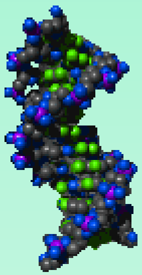
The Basics: GMOs & Traditional Plant Breeding

Richard H. Molinar, Farm Advisor Emeritus



100

UC Cooperative Extension

University of California

Division of Agriculture and Natural Resources

❖Is it just Black or White?

❖Is it a Yes for it, or no against it?

❖Or is there a middle of the road?

Q: What is genetic engineering?

- Genetic engineering generally refers to the use of recombinant DNA techniques to introduce new characteristics or traits into an organism.

  It entails producing a piece of DNA (the recombinant DNA or rDNA construct) and introducing it into an organism so that new or altered traits can be imparted to that organism. The genes and other segments of DNA that are part of the rDNA construct may be obtained from other organisms, or synthesized from scratch in a laboratory. ……..

Genetic engineering enables people to introduce a much wider range of new traits into an organism than is possible by conventional breeding. It has been widely used in agriculture, for example to make crops resistant to certain pests or herbicides, in medicine, for example to develop microbes that can produce pharmaceuticals for human or animal use, and in food to produce microorganisms that aid in baking, brewing, and cheese-making.

http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/GeneticEngineering/GeneticallyEngineeredAnimals/ucm113605.htm

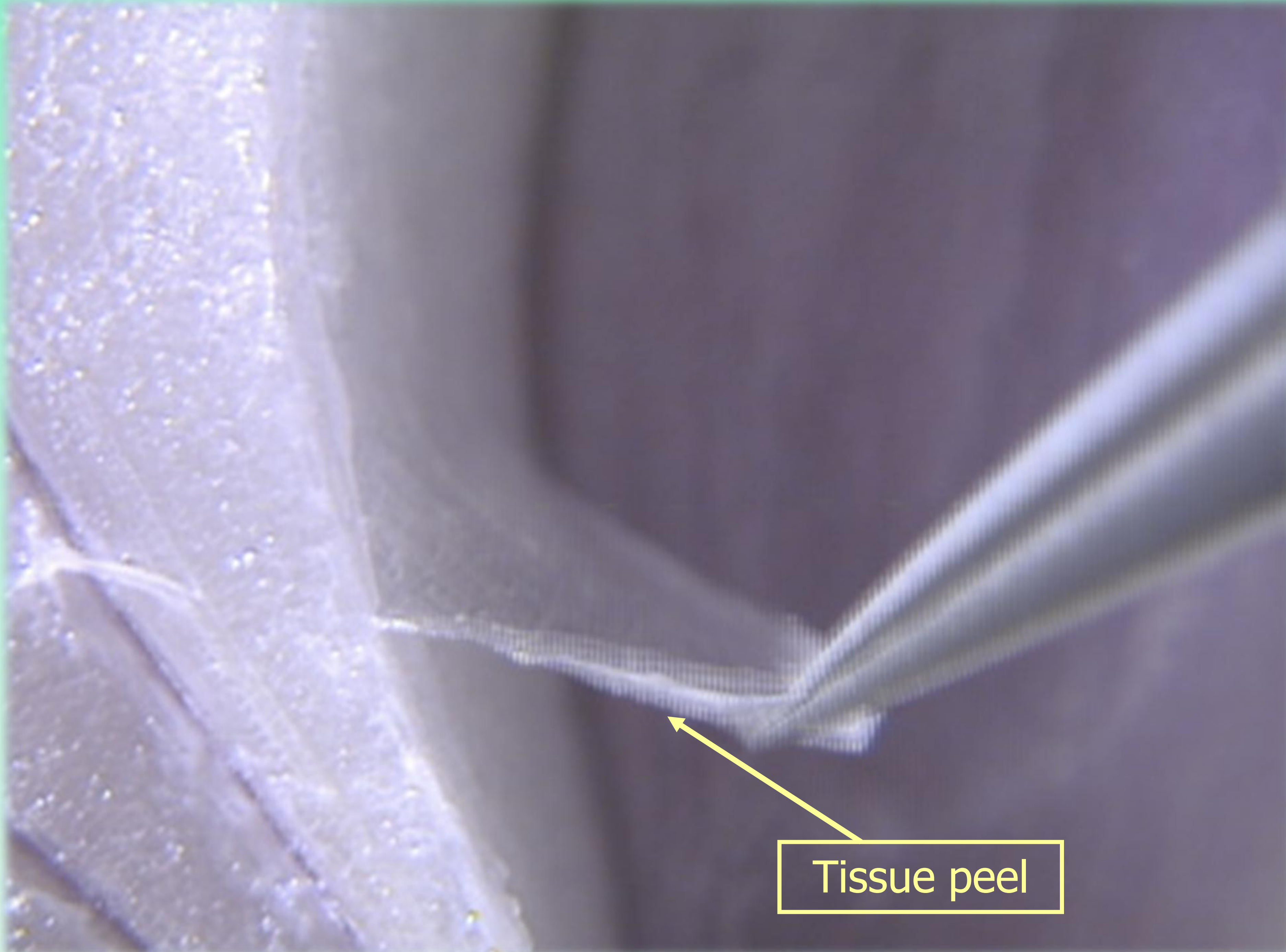
GMO - Similar terms

- Genetically modified organism (GMO)
- Genetic modification (GM)
- Genetic engineering (GE)
- Biotechnology
- Biotech seeds
- Transgenic
- Recombinant DNA

