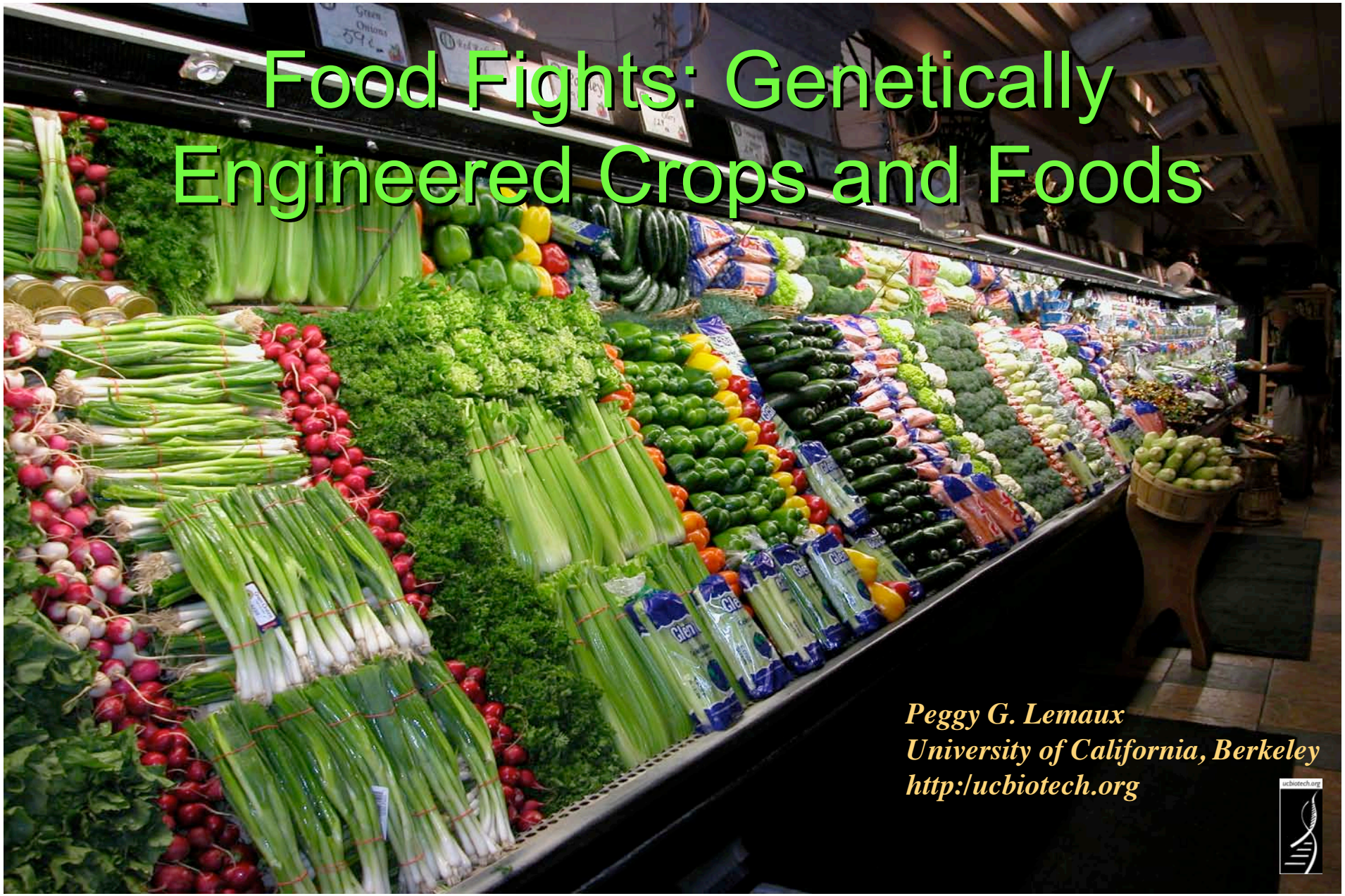
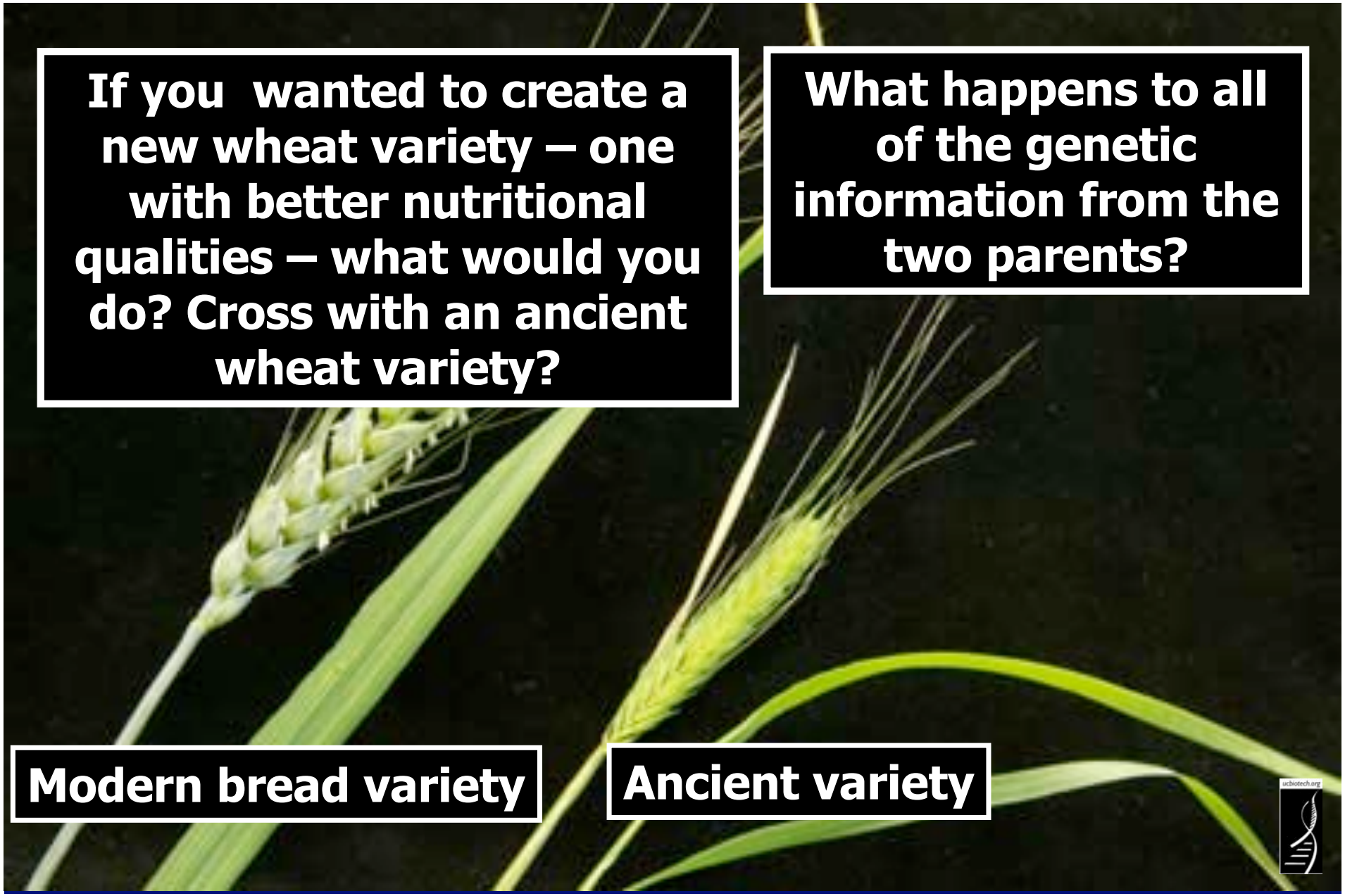


