
OHIO
UNIVERSITY
1804
"Genetic Engineering New Crops: Importance for Food, Fuel, and the Future"
Bob Goldberg
10/10/08

Today's Headlines

The New York Times

A Global Need for Grain That Farms Can't Fill

Published: March 9, 2008

Los Angeles Times

Economist.com

High Rice Cost Creating Fears of Asia Unrest

By KEITH BRADSHER
Published: March 29, 2008

U.S.News & World Report

CNN.com

THE FOOD CHAIN

A Drought in Australia, a Global Shortage of Rice

Across Globe, Empty Bellies Bring Rising Anger

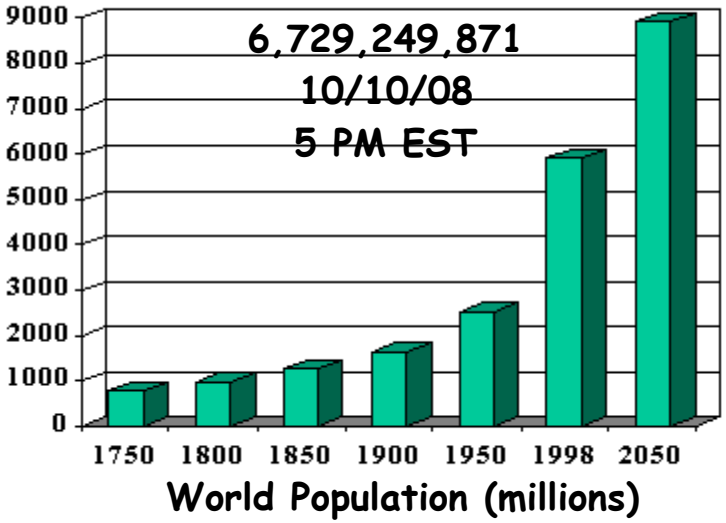
Newsweek

updated 10:42 p.m. EDT, Mon April 14, 2008

Riots, instability spread as food prices skyrocket

The Washington Post

We Face Challenges In Agriculture Even Greater Than Those in Today's Headlines

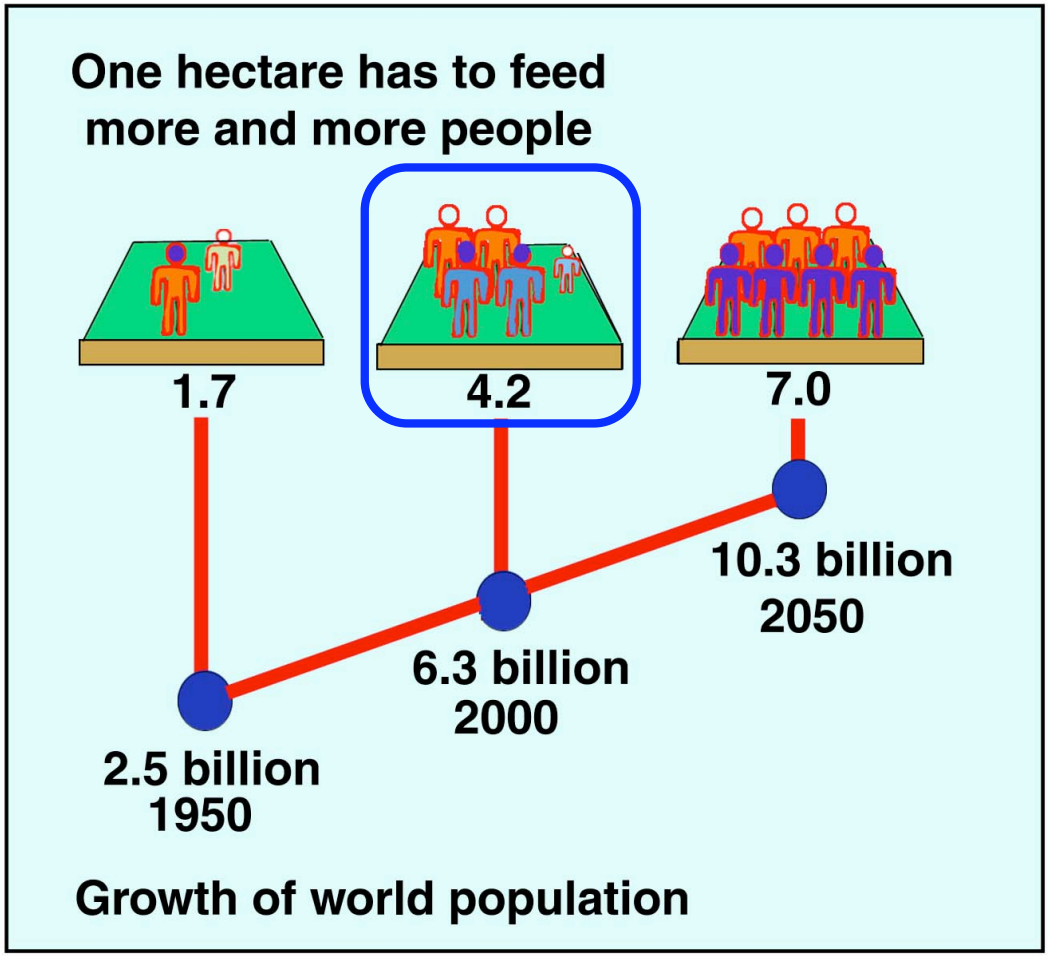


OVER THE NEXT 50 YEARS WE WILL NEED TO PRODUCE MORE FOOD THAN IN THE WHOLE OF HUMAN HISTORY

AND DO IT WITH FEWER INPUTS ON LESS ARABLE LAND!!!!

∴ CROP YIELDS NEED TO BE INCREASED SIGNIFICANTLY!!

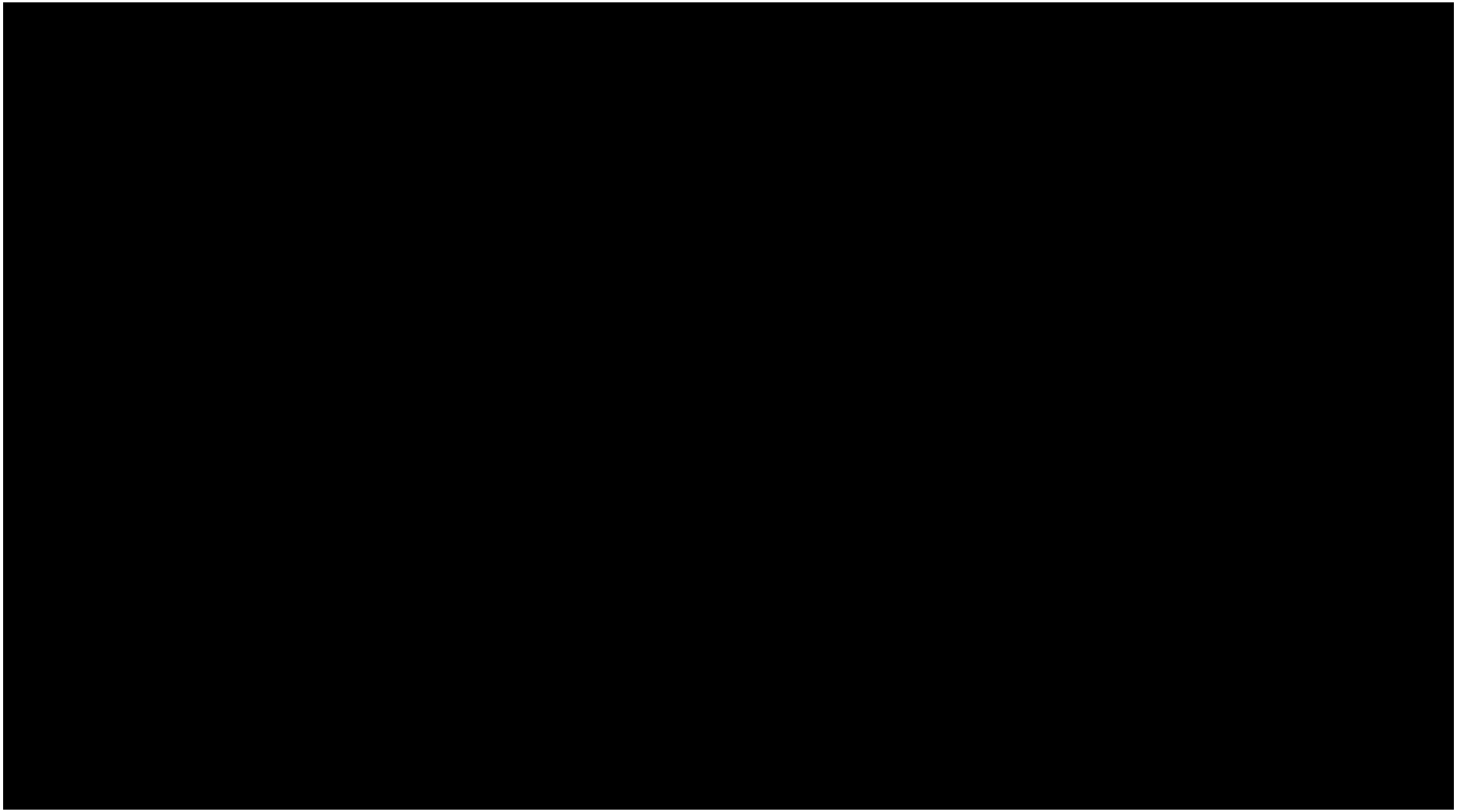
There is a Limited Amount of Land For Agriculture



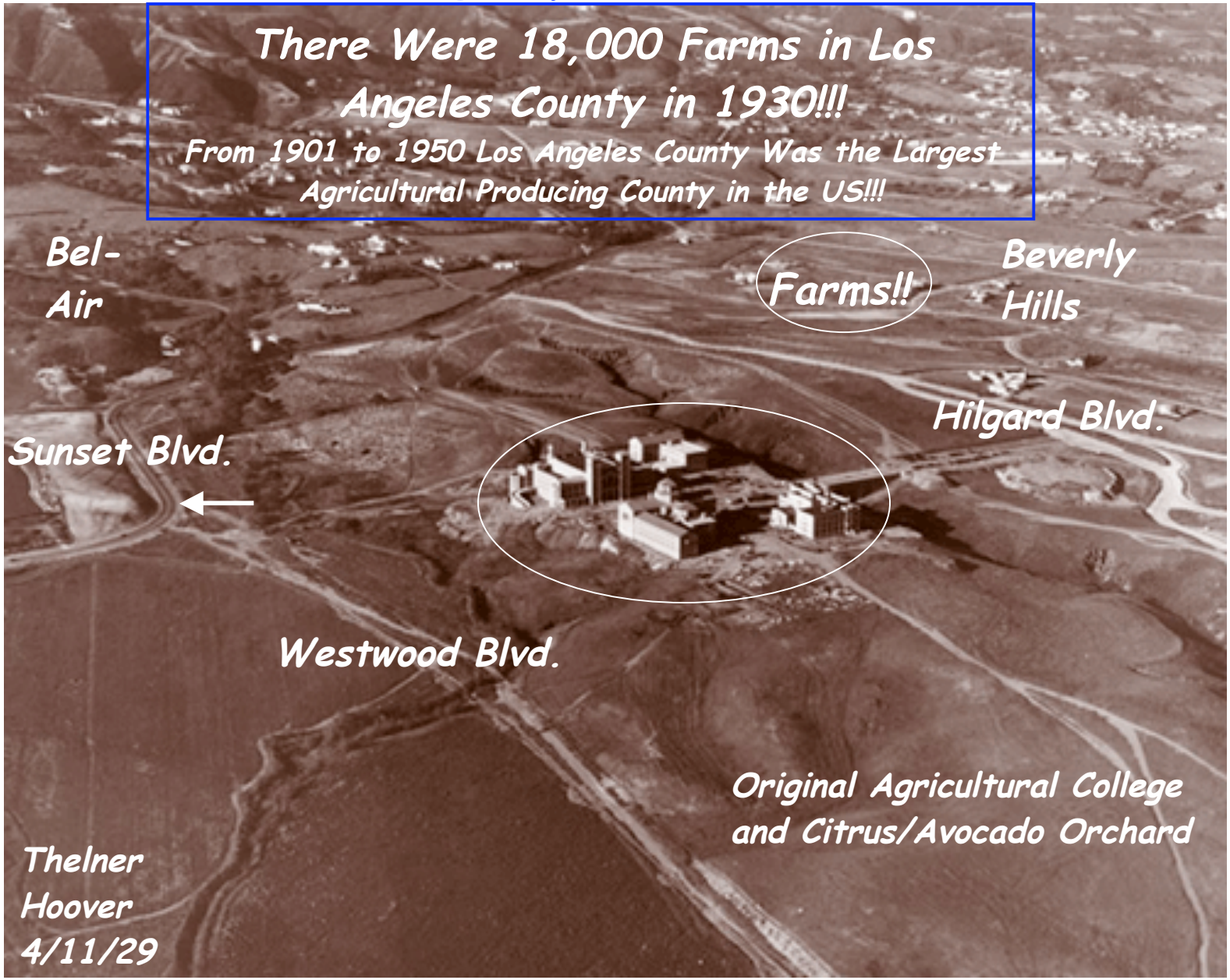
NOTE:
Only 35% of Earth's Land Mass is Suitable For Agriculture… and 67% of that is used for Pasture & Range! Only ~8% is used for Crops Eaten Directly as Food!

Without Increases in Crop Yield We Will Need to Farm
Every "Square Inch" of Land on the Earth To Satisfy Crop Demand

And……..There's Also A Problem With Using Land For Energy Production……



Aerial Photograph of UCLA in 1929




Aerial Photograph of UCLA in 2008
Bel-
Air
Beverly
Hills
Former Farms
Sunset Blvd.
Hilgard Blvd.
Original Agricultural College
and Citrus/Avocado Orchard
Westwood Blvd.
Image © 2007 Sanborn
Technologies
9/23/08
Google


How Will Crop Yields Be Increased?
As We Always Have……..
By Using State-of-the-Art Science & Technology

…….And 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

From "Low-Tech" Genetics to "High-Tech" Genomics

From Lab to Improved Seeds For Farmers

…….And Use Breeding and Genetic Engineering to Introduce These "Yield" Genes Into Existing Crops

Optimal Flowering Time

Seeds Without Fertilization

Hybrids

High Photosynthetic Efficiency

Drought Resistant

Pathogen Resistant

Efficient Uptake of Micronutrients

High Yields Under Suboptimal Conditions

Reduced Pod Shattering

Architecture Designed For Specific Growth Conditions

More Seeds

Bigger Seeds

Seeds Optimal For Human/Animal Health & Nutrition

Ability to Fix Nitrogen

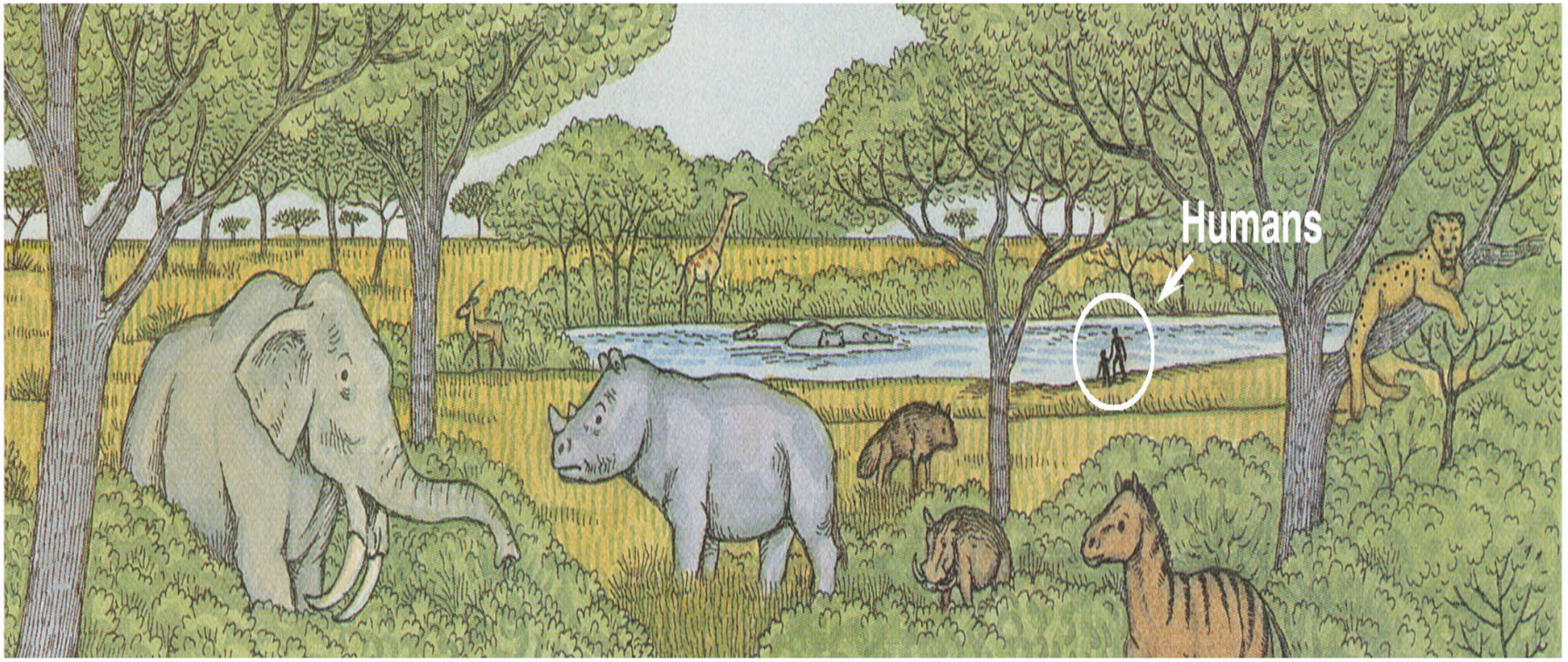
What are the Other Major Challenges For the Future?

