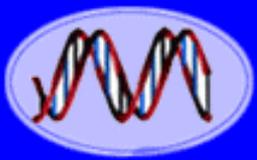


*An Insider's View of GMOs
Past, Present. & Future*

*Bob Goldberg
3/2/17*

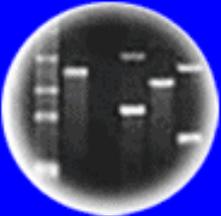




DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Modern Genetic Engineering Was Invented Almost 50 Years Ago!

Proc. Nat. Acad. Sci. USA
Vol. 70, No. 11, pp. 3240-3244

November 1973

*This is the 40th Anniversary of Genetic
Engineering's Origins*

Construction of Biologically Functional Bacterial Plasmids *In Vitro*

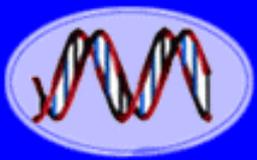
(R factor/restriction enzyme/transformation/endonuclease/antibiotic resistance)

STANLEY N. COHEN*, ANNIE C. Y. CHANG*, HERBERT W. BOYER†, AND ROBERT B. HELLING†

* Department of Medicine, Stanford University School of Medicine, Stanford, California 94305; and † Department of Microbiology, University of California at San Francisco, San Francisco, Calif. 94122

Communicated by Norman Davidson, July 18, 1973

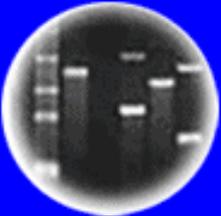
*It is Not a New Technology...In Fact, To
Those of Us Who Have Done This Our
Entire Careers, It is an OLD technology!!*



DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



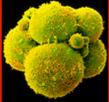
Plants of Tomorrow

Genetic Engineering in the News.. *Medicine*

In Girl's Last Hope, Altered Immune Cells Beat Leukemia

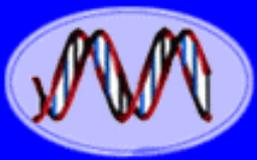
British Lawmakers Approve 'Three-Parent' In-Vitro Fertilization

Gene therapy trial 'cures children'

Chinese scientists genetically modify human embryos 

UCLA researcher pioneers gene therapy cure for 'Bubble Baby' disease

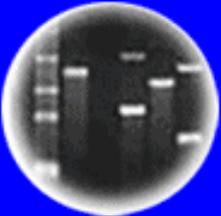
UK scientists apply for licence to edit genes in human embryos



DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Genetic Engineering in the News..

The Law

DNA Test Frees Man After 34 Years In Prison

Supreme Court OKs DNA swab of people under arrest

Supreme Court Supports Monsanto in Seed-Replication Case

NOVEMBER 7, 2012, 9:21 AM

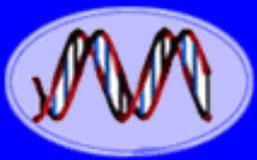


California Votes No on 37: Flawed Proposition on Food Labeling

Federal judge rules against Big Island GMO law

Supreme Court Free-Speech Decision Clobbers GMO Food-Labeling Activists

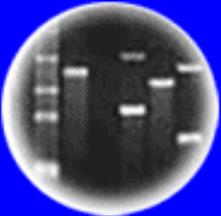
Justices, 9-0, Bar Patenting Human Genes



DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Genetic Engineering in the News..

Agriculture

Super-muscly pigs created by small genetic tweak

Genetically Modified Salmon Is Safe To Eat, FDA Says

Gene-Altered Apples and Potatoes Are Safe, F.D.A. Says

NOVEMBER 7, 2012, 9:21 AM



California Votes No on 37: Flawed Proposition on Food Labeling

G.M.O. Labels for Food Proliferate Even as a Battle Over Them Rages

SCIENTISTS DEVELOP GM CITRUS WITH ENHANCED RESISTANCE TO GREENING



The Politics of...

NO ON **37**
STOP THE DECEPTIVE
FOOD LABELING SCHEME

G**M****O****S**



US rethinks crop regulation

Committee begins study to guide oversight of gene-edited organisms.

Congress Passes GMO Food Labeling Bill

The world's first GMO apple will not turn brown, but is it safe?

FDA, EPA approve 3 types of genetically engineered potatoes

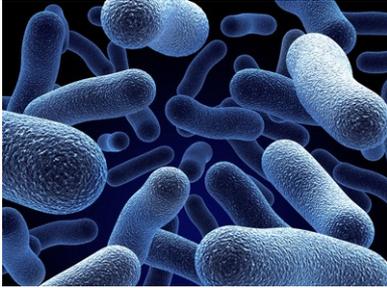
Justices Back Monsanto on Biotech Seed Planting

Human Gene Editing Receives Science Panel's Support

What's a *GMO*?



What's a GMO?



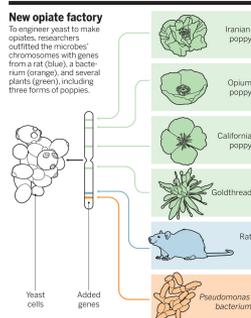
*A Genetically Engineered Bacteria
Synthesizing
Human Insulin Used as a Drug to
Treat Diabetics?*



*A Genetically Engineered GloFish
Used as a Pet?*



*A Genetically Engineered Pig
With Double Muscles For Leaner
& More Meat*



*A Genetically Engineered Yeast
That Synthesizes Opiates For
Medicine?*

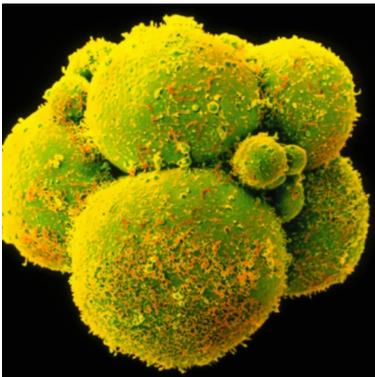
What's a GMO?



A Genetically Engineered Salmon That Grows Faster Than Non-Engineered Salmon & Has Been Approved by the FDA For Human Consumption?



A Genetically Engineered Person With a Gene That They Weren't Born With That "Cures" a Lethal Genetic Disease?



A Human Embryo With a Defective Blood Disease Gene That Was "Edited" and Engineered to Be Normal?

So.....What's a GMO?



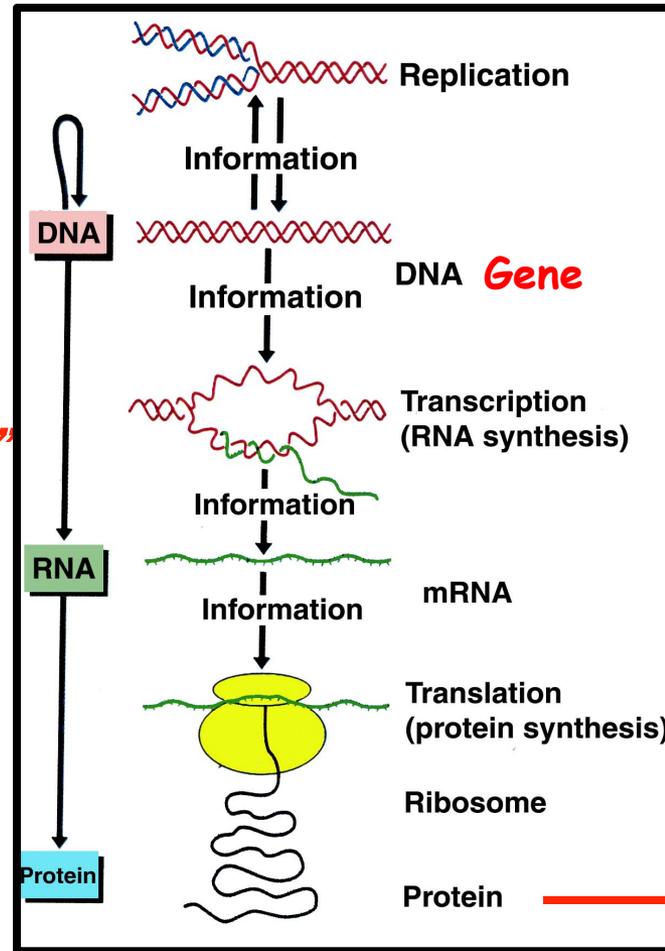
*Crops That Are Grown
For For
Human & Animal
Consumption?*



Genes Obey the Same Rules Using **Either** Classical or Molecular Genetic Engineering Approaches!! **BOTH Produce GMOs!**

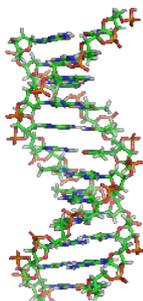
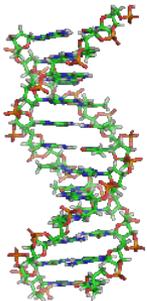
Can Intervene in This Process in Cells

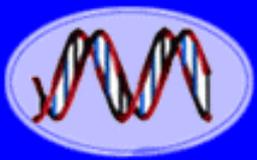
Genetic Engineering Is not "Hocus Pocus." It Uses "Natural" Cell Processes!!!!



All Organisms Use The **SAME** Processes And "RULES" to Generate Traits!! And The **SAME** Molecules & Chemistry!!

Coat Color Trait

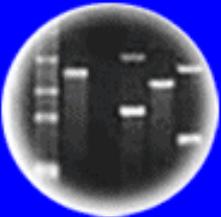




DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Genetic Engineering is a TECHNIQUE!

What Is a GMO? | GMOs are the product of a specific type of plant breeding where precise changes are made to a plant's DNA to give it characteristics that cannot be achieved through traditional plant breeding methods.

SELECTIVE BREEDING

Plant breeders look for, select and cross-breed the best performing plants in the field, similar to how farmers have naturally improved the crops they grow since farming began.

ADVANCED BREEDING

Breeders identify and tag desirable characteristics (traits) within a plant genome. They use this information to pick which plants to cross-breed and create better performing crops.

DROUGHT TOLERANCE

STRONG STALKS AND ROOTS

GM PLANT BREEDING

If a plant needs a trait that can't be achieved through advanced breeding, a gene can be turned off or moved, or a gene from another source can be inserted.

GMOs can help farmers ...

- prevent crop disease
- control insects
- manage weeds
- change nutritional profile

There are eight GMO crops available in the U.S. today:

- Corn (field and sweet)
- Soybeans
- Cotton
- Canola
- Alfalfa
- Sugar Beets
- Papaya
- Squash

For more information, visit www.GMOAnswers.com

Breeding or DNA - It's the Same
& Called *Gene Manipulation*
WHAT IS A GMO!!!!



