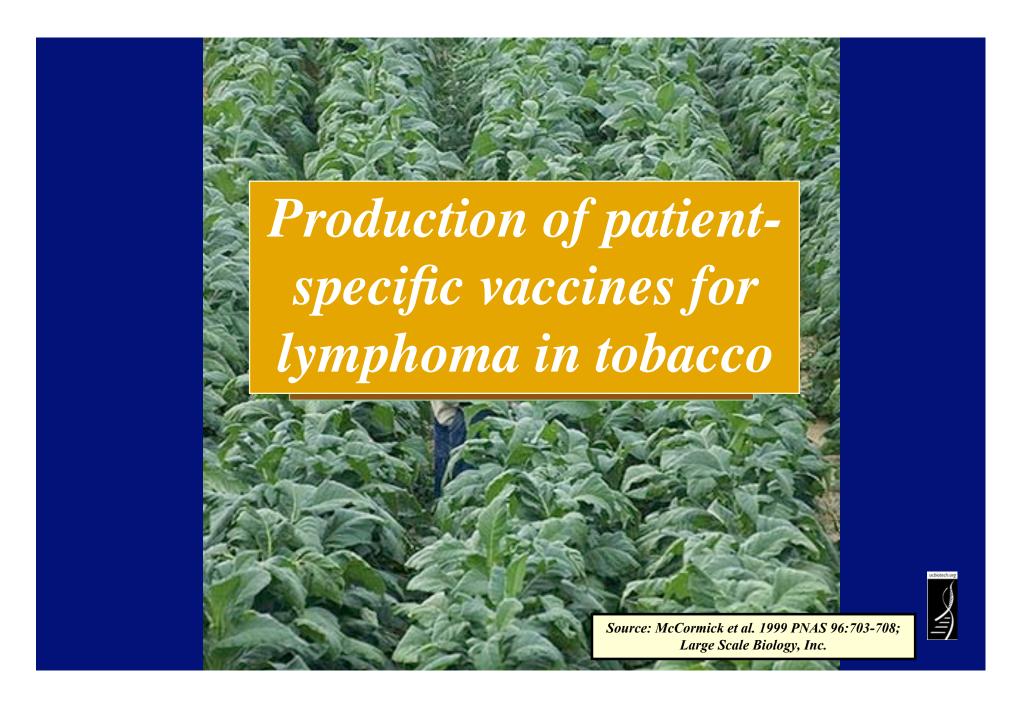




Subunit vaccine
against pneumonic
and bubonic plague,
produced in tomato
orally immunogenic in
mice

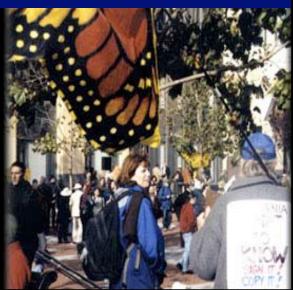






#### What Are Some of the Issues?







## Are there any foods produced through biotechnology in the supermarket today?

		Jan.	Apr.	July	
	1997	<u>2001</u>	<u>2003</u>	2006	
• Yes	40%	36%	36%	36%	
• No	37%	44%	34%	30%	
<ul> <li>Don't Know/Refused</li> </ul>	23%	20%	30%	34%	

## What, if anything are you concerned about when it comes to food safety?

		Jan. 2001	Apr. 2003	July 2006
•	Packaging	27%	15%	15%
•	Food Handling/Preparation	23%	41%	35% ←
•	Other	19%	9%	4%
•	Disease/Contamination	16%	28%	<b>36</b> % <b>←</b>
•	Chemicals/Pesticides in Food	10%	7%	16%
•	Altered/Engineered Food	2%	1%	<b>3</b> % <b>←</b>
•	Nothing	9%	5%	_

#### What are some food safety issues?

- No peer-reviewed food safety tests
- Creation of allergens or activation of toxins
- Pharma crops contaminate food supply
- Labeling
- Changes in nutritional content
- Gene flow from food to intestinal bacteria; increase in antibiotic resistance



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### Difficulties with food safety testing What to do and how to do it?