Tour d'Onion

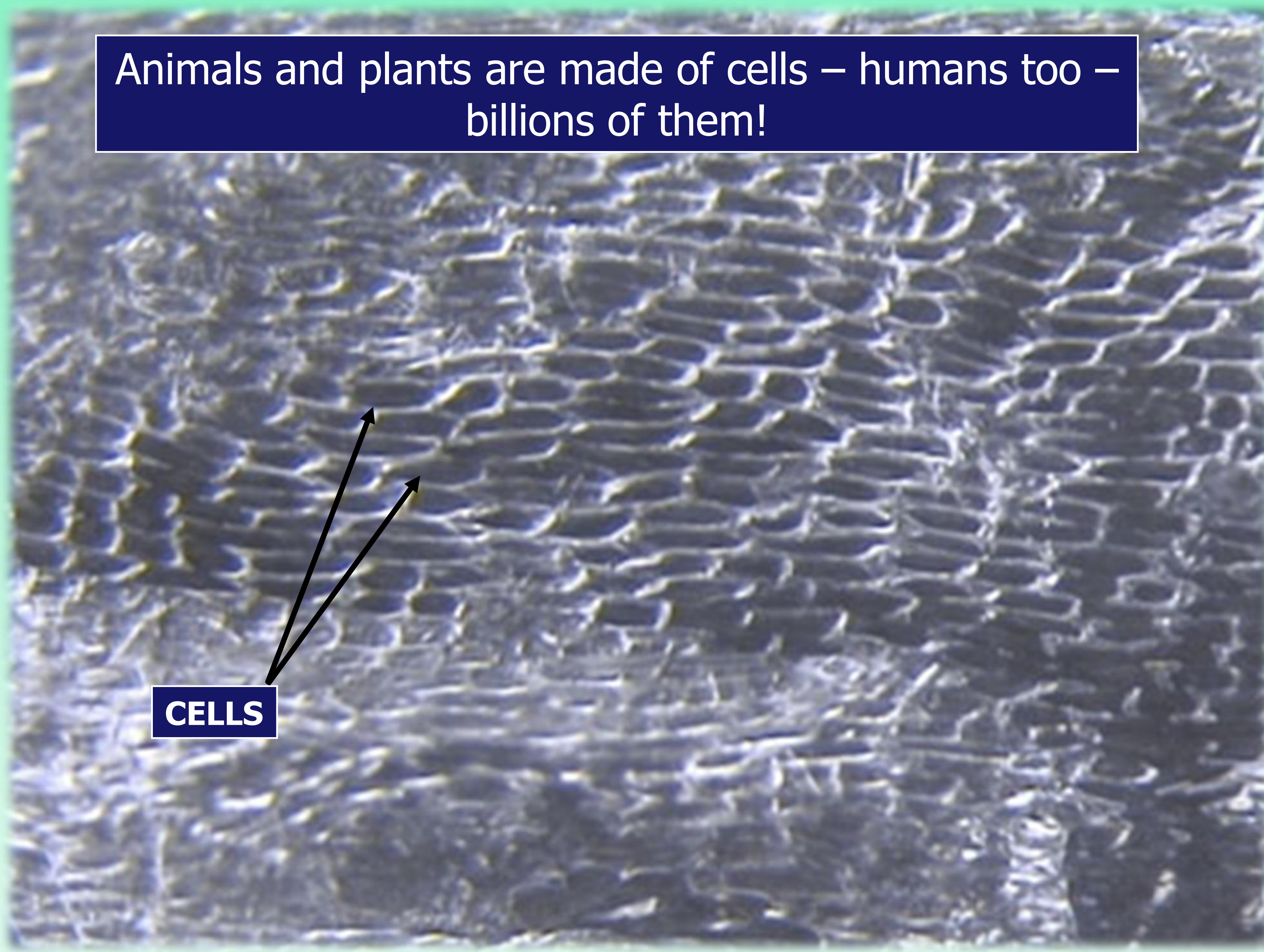
These and some other powerpoint slides Thanks to UC Biotech website, Peggy G. Lemaux, Ph.D.

Or what makes an onion, an onion?