Major Challenges For 21st Century Agriculture

- Increase Crop Yield To Provide More Food And Save/Create More Open Space
- Reduce Inputs Required For Growing Crops (e.g., water, fertilizer) -- A Sustainable Agriculture
- Reduce Environmental Impacts of Intensive Agriculture (e.g., pesticides)
- Optimize Crops For Human Health and Nutrition
- Use Crops as Factories For Specialized Industrial and Pharmaceutical Applications (e.g., vaccines)
- Facilitate the Conversion From a Petroleum-Based Energy System to a Dedicated Plant-Based Renewable Energy System (e.g., cellulose to ethanol)
- Help Reduce CO_2 Emissions and Mitigate Effects of Climate Change (e.g., switch from coal to biomass)

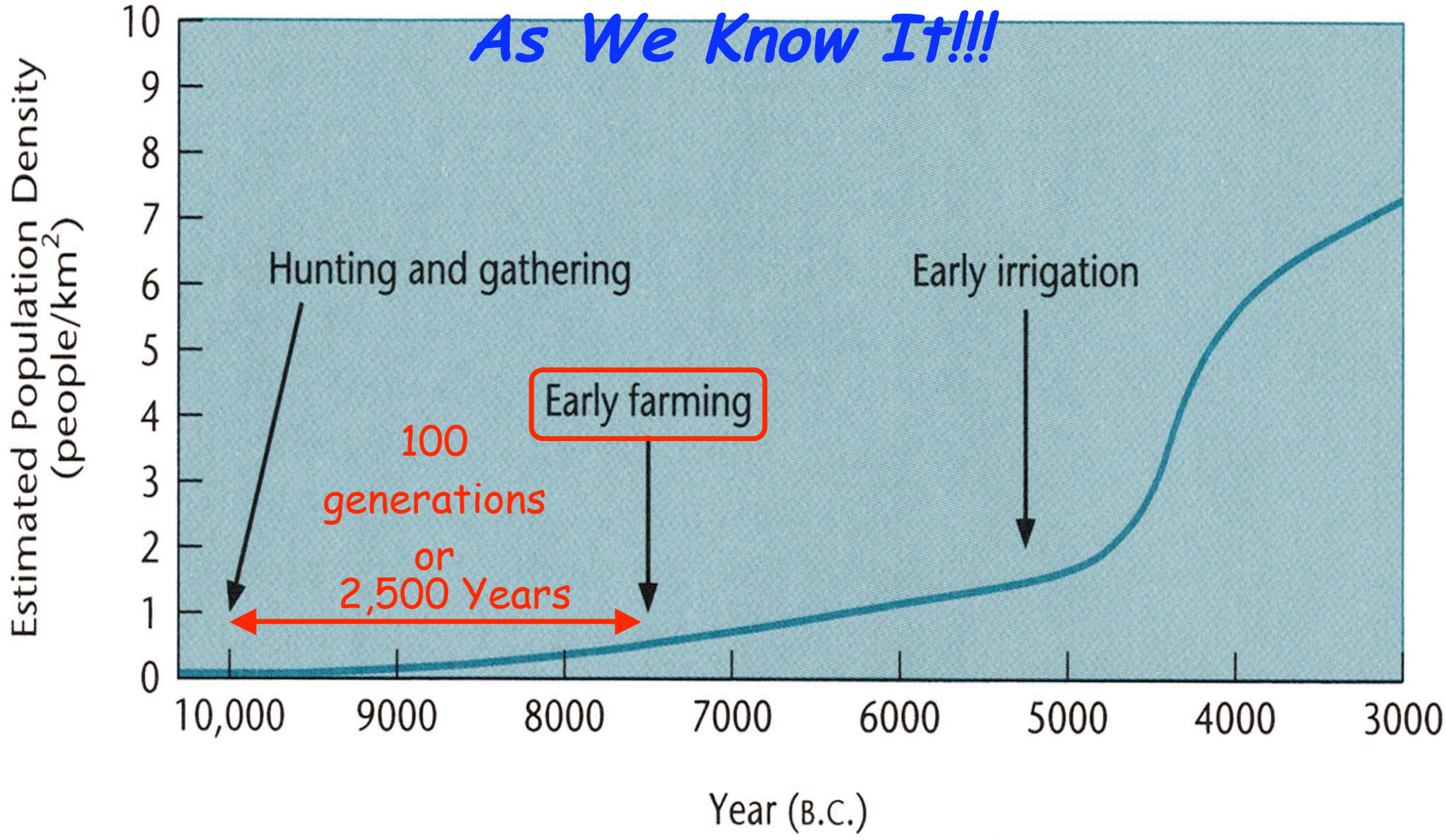
Plant Genome Projects and Identifying Novel New Traits Can Help Meet This Challenge!!!!!

Early Humans Faced Major Challenges Finding Food



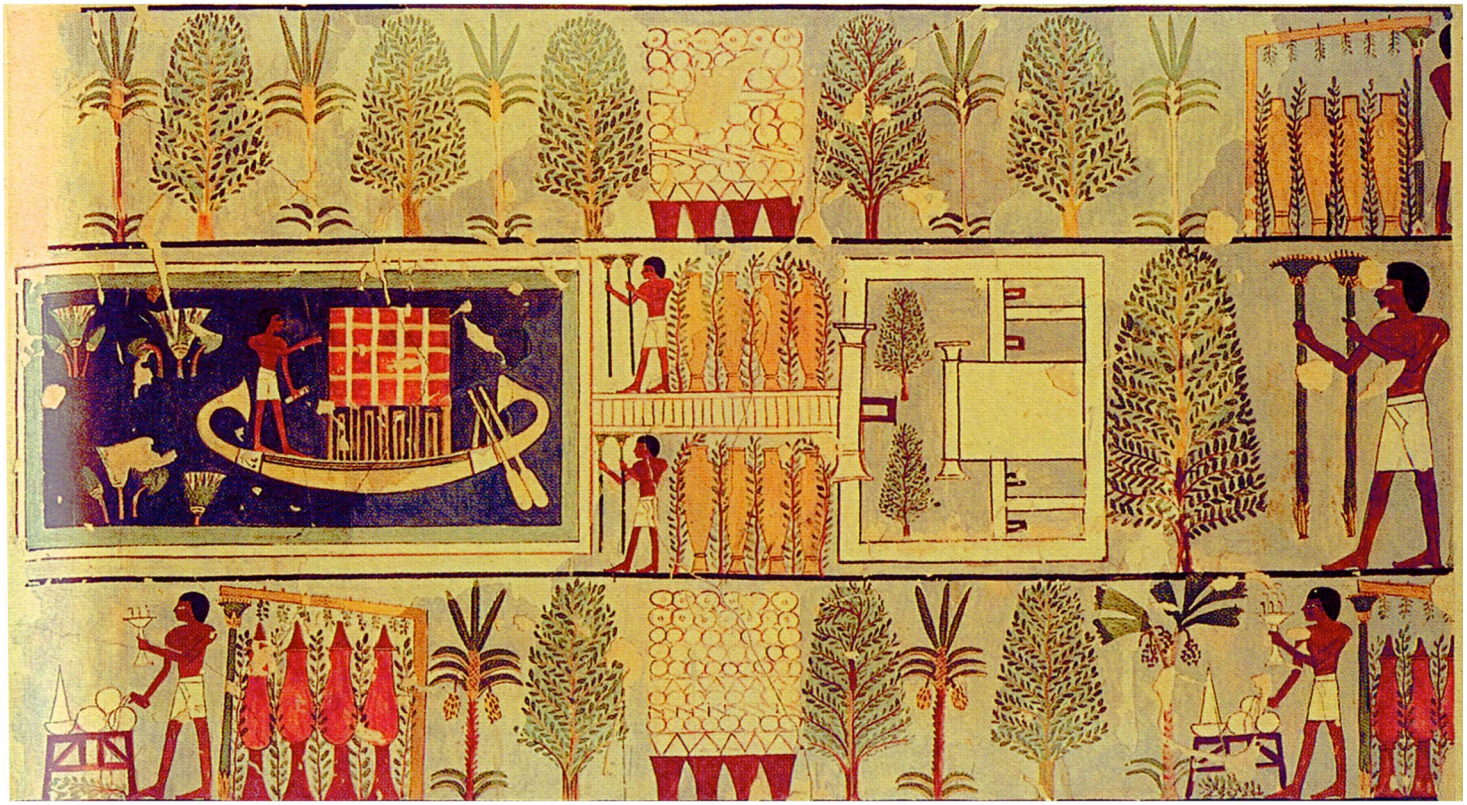
Inventing Agriculture and "Domesticating" Plants and Animals 10,000 Years Ago Changed That & Everything Else!!!

The Invention Of Agriculture Led To Civilization As We Know It!!!



Agriculture Dates Back 10,000 Years

Breeding And Cultivation Of Plants Have Taken Place Over Thousand Of Years



Generating New Types Of Crops Is Not New To The 21st Century!!

Crops of Egypt - 400 BC

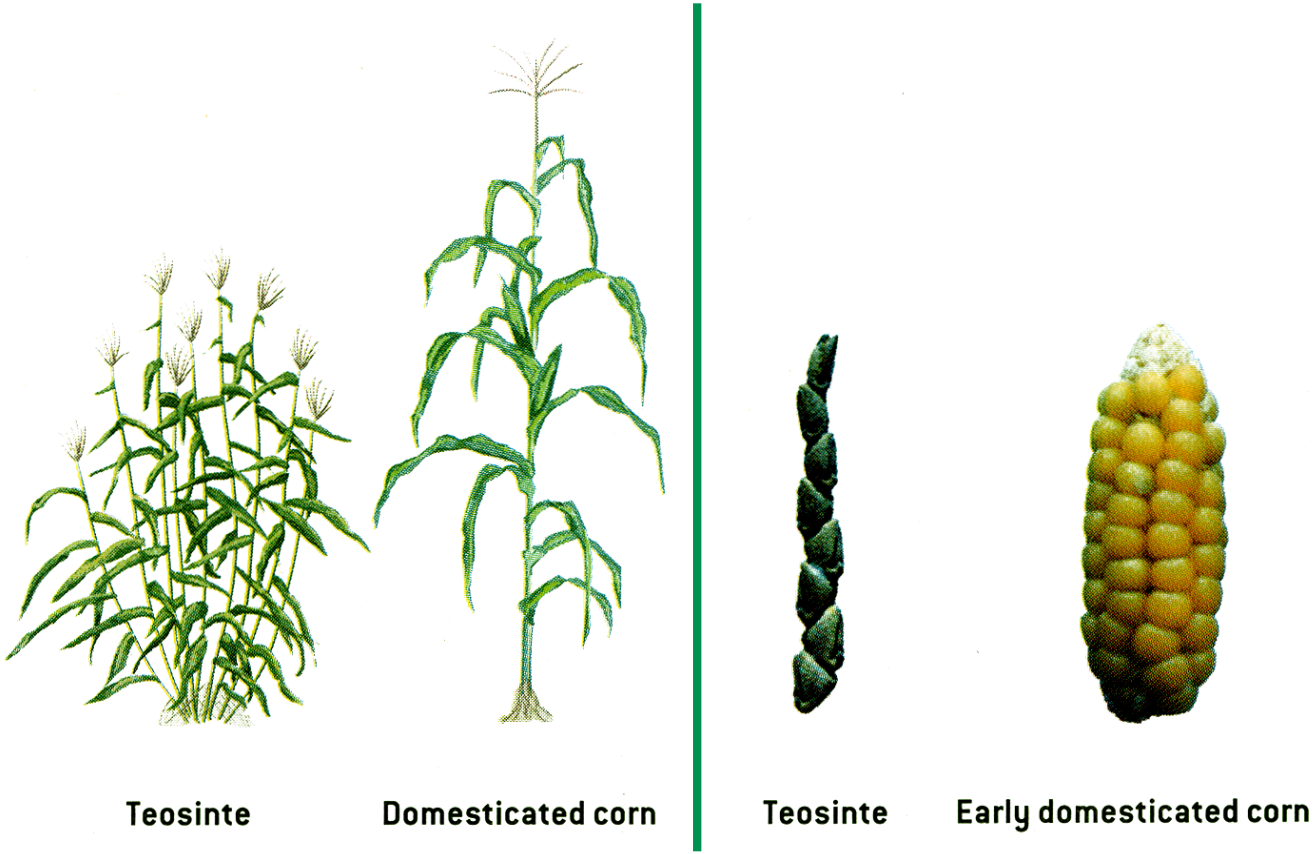
Most Major Food Crops Were "Engineered" By Breeding ~10,000 Years Ago

- **SEEDS (cereals):** *corn, rice, wheat, barley, millet, sorghum*
- **SEEDS (legumes):** *soybean, beans, peanut*
- **ROOTS AND STEMS:** *potato, cassava, yam, sugar beet, sugar cane, radish*
- **FRUITS:** *tomato, banana, coconut, papaya*
- **LEAVES:** *cabbage, kale, lettuce, spinach*
- **FLOWERS:** *broccoli, cauliflower, artichoke*

Crops were selected by using pre-existing genetic variability in wild plant populations -- They Were Made by "Man" and Not by Nature !!

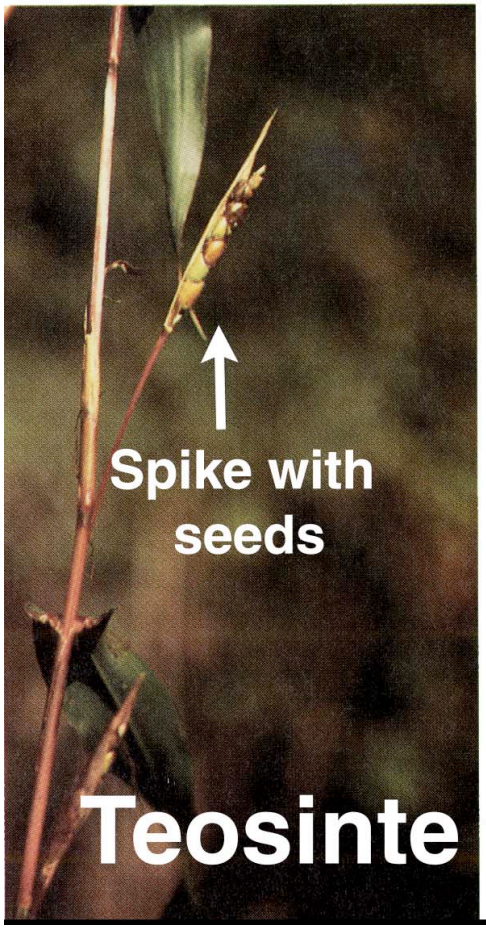
Breeding, By Definition, Means Manipulating Genes!!!!