Food Fights: Genetically Engineered Crops and Foods

Peggy G. Lemaux
University of California, Berkeley
http:/ucbiotech.org


If you wanted to create a new wheat variety – one with better nutritional qualities – what would you do? Cross with an ancient wheat variety?
What happens to all of the genetic information from the two parents?
Modern bread variety
Ancient variety

Information in the wheat genome

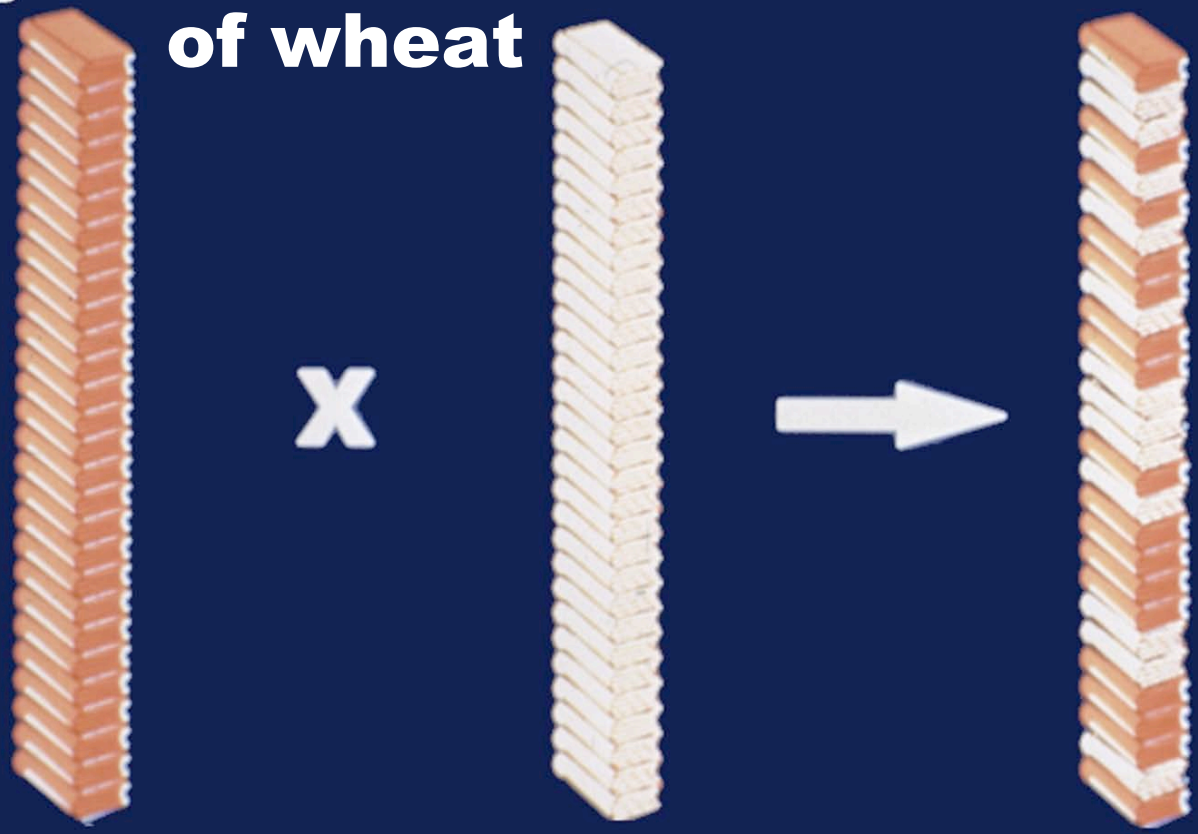
Chemical units represented by alphabetic letters

...CTGACCTAATGCCGTA...

1700 books
1000 pages each

1700 books
(or 1.7 milion pages)

Hybridization or cross breeding of wheat



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)