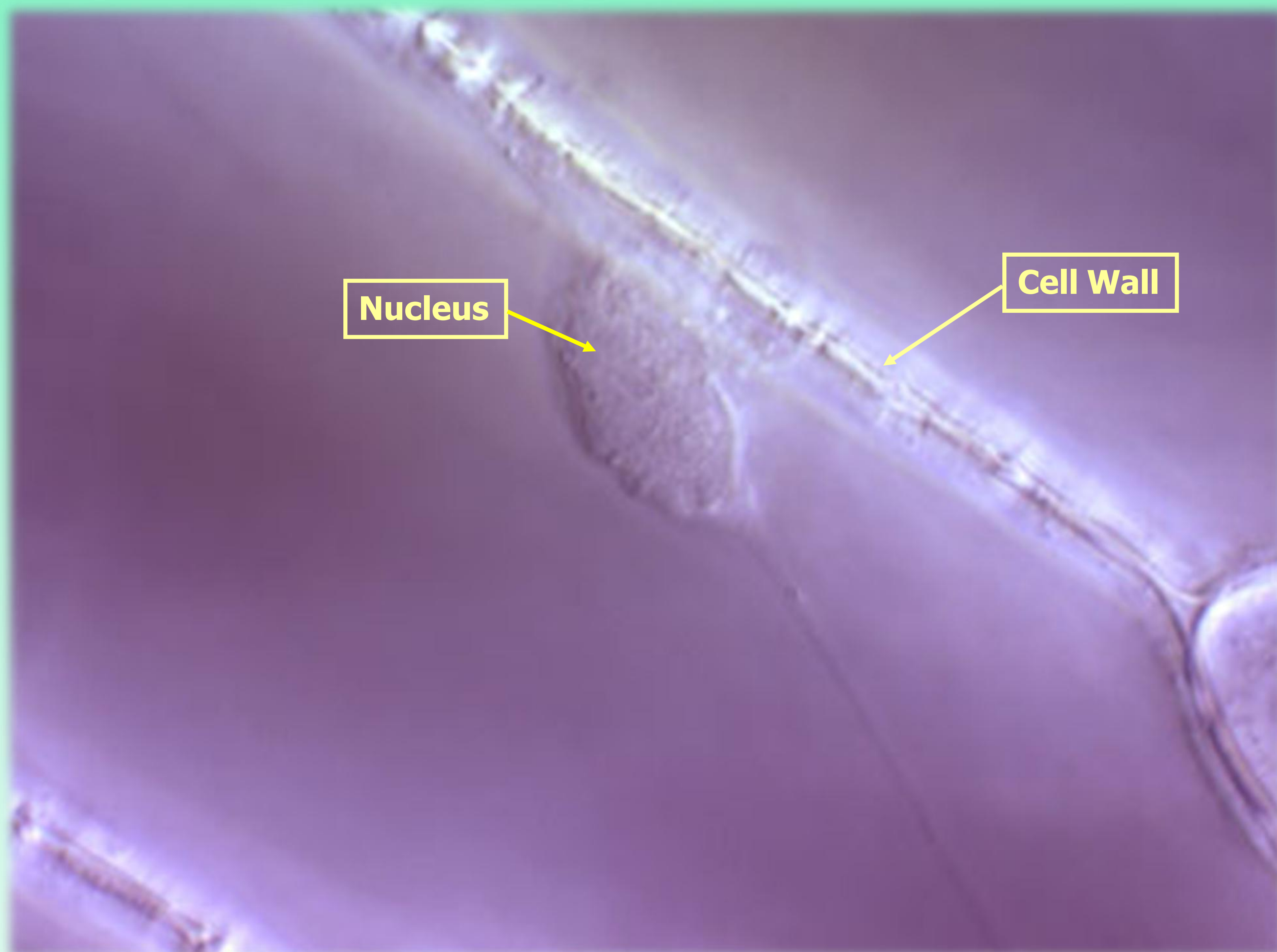


Lemaux

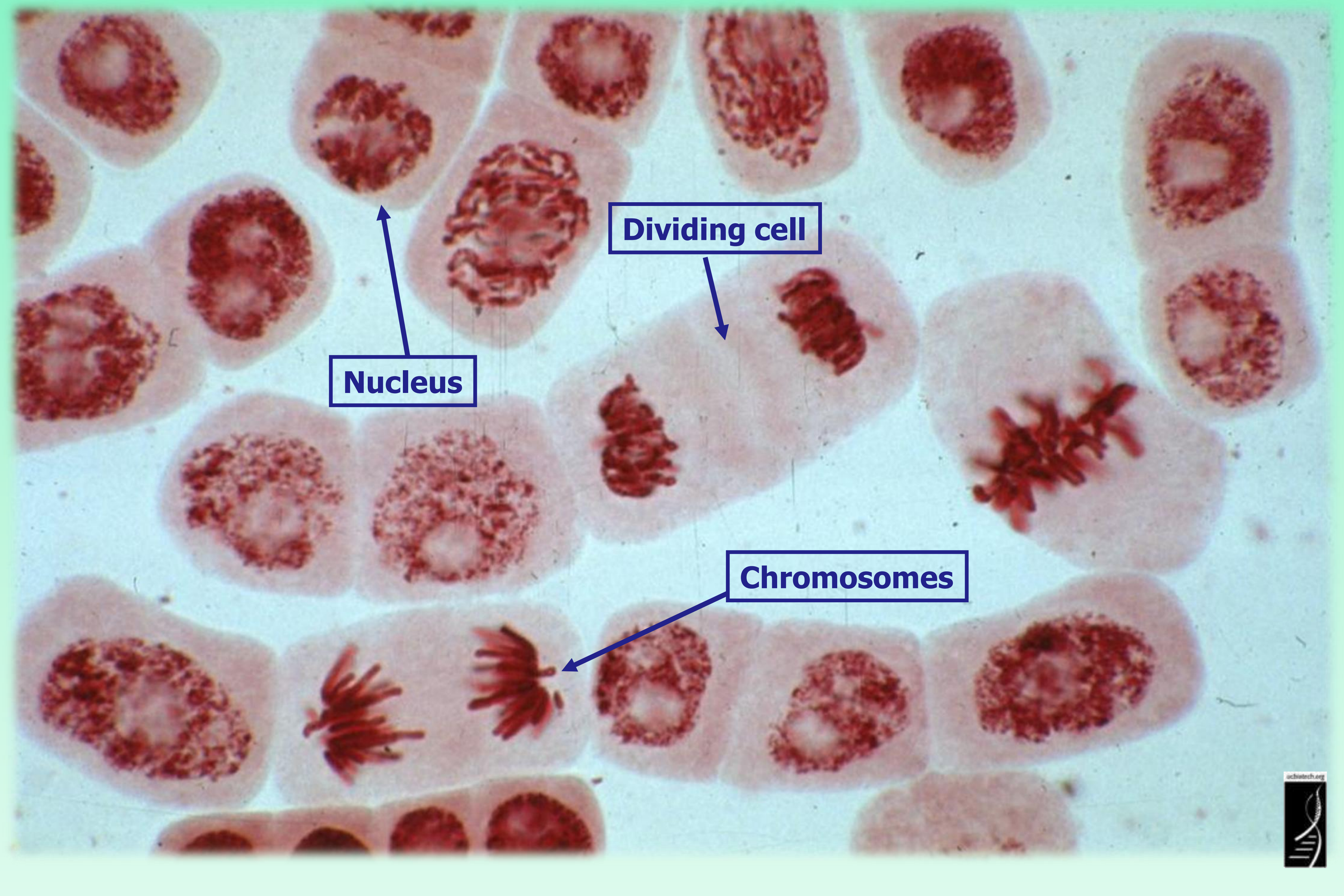
Animals and plants are made of cells – humans too – billions of them!



Lemaux



Lemaux

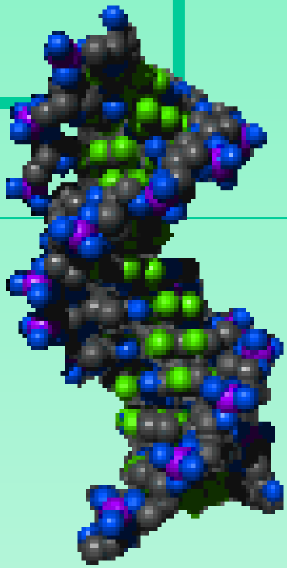

Dividing cell
Nucleus
Chromosomes

<u>Chromosomes</u> are thread-like structures located inside the nucleus of animal and plant cells. Each chromosome is made of protein and a single molecule of deoxyribonucleic acid (DNA). Passed from parents to offspring, DNA contains the specific instructions that make each type of living creature unique. In humans, one copy of each chromosome is inherited from the female parent and the other from the male parent. This explains why children inherit some of their traits from their mother and others from their father.

single genes are responsible for characteristics like cystic fibrosis and muscular dystrophy

http://www.genome.gov/10000202

Genetic Modification

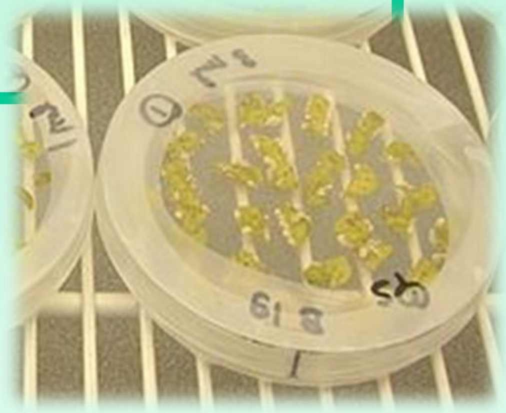


- It is the adding, deleting, changing of the genes
- Human cells have 46 (23 pairs) chromosomes, 21,000 genes (Chromosome #1 has 4,220 genes)
- Plant chromosomes vary –

peas 14	potato 24
corn 20	oats 42
alfalfa 32	rice 24
beans 22	barley 14

(26,000-45,000 genes total)

- Most biotech or GE crops (maize, soy, cotton…) are actually developed with agrobacterium which acts as a transfer agent. The most common traits in GE crops are herbicide tolerance (HT) and insect resistance (IR). HT plants contain genetic material from common soil bacteria. IR crops contain genetic material from a bacterium that attacks certain insects. One example is Bacillus thuringiensis (Bt), an IR trait. Bt is expressed in the plant and targets specific insects–and is not harmful to humans. BT is actually used in organic farming too, but it’s sprayed on the plants.



http://monsantoblog.com/2009/04/13/gmo-vegetables-animal-dna/

With GE, scientists can breach species barriers set up by nature. For example, they have spliced fish genes into tomatoes. The results are plants (or animals) with traits that would be virtually impossible to obtain with natural processes, such as crossbreeding or grafting.

- **How is genetic engineering done?**

  In order to breach these natural barriers and make possible the introduction of DNA from a different species, genetic engineers have to find ways to force the DNA from one organism into another. These methods include:

- Using viruses or bacteria to "infect" animal or plant cells with the new DNA.
- Coating DNA onto tiny metal pellets, and firing it with a special gun into the cells.
- Injecting the new DNA into fertilized eggs with a very fine needle.
- Using electric shocks to create holes in the membrane covering sperm, and then forcing the new DNA into the sperm through these holes.