Agriculture is Facing the Perfect Storm

Population Growth & Increased Demand For Food

Reduced Land For Agriculture

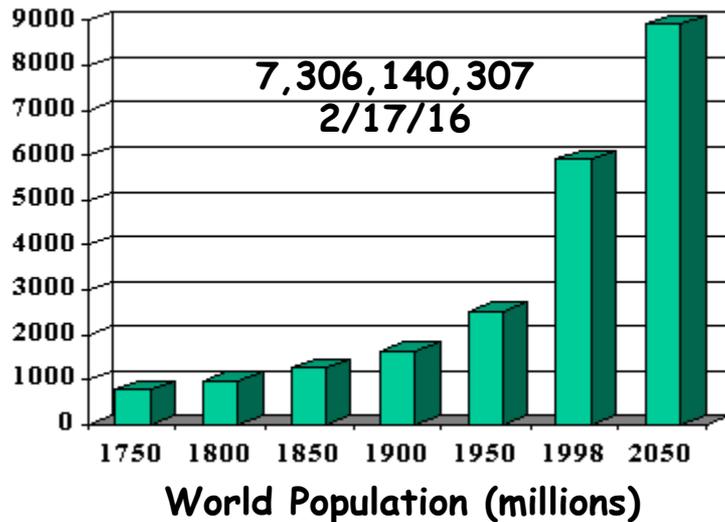
Scarcity of Natural Resources (e.g., Water)

Climate Change

Expanding Pest Habitats



We Face Major Challenges in Agriculture

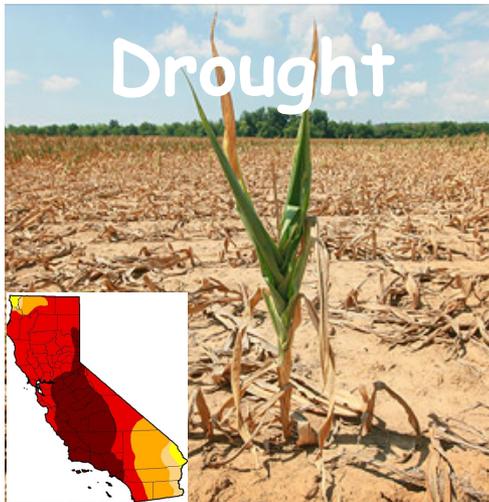


OVER THE NEXT 50 YEARS WE WILL NEED TO PRODUCE MORE FOOD THAN IN THE WHOLE OF HUMAN HISTORY AND DO IT WITH FEWER INPUTS ON LESS ARABLE LAND!!!!

CROP YIELDS NEED TO BE INCREASED SIGNIFICANTLY!!

And..... There is a Constant Battle Between Crops & Environment That Affects Yield!!

Abiotic (Drought, Heat) & Biotic (Insects, Fungi, Viruses) Stresses Reduce Crop Production (Yield) Worldwide Significantly

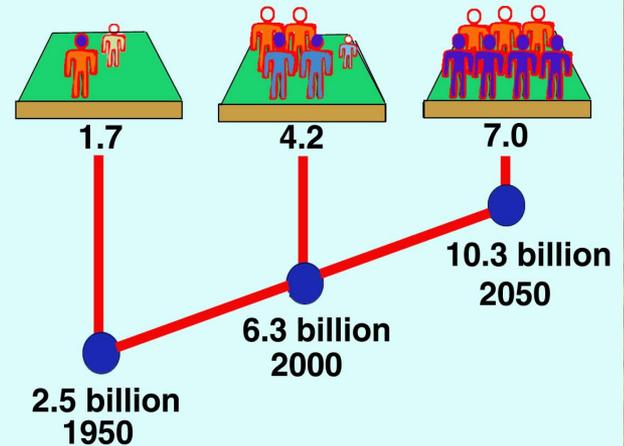


**Biotic Stress Results in 30-40% Crop Loss Per Year or
\$500B Annually! *FAO Statistics***

**Abiotic Drought Stress Costs California Agriculture \$1.84B
and 10,000 jobs in 2015! *UC Davis News & Information***

*Thus....Crop YIELDS MUST Be Increased
Using Every Discovery & Technique
Available (Holy Grail of Agriculture)!*

One hectare has to feed
more and more people



Growth of world population

Loss of Land & Increased Population Affects Crop Yield!!!

There Were 18,000 Farms in Los Angeles County in 1930!!!

From 1901 to 1950 Los Angeles County Was the Highest Agricultural Producing County in the USA!!!

Bel-Air

Farms!!

Beverly Hills

Sunset Blvd.

Hilgard Blvd.

Westwood Blvd.

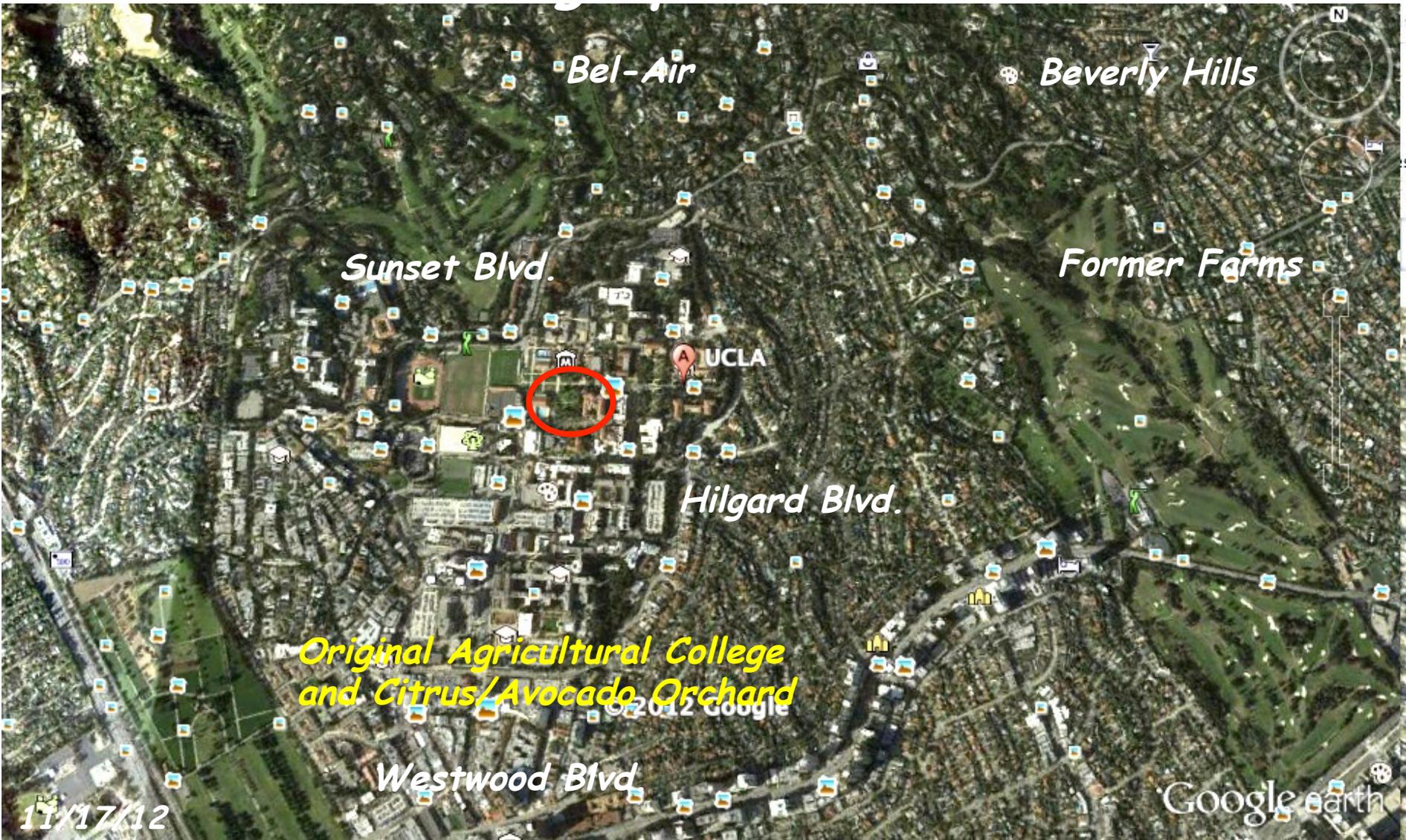
*Original Agricultural College
and Citrus/Avocado Orchard*

*Thehner Hoover
4/11/29*

Los Angeles Population = 1,238,000



Aerial Photograph of UCLA in 2016



Note: Los of Crop Land!! Gone Forever!!

Los Angeles Population = 3,893,000

*How Have Crop Yields Increased Over
the Past 100 Years?*



THE ADMINISTRATION'S PROMISES HAVE BEEN KEPT

Big Changes in the US Over The Past 100+ Years

“We’ve Come a Long Way Baby”

	1900	2016
Life Expectancy	48 (women)	81 (women)
Average Family Income (2016 Dollars)	\$8,000	\$50,000
Gasoline Use Per Capita	34 gallons	1,100 gallons
Flush Toilets Per Housing Unit	10%	99%
High School Grads	13%	90%
Farm Workers	55%	1.5%

AMERICAN FLAG

HAS NOT BEEN PLANTED IN FOREIGN SOIL
TO ACQUIRE MORE TERRITORY
BUT FOR
HUMANITY'S SAKE

(THE WASHINGTON POST, JULY 12, 1900)

CROP **YIELD** INCREASES HAVE “ROCKETED UPWARDS” OVER THE LAST 100 YEARS AND CONTRIBUTED TO A **LONGER AND “BETTER” LIFE**