"It is difficult if not impossible to test food safety of whole foods and feeds with animal tests. Despite what non-experts commonly think, animal tests are not the gold standard. Compositional analysis and toxicity testing of individual components is much more sensitive than whole foods testing."

"Nutritional and Safety Testing of Foods and Feeds Nutritionally Improved through Biotechnology" 2004. Comprehensive Reviews in Food Science and Food Safety, ILSI

"There are publications on the toxicity and animal testing of Bts and at least 112 studies of food safety of GM crops in animals."

Bruce Chassy, (2004) Chair, Department of Food Science and Human Nutrition, University of Illinois

"Preventing adverse health effects...requires application of appropriate scientific methods to predict and identify unintended compositional changes that may result from genetic modification of plants, animals and microbes" However "it is the final product...rather than the modification method or process, that is more likely to result in unintended adverse effects."

National Academy of Sciences report, ... "Safety of Genetically Engineered Foods: Approaches to Unintended Health Effects" (2004)



### **Experiments comparing first generation GE** crops with isogenic counterparts

Animal (Species/categories)	Number of experiments	Nutritional assessment
Ruminants Dairy cows Beef cattle Others	23 14 10	No unintended effects in composition (except lower mycotoxins concentration in Bt plants)
Pigs	21	No significant differences
Poultry Laying hens Broilers	3 28	in digestibility and animal health as well as no unintended effects on performances of animals
Others (Fish, rabbits etc.)	8	and composition of food of animal origin



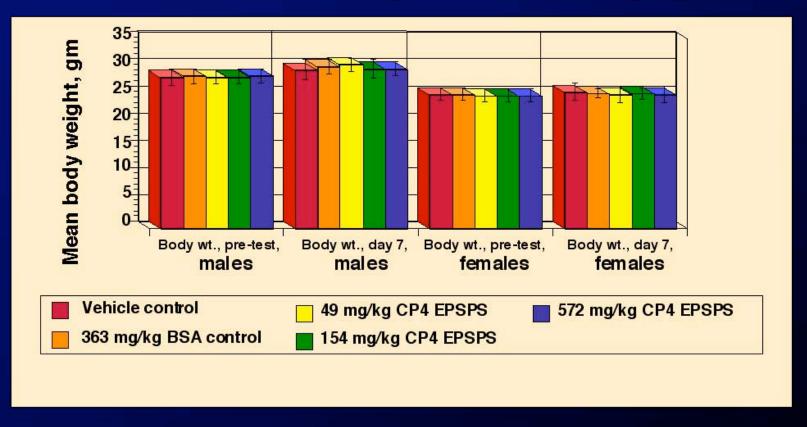
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## Toxicity Assessment: Roundup Ready/CP4 EPSPS protein

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







Classically bred foods can cause allergy problems too —

**Example: Kiwi** 





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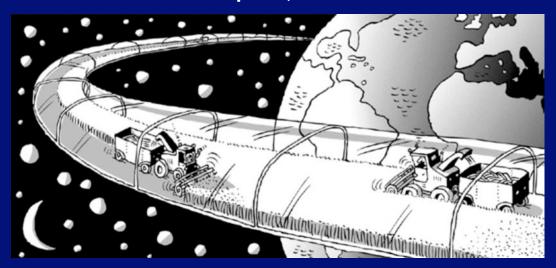
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#### The New York Times

How to Confine the Plants of the Future?

April 8, 2007



"A new generation of genetically engineered crops that produce drugs and chemicals is fast approaching the market — bringing with it a new wave of concerns about the safety of the global food and feed supply."





#### 'Pharm crop' debate takes root in California Biotech

California company growing pharma rice with two genes to speed recovery from childhood diarrhea causes a "raging international dispute" over use of edible GE crops to produce drugs

Sacramento-based Ventria Bioscience is seeking state approval to grow rice that can make two human proteins, normally found in breast milk and tears, for use in treating human illnesses.