("Gene gun" method and *Agrobacterium* method)

- http://www.nongmoshoppingguide.com/about-gmos.html

What combinations have been tried? Scientists have worked on some interesting ones

- Spider genes were inserted into goat DNA, in hopes that the goat milk would contain spider web protein for use in bulletproof vests.
- Cow genes turned pigskins into cowhides.
- Jellyfish genes lit up pigs' noses in the dark.
- Artic fish genes gave tomatoes and strawberries tolerance to frost.
- Potatoes that glowed in the dark when they needed watering.
- Human genes were inserted into corn to produce spermicide.
- Corn engineered with human genes (Dow)
- Sugarcane engineered with human genes (Hawaii Agriculture Research Center)
- Corn engineered with jellyfish genes (Stanford University)
- Tobacco engineered with lettuce genes (University of Hawaii)
- Rice engineered with human genes (Applied Phytologics)
- Corn engineered with hepatitis virus genes (Prodigene)

http://www.nongmoshoppingguide.com/about-gmos.html

Other terms

- **Classical Plant Breeding**
- **Traditional Plant Breeding**

In Traditional Plant Breeding

- Pollen (male) is transferred to the Pistil (female) by
  - Selfing (the plant itself)
  - Insects, animals
  - Wind
  - People

In Traditional Plant Breeding

- **But it is 99.999% on like types of plants, i.e. same species**

tomato | does not cross with | squash

$\neq$

Luther Burbank 1849-1926

How are the genes and chromosomes manipulated to create a new plant variety… by classical breeding?

Triticum monococcum

Ancient variety

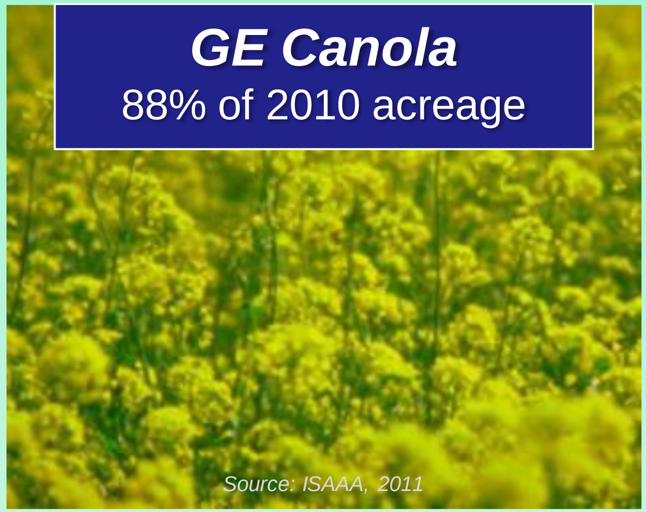
Triticum aestivum

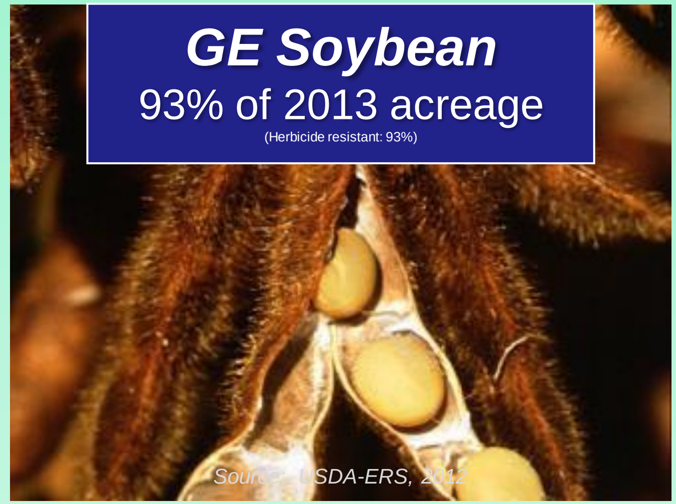
Modern bread variety

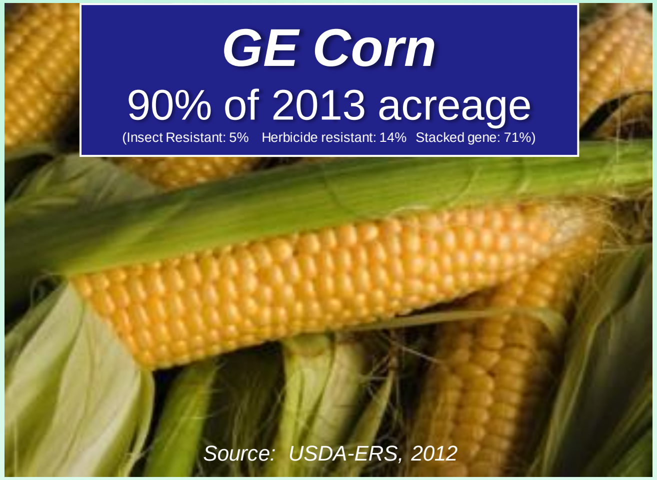
Lemaux

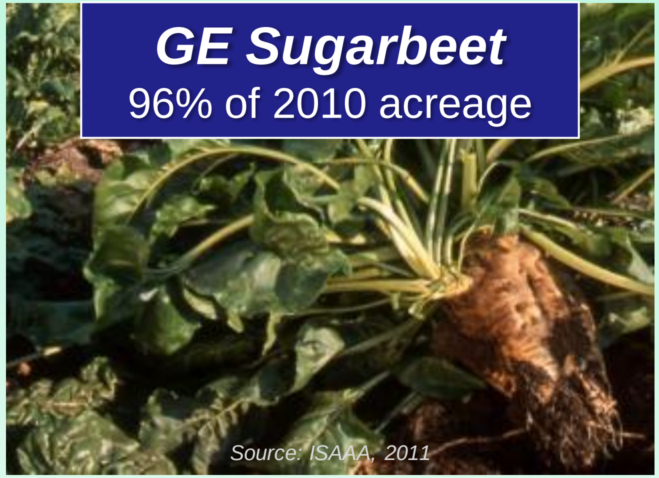
ucbiotech.org

Number of different commercially available GE crops is limited



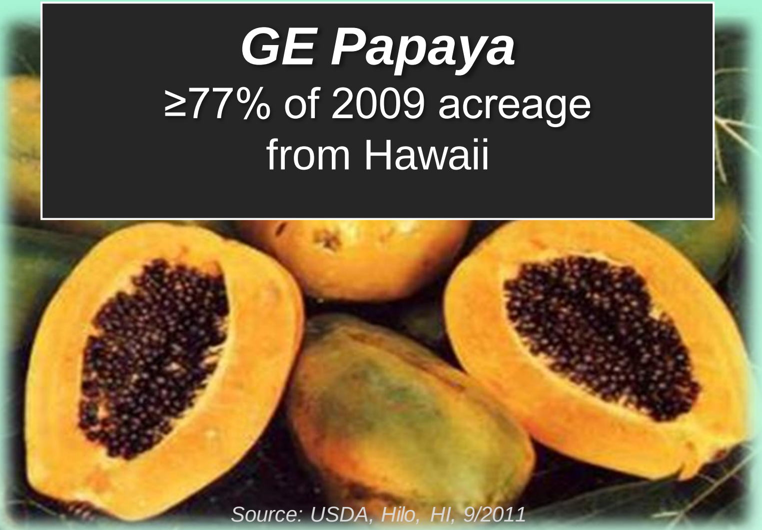






Lemaux

Only a few whole foods on the market are genetically engineered



Lemaux

Uses for GE

Less Fertilizer
GM drought tolerant corn in the US (this is fully approved in the US and beginning limited commercial testing this year)
Corn seeds that require less nitrogen, a fertilizer that can be costly to farmers and can have environmental impacts

Plant Disease Resistance
Examples:
Genetically modified squash plants withstand various viruses farmers encounter in the field.