% Farm % Income
Workers on Food

Life Span

55%

50% →

• 1900

Bushels/Acre

30

• 1920

30

• 1940

40

• 1960

60

• 1980

100

• **2016**

185



← 48 Years

1.5%

22% →

7% →

← 80 Years

1930: 30 bushels/acre

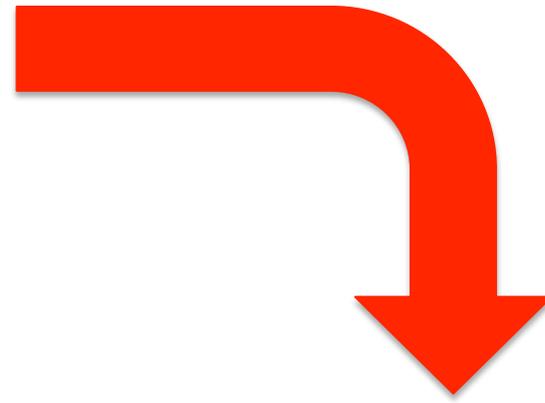
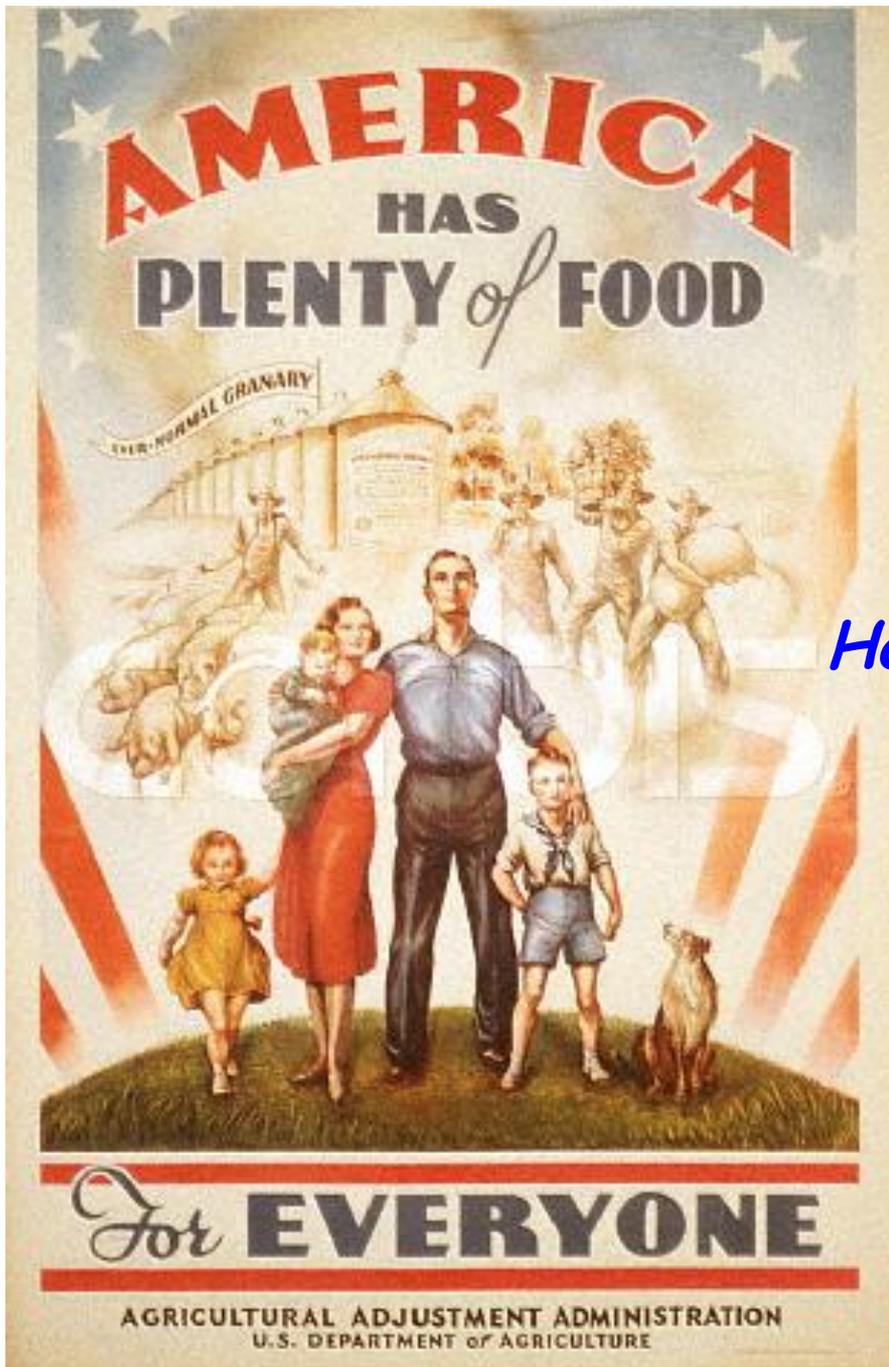
2016: 185 bushels/acre

1930: 1 farmer fed 10 people

2016: 1 farmer feeds 200 people

Conclusion: Crop yields increased >500% over the past 100 years
and lead to a similar reduction in food costs!!!!





*How Were Crop Yields Increased
Over the Past 100+ Years?*





Explore The Possibilities





WHAT TECHNOLOGIES CAUSED AN INCREASE IN CROP YIELDS OVER THE PAST 100 YEARS?

- **PLANT BREEDING (New Hybrids-Green Revolution)**
- **IRRIGATION (Abiotic Stress)**
- **FERTILIZERS (Nutrients)**
- **PESTICIDES & HERBICIDES (Biotic Stress)**
- **MECHANIZATION (e.g., Tractor)**
- **GLOBAL POSITIONING AND SATELLITE IMAGING**
- **GENOMICS & GENETIC ENGINEERING (New Traits)**

These technologies have resulted in a >300% increase in US crop productivity!

Need to sustain this yield increase by applying the best technology and agricultural practices!



*How Will Crop Yields Be Increased
In the Next 100 Years?*



*Our Food is Derived From Fifteen Crops & Over Half Produce Seeds For Human and Animal Consumption
All of These Genomes Have Been Sequenced!*

Seed Crops



- *Wheat*
- *Rice*
- *Corn**
- *Barley*
- *Sorghum*
- *Soybean**
- *Common Bean*
- *Coconut*
- *Canola**

Non-Seed Crops

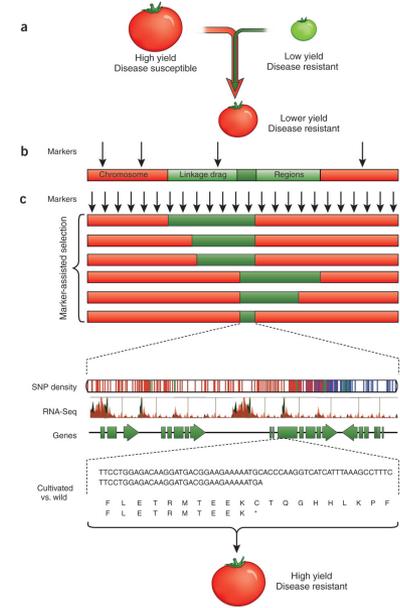
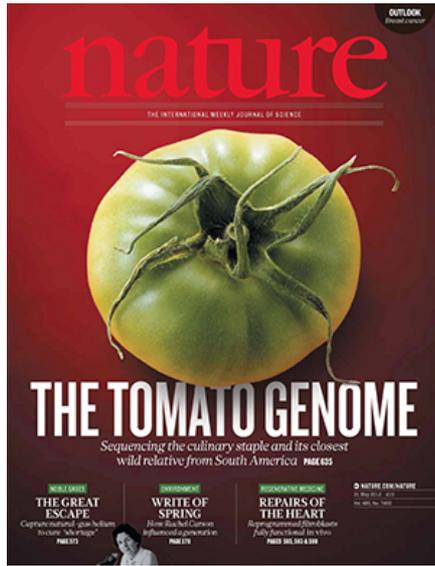
- *Potato*
- *Sweet Potato*
- *Cassava*
- *Sugar Beet**
- *Sugar Cane*
- *Banana*

We Understand the Science of These Genomes - It's No Longer a "Black Box" as in the Pre-Genomics Era!!!!

** Genetically Engineered*



Road to Understanding Plant Processes Runs Through Genome Sequences

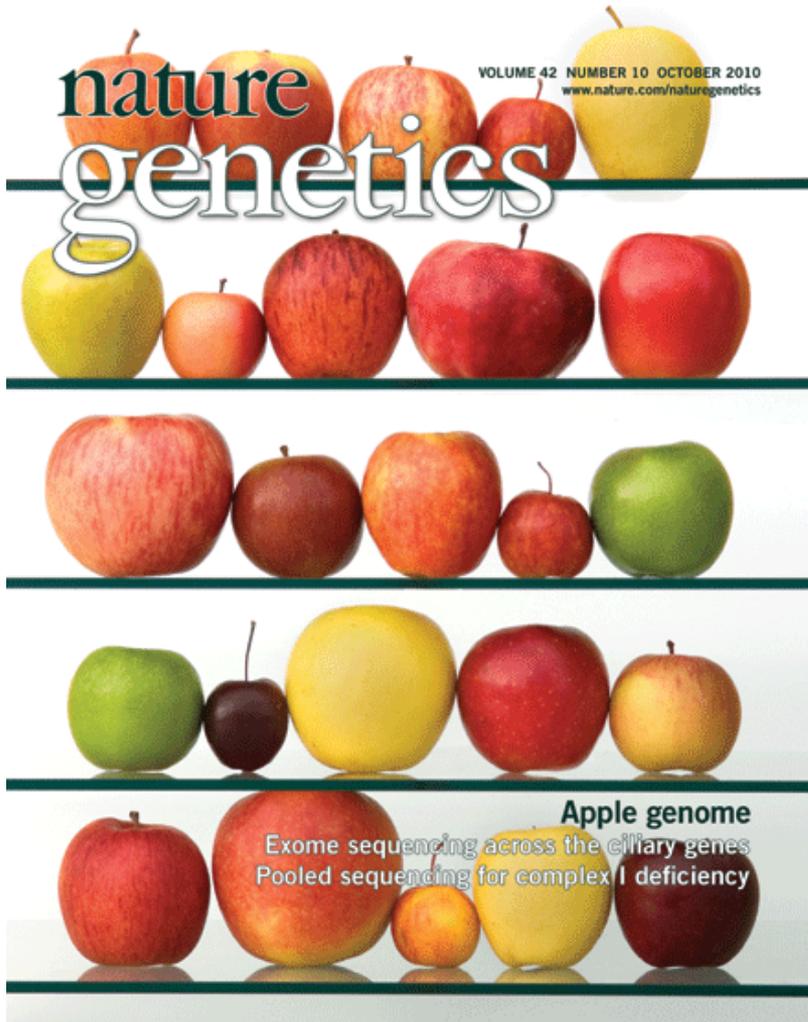


Researchers Discover Key to Restoring Great Tomato Flavor

Tomato Flavor Guide					
	Red or Pink "The Classic"	Orange "The Fruity"	Yellow or White "The Mild"	Green "The Tangy"	Black "The Smokey"
	Balanced Sugar Balanced Acidity	Medium Sugar Medium Acidity	High Sugar Low Acidity	Low Sugar High Acidity	High Sweetness High Acidity
Slicers "Burgers and Salads" High Water Meaty Texture					
Plums "Sauce" Low Water Chewy Texture					
Minis "Snacking" High Water Smaller = Sweeter					

GASTRONOMICS

Genetically modified apple that never browns to hit stores



Arctic APPLES

MAKING THE PERFECT FRUIT EVEN BETTER

HOW APPLES BROWN
When an apple is cut, bitten or bruised, an enzyme called Polyphenol Oxidase (PPO) triggers the browning reaction

CONVENTIONAL APPLE → **PPO ENZYME REDUCED** → **ARCTIC APPLE**

24 WKS
Creating an Arctic apple tree takes about 24 weeks

50% WASTED
About 50% of apples grown are wasted

71% MORE
Kids eat 71% more apples when they're pre-sliced

STOP

HOW DO WE STOP BROWNING?
One way to think of it: We replace one piece of a "railway track" (the PPO genes) on a coast-to-coast railway (genetic code) with a slightly different piece of track

Another way to think of it

- 1 We introduce apple genes that produce less PPO into apple leaf tissue
- 2 A successful transformation is confirmed by growing this tissue under special conditions
- 3 Once the tissue has grown into plantlets we graft it onto rootstock
- 4 Arctic trees can then be planted and grown just like any other apple tree!

WHY MAKE A NONBROWNING APPLE?
After learning about Arctic apples, consumers say they're 3 times more likely to buy them than not buy them

ARCTIC® APPLES ARE JUST AS SAFE & HEALTHY AS ALL APPLES

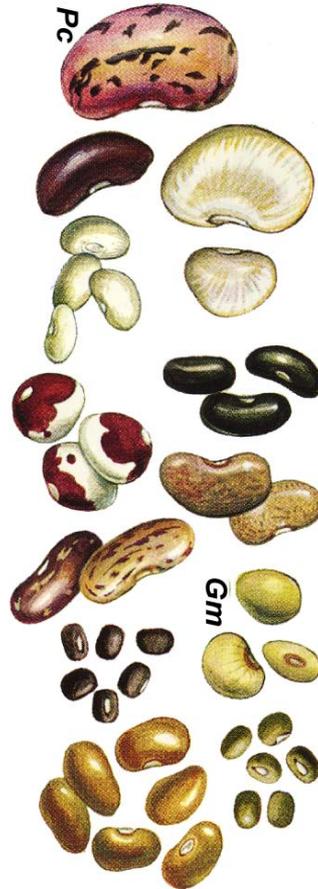
- No new proteins
- The only difference is when you bite, cut or bruise the apple!
- The same nutrition

© 2013 by Okazaki Specialty Fruits. All rights reserved.
"Arctic" is an OSF trademark

...By Using a Variety of Approaches to Identify Genes and Processes That Will Help Increase Crop Yields and Food Production Significantly in the 21st Century...