If it gets the necessary approvals, the decade-old company would become the first commercial producer of genetically engineered ``pharm crops." Scientists



## The Washington Post

November 14, 2002

#### Biotech Firm Mishandled Corn in Iowa

Concern began with mishandling of Pharma corn in 2002 – resulted in large fines for the company and changes in USDA guidelines on pharma crops

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# Why Doesn't FDA Have a Labeling Policy for GM Foods? Actually it does...

Govt-mandated label information relates to composition or food attributes <u>not agricultural or manufacturing practices</u>

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

#### **GM food labeled if:**

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





# Processed foods are different. Tomato sauce can contain 8 or more different varieties — each requires tracking to assure accurate content information.



May contain genetically modified tomatoes



Contains genetically modified tomatoes



Contains tomatoes genetically modified with polygalacturonase gene from tomato, phosphinothricin acetyl transferase from *Streptomyces hygroscopicus*, crystal toxin from *Bacillus thuringiensis*, alpha amylase gene from barley, s-adenosyl methionine transferase gene from tobacco, N protein gene from tobacco, coat protein gene from tomato bushy stunt virus



## But there are foods that are tracked for consumer choice... like organic and...

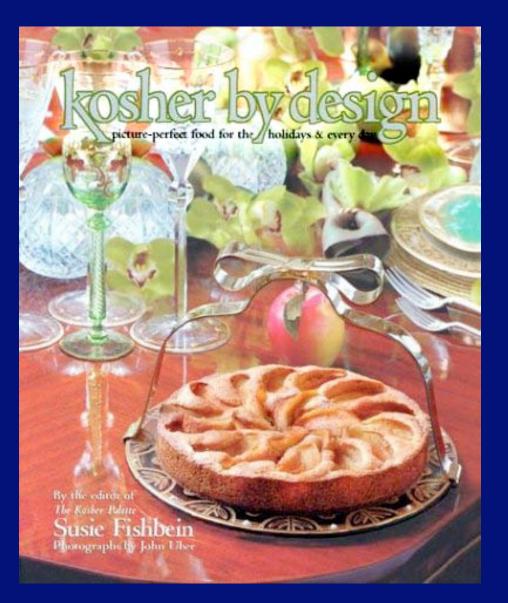






#### ...Kosher

For which people pay premium prices



Should everyone pay a premium price for GE- free foods?



#### What are some environmental issues?

- Gene flow via pollen flow to generate superweeds" (herbicide tolerance to wild/weedy species)
- Transfer of transgenes to non-GMO / organic crops?
- Loss of genetic diversity?
- Property rights (gene patents)?
- Spread of pharmaceutical genes into commercial crops?

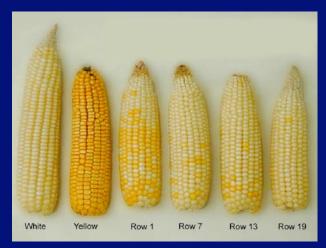


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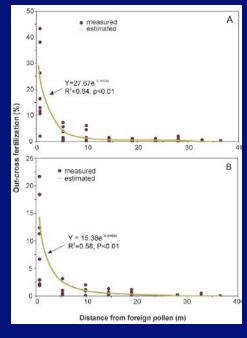
#### **Pollen Drift of GE Corn**



White maize

36m

It is possible (and has been necessary) to measure gene flow





#### **Pollen Flow Distances for Crop Species of Interest**

Crop	Mode of Pollination	Means of	Fdn Seed Prod	Measure Pollen
Type		Movement	Isolation Distance	Movemnt Dstance
Alfalfa	Self-sterile; obligate	Bees	90 <del>0 ft</del>	2000 ft (0.48 mi)
	outcrossing		(0.17 mi)	
Bentgrass	Clonal (stolons); type	Wind	900 ft (98%purity)	13.05 mi
	outcrossing dep on		(0.17 mi)	
	environment			
Canola	Predom. selfing; 30%	Wind/insects	>1320 ft	1.9 mi