Table of contents for genes in wheat

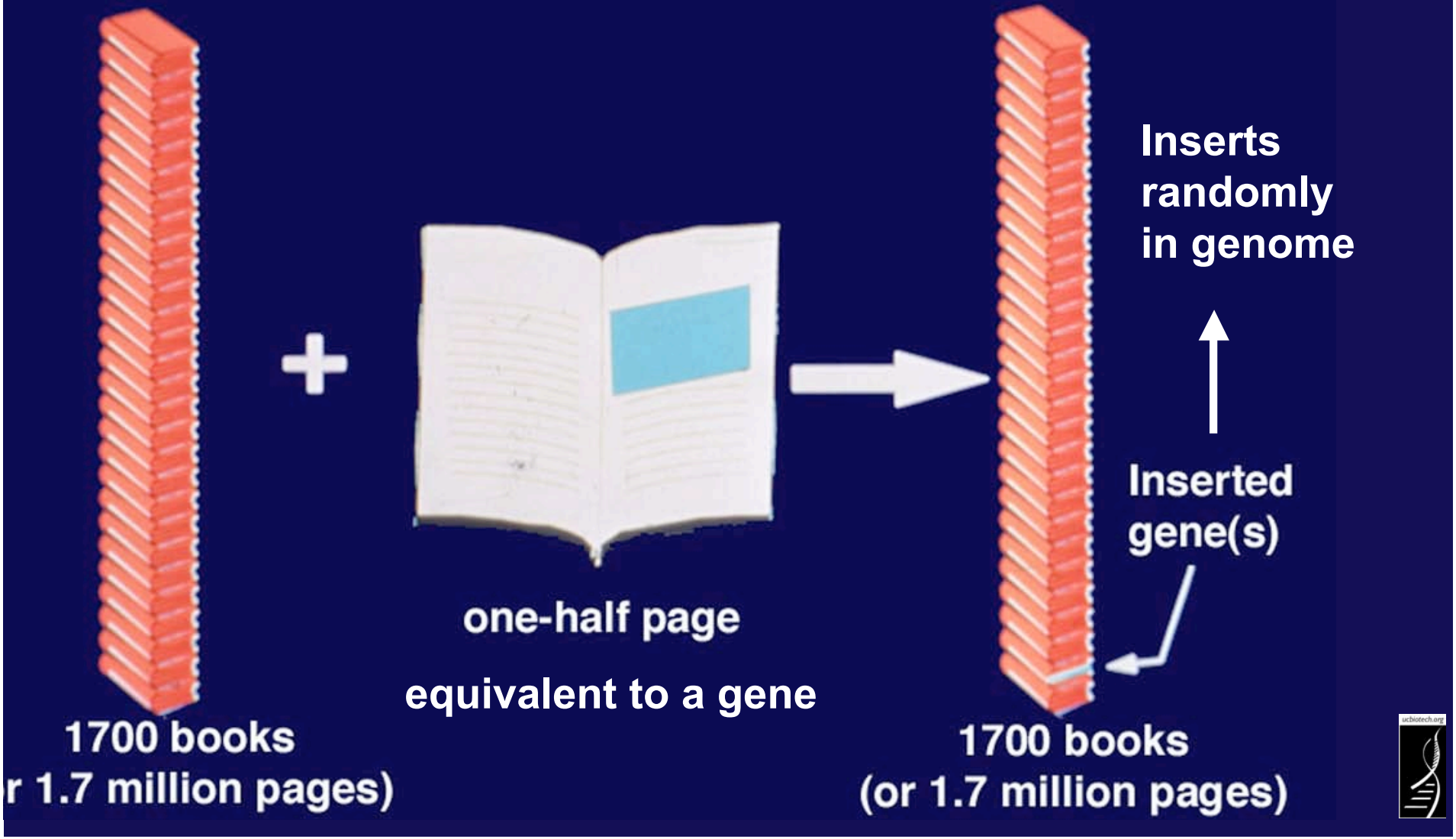
...CTGACCTAATGCCGTA...

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

Genomics

1700 books
(or 1.7 million pages)

Genetic Engineering Technology



TERMS USED

GMO

Genetically Modified Organism

GEO

Genetically Engineered Organism

LMO

Living Modified Organism

rDNA

Recombinant DNA

Biotechnology

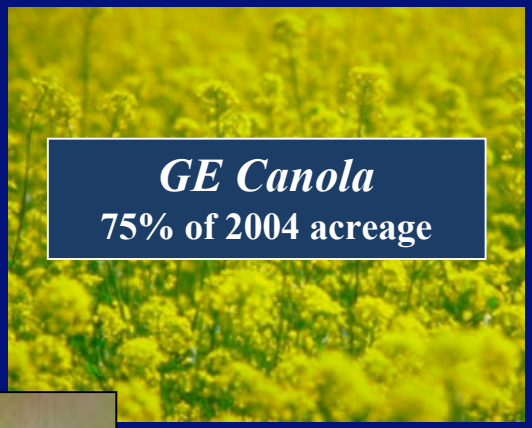
Classical Breeding compared to *Genetic Engineering*

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

GE Corn

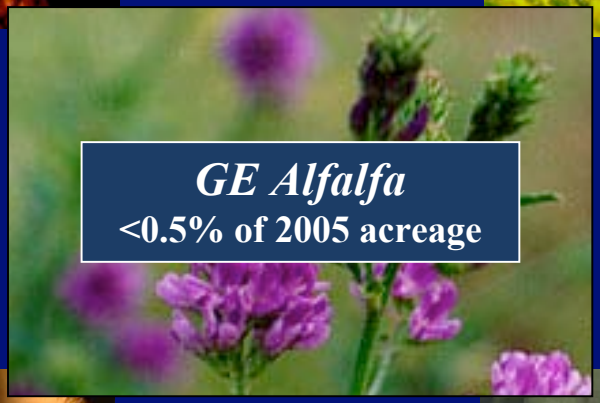
61% of 2006 acreage

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



GE Canola

75% of 2004 acreage



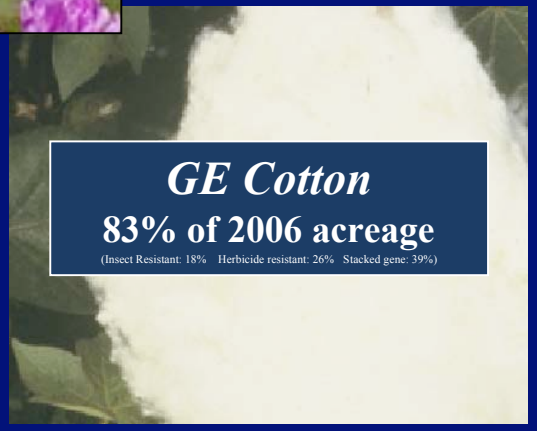
GE Alfalfa

<0.5% of 2005 acreage

GE Soybean

89% of 2006 acreage

(Herbicide resistant: 89%)