Yield (Developmental Traits)

- *Seed Number*
- *Seed Size*
- *Growth Rate*
- *Organ Size (More Seeds)*
- *Plant Architecture*
- *Flowering Time*
- *Senescence*
- *Maturity*
- *Stature*



Yield (Stress Traits)

- *Nutrient Uptake*
- *Drought Resistance*
- *Heat Resistance*
- *Cold Tolerance*
- *Salt Tolerance*
- *Shade Tolerance*
- *Disease Resistance*



.....And by Using Genomics, Breeding, and Genetic Engineering to Introduce These “Yield” Genes Into Crops (One thing we can be sure of-we can't predict what new technology will be the driver 10-25 years out!)

All Crops Have Been Engineered - Turning Wild Teosinte Into Domesticated Corn 10,000 Years Ago - Seed & Plant Engineering!!



All Vegetables in Grocery Stores Are "GMOs!!"

- Types & amounts of seed starch production
- Seeds not dropping from cob
- Length and number of seed rows
- Seed size, shape, and color
- Seed taste
- Resistance to pests



Teosinte



Domesticated corn



Made by "Nature"

Teosinte



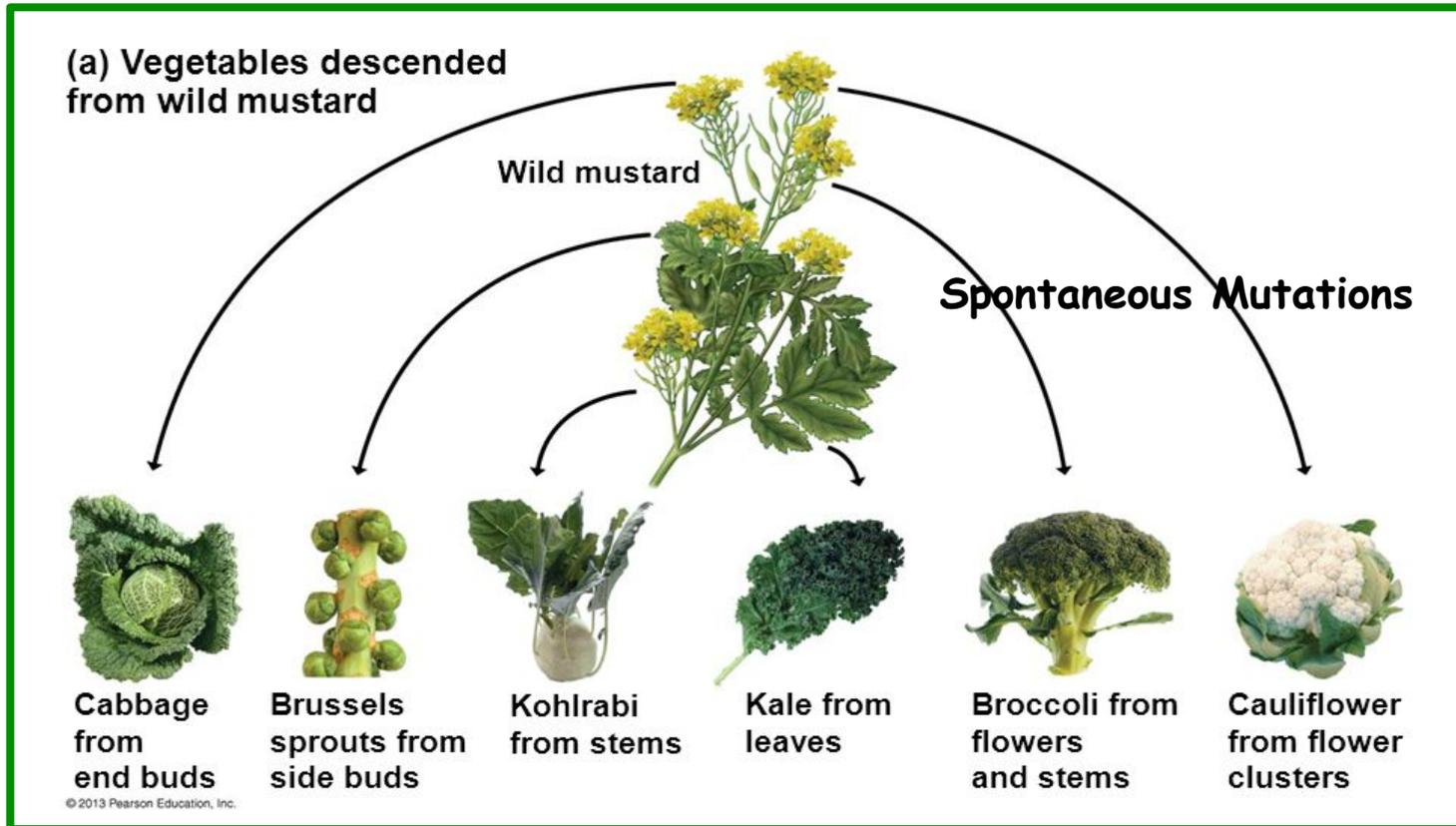
Engineered by Humans

Early domesticated corn

Note: Architecture and Fruit (cob) Size

Only Five Genes Cause These Plants to Differ & We Now Know What They Are

Engineering Vegetables With Different Plant Architectures



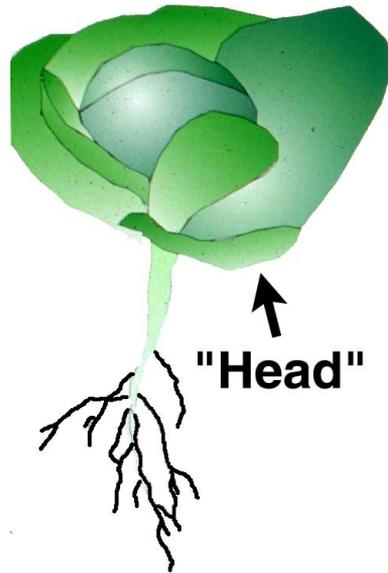
Manipulating Existing Genetic Variability Brought About By Chance Mutations!

The Problem With Breeding the "Old Fashioned Way"

Engineering A Novel Crop By "Wide" Breeding

Cabbage (*Brassica*)

Radish (*Raphanus*)



"Head"

X



Storage
Root

???

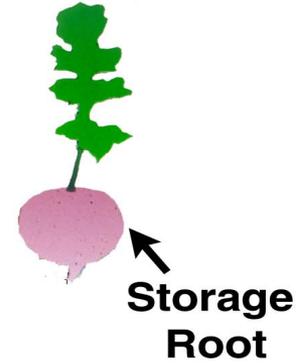
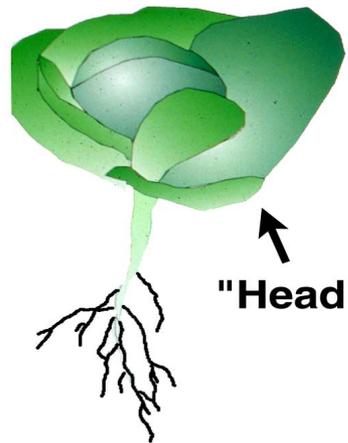
Karpechenko
1925



Engineering A Novel Crop By "Wide" Breeding

Cabbage (*Brassica*)

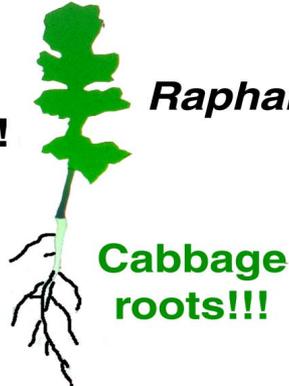
Radish (*Raphanus*)



X

Radish
leaves!!!

RaphanoBrassica

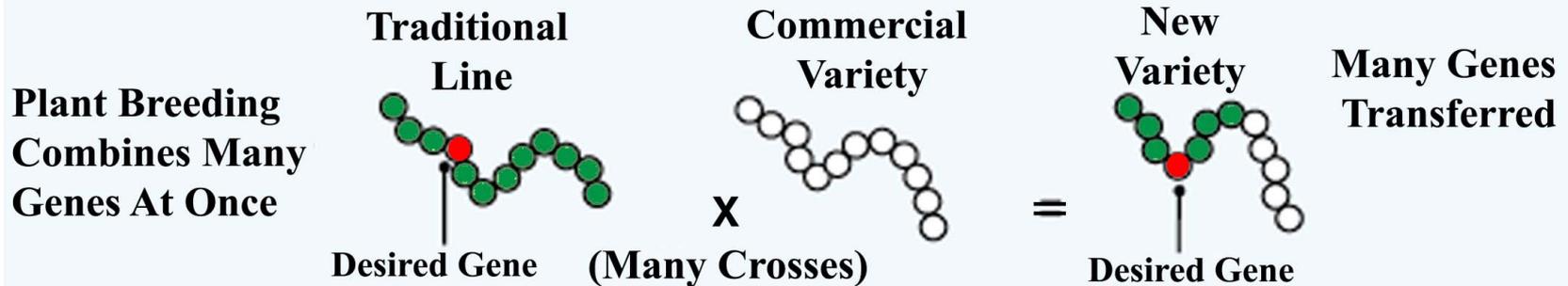


Cabbage
roots!!!