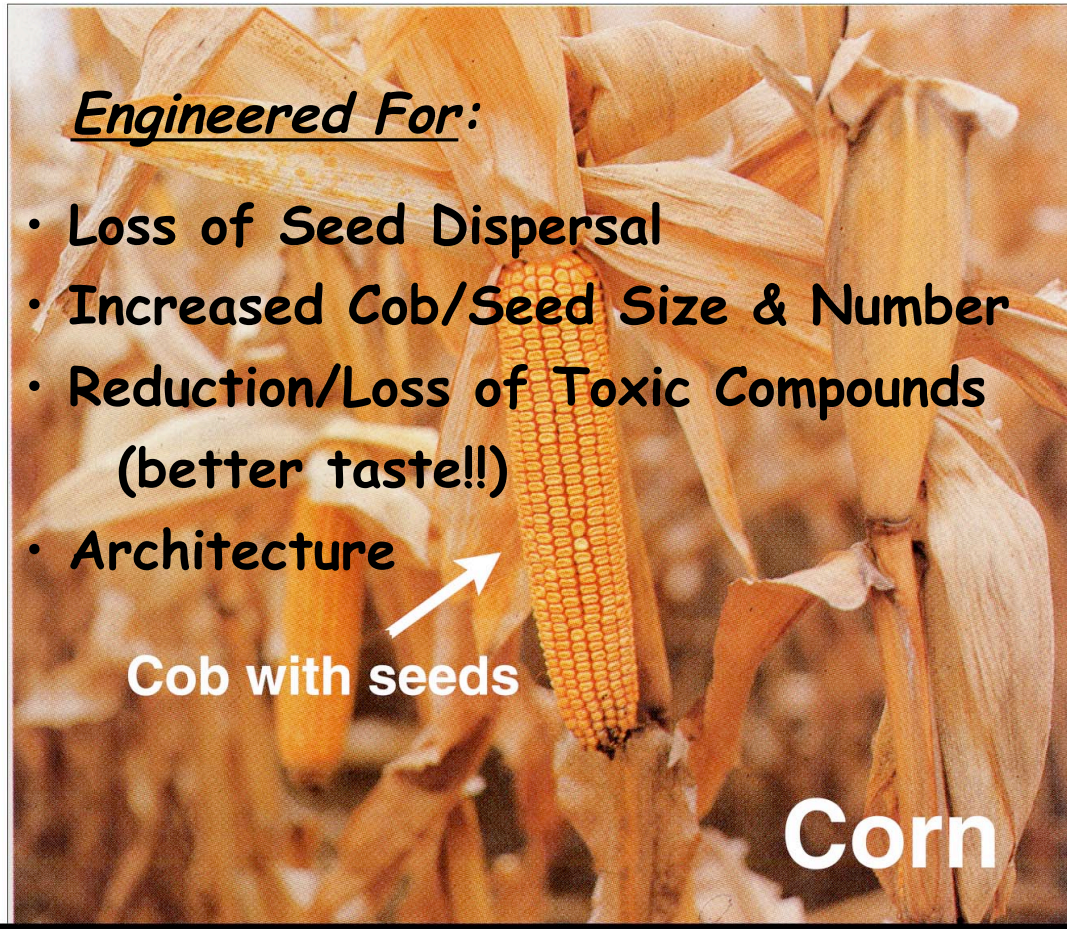
Engineering Teosinte Into Domesticated Corn



Note: Architecture and Fruit (cob) Size

Early Breeders Generated Corn From Teosinte

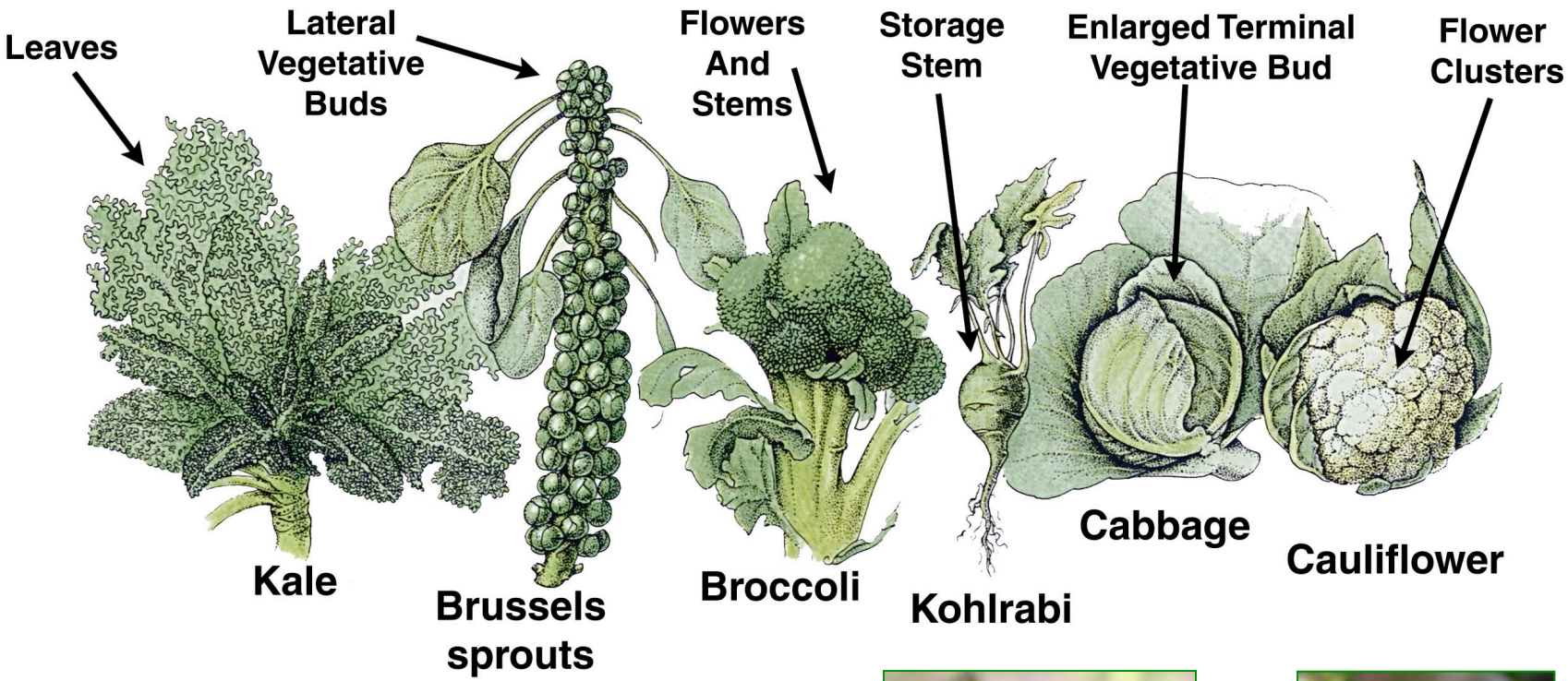




Modern Corn Was "Engineered" From Teosinte 10,000 Years Ago & Cannot Survive in "Nature!!"

Tomatoes Were Engineered From Small Wild Relatives

Broccoli, Cauliflower, Cabbage, and Brussels Sprouts Were "Engineered" As Well!



…….Brassicas or Crucifers

Big Changes in the US Over The Past 100 Years

"We've Come a Long Way Baby"

	1900	2008
Life Expectancy	48 (women)	79 (women)
Average Family Income (2008 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%

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

% Farm Workers	% Income on Food		Life Span	
55%	50% →	• 1900	100	← 48 Years
		• 1920	115	
		• 1940	145	
		• 1950	200	
1.5%	9% →	• 2008	300	← 79 Years

1930: 30 bushels/acre

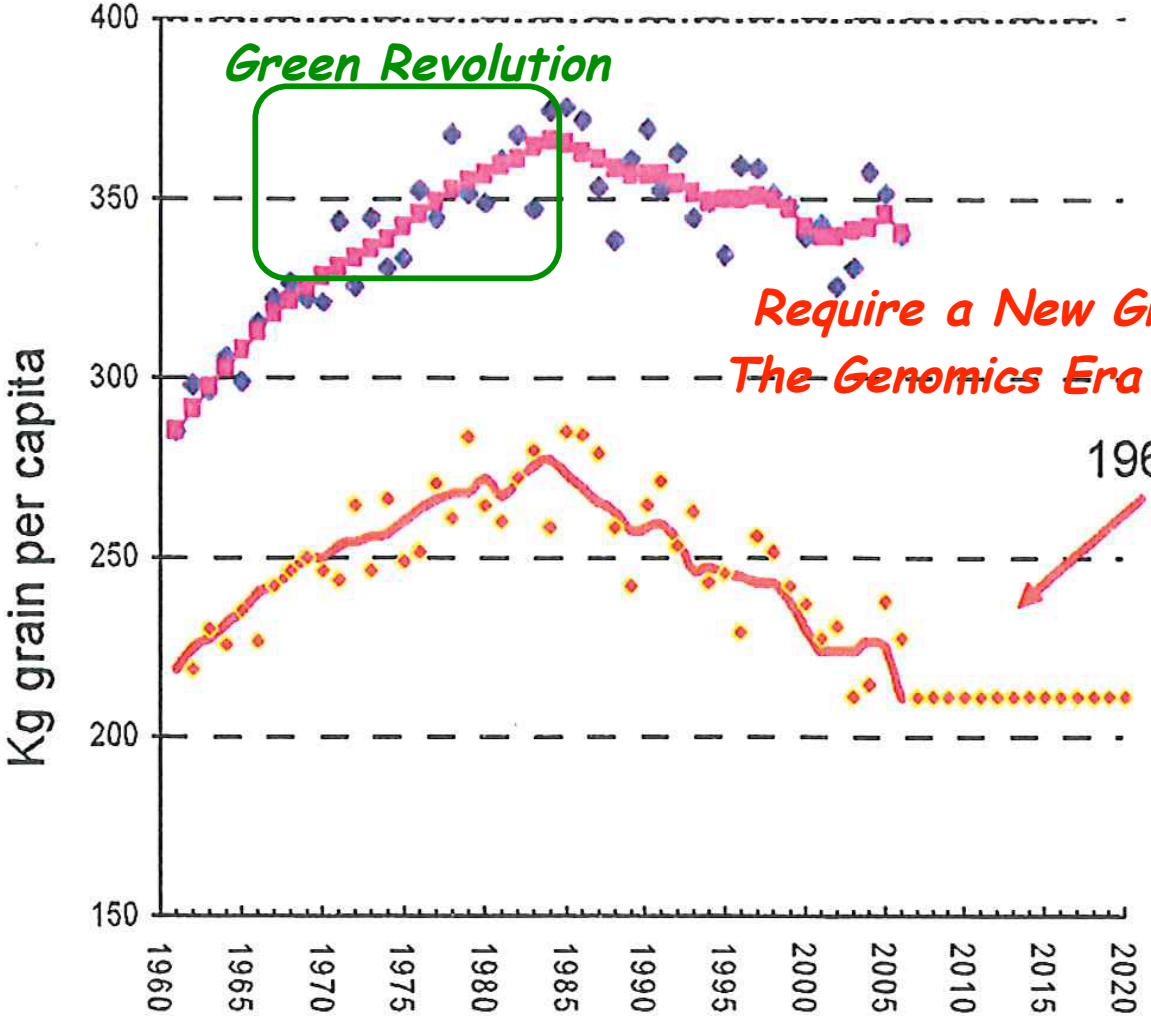
1930: 1 farmer fed 10 people

2008: 150 bushels/acre

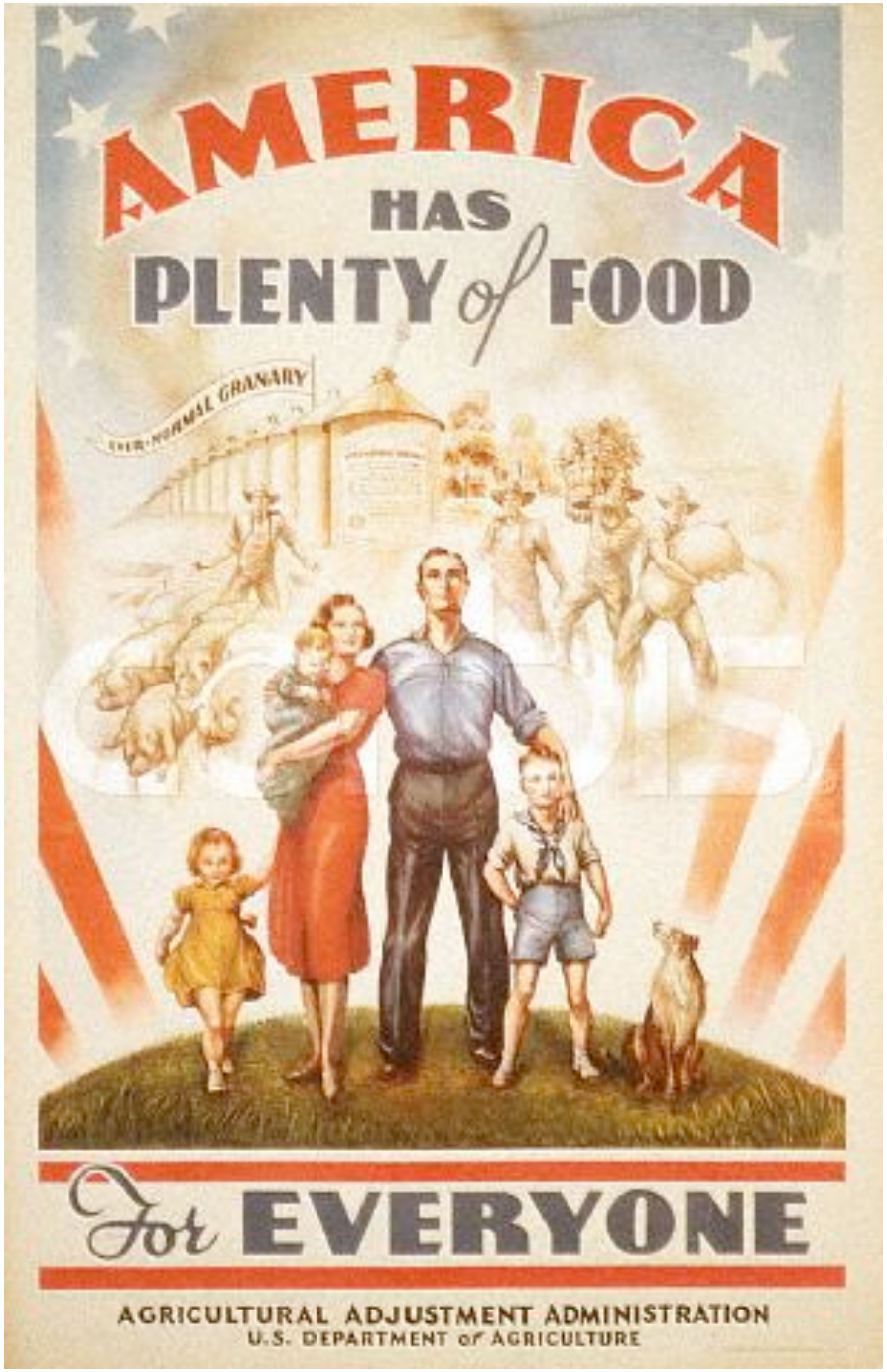
2008: 1 farmer feeds 200 people

Conclusion: Crop yield increased ~ 300% over the past 100 years and lead to a similar reduction in food costs!!!!!

But…World Food Production is Leveling Off on a Per Capita Basis!



Per Capita Cereal Production



How Was This Accomplished Over the Past 100 Years?

What Role Did Science & Technology Play?

What About in the Future When There are 400 Million People in the USA and 9 Billion in the World?

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

- PLANT BREEDING (New Hybrids-Green Revolution)
- IRRIGATION
- FERTILIZERS
- PESTICIDES & HERBICIDES
- 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 during the 20th-21st century!
Need to sustain this yield increase by applying the best technology and agricultural practices!

Genetics Has Also Changed Dramatically Over the Past 100 Years!!

1900: Rediscovery of Mendel's Work

DeVries, Correns and Tschermak independently rediscover Mendel's work.

Three botanists - Hugo DeVries, Carl Correns and Erich von Tschermak - independently rediscovered Mendel's work in the same year, a generation after Mendel published his papers. They helped expand awareness of the Mendelian laws of inheritance in the scientific world.

The three Europeans, unknown to each other, were working on different plant hybrids when they each worked out the laws of inheritance. When they reviewed the literature before publishing their own results, they were startled to find Mendel's old papers spelling out those laws in detail. Each man announced Mendel's discoveries and his own work as confirmation of them.

1909: The Word Gene Coined

Danish botanist Wilhelm Johannsen coined the word gene to describe the Mendelian units of heredity.

He also made the distinction between the outward appearance of an individual (phenotype) and its genetic traits (genotype).