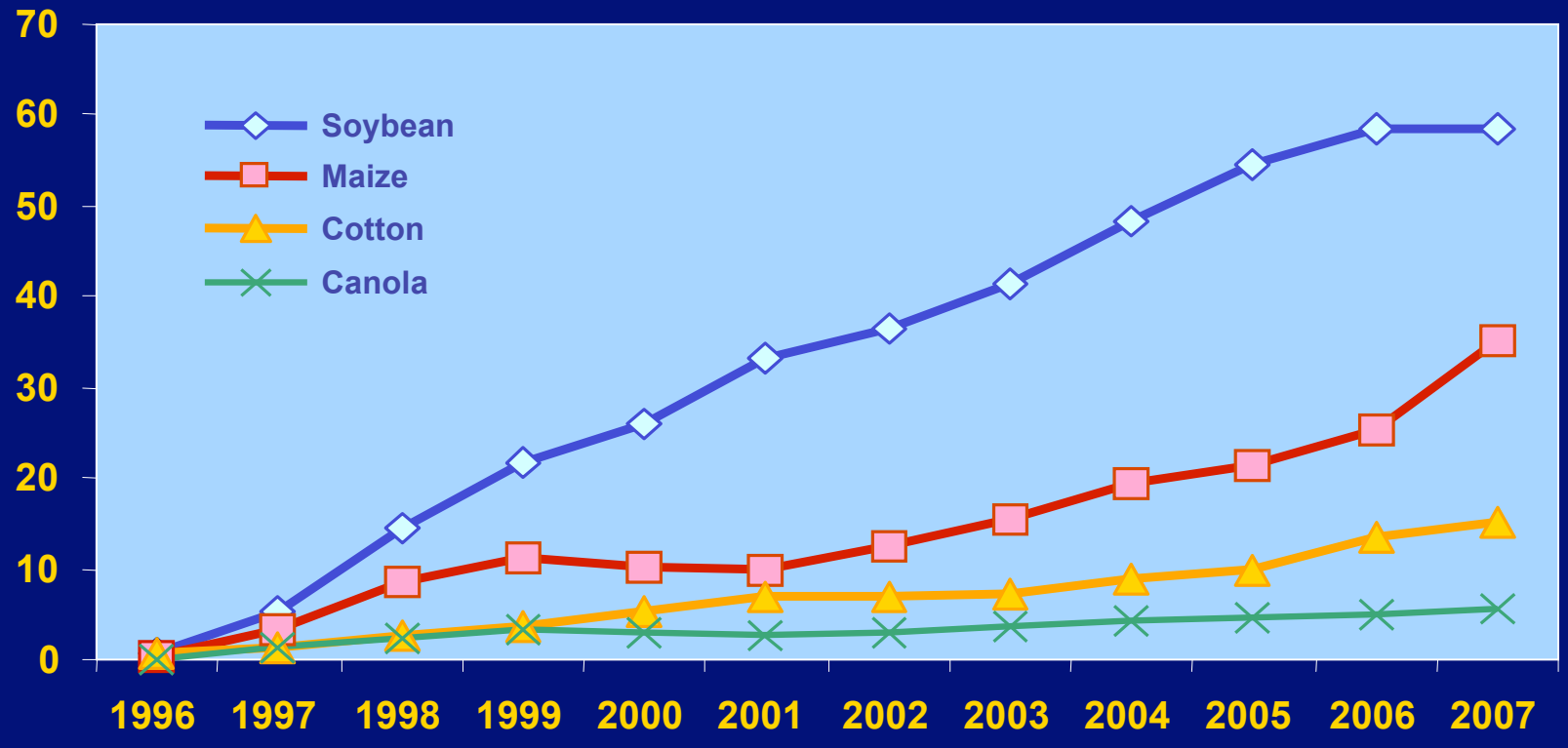
GE Cotton

83% of 2006 acreage

(Insect Resistant: 18% Herbicide resistant: 26% Stacked gene: 39%)