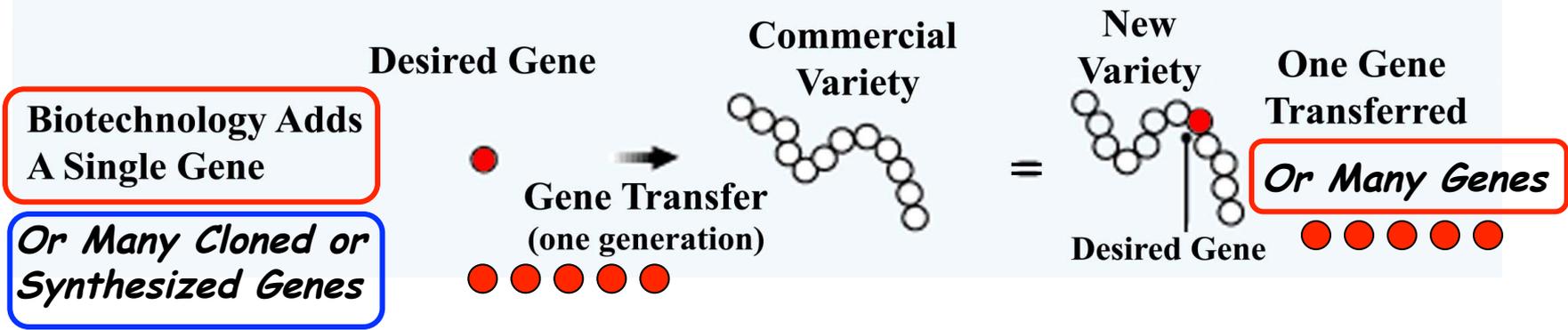
*Results Show the Unpredictability of Classical
Breeding Approaches!!*

Classical vs. DNA or Molecular Genetic Engineering Techniques

TRADITIONAL PLANT BREEDING

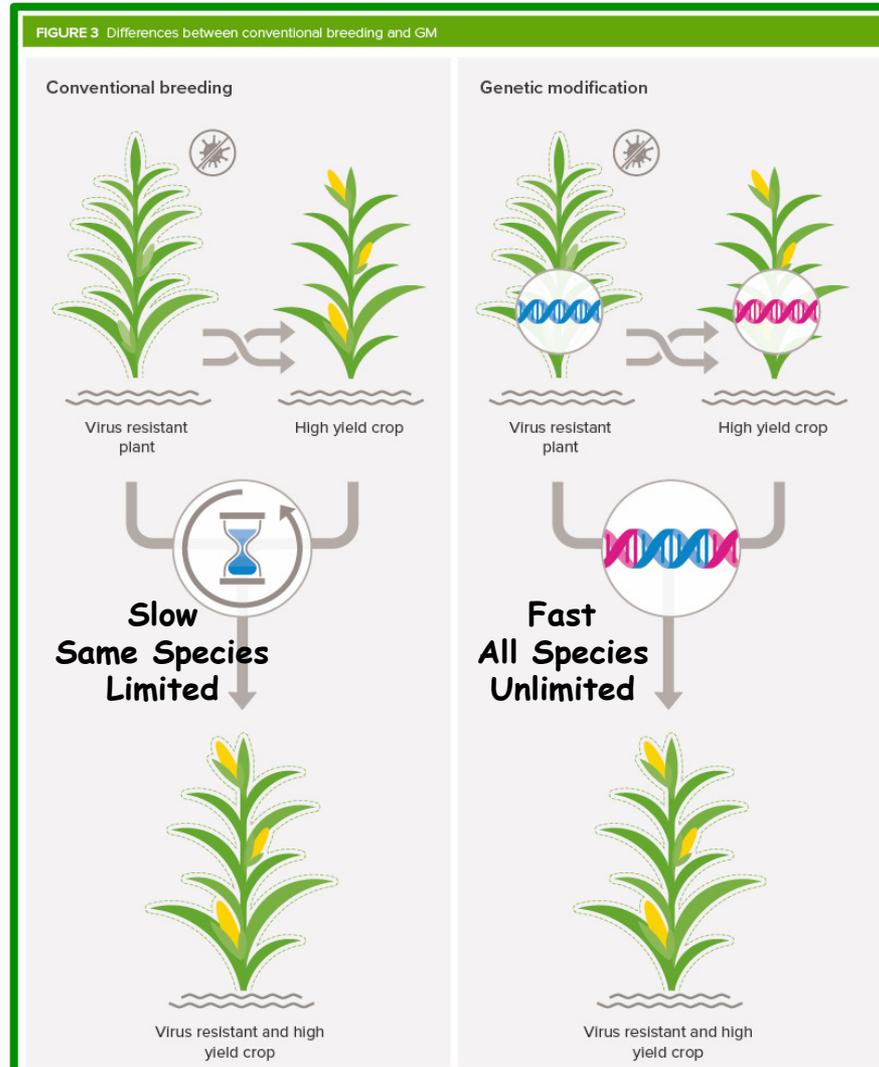


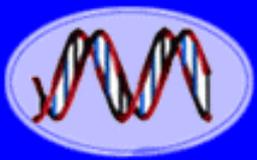
PLANT BIOTECHNOLOGY



All Manipulate Genes - But in Different Ways!!

Classical vs. DNA or Molecular Genetic Engineering Techniques

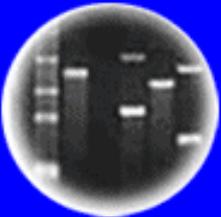




DNA
Genetic Code of Life



Entire Genetic Code
of a Bacteria



DNA Fingerprinting



Cloning: Ethical Issues
and Future Consequences



Plants of Tomorrow

Genetic Engineering is a TECHNIQUE!

What Is a GMO? | GMOs are the product of a specific type of plant breeding where precise changes are made to a plant's DNA to give it characteristics that cannot be achieved through traditional plant breeding methods.

SELECTIVE BREEDING

Plant breeders look for, select and cross-breed the best performing plants in the field, similar to how farmers have naturally improved the crops they grow since farming began.

ADVANCED BREEDING

Breeders identify and tag desirable characteristics (traits) within a plant genome. They use this information to pick which plants to cross-breed and create better performing crops.

GM PLANT BREEDING

If a plant needs a trait that can't be achieved through advanced breeding, a gene can be turned off or moved, or a gene from another source can be inserted.

GMOs can help farmers ...

- prevent crop disease
- control insects
- manage weeds
- change nutritional profile

There are eight GMO crops available in the U.S. today:

- Corn (field and sweet)
- Soybeans
- Cotton
- Canola
- Alfalfa
- Sugar Beets
- Papaya
- Squash

For more information, visit www.GMOAnswers.com

Breeding or DNA - It's the Same & Called *Gene Manipulation* **WHAT IS A GMO!!!!**

Crop GMOs in Cultivation Today



Cotton



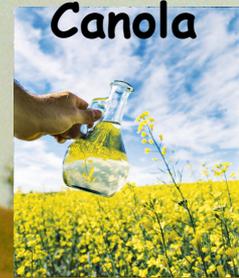
Soybean



Corn



Sugar Beet



Canola



Alfalfa

*There Are Ten Crops
Grown For Human &
Animal Consumption*

Arctic
Apple



Papaya

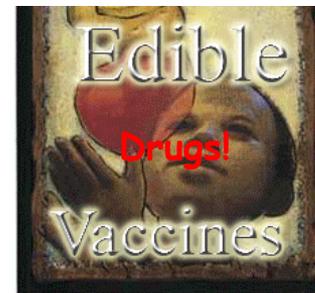
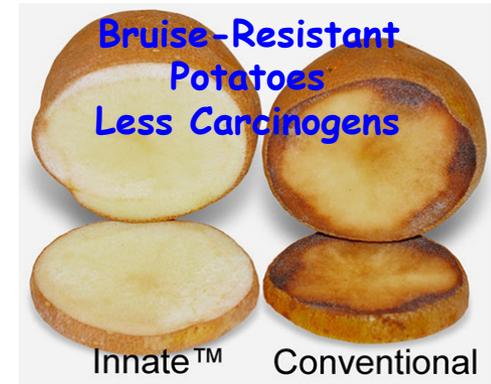
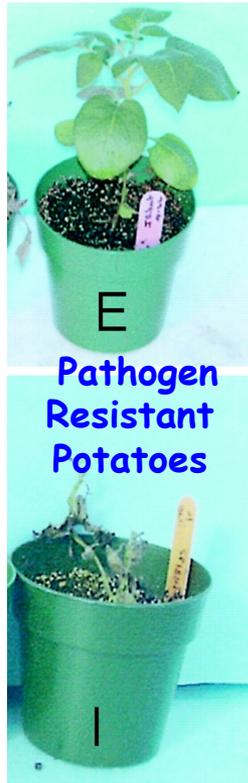
Innate
Potato



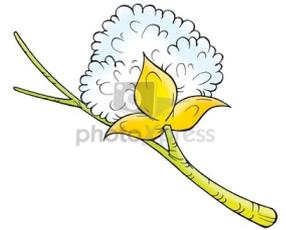
Squash



Crop Genetic Engineering Examples



Genetic Engineering - Most Rapidly Adopted Technology in Agricultural History



2014 GLOBAL STATUS OF COMMERCIALIZED BIOTECH/GM CROPS

18 MILLION FARMERS BENEFITED FROM BIOTECH CROPS

90% SMALL, RESOURCE POOR FARMERS FROM DEVELOPING COUNTRIES



GLOBAL BIOTECH CROP AREA MARKS

19 YEARS (1996-2014)

OF CONSECUTIVE GROWTH



MORE DEVELOPING COUNTRIES GROW BIOTECH CROPS

28 COUNTRIES ALL OVER THE WORLD PLANT BIOTECH CROPS

20 DEVELOPING

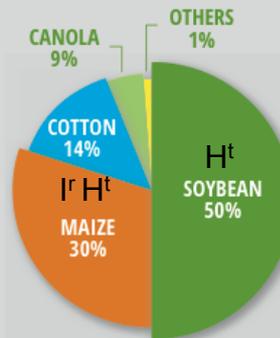
8 INDUSTRIAL



1.8 BILLION HECTARES

BIOTECH CROPS PLANTED SINCE 1996

TOP 5 COUNTRIES IN BIOTECH CROPS HECTARAGE:



MAJOR BIOTECH CROPS

**SOYBEAN
MAIZE
COTTON
CANOLA**

OTHER BIOTECH CROPS

**SUGAR BEET
ALFALFA
PAPAYA**



FIRST COMMERCIAL PLANTING OF **Bt BRINJAL/EGGPLANT** IN **BANGLADESH**

POLITICAL WILL AND PUBLIC-PRIVATE PARTNERSHIP WERE ESSENTIAL FOR SUCCESS

HERBICIDE TOLERANCE IS DOMINANT TRAIT DEPLOYED IN SOYBEAN, MAIZE, CANOLA, COTTON, SUGAR BEET, & ALFALFA
Also Insect Tolerance & Viral Resistance



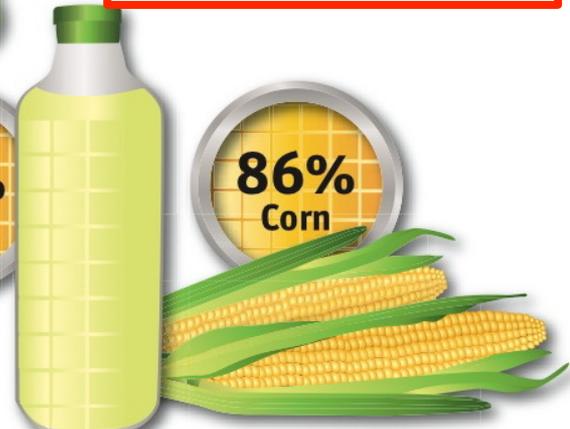
Most Genetically Engineered Crops Are Fed To Animals or in Processed Foods

GMOs are found in **80%** of packaged food in the US

Percentage of each Genetically Modified Crop that is grown in the United States



Most Fruits & Vegetables Bought in Grocery Stores Are **Not** DNA-Spliced GMOs!



*Most Fruits & Vegetables Bought in Grocery Stores Are **Not** DNA-Spliced GMOs!*



These Are GMOs
Produced By Selective
Breeding



Some Benefits of Biotech Crops - Dispelling the Myths (1996-2016)

- **Increased Crop Value by \$78B**
- **~75% of Crop Added Value Went to Small Farmers**
- **Reduced Pesticide Use 37% or 200M Pounds!**
- **Reduced CO₂ Emissions by 40B Pounds or the Equivalent of Taking 9M Cars Off the Road**
- **Saved Billions of Tons of Topsoil by Using No-Till Farming (1B per year)**
- **Improved the Health of Farmers in Developing Countries (Reduced Pesticides)**
- **Contributed to Reduced Food Costs in the US and Elsewhere**



A Meta-Analysis of the Impacts of Genetically Modified Crops

Funded by German Federal Ministry of Development & European Union

Wilhelm Klümper, Matin Qaim*

Department of Agricultural Economics and Rural Development, Georg-August-University of Goettingen, Goettingen, Germany

Abstract

Background: Despite the rapid adoption of genetically modified (GM) crops by farmers in many countries, controversies about this technology continue. Uncertainty about GM crop impacts is one reason for widespread public suspicion.