Four years earlier, William Bateson, an early geneticist and a proponent of Mendel's ideas, had used the word *genetics* in a letter; he felt the need for a new term to describe the study of heredity and inherited variations. But the term didn't start spreading until Wilhelm Johannsen suggested that the Mendelian factors of inheritance be called *genes*.

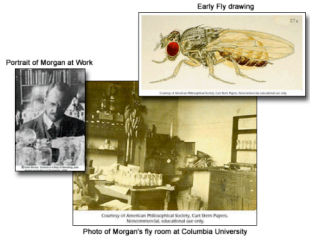
The proposed word traced from the Greek word *genos*, meaning "birth". The word spawned others, like *genome*.

1911: Fruit Flies Illuminate the Chromosome Theory

Using fruit flies as a model organism, Thomas Hunt Morgan and his group at Columbia University showed that genes, strung on chromosomes, are the units of heredity.

Morgan and his students made many important contributions to genetics. His students, who included such important geneticists as Alfred Sturtevant, Hermann Muller and Calvin Bridges, studied the fruit fly *Drosophila melanogaster*. They showed that chromosomes carry genes, discovered genetic linkage - the fact that genes are arrayed on linear chromosomes - and described chromosome recombination.

In 1933, Morgan received the Nobel Prize in Physiology or Medicine for helping establish the chromosome theory of inheritance.



2000: *Drosophila* and *Arabidopsis* genomes sequenced

Drosophila melanogaster (fruit fly)has been a primary tool for geneticists since the early part of the twentieth century. The sequencing of its genome is the result of a collaborative effort between the *Drosophila* Genome Project Group, led by Gerald Fink at the University of California, Berkeley and researchers from Celera Genomics Corporation led by Craig Venter. The *Drosophila* genome is estimated to have approximately 13,600 genes as compared to 20,000—25,000 genes in humans. The popularity of *Drosophila* as an experimental organism ensures that its genome sequence will be a valuable resource for research in genetics and medicine. Many genes of *Drosophila* have been conserved through evolution and have human counterparts. This means that scientists can perform experiments using flies and apply their findings to human biology.

Arabidopsis thaliana is the first plant to have its genome sequenced. This plant from the mustard family has become the plant biologists' equivalent of the laboratory mouse. Its genome was completed by the collective efforts of an international group of researchers called the *Arabidopsis* Genome Initiative. The *Arabidopsis* genome has an estimated 25,000 genes—apparently even more than humans. Although not a crop plant, *Arabidopsis* was chosen as a model organism because its genome is small and it has relatively little of the noncoding, so-called junk, DNA. It does, however, share very similar biochemistry to crop plants such as rice or barely. The study of its sequence is expected to have widespread applications for agriculture and medicine.

2004: Refined Analysis of Complete Human Genome Sequence

The International Human Gene Sequencing Consortium led in the United States by the National Human Genome Research Institute and the Department of Energy published a description of the finished human gene sequence. The analysis reduced the estimated number of genes (which as recently as the mid-1990's had been ~100,000) from 35,000 to only 20,000-25,000. The fact that the human genome has far fewer genes than was originally thought suggests that humans "get more" out of their genetic information than do other animals. For example, the average human gene is able to produce three different gene products.

The finished sequence contains 2.85 billion nucleotides interrupted by only 341 gaps. It covers 99 percent of the genome with an accuracy of 1 error per 100,000 bases. Researchers confirmed the existence of 19,599 protein-coding genes and identified 2,188 other DNA segments that are thought to be protein-coding genes. Although the genome sequence is described as "finished," it isn't perfect. The small gaps that remain cannot be sequenced by the industrial-scale methods used by the Human Genome Project. Filling in these gaps will have to await a series of small targeted efforts by researchers using other techniques and possibly new technologies. The finished genome sequence can be freely accessed through public databases and may be used by researchers without restrictions.

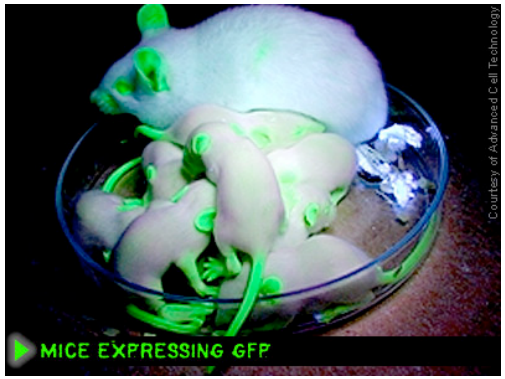
Modern Genetic Engineering Has Come a Long Way Since Its Origins in 1973!

Gene Transplants Seen Helping Farmers and Doctors;

By VICTOR K. McELHENY
May 20, 1974, Monday
Page 61, 1335 words

NY Times-1974

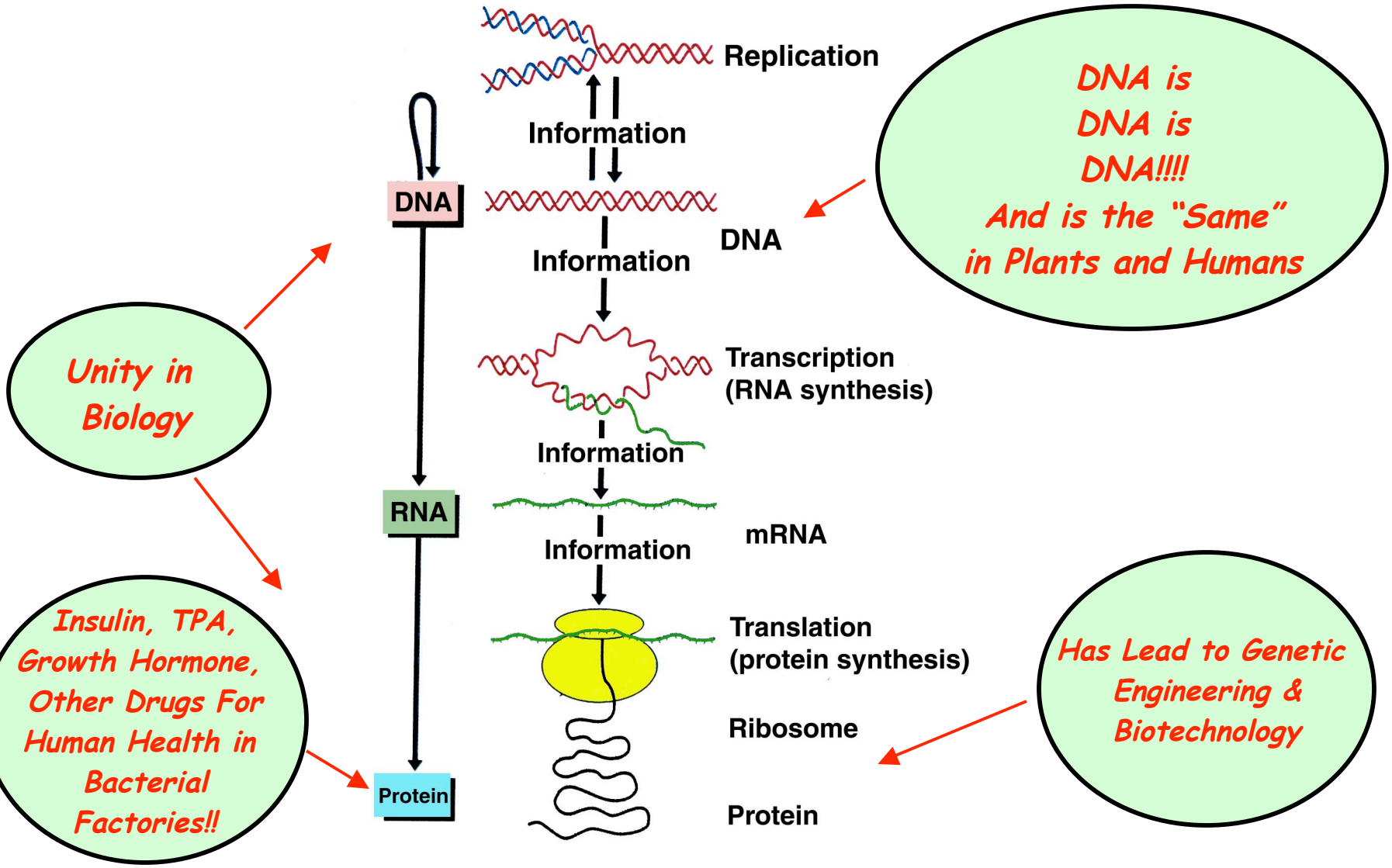
Biochemists working in California have developed a practical method of transplanting genes, the chemical units of heredity, from cells as complex as those of animals into the extremely simple, fast-multiplying cells known as bacteria. [END OF FIRST PARAGRAPH]



Genetic Engineering

Translating The Genetic Code Into Proteins is a Conserved Process

A Natural Process!!



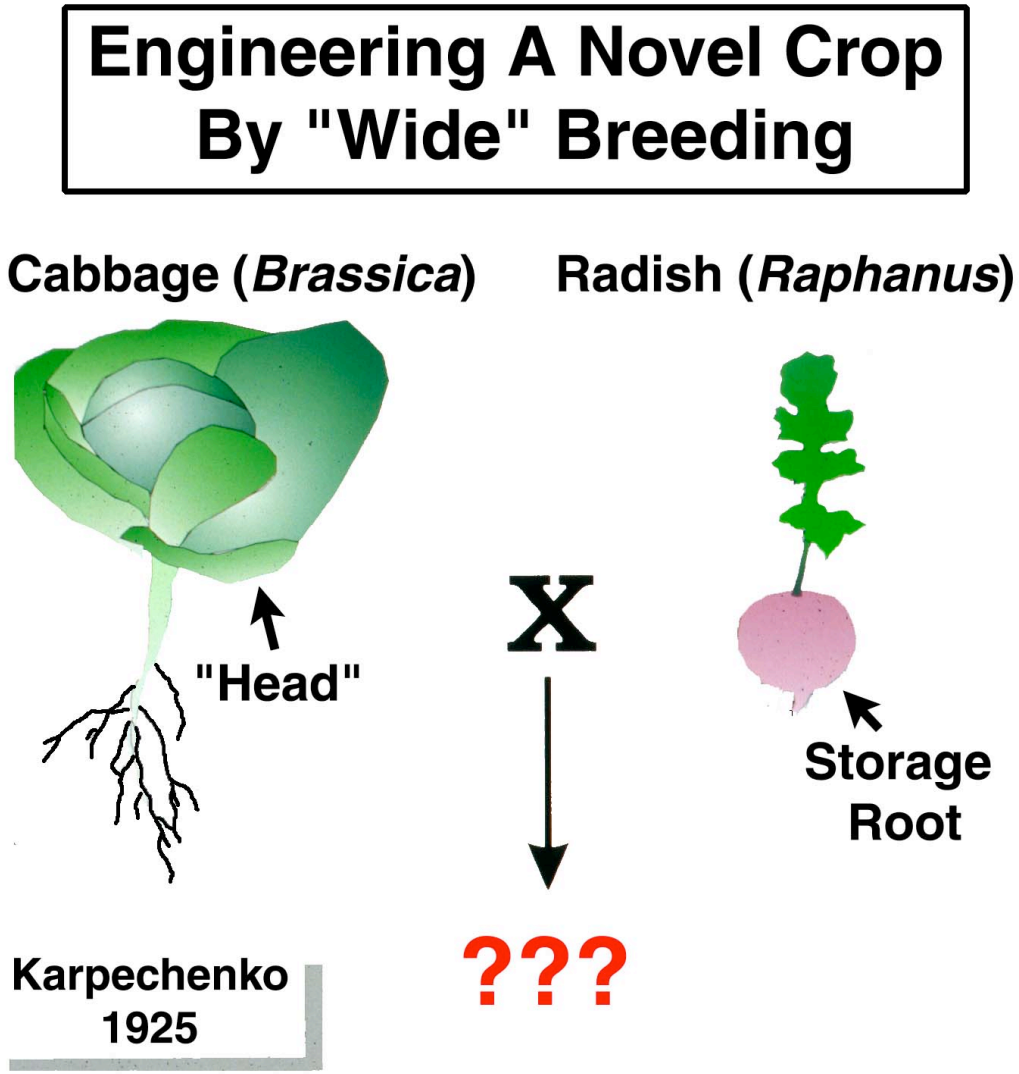
DNA is DNA is DNA!!!! And is the "Same" in Plants and Humans

Unity in Biology

Insulin, TPA, Growth Hormone, Other Drugs For Human Health in Bacterial Factories!!

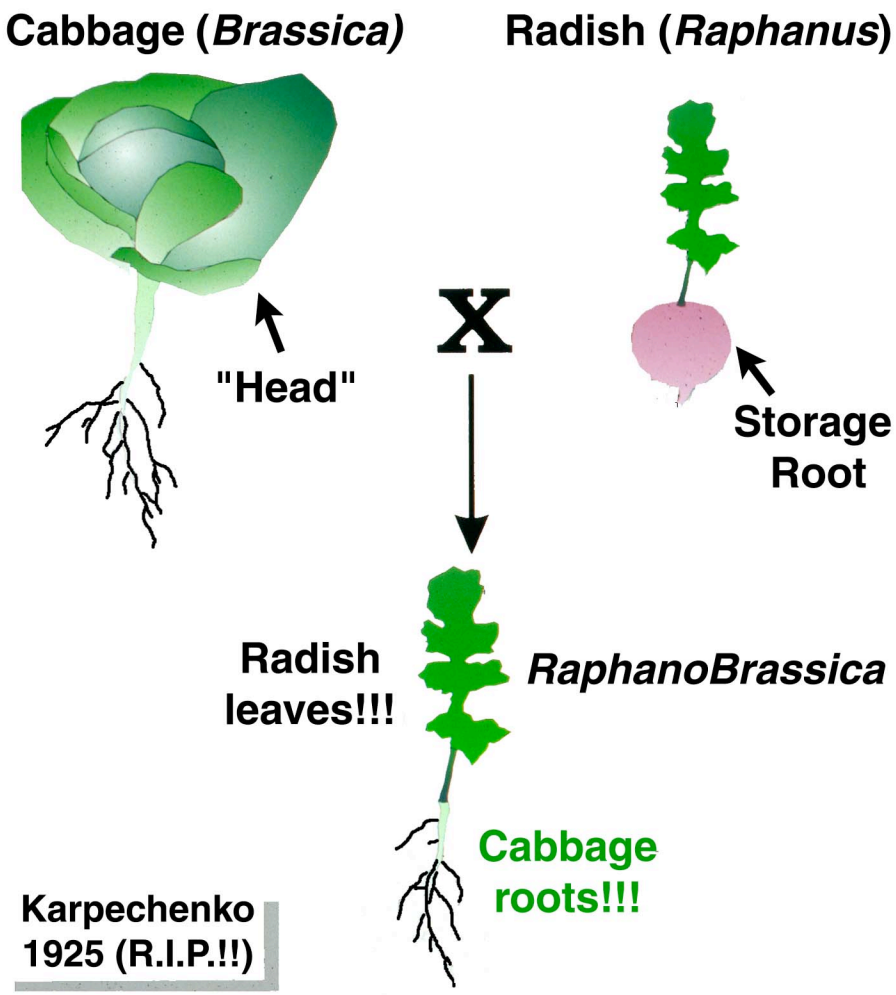
Has Lead to Genetic Engineering & Biotechnology

Genetic Engineering in Plants Has Also Come a Long Way!



Karpechenko, G.D., 1927. The production of polyploid gametes in hybrids. Hereditas 9, 349-368.

With Unpredictable Results in the Beginning…



Modern Plant Genetic Engineering is Less Than 30 Years Old!

The New York Times
nytimes.com

June 30, 1981

Protein Gene Is Transplanted From Bean to Sunflower

1981

UPI

The New York Times
nytimes.com

August 29, 1986

GENE-ALTERED PLANT TO GET TEST

AP

1986

The crop will consist of only 20 plants, but experts say the tiny tobacco stand may lead to an inexpensive genetic way to fight costly plant-devastating insects.

The Rohm & Haas Company of Philadelphia, one of the world's largest producers of chemicals, announced Wednesday that the United States Department of Agriculture had approved the world's first field test of genetically alterted caterpillar-resistant plants. The Agriculture Department confirmed that the approval had been granted.

Two other chemical companies, Ciba-Geigy and Agracetus, have been conducting similar tests with genetically altered plants resistant to weeds.

The New York Times
nytimes.com

September 3, 1987

COMPANY NEWS; Insect-Resistant Plant Reported

REUTERS

1987

LEAD: A Belgian company said it had made an important scientific breakthrough by altering plants genetically so they became poisonous to insects. Plant Genetic Systems of Ghent said its technique could result in a big reduction in the spraying of farm crops with insecticides.