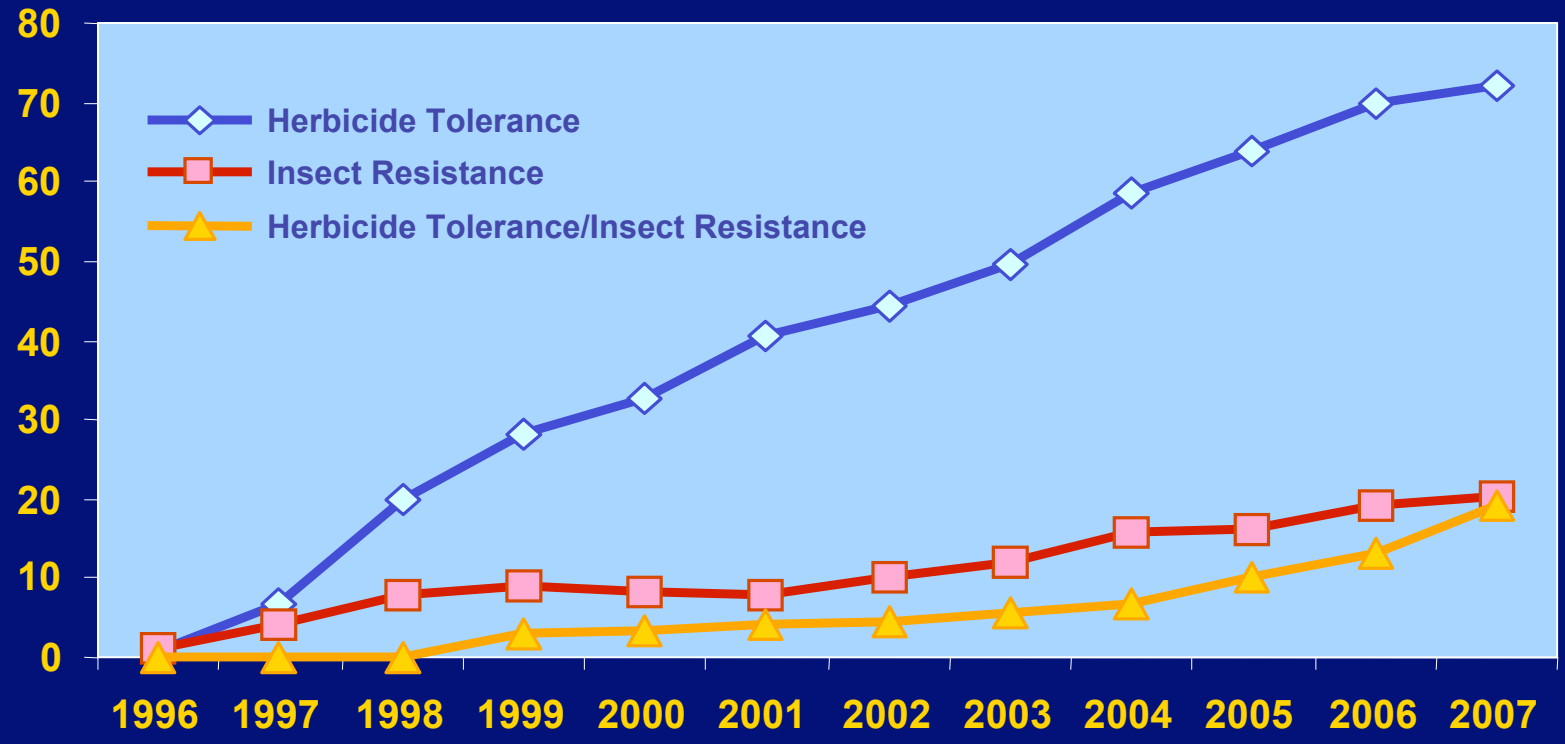
SOURCE: NCFAP; USDA

Global Area of Biotech Crops, 1996 to 2007: By Crop (Million Hectares)



Source: Clive James, 2008

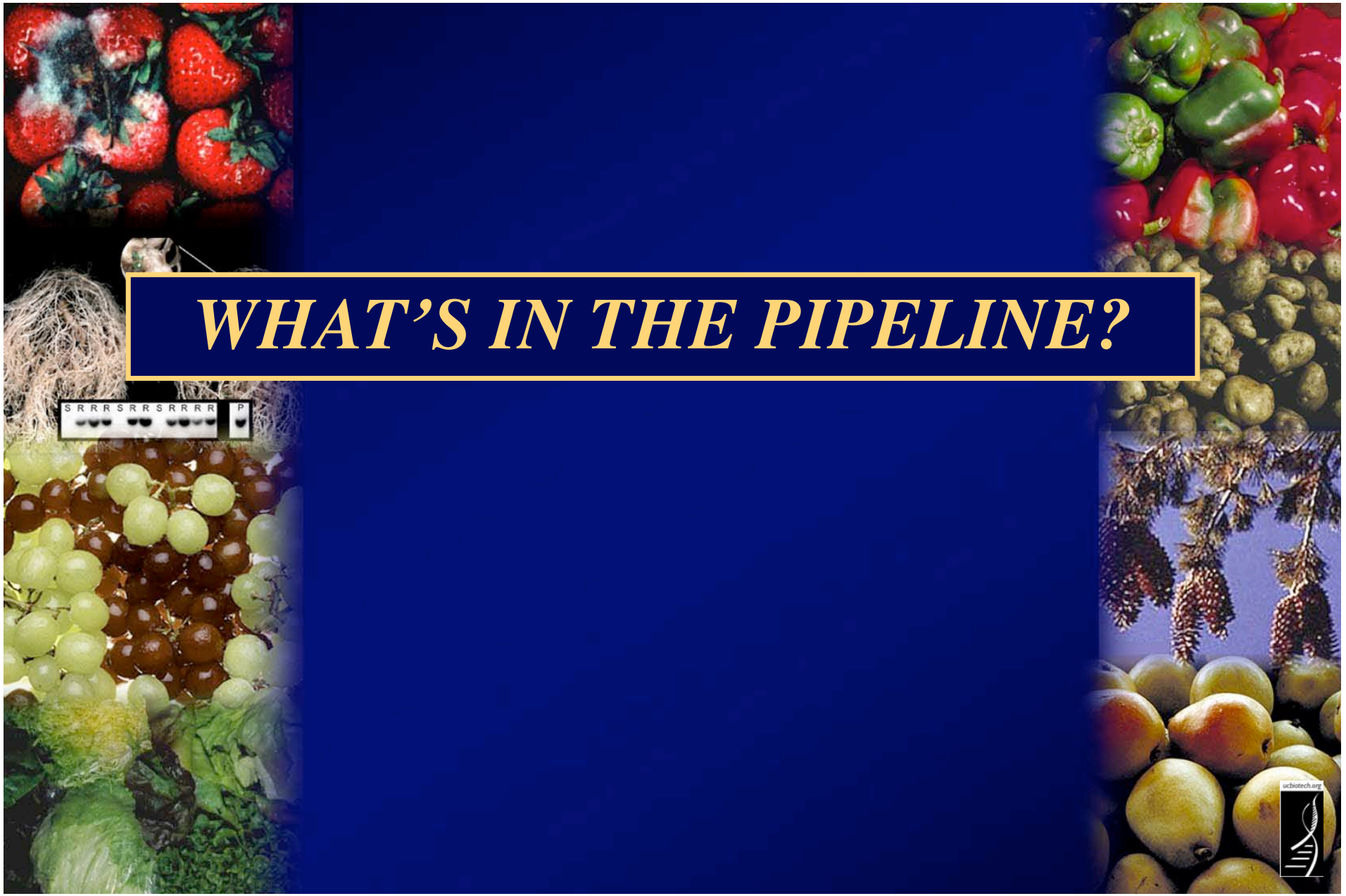
Global Area of Biotech Crops, 1996 to 2007: By Trait (Million Hectares)



Source: Clive James, 2008


Estimated over 75% of Processed
Foods in U.S. Have GE Ingredients
Wish-Bone
EDENSOY
Nutri-Grain
ProSobee
SOY FORMULA
Betty Crocker
Creamy Deluxe
SILKEN
TOFU
SOYGOLD
MULTI-PURPOSE INDUSTRIAL SOLVENT
YVES
VEGGIE
TOFU WIENERS
LOW FAT
Natural Touch
Okara Pattie
KEN & ROBERT'S
Veggie Burger
TRULY AMAZING
NACHO CHEESE
AT&T breaks
ucbiotech.org

Only a few whole foods on the market are genetically engineered



WHAT'S IN THE PIPELINE?