Improved visual appeal to reduce waste

Example:
Apple varieties that have been enhanced through biotechnology so they don't brown

Improving Nutrition
Examples:
Golden Rice that includes B-Carotene to deliver vitamin A to children in developing nations. Pineapple with lycopene, which may help prevent lung and prostate cancer. EPA/DHA Omega-3 oils from canola oil, which are scientifically proven to prevent heart disease and enhance cardiovascular outcomes

GENETIC TRAITS EXPRESSED IN GMOS IN THE U.S.

FIELD CORN

Genetic Traits
Insect Resistance
Herbicide Tolerance

Uses
- Livestock and poultry feed
- Fuel ethanol
- High-fructose corn syrup and other sweeteners
- Corn oil
- Starch
- Cereal and other food ingredients
- Alcohol
- Industrial uses

CANOLA

Genetic Traits
Herbicide Tolerance

Uses
- Cooking oil
- Animal feed

RAINBOW PAPAYA

Genetic Traits
Disease resistance

Uses
- Table fruit

SOYBEAN

Genetic Traits
Insect Resistance
Herbicide Tolerance

Uses
- Livestock and poultry feed
- Aquaculture
- Soybean oil (vegetable oil)
- High oleic acid (monounsaturated fatty acid)
- Biodiesel fuel
- Soymilk, soy sauce, tofu, other food uses
- Lecithin
- Pet food
- Adhesives and building materials
- Printing ink
- Other industrial uses

ALFALFA

Genetic Traits
Herbicide Tolerance

Uses
- Animal feed

COTTON

Genetic Traits
Insect Resistance
Herbicide Tolerance

Uses
- Fiber
- Animal feed
- Cottonseed oil

SUGAR BEETS

Genetic Traits
Herbicide Tolerance

Uses

- Sugar
- Animal feed

SWEET CORN

Genetic Traits
Herbicide Tolerance
Insect Resistance

Uses
- Food

SUMMER SQUASH

Genetic Traits
Disease resistance

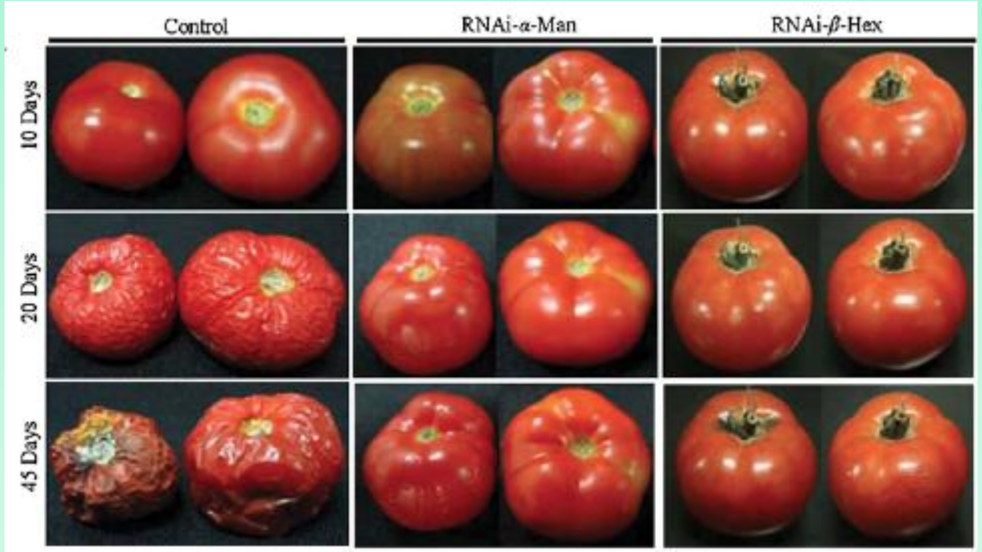
Uses
- Food

Lemaux

How Many Foods Are Genetically Engineered?

Estimates are 80% of U.S. processed food may contain an ingredient from a GE crop -- such as corn starch, high fructose corn syrup, corn oil, canola oil, soybean oil, soy flour, soy lecithin, or cottonseed oil.

There are very few commercially available whole GE foods. The first commercial GE whole food was the FlavrSavrTM tomato, engineered to have a longer shelf life. (1994)



Q: Are there GE animals in the food supply?

- A: FDA has not approved any GE animals for food (or for any other purpose). During the pre-approval investigational phase, there are strong statutory and regulatory prohibitions against unreported movement of GE animals as well as against their disposal in the food supply unless explicitly approved by the FDA. In addition, there are strict requirements for good record-keeping during the investigational phase.

http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/GeneticEngineering/GeneticallyEngineeredAnimals/ucm113605.htm

Animals

The first transgenic (genetically modified) animal was produced by injecting DNA into mouse embryos then implanting the embryos in female mice. Genetically modified animals currently being developed can be placed into six different broad classes based on the intended purpose of the genetic modification:

1. to research human diseases (e.g. to develop models for these diseases)
2. to produce industrial or consumer products (fibers)
3. to produce products intended for human therapeutic use (pharmaceutical products or tissue for implantation);
4. To enhance the animals' interactions with humans (hypo-allergenic pets)
5. to enhance production or food quality traits (faster growing fish, pigs that digest food more efficiently);
6. to improve animal health (disease resistance)

http://en.wikipedia.org/wiki/Genetically_modified_organism

Pharmaceutical products & GE – medicine

"pharming," "bio-pharming," "molecular farming," "Plant-made pharmaceuticals (PMP"

Insulin was the first pharmaceutical protein produced using genetically engineered bacteria. Insulin originally was isolated from cows and pigs that were slaughtered for food. This method was inefficient and caused some patients to develop allergies from the animal-derived insulin. Today it is made from the human gene that codes for the insulin protein and is expressed and cloned in the bacterium, *Escherichia coli*. Large quantities of *E. coli* are now grown in fermentation vats to make tons of human insulin available to the growing number of diabetic patients.

Human growth hormone, or HGH, can now be extracted from genetically manufactured bacteria. It can be used to treat those suffering from dwarfism

Three PMPs currently undergoing evaluation in clinical trials are designed to target non-Hodgkins lymphoma, cystic fibrosis, and E. coli/traveler's diarrhea

http://agbiosafety.unl.edu/biopharm.shtml http://www.ext.colostate.edu/pubs/crops/00307.html

Pollination of Fruit Trees

- Trees require pollen from a different variety of the same type of tree and are considered self-unfruitful. **Apricots, peaches, nectarines, and sour cherries** do not require cross-pollination. **Sweet cherries** do. **Apples**, **pears**, and most **plums** need cross-pollination.
  - PEARS require another cultivar for cross-pollinization. European and Asian pears will cross-pollinate if blooming at the same time.
  - PEACHES and nectarines are self-fertile.
  - APPLES cross with apples and crab apples
  - PLUMS/Prunes: all Japanese plums require a pollinizer except Santa Rosa

CROSS POLLINATION IN CUCURBITS

Cross pollination generally occurs only among members **within** the same species. However some crossing **between** species occurs in the genus *Cucurbita*, among pumpkins, squash and gourds. **C. pepo** will cross with **C. mixta** and **C. moschata:** and **C. maxima** will cross with **C. moschata. C. pepo** will not cross with **C. maxima.** Cross pollination does not occur between melons, cucumbers or other species. See the chart below for a breakdown of the Cucurbit Family by species.