# To maintain seed purity, seed foundations had to establish isolation distances long before GE crops but they don't assure 100% purity

Squasii	Obligate outcrossing	(predom. bees)	(0.25 mi)	0.0 1111
Soybean	Self-pollinating (99%)	Physical touching/wind	5 ft	n.a.
Wheat	Self-pollinating (99.9%)	Physical touching/wind	5 ft	>160 ft

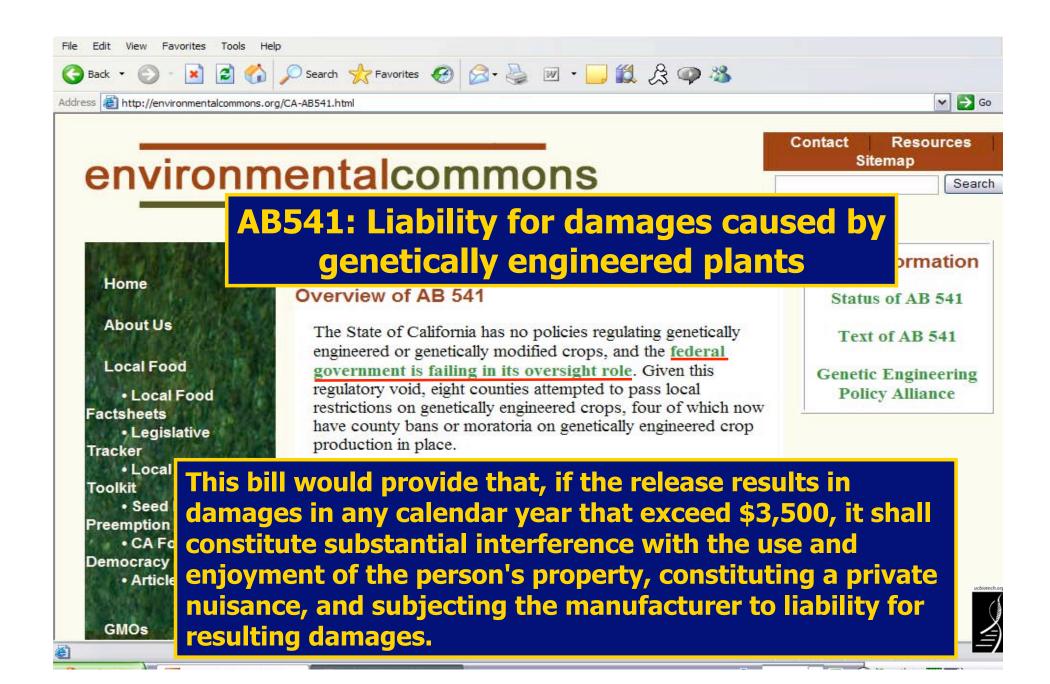


# Question – What Are the Consequences of Gene Flow? Consider Vitamin A Genes vs. Herbicide Tolerance Genes from GE Rice to Weedy Red Rice



Is the issue just whether the gene is present or not or what consequences might movement of the gene have?





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## ...And What Genetic Modification Input Methods Are PROHIBITED?

(§ 205.2 National Organic Program)

 "A variety of methods...are not considered compatible with organic production. Such methods include cell fusion, micro- and macroencapsulation, & recombinant DNA technology (including gene deletion, gene doubling, introducing a foreign gene, & changing the positions of genes when achieved by recombinant DNA technology)."



## **Are There Tolerances for GE in Organic Products?**

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.



- "As long as an organic operation has not <u>used</u> excluded methods and <u>takes reasonable steps</u> to avoid contact with the products of excluded methods ...<u>unintentional presence of products of excluded</u> methods should not affect status of an organic product or operation."

Pesticides: "When residue testing detects prohibited substances at levels that are greater than 5% of the EPA's tolerance for the specific pesticide residue detected...the agricultural product must not be sold or labeled, or represented as organically produced."