Objective: We carry out a meta-analysis of the agronomic and economic impacts of GM crops to consolidate the evidence.

Data Sources: Original studies for inclusion were identified through keyword searches in ISI Web of Knowledge, Google Scholar, EconLit, and AgEcon Search.

Study Eligibility Criteria: Studies were included when they build on primary data from farm surveys or field trials anywhere in the world, and when they report impacts of GM soybean, maize, or cotton on crop yields, pesticide use, and/or farmer profits. In total, 147 original studies were included.

Synthesis Methods: Analysis of mean impacts and meta-regressions to examine factors that influence outcomes.

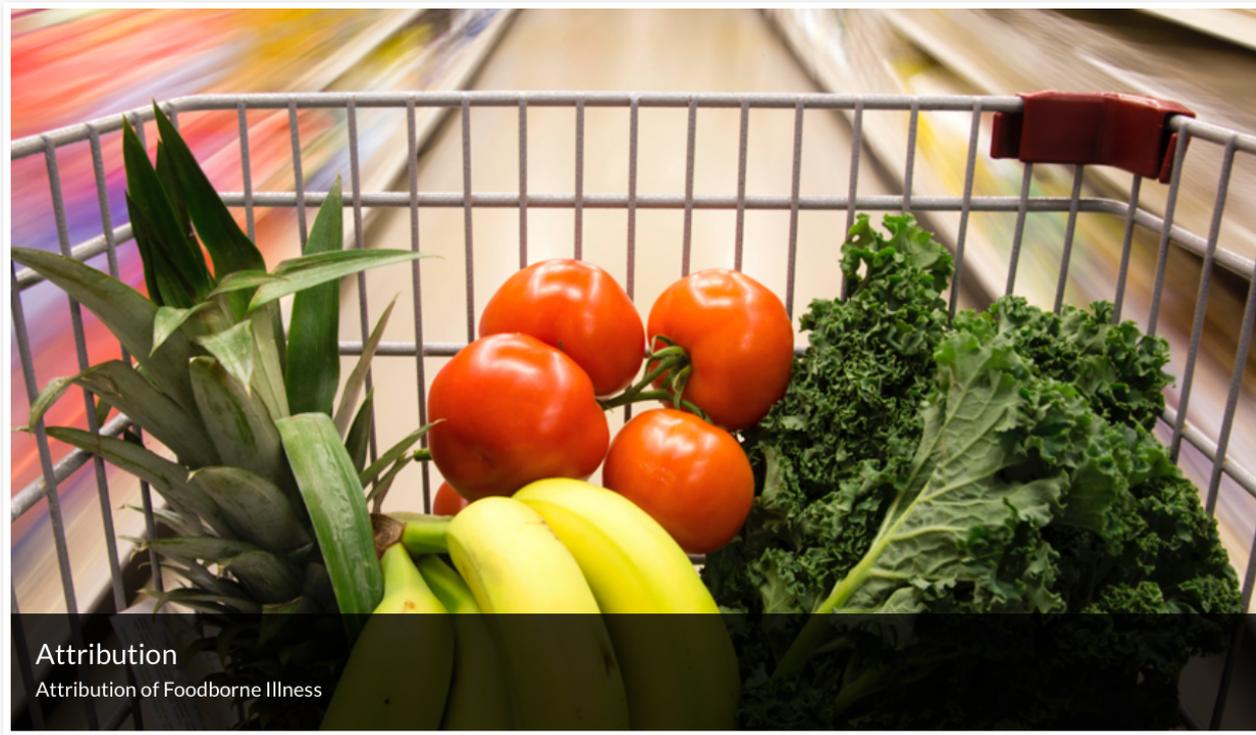
Results: On average, GM technology adoption has reduced chemical pesticide use by 37%, increased crop yields by 22%, and increased farmer profits by 68%. Yield gains and pesticide reductions are larger for insect-resistant crops than for herbicide-tolerant crops. Yield and profit gains are higher in developing countries than in developed countries.

Limitations: Several of the original studies did not report sample sizes and measures of variance.

Conclusion: The meta-analysis reveals robust evidence of GM crop benefits for farmers in developed and developing countries. Such evidence may help to gradually increase public trust in this technology.

FOOD SAFETY IS A MAJOR ISSUE

Estimates of Foodborne Illness in the United States



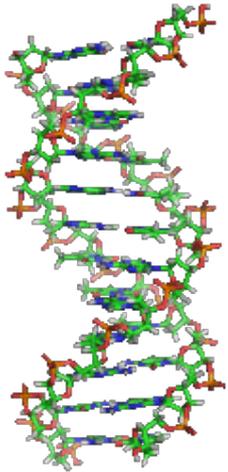
Attribution
 Attribution of Foodborne Illness

CDC estimates that each year roughly 1 in 6 Americans (or 48 million people) get sick, 128,000 are hospitalized, and 3,000 die of foodborne diseases. Estimating illnesses, hospitalizations, and deaths for various types of diseases is a common and important public health practice.

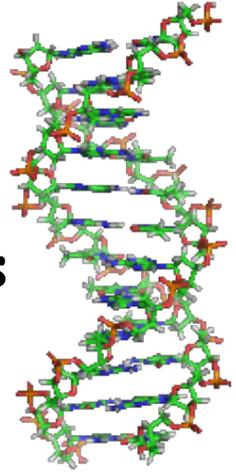
Estimating the number of illnesses associated with specific food sources is called [foodborne illness source attribution](#). These analyses are the logical extension of our 2011 analyses estimating the burden, or number, of foodborne illnesses, hospitalizations, and deaths in the US.



How Many Genes Did You Eat Today?



- One Lettuce Leaf Has Two Million Cells
- Each Lettuce Cell Has ~25,000 Genes
- One Lettuce Leaf Has Fifty Billion Genes
- A Small Salad Has 10 Lettuce Leaves Or Five Hundred Billion Genes!!!



What About the Carrots, Celery, Tomatoes, etc.?

What Happens to the Genes That You Eat?



Summary of Acute Toxicity Evaluation of Proteins Introduced in Commercial GM Crops

Protein Studied*	Noel**	Stable to Digestion?	Stable to Processing?
Cry1Ab	>4000	No (30s)	No
Cry1Ac	>5000	No (30s)	No
Cry2Aa	>4011	No (30s)	No
Cry2Ab	>1450	No (30s)	No
Cry3A	>5220	No (30s)	No
Cry3Bb	>3780	No (30s)	No
Cry9C	>3760	+/- (30 min)	Partial
NPT II	>5000	No	No
CP4 EPSPS	>572	No	N.A.
GUS	>100	No	N.A.



Genetically Engineered Crops Are the Most Tested Crops in Agricultural History!

GMO RESEARCH, REVIEW AND REGULATION | How Does a GMO Get to Market?

On average, GMOs take **13 years** and **\$130 million**  of R&D **BEFORE** coming to market

The **regulatory process** alone can take **5 to 7 years**

REGULATORY SCIENCE

75+ different studies¹ are conducted to demonstrate each new GMO is:

Safe to grow

- Crop grows the same as non-GM varieties
- Crop exhibits expected characteristics (e.g., insect resistance)



Safe for the environment and beneficial insects



Safe to eat

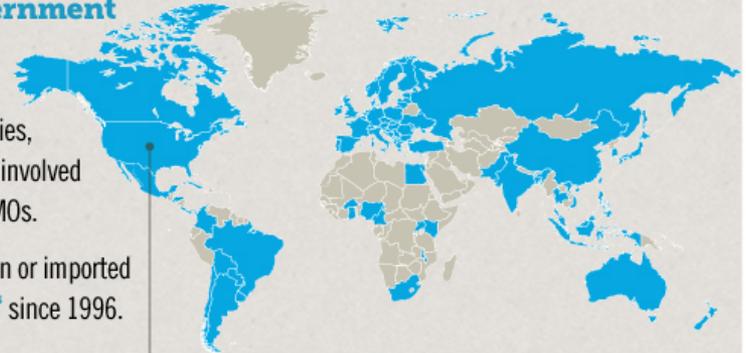
- Same nutrients as non-GM crops
- No new dietary allergens



REGULATORY REVIEW

More than **90 government bodies²** globally review and approve GMOs. In many countries, multiple agencies are involved in the regulation of GMOs.

GMOs have been grown or imported by **70 countries³** since 1996.



U.S. REGULATORY AGENCY REVIEWS


Safe to grow




Safe for the environment




Safe to eat



¹Estimated numbers from DuPont Pioneer based on studies from recent biotech applications. ²Includes agencies reviewing new biotechnology applications from 62 individual countries and 28 EU member countries. ³Country count cited from ISAAA.org



Federal Agencies Regulating GMOs



TABLE 12.1 PRIMARY FEDERAL REGULATORY AGENCIES IN THE UNITED STATES

Regulatory Oversight of Biotechnology Products Agency	Product Regulated
U.S. Department of Agriculture	Plants, plant pests (including microorganisms), animal vaccines
Environmental Protection Agency	Microbial/plant pesticides, other toxic substances, microorganisms, animals producing toxic substances
U.S. Food and Drug Administration	Food, animal feeds, food additives, human and animal drugs, human vaccines, medical devices, transgenic animals, cosmetics

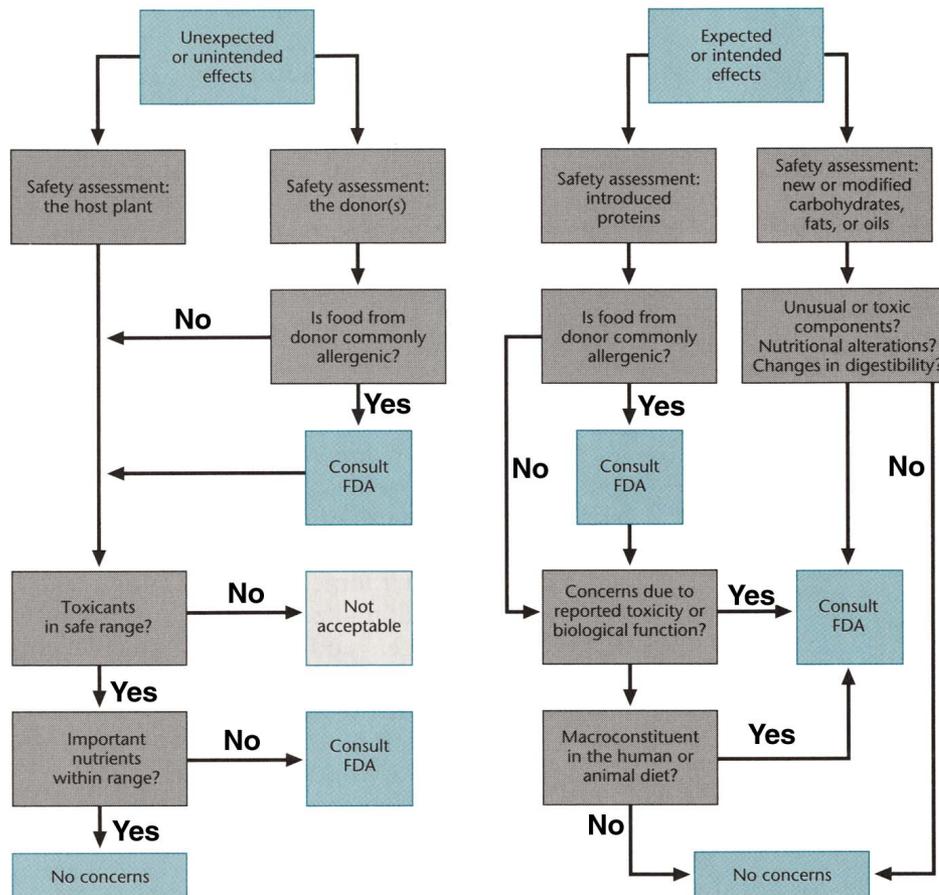
Major Laws that Empower Federal Agencies to Regulate Biotechnology

Law	Agency
The Plant Protection Act	USDA
The Meat Inspection Act	USDA
The Poultry Products Inspection Act	USDA
The Eggs Products Inspection Act	USDA
The Virus Serum Toxin Act	USDA
The Federal Insecticide, Fungicide, and Rodenticide Act	EPA
The Toxic Substances Control Act	EPA
The Food, Drug, and Cosmetics Act	FDA, EPA
The Public Health Service Act	FDA
The Dietary Supplement Health and Education Act	FDA
The National Environmental Protection Act	USDA, EPA, FDA

© 2013 Pearson Education, Inc.