From: The Ortho Book "All About Vegetables," pg. 86.

THE CULTIVATED MEMBERS OF THE GOURD FAMILY

FAMILY	GENUS	SPECIES	VARIETY OR COMMON NAME
Cucurbitaceae	*Cucurbita*	*pepo**	'Jack O'Lantern' pumpkin 'Connecticut Field' pumpkin ' 'Acorn' or 'Table Queen' squash 'Vegetable Spaghetti' 'Zucchini', 'Yellow Crookneck' and Bush Scallop summer squash Small, hard shell gourds Edible gourd Vegetable gourd
		*moschata**	'Buttercup' squash 'Kentucky Field' pumpkin 'Dickinson' pumpkin 'Sweetmeat' squash 'Marblehead' squash 'Turks Turban' squash
		*maxima**	'Buttercup' squash 'Hubbard' squash 'Banana' squash 'Sweetmeat' squash 'Marblehead' squash 'Turks Turban' squash 'Big Max' pumpkin 'King Of Mammoths' pumpkin
		ficifolia	Malabar gourd
		*mixta**	'Green Striped Cushaw' pumpkin 'White Cushaw' pumpkin
	Lagenaria	*siceraria*	Bottle or White Flowered gourd Cucuzzi
	Luffa	*cylindrica*	Dishrag gourd
	Momordica	*balsamina*	Balsam apple
		charantia	Balsam pear
	Sechium	*edule*	Chayote
	Benincasa	*hispida*	Chinese Preserving melon or White Gourd of India
	Cucumis	*melo*	Netted muskmelon or Cantaloupe ('Hales Best', 'Harper Hybrid' ,etc,) Honeydew & Casaba muskmelons (Honeydew, Crenshaw, etc.) Oriental Pickling melon Dudaim melon Snake or Serpent melon Mango melon
		sativus	Cucumber, all varieties
		anguria	West Indian Gherkin
	Citrullus		Watermelon, all varieties Citron
	Trichosanthes	*anguina*	Snake or Serpent gourd

Alfalfa flowers pollinated on right

- Other genetically modified vegetables that have been approved for sale in the U.S. are **tomatoes, radicchio, zucchini and yellow squash**.

- **Salmon:** Currently no meat, fish, or egg products are genetically engineered, though a company called Aqua Bounty has an application in with the FDA to approve its GE salmon (2011)

- **Potatoes:** In 1995, Monsanto introduced genetically modified potatoes for human consumption, but after pressure from consumers, McDonald's and several other major fast food chains told their French fry suppliers to stop growing GE potatoes. The crop has since been removed from the market.

Splicing Genes Together

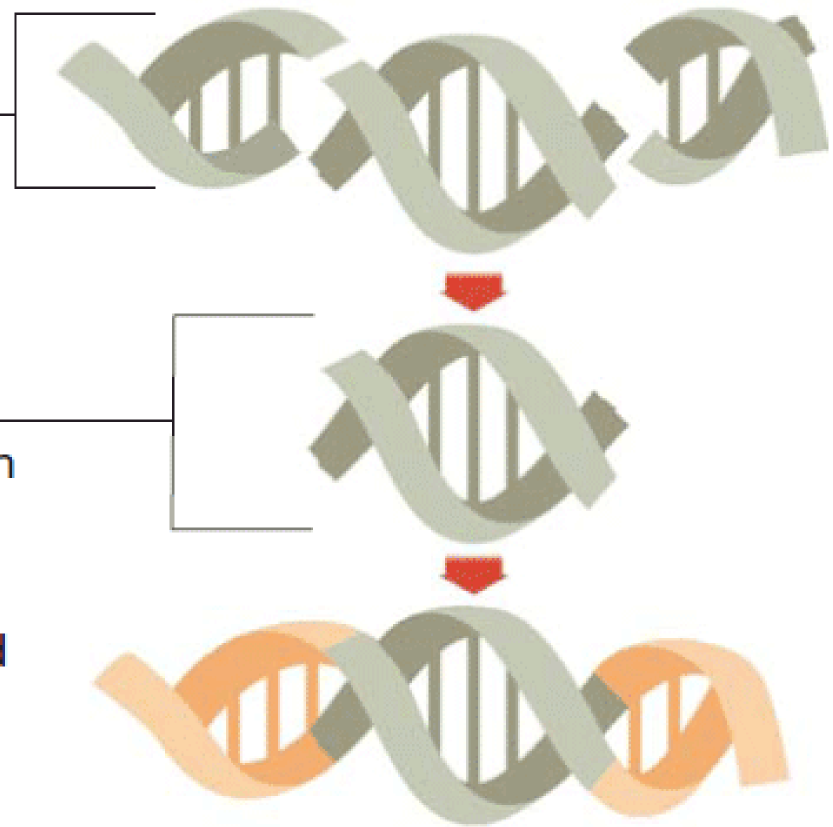
Employing genetic engineering, researchers can take certain genes from a source organism and put them into another plant or animal.

An Example of Genetic Engineering:

1 Scientists take *Bacillus thuringiensis*, a commonly occurring soil bacteria…

2 …and use enzymes to remove from it the Bt gene, which produces a protein that turns toxic in the digestive tract of caterpillars.