A Belgian company said it had made an important scientific breakthrough by altering plants genetically so they became poisonous to insects. Plant Genetic Systems of Ghent said its technique could result in a big reduction in the spraying of farm crops with insecticides.

P.G.S. said field trials of tobacco plants altered with the gene of a natural, nontoxic insecticide showed that successive generations of the plants produced enough of the insecticide in their leaves to kill caterpillars.

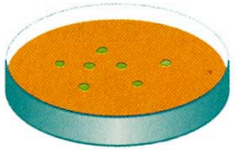
Plants Can Be Regenerated From Cells in Culture

Engineering Crops…..

1. Leaf explant

2. Create single cells

3. Purify cells

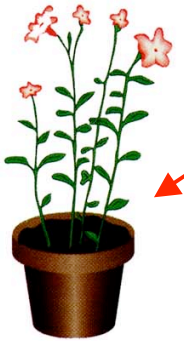


4. Plate out cells

Add New Gene

5. Callus formation

6. Shoot and root development



7. Transplant new plantlets

Engineered Crop

Plants ⟶ Cells ⟶ Fertile Plants

Before There Was Dolly the Sheep There Were Cloned Orange Carrots!!!!

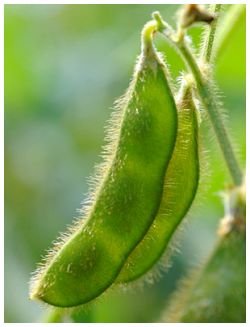
Plant Genome Projects Are Identifying Genes Essential For Increasing Crop Yields!!

Plant Genomes Sequenced To Date

- Arabidopsis
- Rice
- Poplar Tree

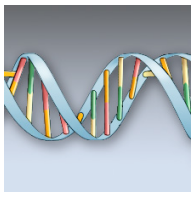
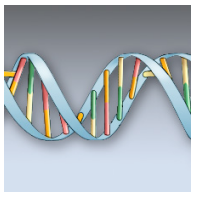


- Soybean
- Corn
- Medicago



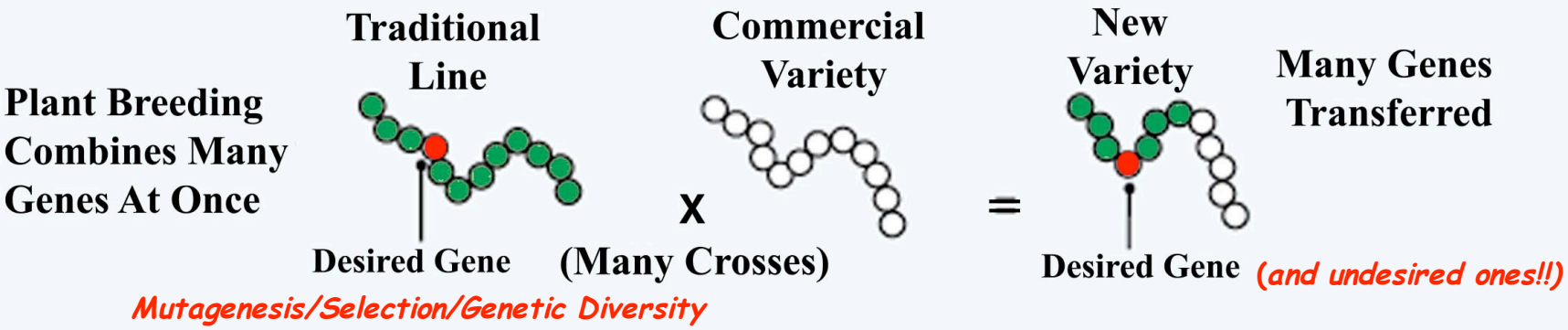
- Papaya
- Grape
- Castor Bean



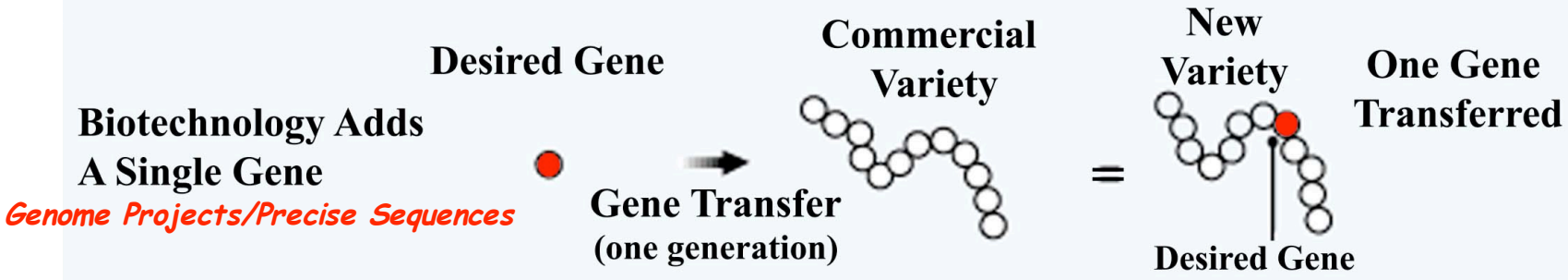



Gene Engineering Techniques Can Also Be Used To Transfer Specific Genes Into Crops

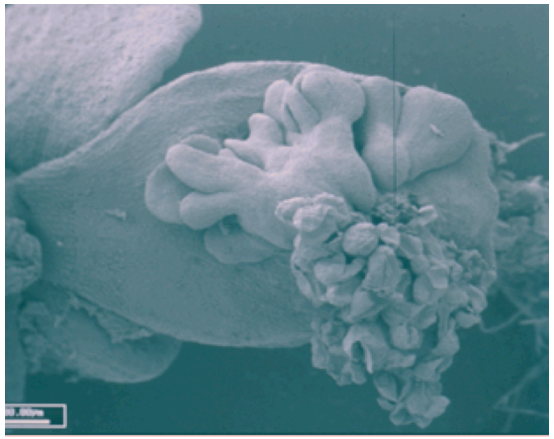
TRADITIONAL PLANT BREEDING



PLANT BIOTECHNOLOGY

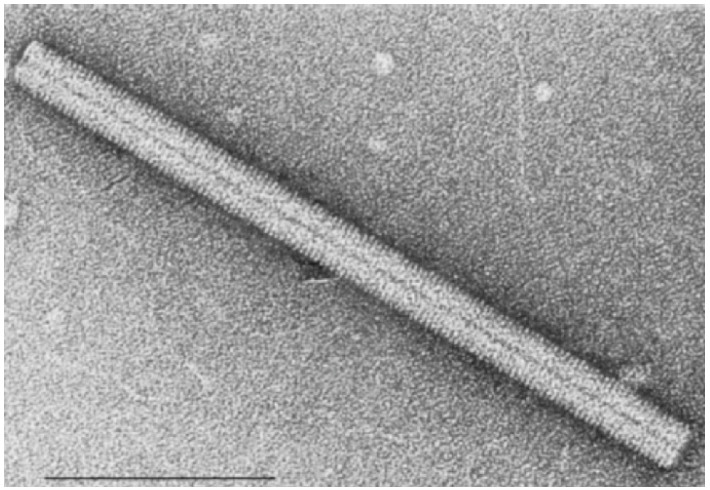


Conclusion: Plant Genome Projects & Genomics Allow Us to Identify Genes That Can Be Used to Improve Crops Plants Using Classical & Genetic Engineering Approaches



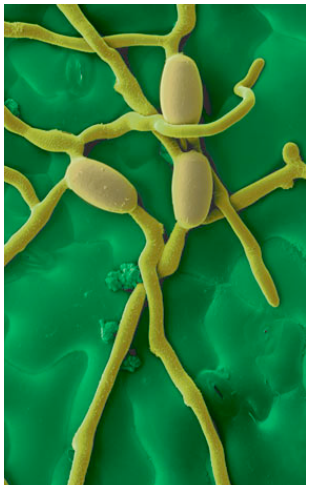
Genetic Engineering Has the Advantage of Allowing Everything That's Possible Biologically To Be Achieved

We Are Only Limited By Our Imagination and Knowledge of Biological Processes



Specific Examples of Bioengineered Crops

Pest Resistance



How to Control Insects?

GARDEN | GUIDE

SUNSET

WHAT TO DO IN YOUR GARDEN IN SEPTEMBER

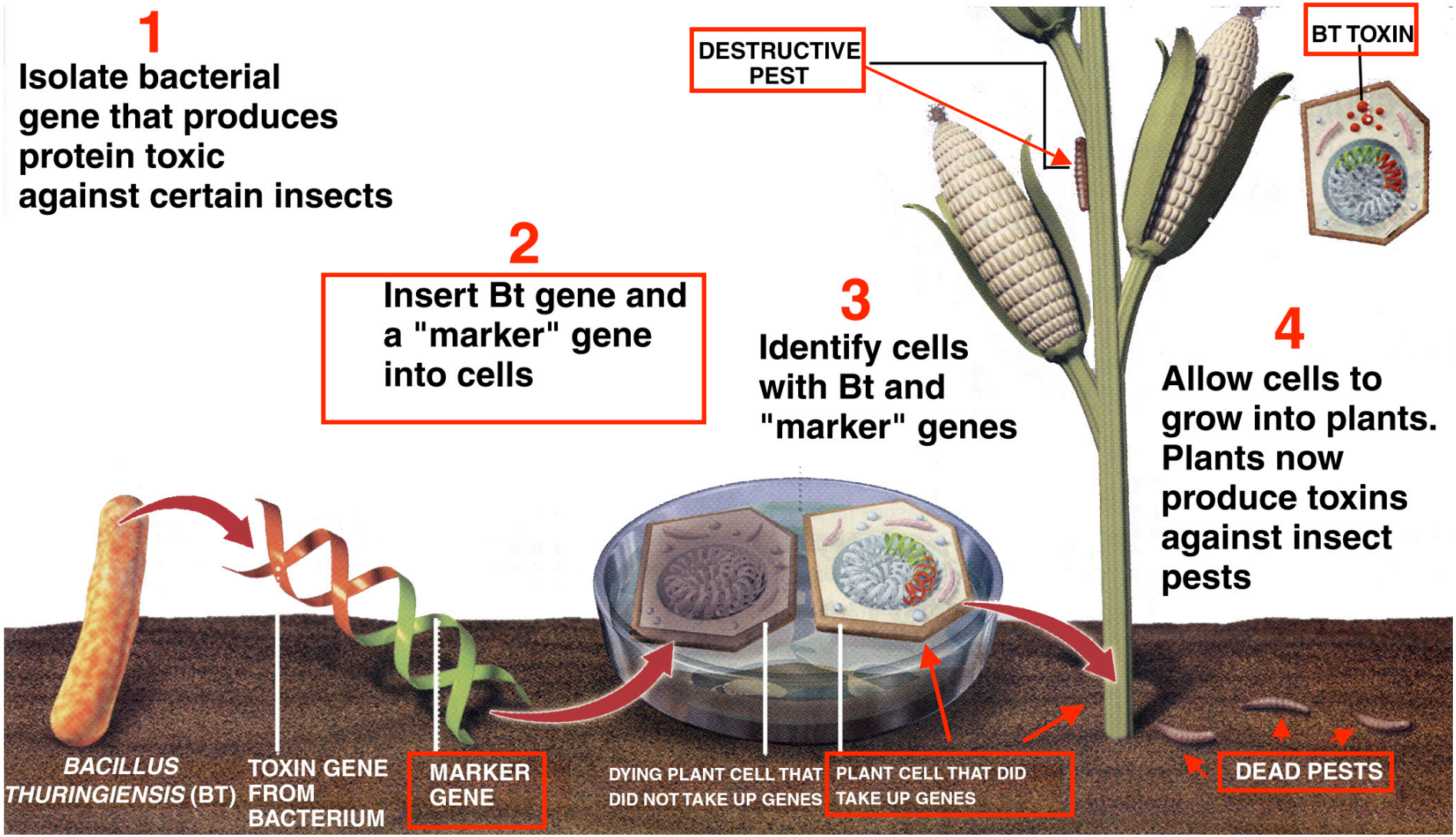
Southern California Checklist

DEBRA LAMBERT

✔ PROTECT CABBAGE CROPS. The minute you plant a brassica, squadrons of cabbage white butterflies seem to descend on it to lay their eggs. The easiest way to thwart them is to cover your cabbage crops with row covers right from the start. The next best option is spraying with *Bacillus thuringiensis* to kill the young caterpillar larvae. ◆

Bt Has Been Used For Many Years To Control Pests by Conventional And Organic Farmers !!!

How to Make an Insect-Resistant Plant




INSECT
RESISTANCE
with Bt
CONTROL
Bt


Max Smith, Iowa Farmer

Engineering Papaya For Resistance to Papaya Ringspot Virus

Saved Hawaiian Papaya Industry

Sensitive Non-Transgenic Control Papaya

Resistant Transgenic Papaya

Using a Wild Potato Gene to Engineer Potato Plants Resistant to Potato Blight Fungus

Resistant Transgenic Plant

Sensitive Non-Transgenic Control

Potato Blight Caused the Irish Famine That Killed One Million People in the Late 19th Century and Resulted in a Large Migration of Irish People to the United States!!!

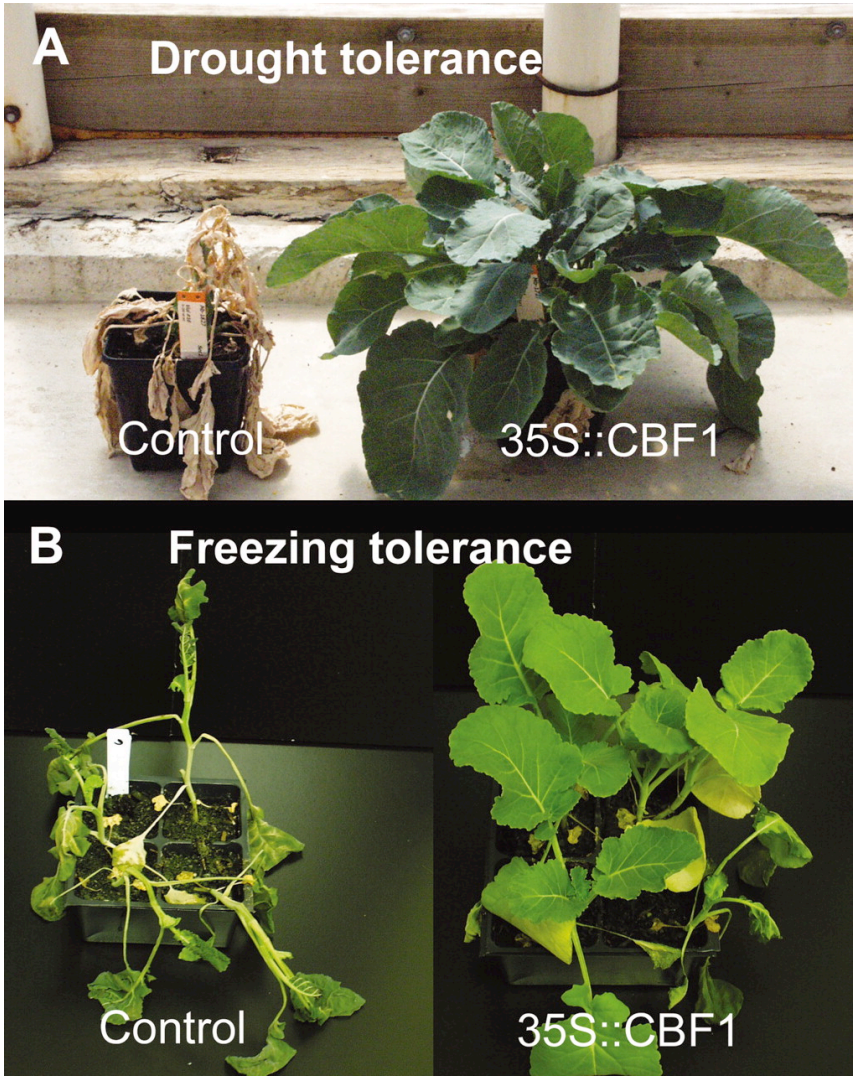
"Gene RB Cloned From Solanum bulbocastanum Confers Broad Spectrum Resistance to Potato Late Blight" Song et al., PNAS 100, 9128-9133 (2003)