Regulatory Process For Release of Transgenic Crops



*These are the MOST Tested Plants Ever!!!
More Than Any Food Produced by Classical Breeding Methods!!!
Average Cost = \$150M*

There is NO Testing For Conventional or Organic Foods!

Toxicants Allergens Composition

NATIONAL ACADEMY OF SCIENCES

National Academy of Sciences Report: Focus on the Food Not the METHOD of Production!!!

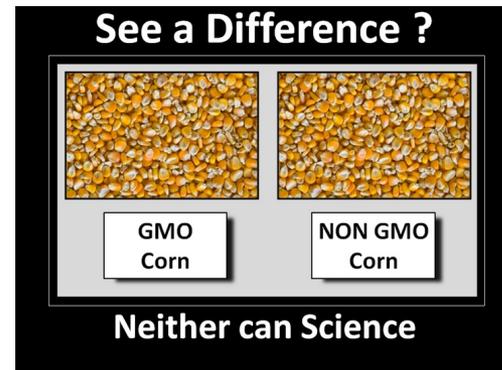
Similar to Those Used For Antibiotics, Vaccines, and Drugs!!

Which Food Would YOU Eat?



- No Testing
- No Regulatory Oversight
- Contains Known Allergen
- 9,000 Hospitalizations Per Year

- Extensive Testing (~10 years)
- FDA, USDA, & EPA Oversight
- Eaten By Billions of People
- **No Documented Health Problems**



Researchers Develop First Hypoallergenic Soybeans

*Will These Ever Get To
The Market?*



"The AMA adopted policy supporting this science-based approach, recognizing that there currently is **no evidence** that there are material differences or safety concerns in available bioengineered foods."

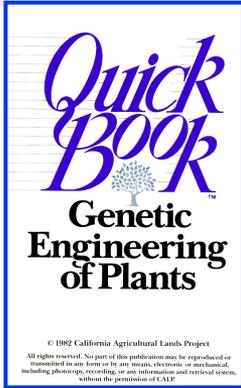


"To date **no adverse health effects** attributed to genetic engineering have been documented in human populations."

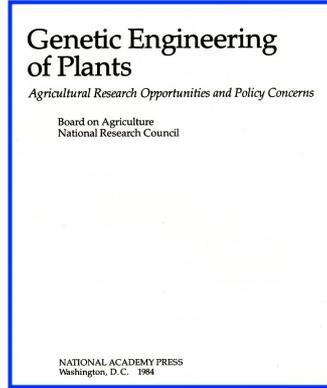


"The scientific literature shows **no compelling evidence** to associate such crops, now cultivated worldwide for more than 15 years, with risks to the environment or with safety hazards for food."

Safety Issues of Genetically Engineered Plants Have Been Investigated and Discussed For 35 Years - Thousands of Studies - Unanimous Conclusion - GMOs are Safe For Human Consumption!!



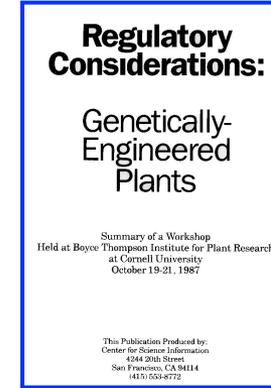
1982



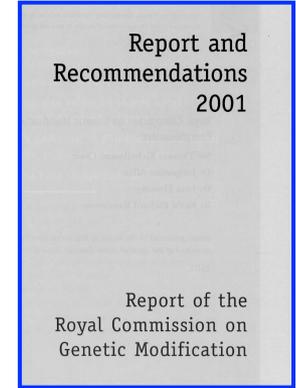
1984



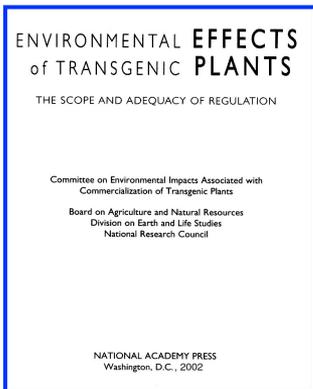
1985



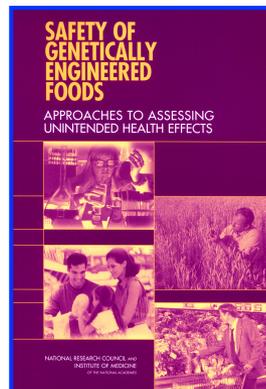
1987



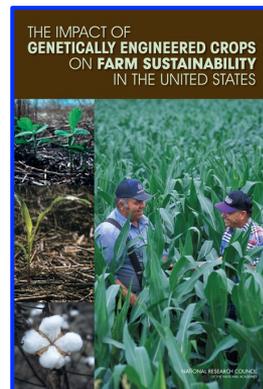
2001



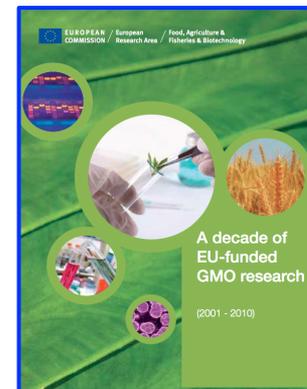
2002



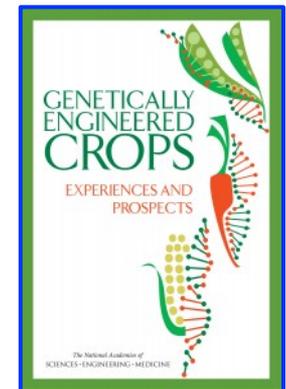
2004



2010



2011



2016



Federal GMO Disclosure Law Creates Uniform Standards for Food Manufacturers & Provides Options for Disclosure

Public Law 114–216
114th Congress

An Act

To reauthorize and amend the National Sea Grant College Program Act, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. NATIONAL BIOENGINEERED FOOD DISCLOSURE STANDARD.

The Agricultural Marketing Act of 1946 (7 U.S.C. 1621 et seq.) is amended by adding at the end the following:

“Subtitle E—National Bioengineered Food Disclosure Standard

device.

“(e) STATE FOOD LABELING STANDARDS.—Notwithstanding section 295, no State or political subdivision of a State may directly or indirectly establish under any authority or continue in effect as to any food in interstate commerce any requirement relating to the labeling or disclosure of whether a food is bioengineered or was developed or produced using bioengineering for a food that is the subject of the national bioengineered food disclosure standard under this section that is not identical to the mandatory disclosure requirement under that standard.

“SEC. 293. ESTABLISHMENT OF NATIONAL BIOENGINEERED FOOD DISCLOSURE STANDARD.

“(a) ESTABLISHMENT OF MANDATORY STANDARD.—Not later than 2 years after the date of enactment of this subtitle, the Secretary shall—

“(1) establish a national mandatory bioengineered food disclosure standard with respect to any bioengineered food and any food that may be bioengineered; and

“(2) establish such requirements and procedures as the Secretary determines necessary to carry out the standard.

“(b) REGULATIONS.—

“(1) IN GENERAL.—A food may bear a disclosure that the food is bioengineered only in accordance with regulations promulgated by the Secretary in accordance with this subtitle.

“(2) REQUIREMENTS.—A regulation promulgated by the Secretary in carrying out this subtitle shall—

“(A) prohibit a food derived from an animal to be considered a bioengineered food solely because the animal consumed feed produced from, containing, or consisting of a bioengineered substance;

“(B) determine the amounts of a bioengineered substance that may be present in food, as appropriate, in order for the food to be a bioengineered food;

“(C) establish a process for requesting and granting a determination by the Secretary regarding other factors and conditions under which a food is considered a bioengineered food;

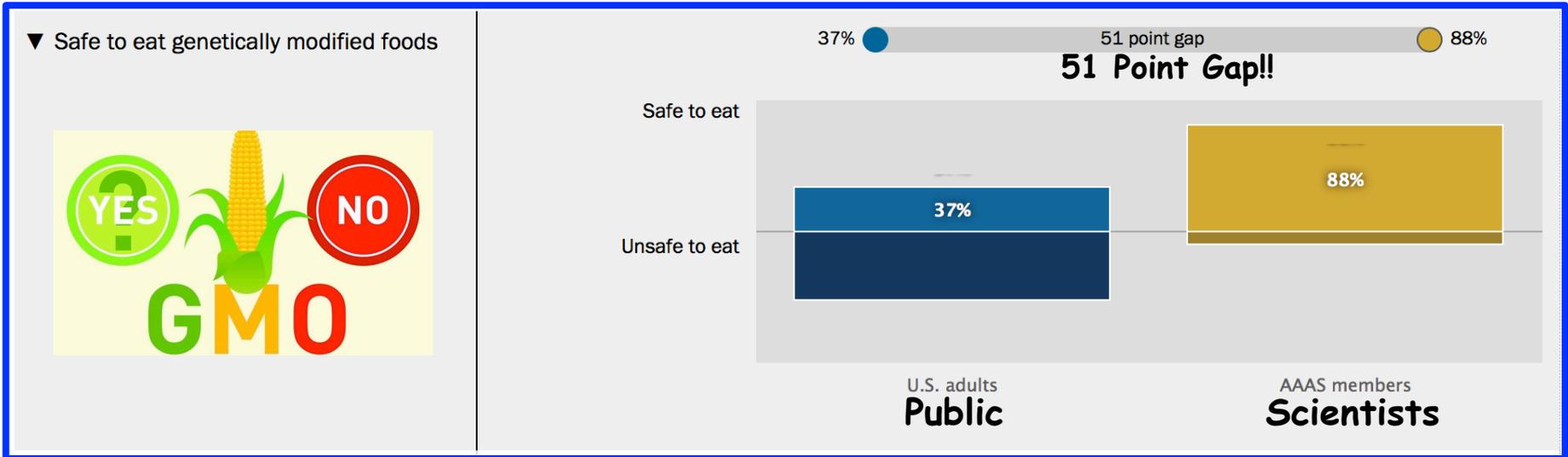
“(D) in accordance with subsection (d), require that the form of a food disclosure under this section be a text, symbol, or electronic or digital link, but excluding Internet website Uniform Resource Locators not embedded in the link, with the disclosure option to be selected by the food manufacturer;

“(E) provide alternative reasonable disclosure options for food contained in small or very small packages;

There Is Major Public Skepticism About GMOs!!!