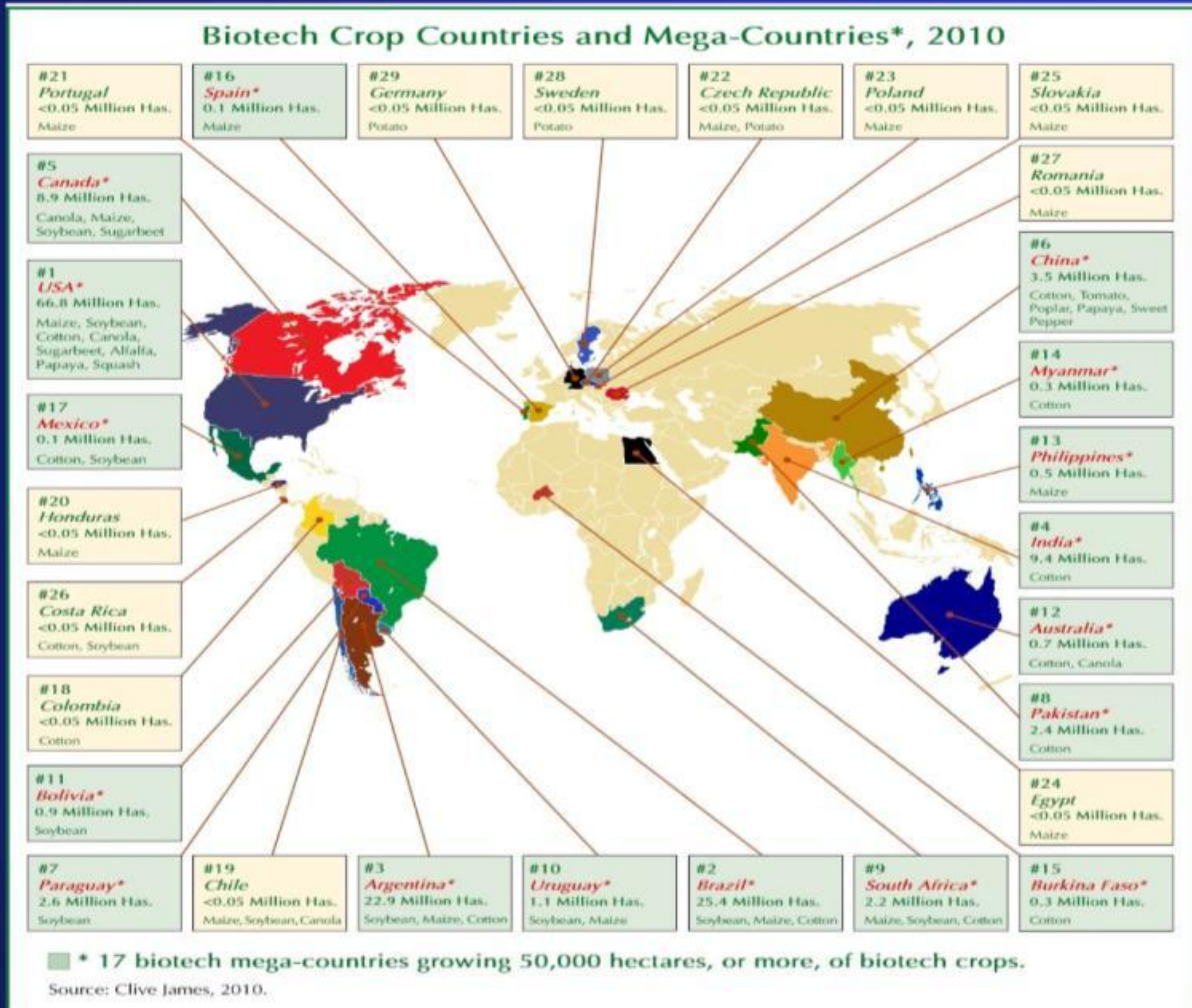
3 The Bt gene is then incorporated into the chromosomes of cotton and corn, killing caterpillars that feed upon these plants.



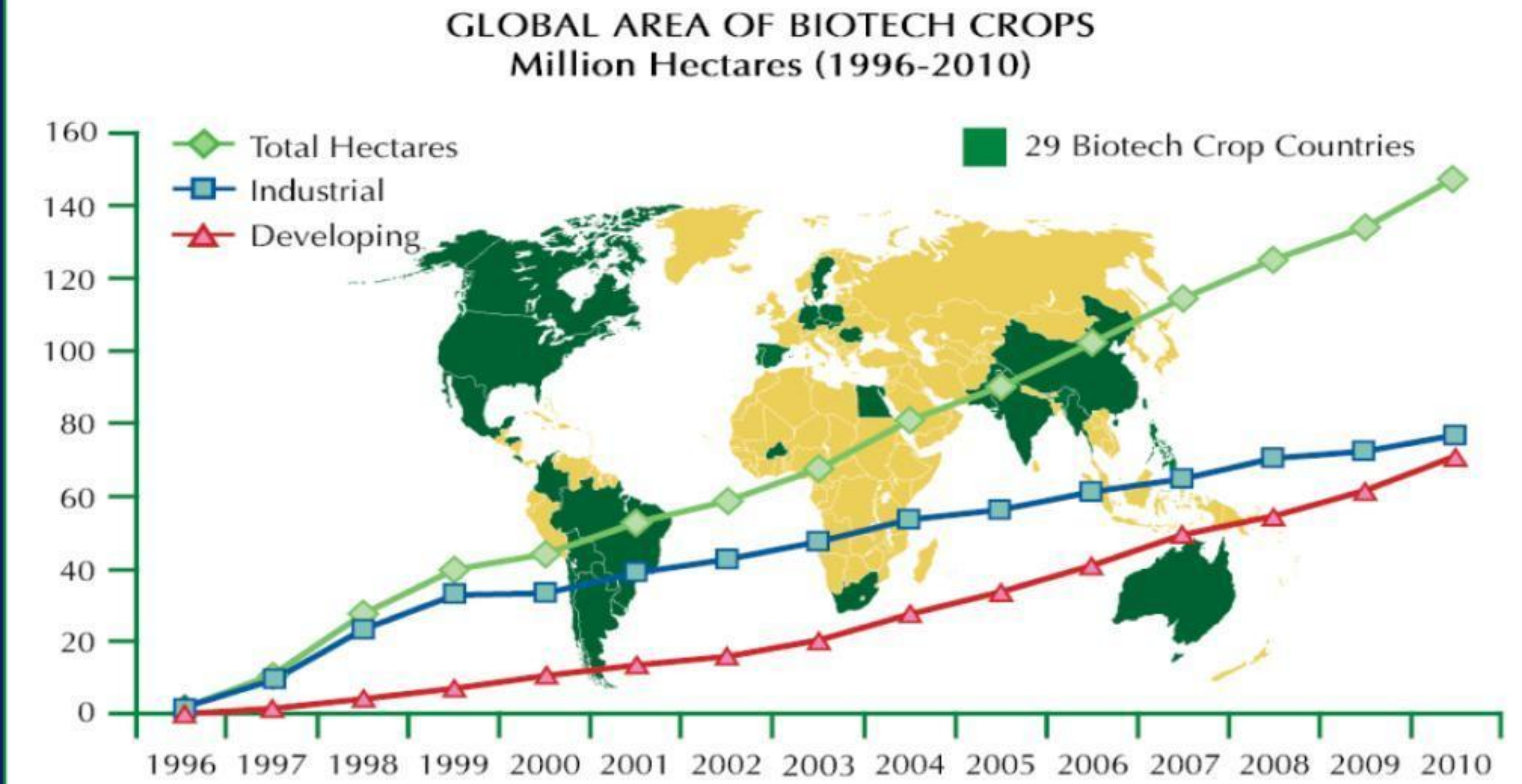
SOURCE: North Carolina State University, College of Agriculture and Life Sciences

http://blogs.discovermagazine.com/d-brief/2014/01/28/monsantos-push-for-non-gmo-vegetables/#.Uwk6VoW8ZD4

Biotech Crop Countries and Mega-Countries, 2010



Lem



A record 15.4 million farmers, in 29 countries, planted 148 million hectares (365 million acres) in 2010, a sustained increase of 10% or 14 million hectares (35 million acres) over 2009.

Source: Clive James, 2010.