Specific Examples of Bioengineered Crops

Abiotic Stress

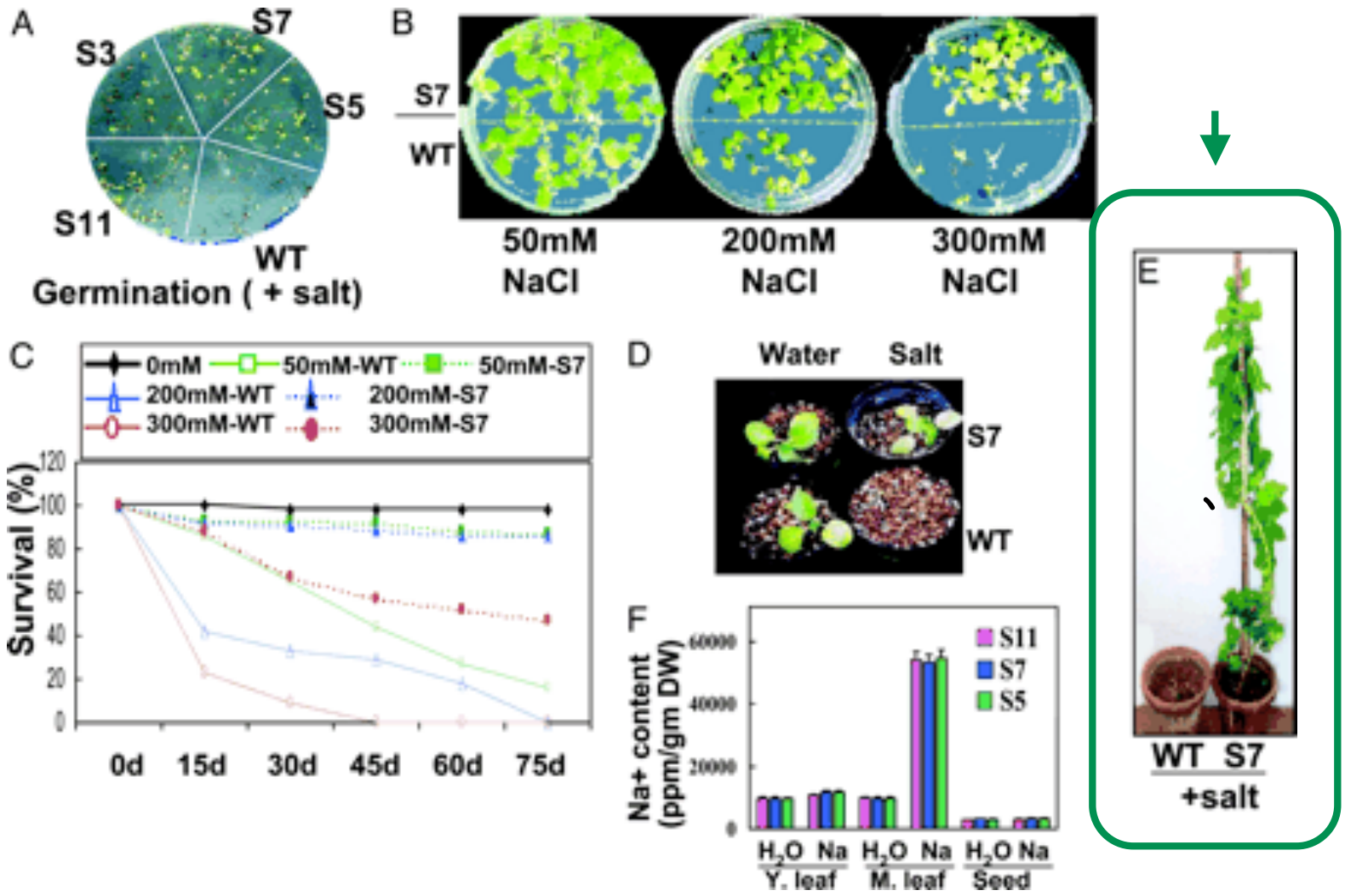
Identifying Genes For Drought and Freezing Tolerance

Major Factors in Lowering Crop Yield



Zhang et al. Plant Physiology 135, 615-621 (2004)

Identifying Salt Tolerant Genes



Sanan-Mishra et al. PNAS 102, 509-514 (2005)


Specific Examples of Bioengineered Crops

Seeds


Seeds Are Used in Many Ways as Food, Beverages, Spices, and Fuels!

Beans

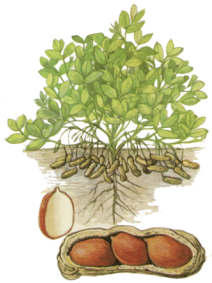
Peas

Wheat

Corn

Coconut

Cashew Nuts



Peanuts

Pecans

Cocoa Beans

Coffee Beans

Nutmeg

Mustard

Most Importantly….. Our Food is Derived From Fourteen Crops &
Over Half Produce Seeds For Human and Animal Consumption

Seed Crops

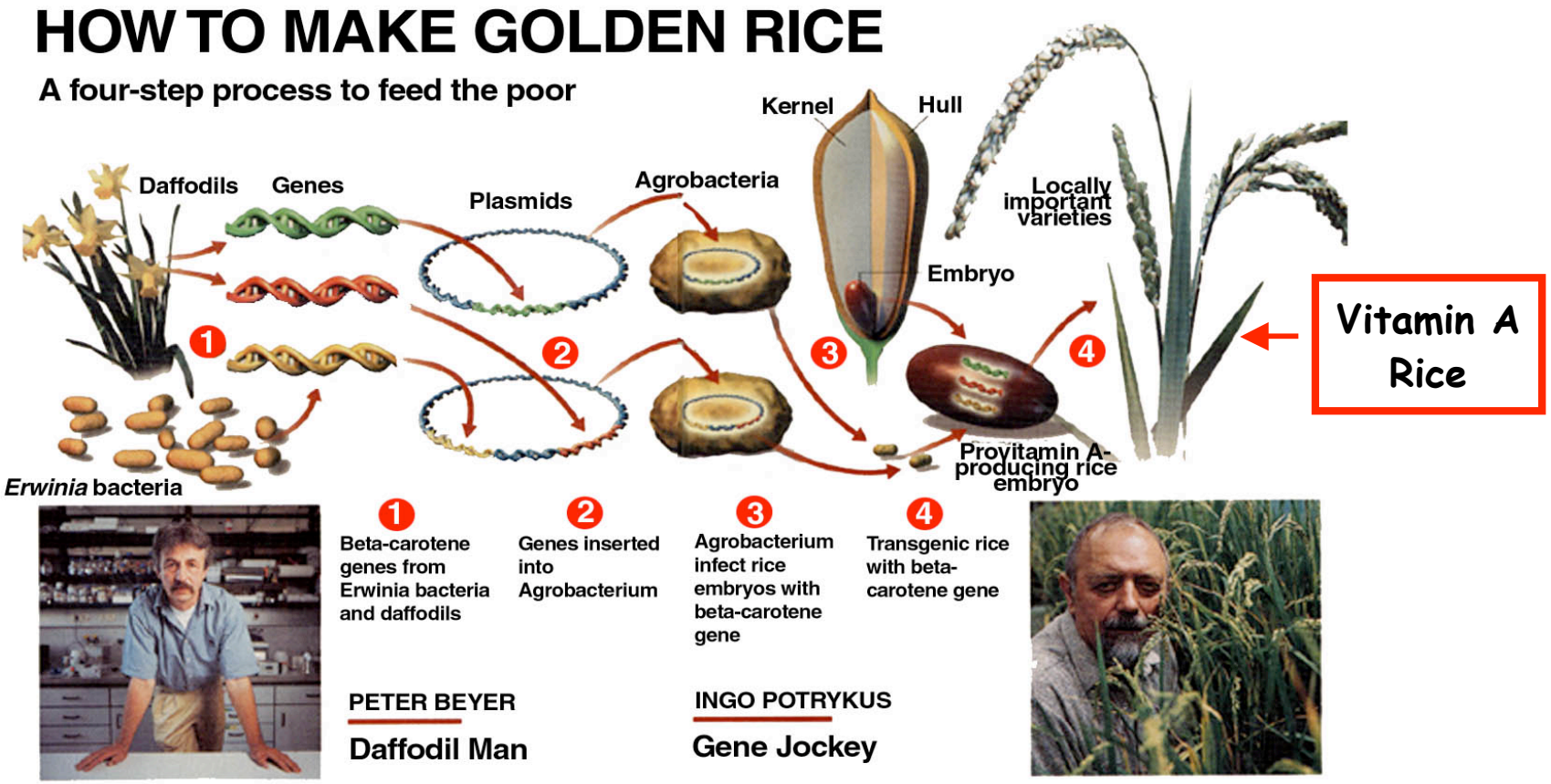
- Wheat
- Rice
- Corn
- Barley
- Sorghum
- Soybean
- Common Bean
- Coconut

Non-Seed Crops

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

In Some World Populations 75% of Calories Are Derived From Seeds!

Vitamin A Deficiency Causes 1,000,000 Deaths Per Year!

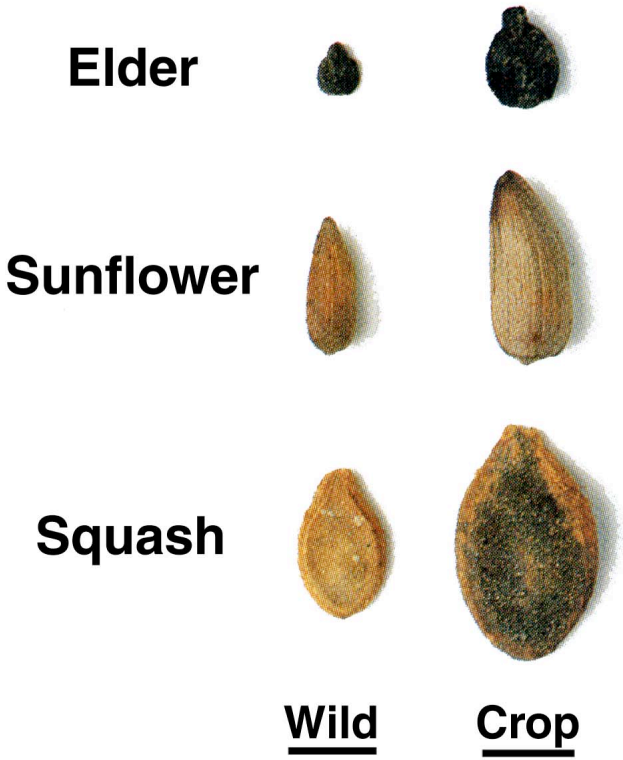


Other Nutritionally-Enhanced Seeds (e.g., Folates, Micronutrients, Vitamin E)

Kinney AJ..Curr Opin Biotechnol. (2006) 17, 130-8.

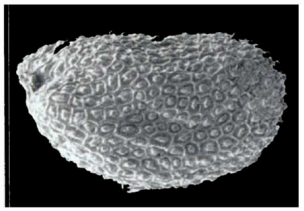
Engineering For Seed Size & Yield Is Not New!

Engineering Bigger Seeds 10,000 Years Ago

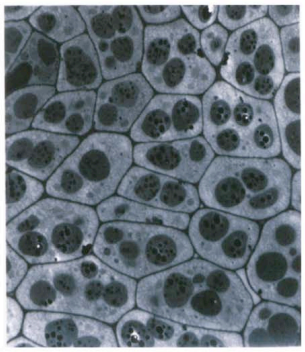


Our American Ancestors, 10,000 BC

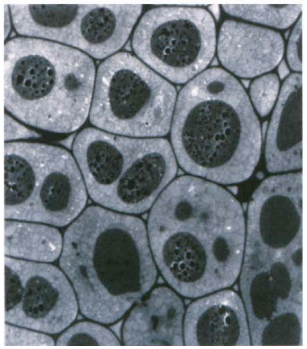
Engineering Bigger Seeds Today



WT



ap2-10

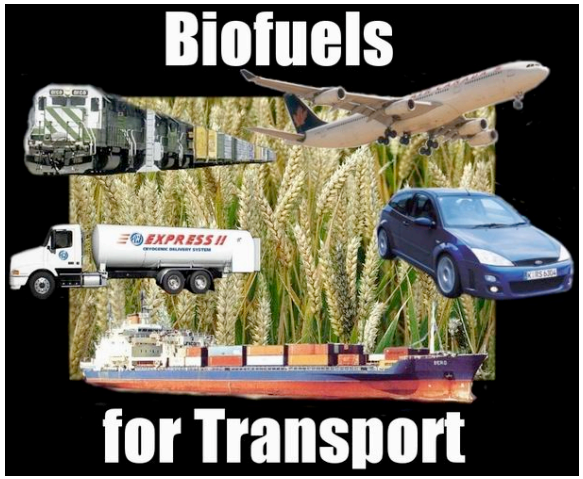


But Need to Identify the Critical Genes

Jofuku et al., PNAS, 2005

Specific Examples of Bioengineered Crops

Biofuels



A Perfect Storm for Energy Crops

Demand Trends
- Consumption outpacing discovery
- China & India

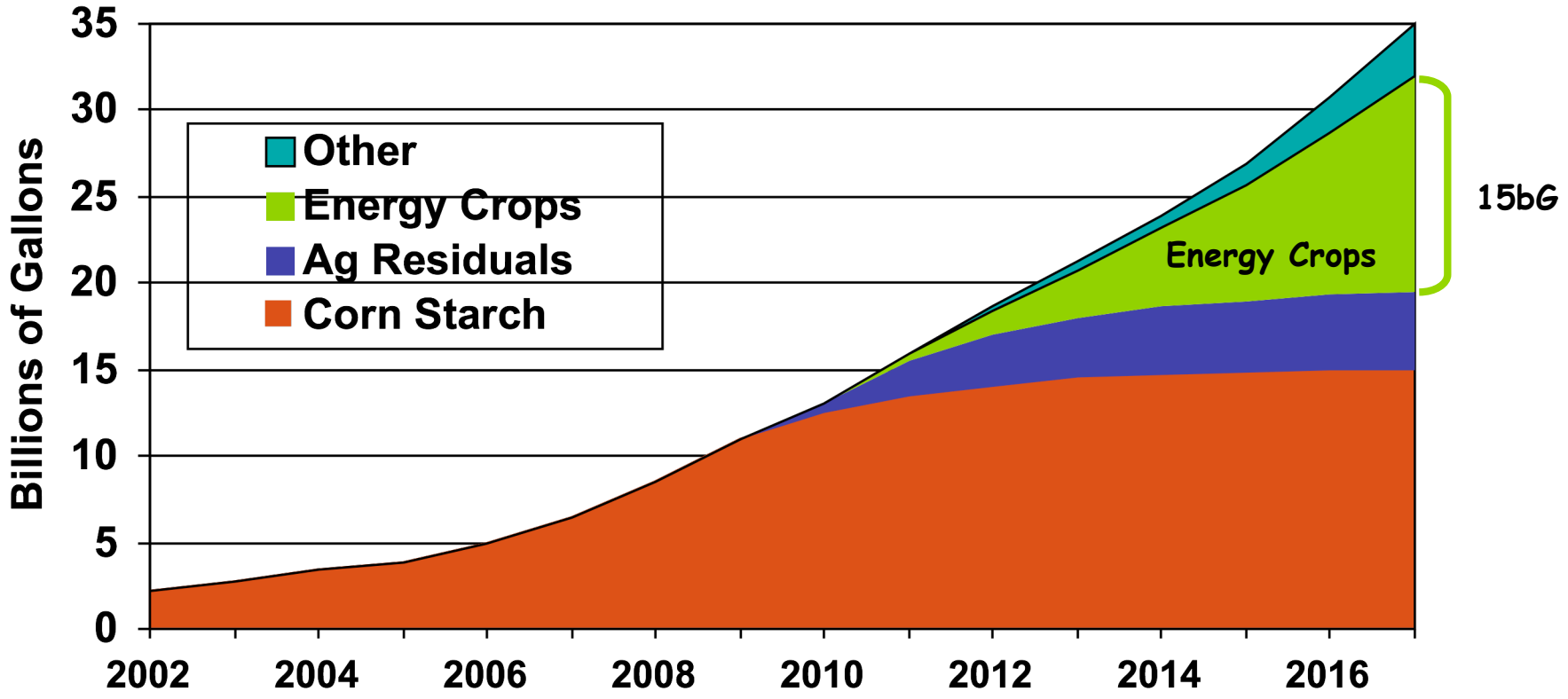
Supply Trends
- Nationalization of reserves
- High oil prices
- Peak production

Oil Security
- Little domestic supply
- Unrest in producing regions

Environmental
- Carbon emissions
- Drilling/mining

Pressure to create a significant, renewable, domestic source of liquid fuels

U.S. Ethanol Production



35 billion gallons of renewable and alternative fuels in 2017 (RFS)