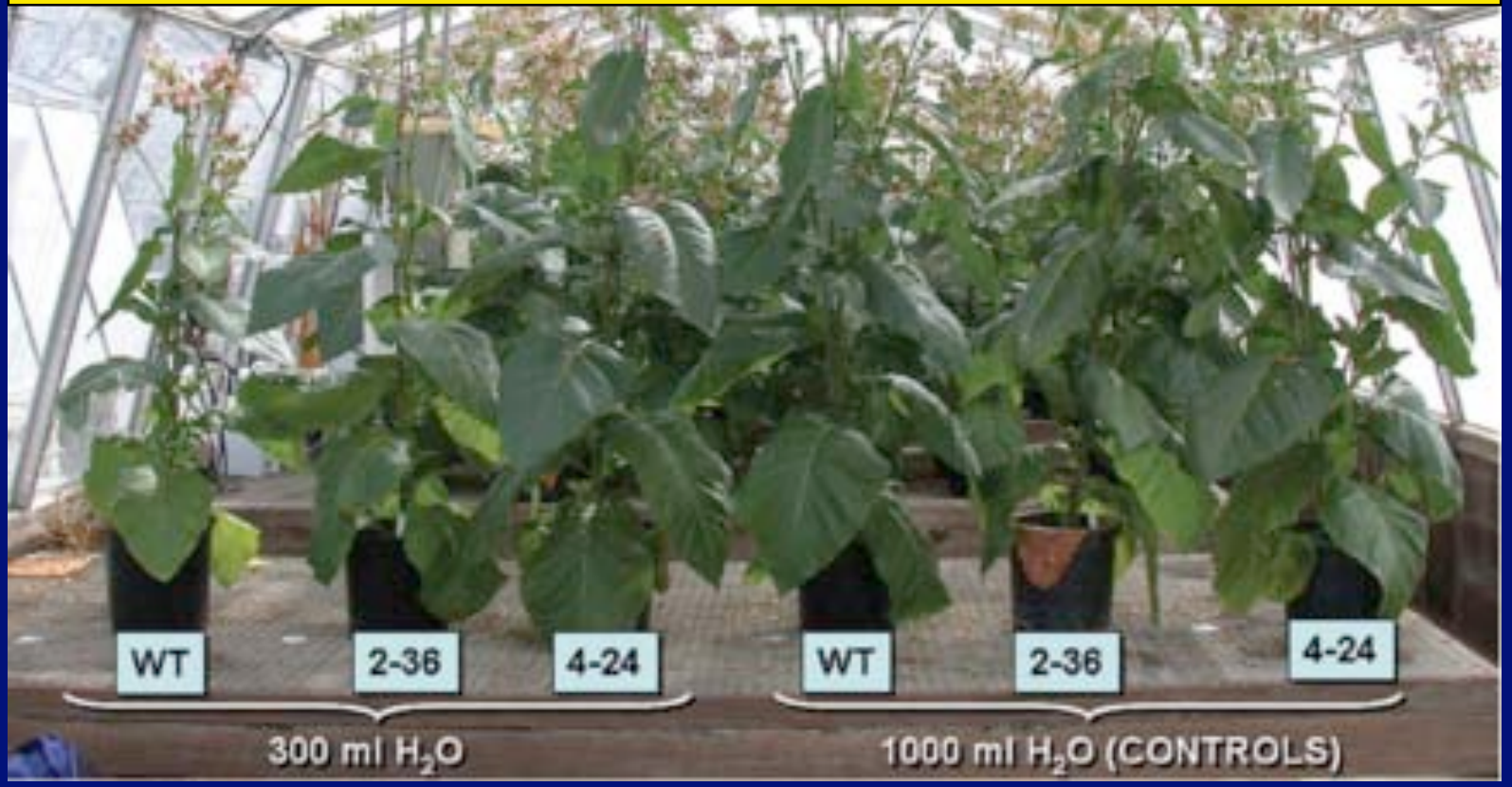
SOURCE: http://archives.foodsafety.ksu.edu/agnet/2007/4-2007/agnet_april_10.htm#story0

Gene from wild rice species improves weed control for cultivated rice

2005 IRRI Field Trail - Recovery after 17 d submergence

SOURCE: http://www.mercurynews.com/mld/mercurynews/news/local/states/california/northern_california/16115998.htm

Engineered drought tolerance leads to vigorous growth of plants after prolonged drought control plants died



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

Salt-tolerant Tomatoes

Engineered ***Control***

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

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

GE Grape Root Stocks Field Tested in Northern France for Fanleaf Virus Protection

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

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


Altering transport gene in carrot results in more bioavailable calcium for humans
SOURCE: Morris, J., Hawthorne, K.M., Hotze, T., Abrams, S.A. and Hirschi, K.D. 2008. Nutritional impact of elevated calcium transport activity in carrots. PNAS 10.1073/pnas.0709005105.
ucbiotech.org