GMOs: At the present time there are no specified tolerances for GMOs in organic products. Organic products are not 'guaranteed' GMO-free, although some organic farmers sign contracts guaranteeing GMO-free



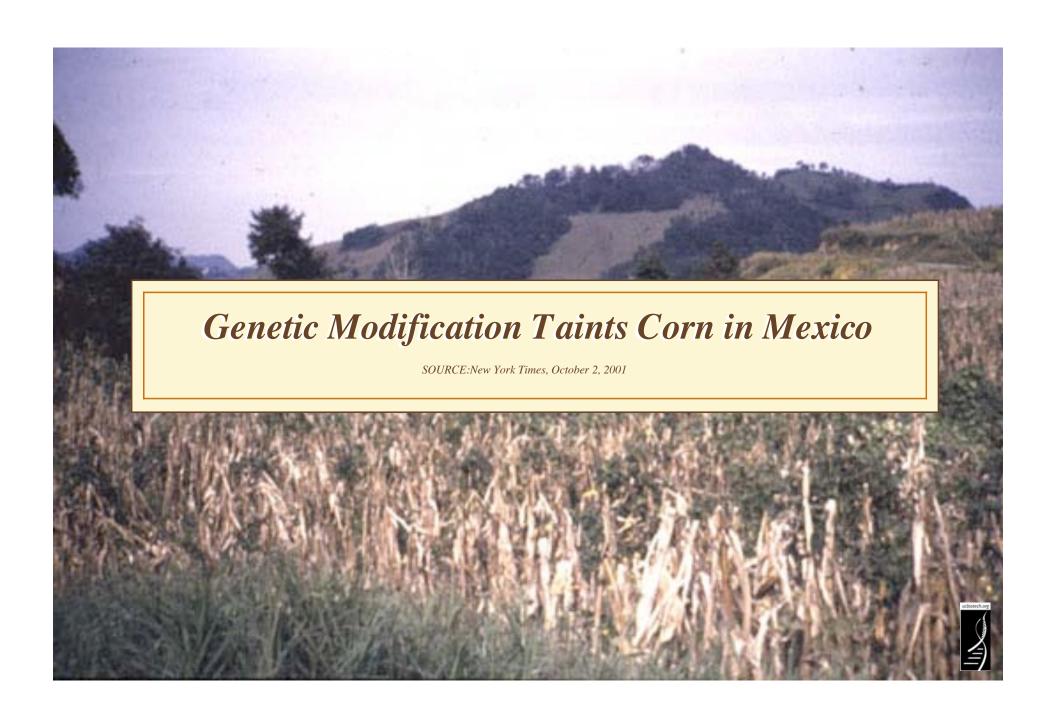




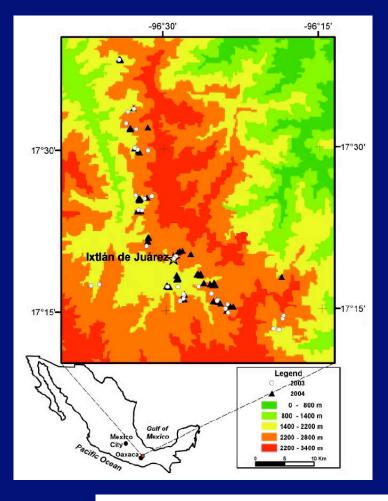
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### Map of fields in Oaxaca, Mexico, where seeds were collected from maize landraces in 2003 and 2004.



No evidence of GE corn found in 2005 study in specific area of Mexico where evidence was found in 2001



## Gene flow in Mexican maize: consequences for genetic diversity?



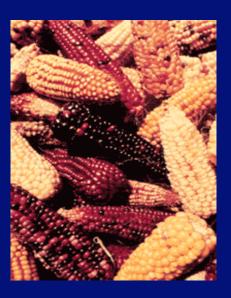
State of Jelisco



Near Amecameca in Chalco area

How does pollen and gene flow occur in Mexico?

Is this the first time gene flow has occurred into Mexican landraces?



What implications does transgene flow have for wild and domesticated maize?



#### Where to get more information on the issues?