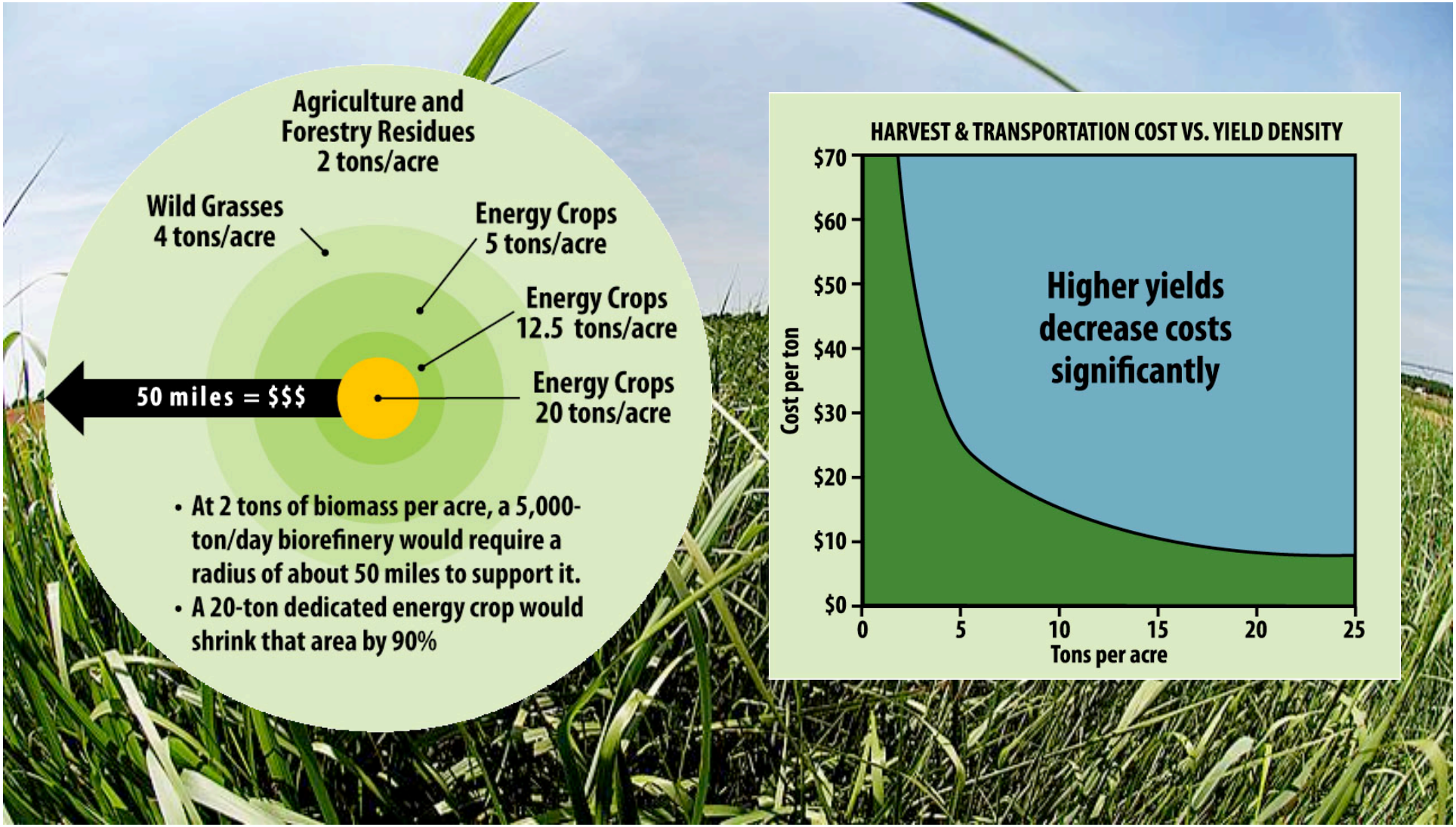
Time is Short-Need Crops in the Ground By 2015!

Using Dedicated Energy Crops To Produce Biofuel

"*With plausible technology developments*, biofuels could supply some *30% of global demand* in an environmentally responsible manner without affecting food production. To realize that goal, so-called advanced biofuels must be developed from *dedicated energy crops*, separately and distinctly from food."

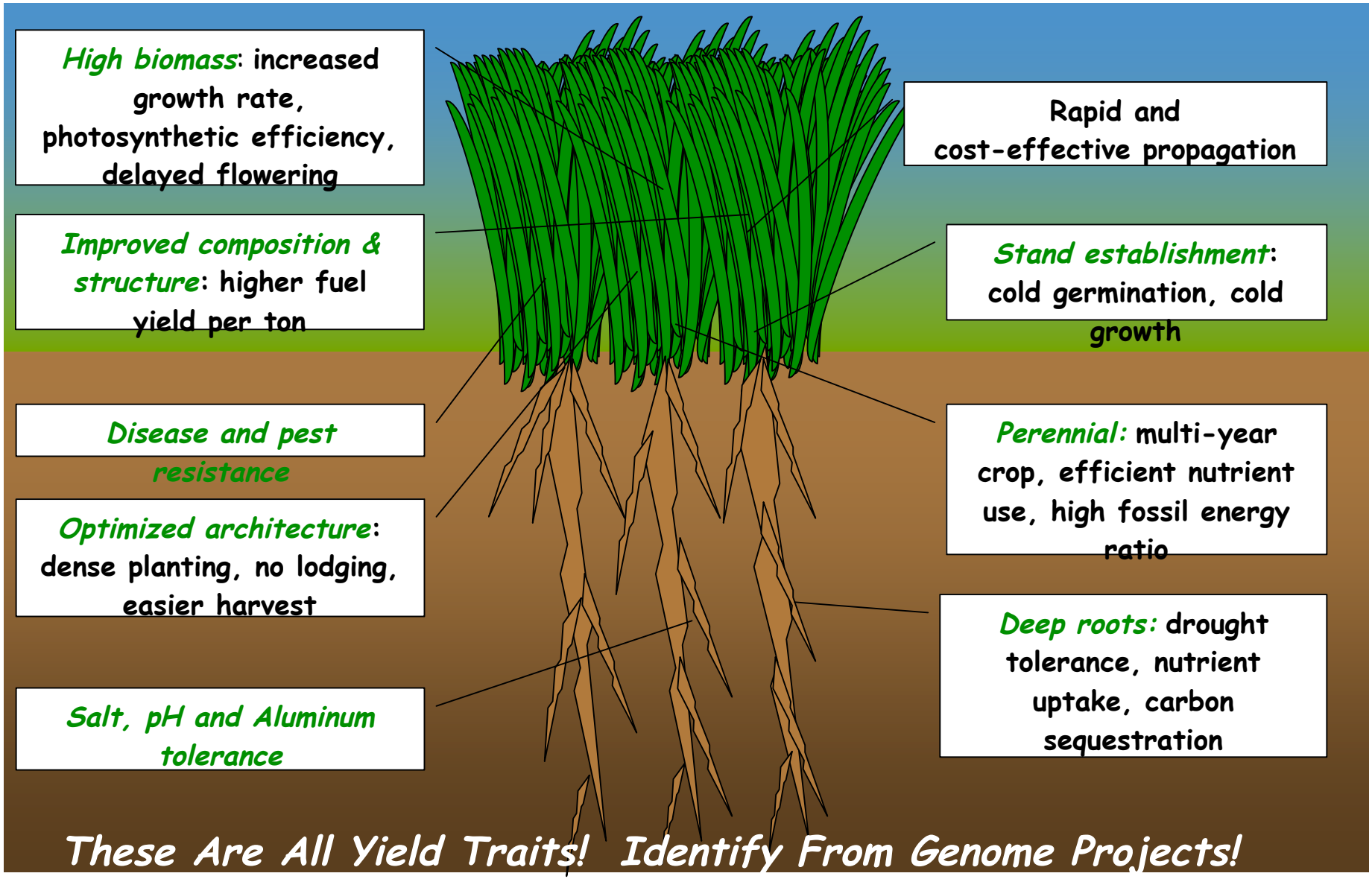
Steven E. Koonin
Chief Scientist, British Petroleum

Biomass Yield Matters



Potential Dedicated Energy Crops

The "Perfect" Energy Crop

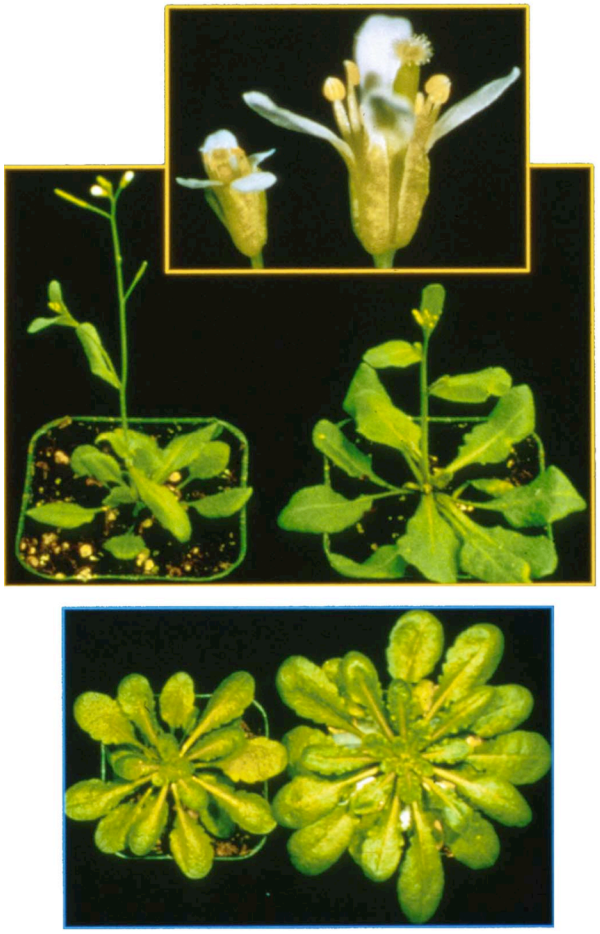


Engineering Biomass
10,000 Years Ago

Foxtail Millet

Wild Domesticated

Engineering Biomass
2008



35S:ANT

Bob Fischer
UC Berkeley

Plants Have Been Engineered For Large Numbers of Traits in Laboratories Around the World

Tens of Thousands of GE Experiments!!

Genetically Engineered Traits

Improving Pest and Weed Management
- Herbicide tolerance
- Virus resistance
- Insect resistance
- Bacterial resistance
- Fungal resistance

Chemical Free Crops

Improving Plant Breeding
- Male sterility; production of hybrid seeds (Canola)

Improving Nutritional Quality
- High-methionine and high-lysine seeds
- Decaffeinated Coffee*
- Vitamin-enriched grains
- Allergen-free seeds/grains*

Healthier Crops

Improving Agronomic Properties
- Altering cold sensitivity
- Improving water stress tolerance
- Improving salt tolerance
- Improving nutrient uptake
- Drought Resistance*

Crops in Desert & Drought

Molecular Farming
- Oils
- Starch
- Plastic
- Enzymes, Pharmaceuticals
- Ethanol/Transportation Fuel*

Crops as Factories & *Vaccines*

Improving PostHarvest Qualities
- Delay of fruit ripening
- Delay of flower senescence/timing
- High-solids tomatoes
- High-starch potatoes
- Sweeter vegetables

Longer Lasting Crops

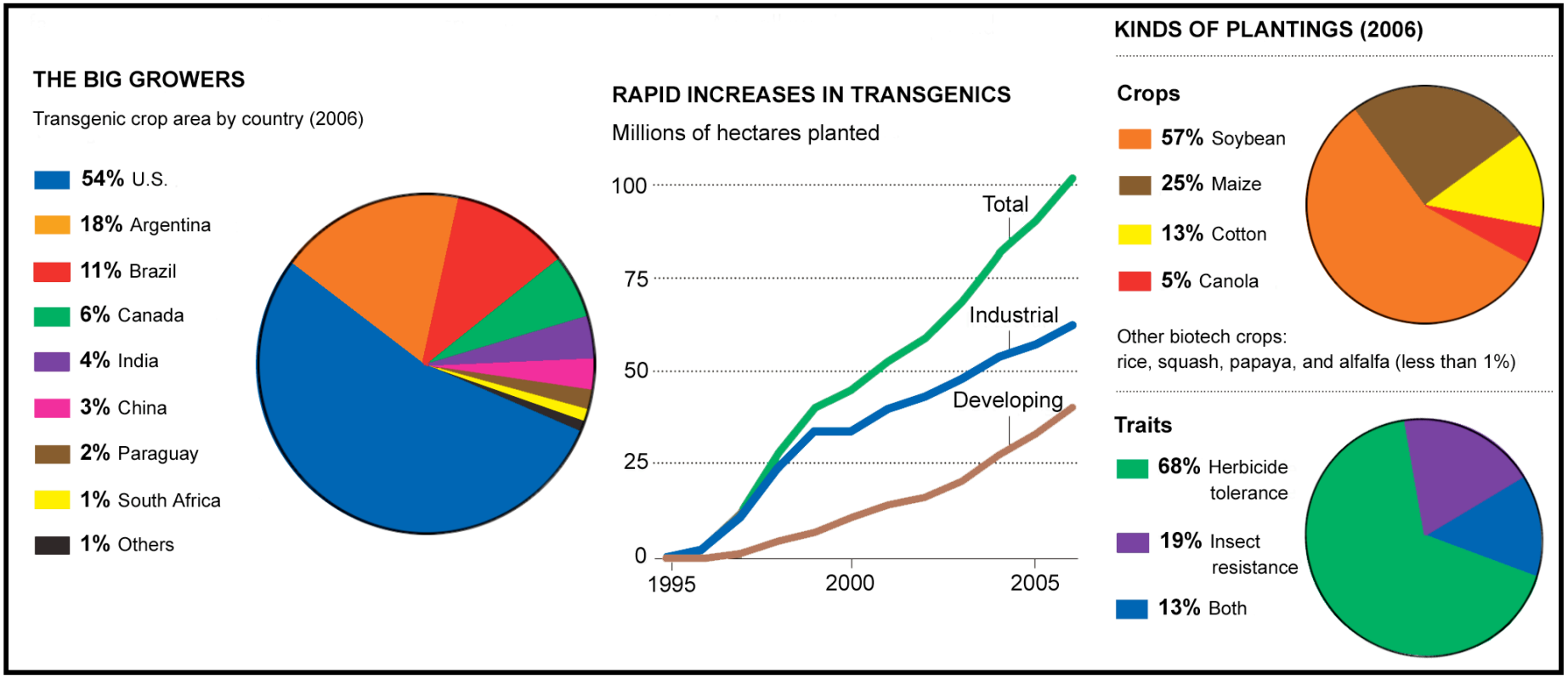
Detoxifying Contaminated Soils

Crops to Clean Environment

But Only a Few Have Helped Generate New Crops!