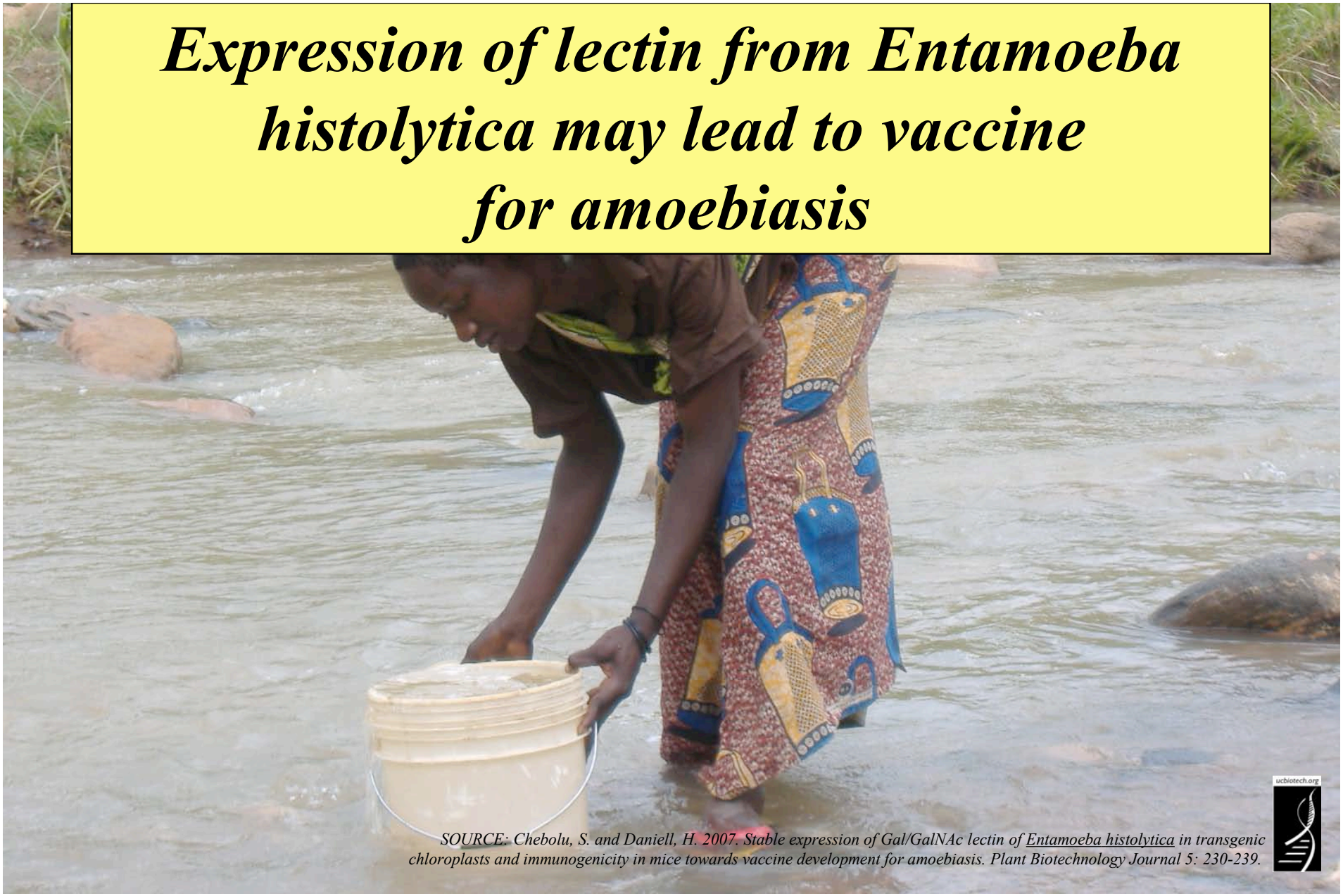

Introduction of single bacterial gene increases folate levels in tomato to levels comparable to spinach
SOURCE: Diaz de la Garza, R.I., Jesse F. Gregory III, J.F. and Hanson, A.D. 2007. Folate biofortification of tomato fruit. Proceedings of the National Academy of Sciences USA 104: 4218-4222.
ucbiotech.org


Mitigating food allergies, like peanut, soy and wheat, through engineering of plants

Production of HIV vaccine in tomato elicits immune response in mice

SOURCE: "HIV vaccine from tomatoes, a long awaited gift for millions", Checkbiotech, 1/23/08, http://www.checkbiotech.org/green_News_Genetics.aspx?infoId=16740
Ramírez, Y.J., Tasciotti, E., Gutierrez-Ortega, A., Donayre Torres, A.J., Olivera Flores, M.T., Giacca, M., Gómez Lim, M.A. 2007. Fruit-Specific Expression of the Human Immunodeficiency Virus Type 1 Tat Gene in Tomato Plants and Its Immunogenic Potential in Mice. Clinical and Vaccine Immunology 14: 685-692.

Expression of lectin from Entamoeba histolytica may lead to vaccine for amoebiasis



SOURCE: Chebolu, S. and Daniell, H. 2007. Stable expression of Gal/GalNAc lectin of Entamoeba histolytica in transgenic chloroplasts and immunogenicity in mice towards vaccine development for amoebiasis. Plant Biotechnology Journal 5: 230-239.


Oral administration of proinsulin in lettuce protects against insulitis in diabetic mice
SOURCE: Ruhlman, T., Ahangari, R., Devine, A., Samsam, M. and Daniell, H. 2007. Expression of cholera toxin B-proinsulin fusion protein in lettuce and tobacco chloroplasts - oral administration protects against development of insulitis in non-obese diabetic mice. Plant Biotechnology Journal 5: 495-510.
ucbiotech.org

Scientists create rice with cholera vaccine

SOURCE: http://www.guardian.co.uk/science/story/0,,2100737,00.html

Nagai et al. 2007. Role of Peyer's patches in the induction of Helicobacter pylori-induced gastritis. Proceedings of the National Academy of Sciences USA 104: 8971-8976.

U.S. Regulatory Agencies
(based oversight on existing regulations)

USDA

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

FDA

- Food safety
- Feed safety

EPA

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

Safety of engineered food: Is it as safe as a conventional food?

Concept of substantial equivalence:

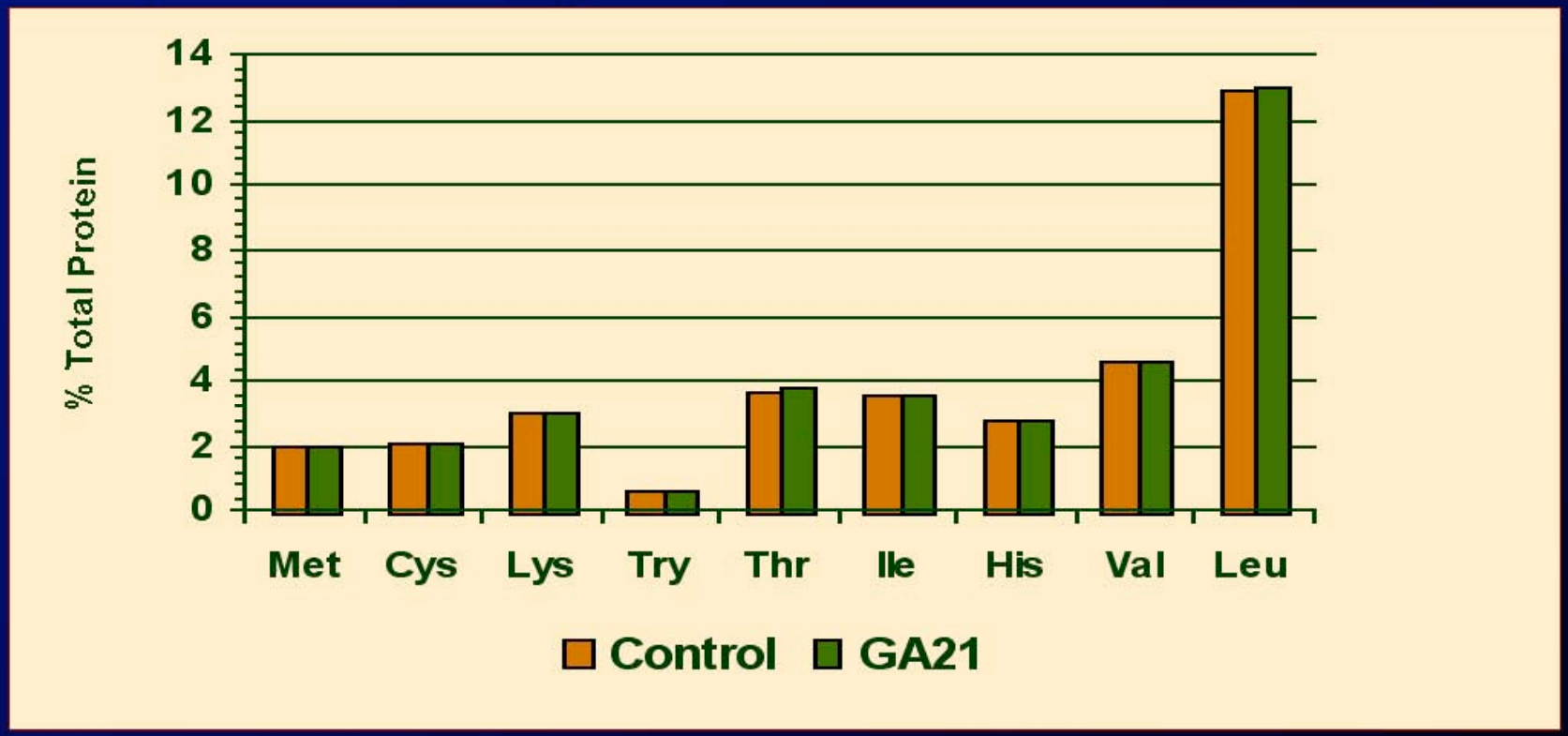
Modified food has essentially all characteristics of nonmodified food with respect to food and feed value