PewResearchCenter Public and Scientists' Views on Science and Society 2015



How Do We Change This?



However... There's a Battle Raging to Get Bioengineered Crops Banned in Many Parts of the World



Los Angeles Proposes Banning GMOs

NO ON 37
STOP THE DECEPTIVE
FOOD LABELING SCHEME



The GMO "Controversy" is Complex and Not Science Based



- *Successful Well-Financed Anti-GMO "Propaganda" Campaign*
- *Bogus Science Studies Sensationalized by the Popular Media*
- *Organic Growers/Markets - Gain Market Share (Follow the \$!!)*
- *Anti-Globalization - Anti-Patent/Intellectual Property*
- *Anti-Industrial-Conventional Farming That Uses GMOs*
- *Anti-Large American AgBiotech Companies (e.g., Monsanto)*
- *Labeling - Right to Know and Choose What is Eaten*
- *No Obvious Consumer Benefits*
- *Ecological & Environmental Issues (e.g., Pollen Flow)*
- *Food Safety & Culture (Not "Natural")*
- *Lack of Public Science Awareness*



What Has Been Some of the *Real Life* Affects of the *GMO Controversy*?

AFRICAN COUNTRIES REJECT GM FOOD AID

Zimbabwe and Zambia have rejected genetically modified food donations intended to avert drought-induced food shortages. Wisdom Mdzungairi reports for Harare that participants to an international conference on genetic engineering and sustainable agriculture in Lusaka, Zambia commended the countries' decision to mill some of the donated food instead.

Dr. Luke Mumba, chairman of the Biosafety Council of Zambia and research of the University of Zambia, commented that while there was respect for the two countries' decision, there was need to adopt safe biotechnological advances, and that the use of GM technology could contribute to the complex problems of alleviating poverty and malnutrition. Meanwhile, Zambian Minister of Science and Technology Judith Kapijimpanga said the problem of food insecurity in Africa was a result of complex issues that required an integrated approach for sustainability.

See the article in <http://allafrica.com/stories/200510110710.html>.

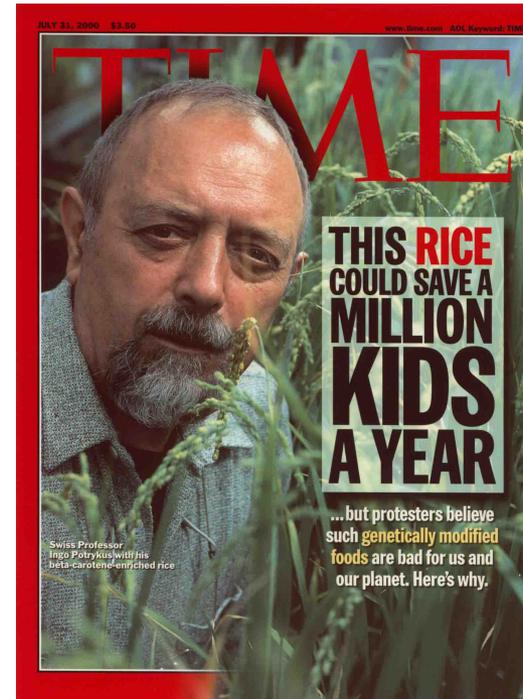
Destroying Golden Rice Test Plots



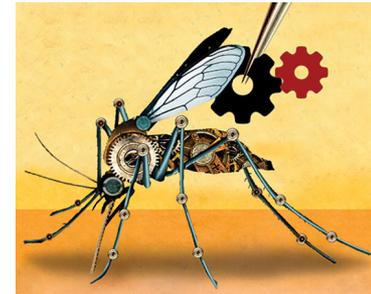
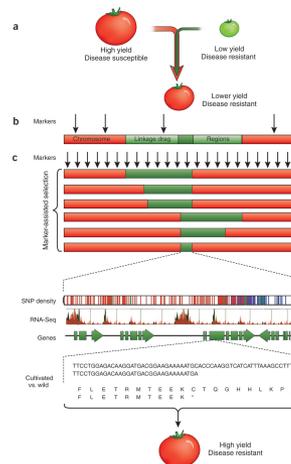
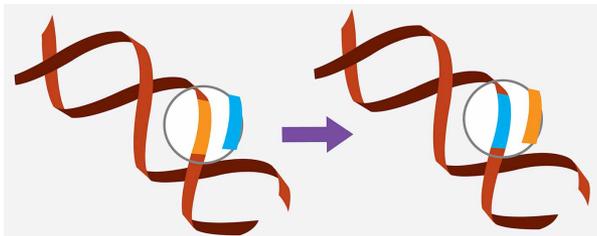
Greenpeace's Crime Against Humanity

8 Million Children Dead

AllowGoldenRiceNow.org

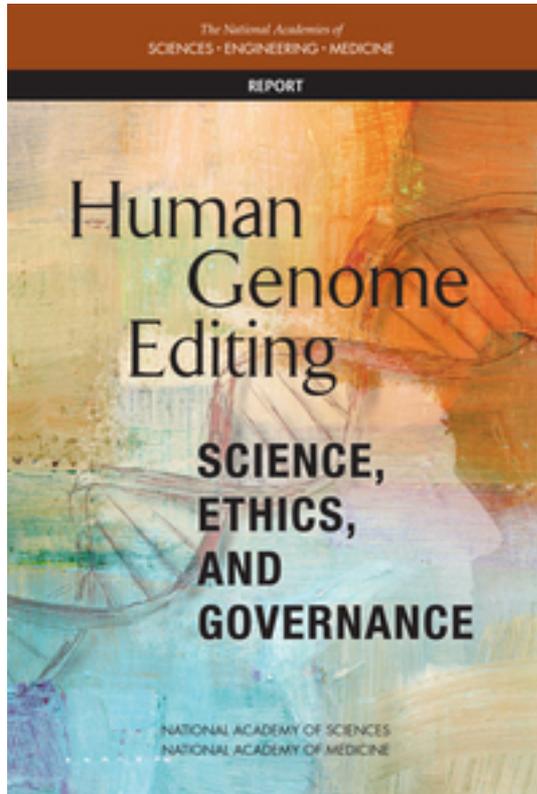


The Game Has Changed - The Age of Gene Editing Has Arrived!





2017

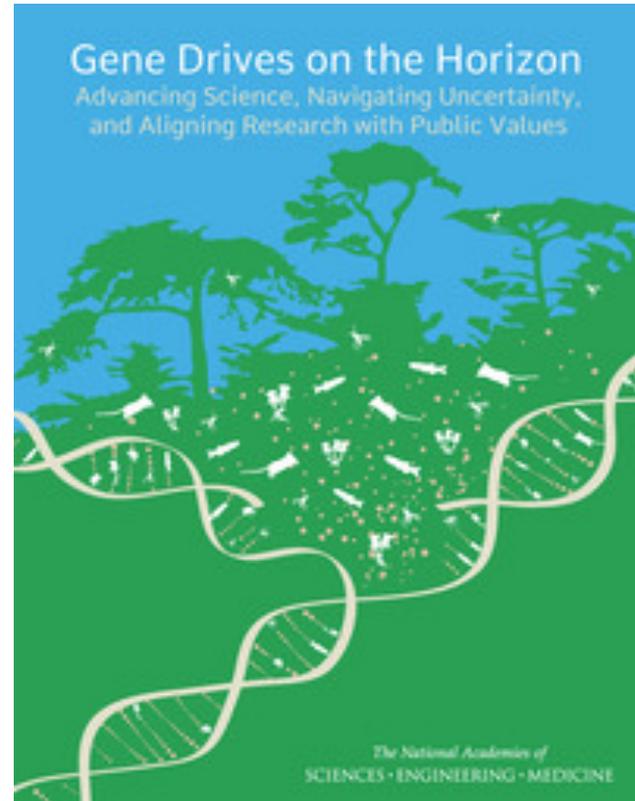


With Stringent Oversight, Heritable Germline Editing Clinical Trials Could One Day Be Permitted for Serious Conditions; Non-Heritable Clinical Trials Should Be Limited to Treating or Preventing Disease or Disability at This Time

First CRISPR clinical trial gets green light from US panel

The technique's first test in people could begin as early as the end of the year.

2016



FDA Approves Genetically Modified Mosquitoes For Release In Florida

How To Regulate Crop Gene Editing - GMO or Similar to Classical Breeding?

What Is a GMO? | GMOs are the product of a specific type of plant breeding where precise changes are made to a plant's DNA to give it characteristics that cannot be achieved through traditional plant breeding methods.

SELECTIVE BREEDING

Plant breeders look for, select and cross-breed the best performing plants in the field, similar to how farmers have naturally improved the crops they grow since farming began.

ADVANCED BREEDING

Breeders identify and tag desirable characteristics (traits) within a plant genome. They use this information to pick which plants to cross-breed and create better performing crops.

DROUGHT TOLERANCE

STRONG STALKS AND ROOTS

GM PLANT BREEDING

If a plant needs a trait that can't be achieved through advanced breeding, a gene can be turned off or moved, or a gene from another source can be inserted.

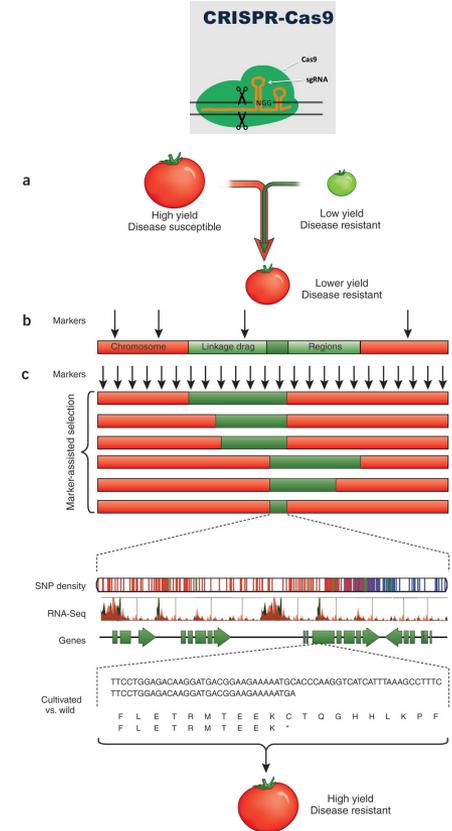
GMOs can help farmers ...

- prevent crop disease
- control insects
- manage weeds
- change nutritional profile

There are eight GMO crops available in the U.S. today:

- Corn (field and sweet)
- Soybeans
- Cotton
- Canola
- Alfalfa
- Sugar Beets
- Papaya
- Squash

For more information, visit www.GMOAnswers.com



Not Regulated Not Regulated

Regulated

???

The End...or The Beginning?