The "Simple Ones With Economic Drivers"

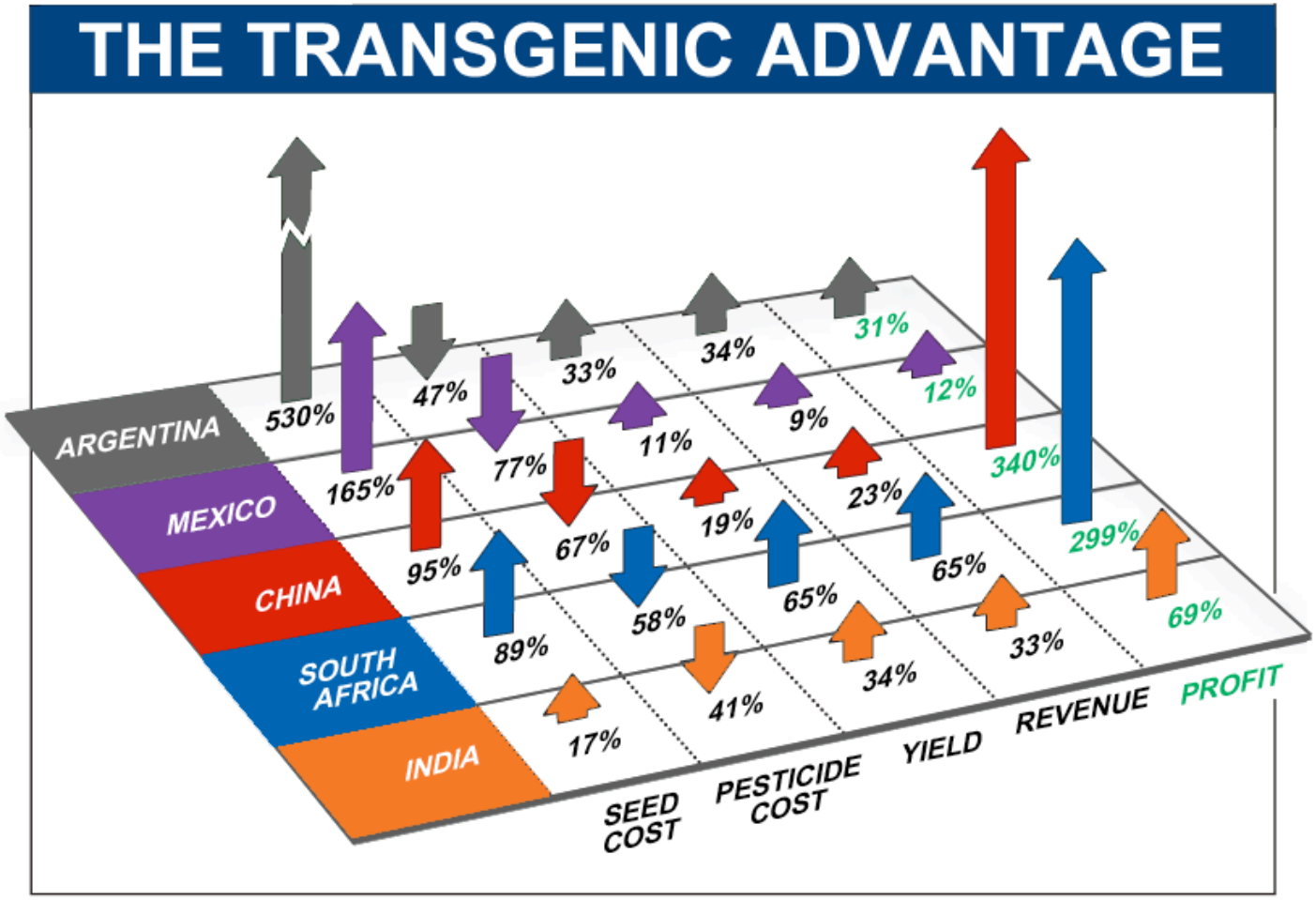
One Way is to Use These New Traits in Engineered Crops That Farmers Have Adopted Faster Than Any New Agricultural Technology In the Past 100 Years!



Over 1.7 Billion Acres of Bioengineered Crops Have Been Grown World-Wide Since 1996 and 280 Million Acres in 2007

ISAAA Brief, 2007

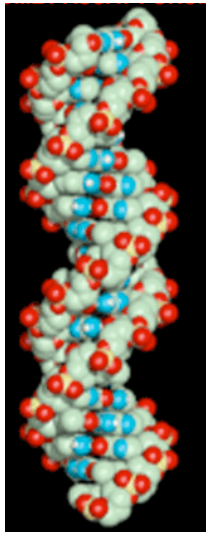
Engineered Crops Have Increased Yields, Reduced Pesticide Use, and Increased Incomes of Farmers in the Developing World



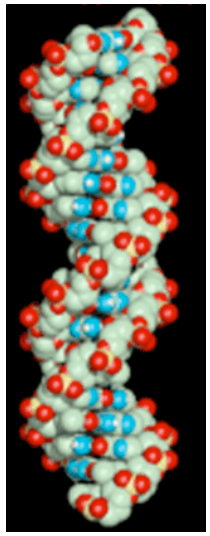
United Nations FAO Report No. 35, 2003-04; Scientific American, September, 2007

WHAT ABOUT SAFETY?

How Many Genes Did You Eat Today?



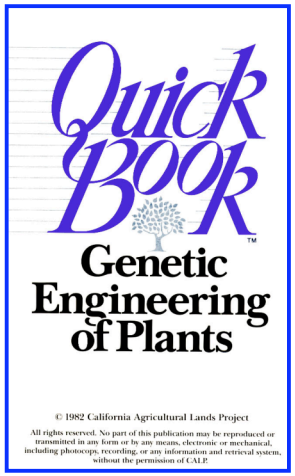
- One lettuce leaf has two million cells
- Each lettuce cell has ~ 25,000 genes
- One lettuce leaf has fifty billion genes
- A small salad has 10 lettuce leaves or FIVE HUNDRED BILLION GENES!!!



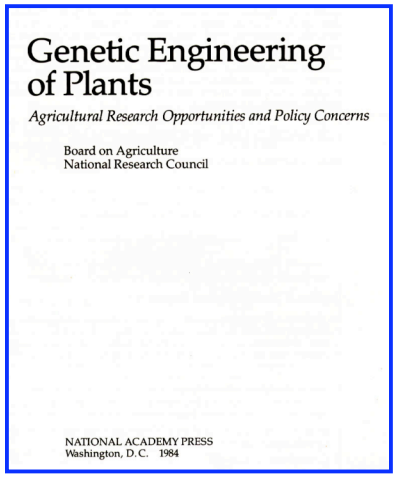
What About the Carrots, Celery, Tomatoes, etc.?

What Happens to the Genes That You Eat?

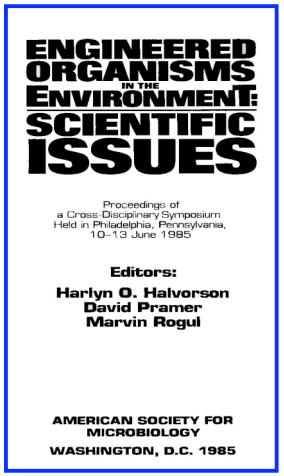
Safety Issues of Genetically Engineered Plants Have Been Investigated and Discussed For Almost 25 Years!!!



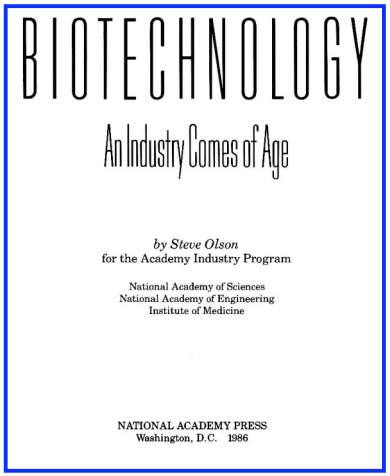
1982



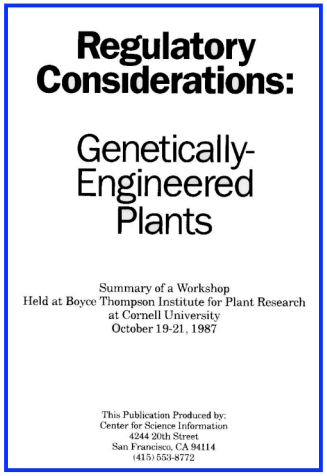
1984



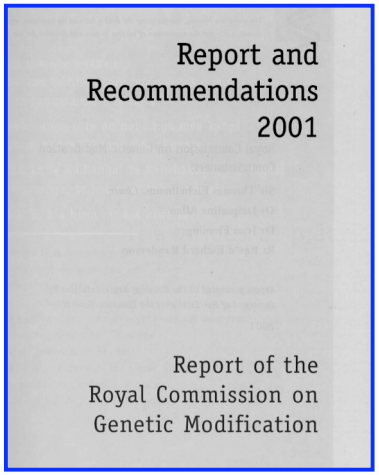
1985



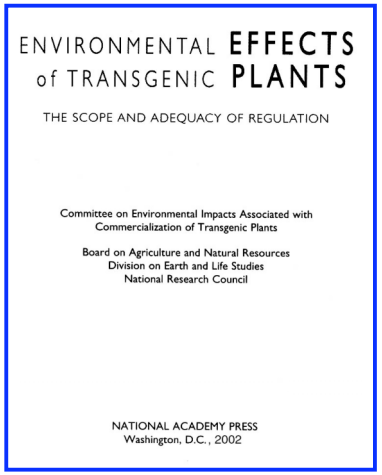
1986



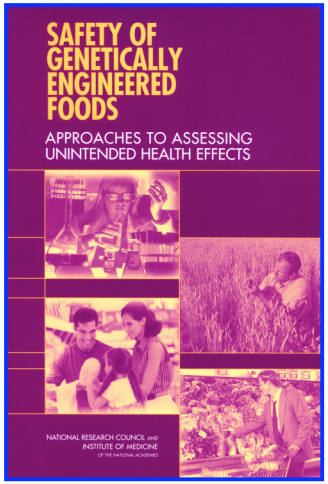
1987



2001



2002



2004

The Royal Society
May, 2003

"The public has been told for several years that GM foods are inherently unsafe to eat. Most people would like to know what evidence exists to back up such claims. We have examined the results of published research and have found nothing to indicate that GM foods are inherently unsafe. If anybody has convincing evidence, get it out in the open so that it can be evaluated."

Hundreds of millions of people have eaten GM foods with no ill effects!

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

The GMO "Controversy" Has European Origins and is Complex and Not Science Based

- *Ideology / Anti-Technology /* Anti-Biotech/Anti-Science/Unnatural/Propaganda
- *Lack of Confidence in Government* -- No Strong USDA, FDA, or EPA Tradition in Europe (*Protect Food Supply -- Mad Cow -- Dioxin*)!
- *Mistrust of International / US Corporations / Anti-Market* -- Taking Over the Food Supply -- Anti-Globalization -- Anti-Patent/Intellectual Property
- *Labeling* -- Want to Know and Choose What is Eaten (Personal Liberty)!
- *Experience of Europe in WWII* -- Wary of Genetic Manipulation
- *Small Farmer Tradition* in Europe
- *Production-Oriented Farming* -- Subsidies/More Production/More Euros ($54B/2003)
- *Organic Growers/Markets* -- Gain Market Share (*Follow the $!!*)/*Pollen Flow --"Contamination"*
- *No "Obvious" Consumer Benefit* -- First Generation AgBiotec/No Need
- *Trade/Protectionism* -- Keeping out US Farm Products -- GM Crops
- *Large European Agrochemical Companies -- Lost First Biotec Round*
- *Ecological Issues -- Native Species "Contamination"*
- *Lack of Public Science Awareness*

The New York Times
nytimes.com

August 18, 2002

Zambia Bars Altered Corn From U.S.

Telegraph.co.uk

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You are here: Home > News > World News > Africa and Indian Ocean > Zambia

Starving Zambia rejects America's GM maize

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

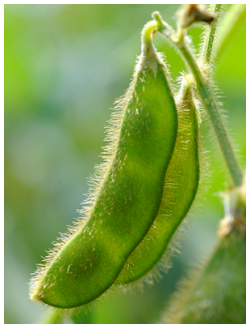
AFRICAN COUNTRIES REJECT GM FOOD AID

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.

Professor Frank Furedi, University of Kent, England



Times are Changing……..

The New York Times
nytimes.com

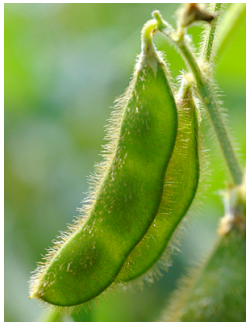
April 21, 2008

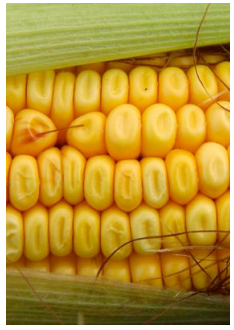
In Lean Times, Biotech Grains Are Less Taboo

By ANDREW POLLACK

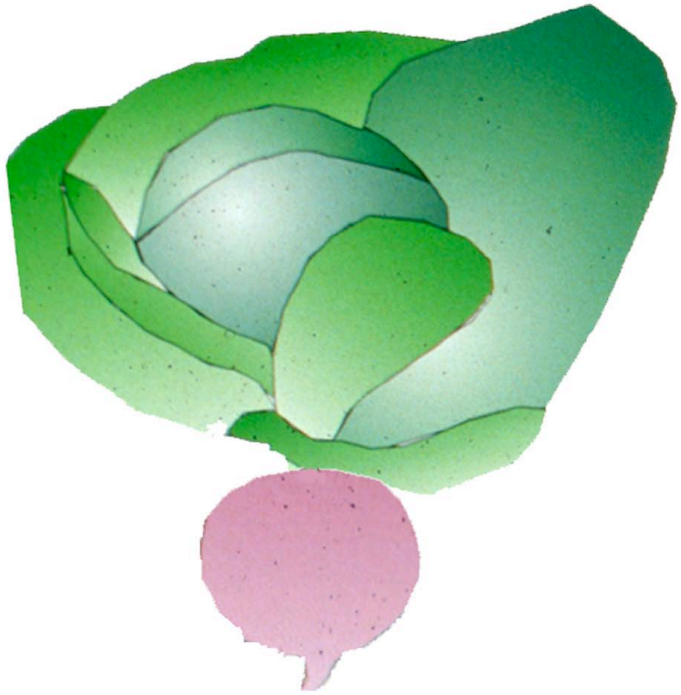
Soaring food prices and global grain shortages are bringing new pressures on governments, food companies and consumers to relax their longstanding resistance to genetically engineered crops.

In Japan and South Korea, some manufacturers for the first time have begun buying genetically engineered corn for use in soft drinks, snacks and other foods. Until now, to avoid consumer backlash, the companies have paid extra to buy conventionally grown corn. But with prices having tripled in two years, it has become too expensive to be so finicky.



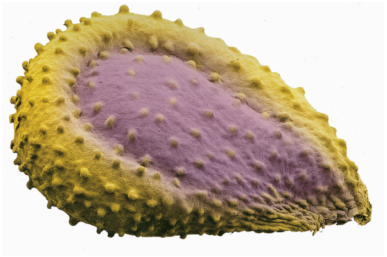


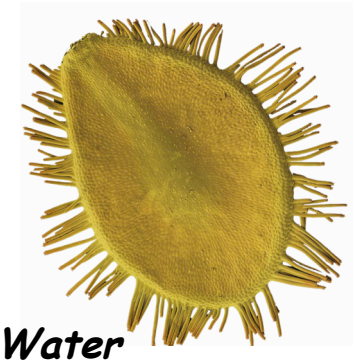
The End……..



….or is it the Beginning?

So……Why Seeds??

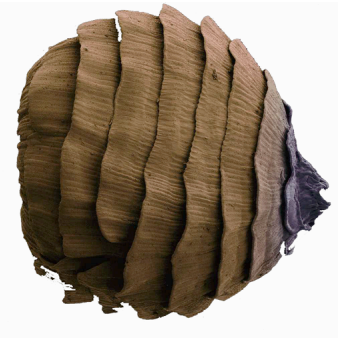


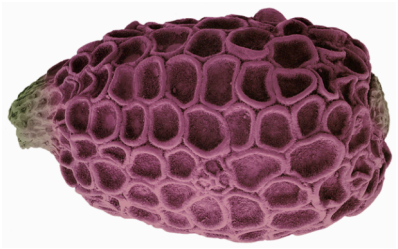


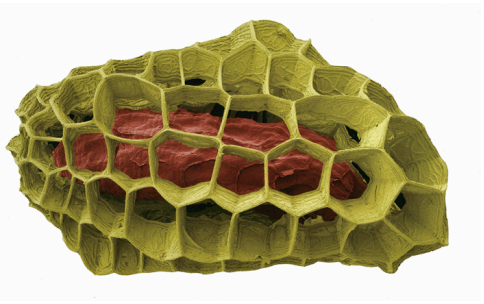
Water

Wind

Animals







Seeds Protect and Disperse Plant Embryos and Come in Many Shapes and Sizes!

Science vs. Non-Science

- ***Non-Scientific Approach***
  - *Starts with conclusion, searches for evidence to support it ("cherry picking")*
  - *Discredits alternative views*
  - *Often lacks context*
  - *"Ideological" (whether gmos, evolution, or stem cells)*

- ***Scientific Approach***
  - *Tests hypotheses by experimentation*
  - *Collects and analyzes all available evidence before reaching conclusion (e.g., rejecting hypothesis)*
  - *Actively seeks alternative interpretations*
  - *Is his/her own greatest critic*
  - *Applies critical thinking skills - what is the basis for this?*

SIGNIFICANT NUMBERS

Number of Bioengineered Crop Field Trials	>10,000
Number of Countries Growing Bioengineered Crops	23
Proportion of World Crop Area	20%
Number of Bioengineered Plant Species Tested	41
Number of Significant Adverse Incidents	0

ADDING TO THE CHALLENGE TO PRODUCE SUFFICIENT FOOD……