except

for the introduced genetic material and the products made from it. These products have to be tested and analyzed separately. Regulators look at, for example, specificity and mode of action of protein, source of protein, its stability during digestion and processing

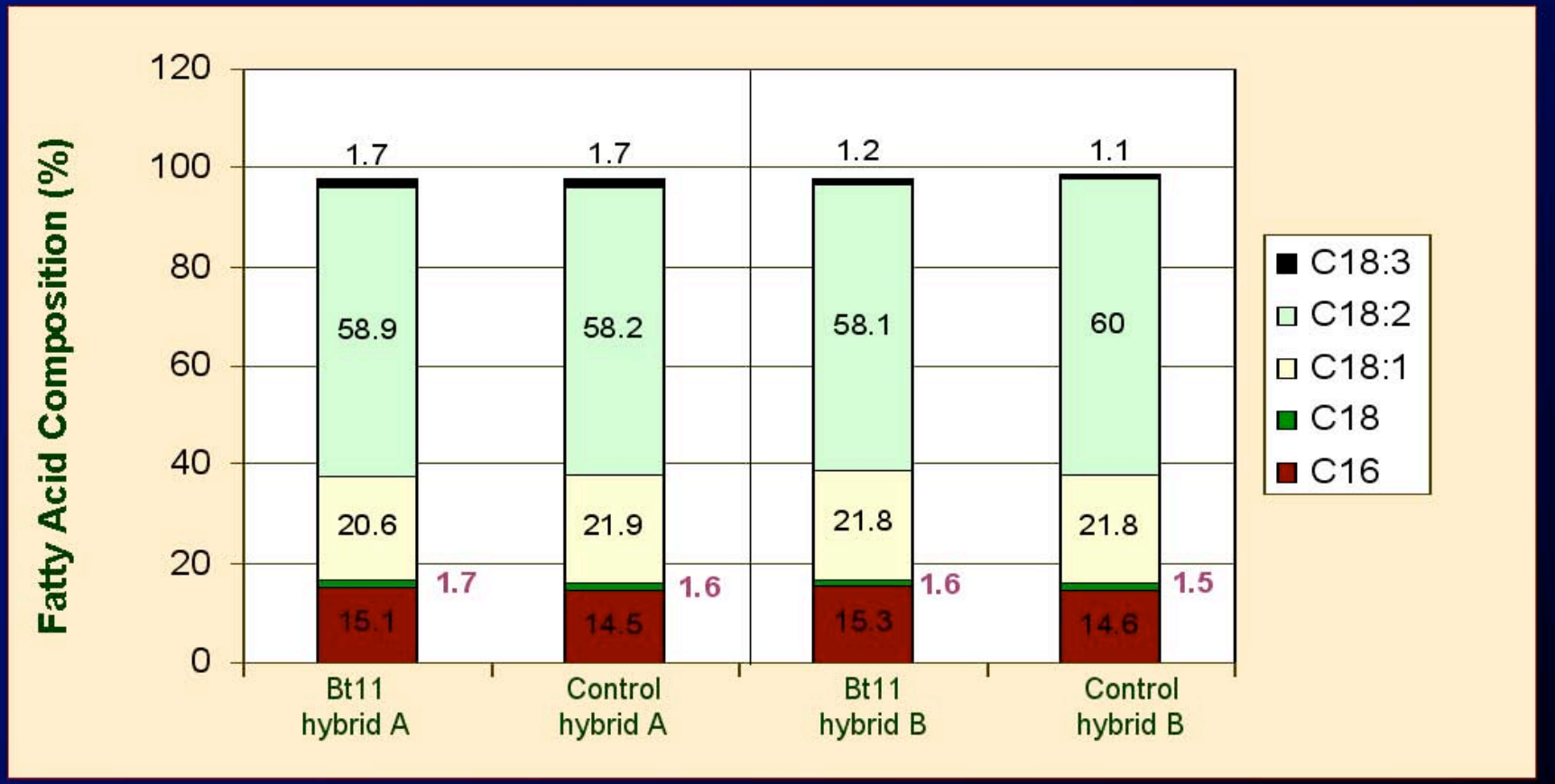
SOURCE: Safety of Genetically Engineered Foods: Aproaches to Assessing Unintended Health Effects 2004. Natl Acad Press

Substantial Equivalence: Amino Acids



These results have been generated on event GA21. Data showing similar amino acid composition have been generated on the other corn events.

Substantial Equivalence: Fatty Acids



These results have been generated on Event Bt 11. Data showing similar fatty acid composition have been generated on the other corn events.