- The first variety of GE yellow squash, Freedom II, was the second GE crop to be cleared by U.S. regulators. Freedom II was engineered with viral coat protein genes to be resistant to two viruses—Watermelon Mosaic Virus 2 (WMV2) and Zucchini Yellow Mosaic Virus (ZYMV). Freedom II reached the market in 1995 but was not labeled like the FlavrSavrTM tomato.

- Other varieties developed with additional virus resistance = Independence II, Liberator III, Freedom III, and Destiny III

- The last whole GE food available in the U.S. is GE sweet corn, engineered with a Bt gene to protect against earworms (*Helicoverpa zea*), one of the most costly crop pests in North America. Earworm damage results in subsequent fungal and bacterial attack and quality loss. Expressing Bt in corn results in reductions in insect attack.

- Sweet corn with the “Attribute”

View the Seminis vegetable seed varieties available in the U.S.

Solanaceous	Cucurbits	Root & Bulb	Large Seed	Brassica
Eggplant	Cucumber	Carrot	Bean, dry & garden	Broccoli
Pepper, hot & sweet	Gourd	Leek	Okra	Cabbage
Tomato	Melon	Onion	Pea	Chinese Cabbage
	Pumpkin		Sweet Corn	Cauliflowe
	Squash			Radish
	Watermelon			

Seminis Vegetable Seed
http://www.seminis.com/global/us/products/Pages/default.aspx

http://www.seminis.com/global/us/products/Pages/ProfessionalGrowersSummerSquash.aspx

 Gold Rush	Deep gold on a rich green stem	Straight, Uniform, Cylindrical	7-8 in. 18-20 cm.	Upright, Open habit	49
 Greyzini	Light green w/ grey mottling and faint stripes	Slight taper and somewhat blocky	5-6 in.; 13-15 cm	Compact bush, open habit	47
 Independence II	Light to medium green, Large specks	Slightly tapered	7-8 in.; 18-20 cm	Strongly vigerous bush	41
 Judgement III	Medium green	Cylindrical	6-7 inches	Vigorous bush	41
 Justice III	Medium-dark green, Waxy appearance	Cylindrical, Uniform	7-8 in.; 18-20 cm	Vigorous bush	[illegible]

Independence II with transgenic high resistance to WMV and intermediate resistance to ZYMV

Judgement III is a zucchini with transgenic high resistance to CMV, WMV and ZYMV.

Justice III has transgenic high resistance to WMV.

Sweet Corn Crop Guide: Syngenta

http://www.syngenta-us.com/seeds/vegetables/sweet_corn/Sweet_Corn_Crop_Guide.pdf

TripleSweet® Plus – setting a higher standard

TripleSweet Plus is the latest advancement in the TripleSweet product line. It features the same exceptional quality and tenderness, but now it's even sweeter tasting thanks to more supersweet kernels on every ear. Combined with an improved shelf life, it is sure to be a hit at roadside stands and in local retail stores.

Primus

- First in a series of new TripleSweet Plus varieties from Syngenta
- Marks the next generation of superior eating-quality corn
- Exceptional flavor and sweetness exceed standard TripleSweet varieties and bring customers back for more
- Tender and extra sweet bi-color kernels, long ears and medium-sized husks preferred for roadside and local markets
- High resistance to southern corn leaf blight and intermediate resistance to common rust and Stewart's wilt
- Approximately 81 days to maturity

WH0809

Attribute

This TripleSweet has high-quality large ears and outstanding eating quality, making it a favorite for roadside markets.

- Produces exceptional eating quality
- Well-suited for local and roadside markets in the Midwest and Northeast
- A white BC 0805-type
- Approximately 80 days to maturity

Providence

- Outstanding eating quality
- Well-suited for roadside and local markets as well as home gardens
- Approximately 82 days to maturity

TripleSweet hybrids boasting superior eating qualities

BC0822

Attribute

BC0822 provides outstanding TripleSweet eating quality with Attribute® insect protection to minimize insect damage and costs — and maximize yield and quality.

- Tender sweet kernels covering a uniform ear length
- Great tip cover and attractive flag leaves
- Ideal for roadside and local markets
- Excellent rust resistance package
- Approximately 77 days to maturity

GH0851

Attribute

- Long ears with good husk extension
- Ideal for main-season plantings in the Midwest and Northeast
- Approximately 80 days to maturity

BC 0805

Attribute

An industry standard for reliability of high yields and eating quality, BC 0805 is packed with superior taste and eating qualities.

- Well-suited for main-season plantings in the Midwest and Northeast
- Long, well-filled ears
- Outstanding eating quality with tender, sweet kernels
- Approximately 82 days to maturity

Honey Select

- All-America Selections Winner
- Exceptional tenderness, flavor and sweetness
- Produces large, high-quality ears
- Medium green husks and good flags
- Approximately 79 days to maturity

Sugary/sugary enhanced (su/se)

Silver Queen

- The industry standard white "su" sweet corn
- Superb eating quality
- Attractive package
- Elegant ears with flavorful, tender kernels
- Approximately 88 days to maturity

Silver King

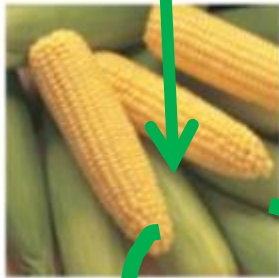
- This white ear has fabulous flavor and tenderness for local market growers and home gardeners
- Tight husk cover helps prevent bird damage
- Optimum ear placement makes for an easy harvest
- Approximately 82 days to maturity

Supersweet (sh2) hybrids that outperform in the field and the market

Legion

Legion is a high-yielding bi-color shipper corn with a robust disease package and strong agronomic characteristics.

- Well-suited for the eastern shipper market
- Straight rowing, good tip fill and uniform ear size
- Excellent husk cover and attractive flag leaves
- Reliable high yields
- Approximately 79 days to maturity



GSS 0966

Attribute

- Main-season yel[illegible] shipper corn with good eating quality
- Well-filled ears with glossy [illegible] and excellent husk cover
- Consistent performance
- Approximately 78 days to maturity

Munition

This is a high-yielding white supersweet hybrid that produces a stylish shipper ear with uniform size, protected by a strong disease package.

- Excellent tip fill appeals to fresh market customers
- Ideal ear size for crating in shipper markets
- Especially well-adapted for regions from south Florida to New York
- High resistance to common rust and intermediate resistance to Stewart's wilt, northern corn leaf blight and maize dwarf mosaic
- Approximately 78 days to maturity

WSS 0987

Attribute

- A consistent performing white for the fresh shipper market
- High resistance to common rust and intermediate resistance to northern corn leaf blight
- Approximately 81 days to maturity

National GM Labeling Laws and Policies

Type of GM labeling	Countries that enforce labeling policies	Countries with partially enforced or unenforced labeling policies	Countries with probable plans to introduce a labeling policy
Mandatory	Australia, Brazil, China, European Union, Japan, New Zealand, Norway, Russia, Saudi Arabia, South Korea, Switzerland, Taiwan	Croatia, Ecuador, El Salvador, Indonesia, Malaysia, Mauritius, Serbia, Sri Lanka, Thailand, Ukraine, Vietnam	Nigeria, Uganda, UAE, Zambia
Voluntary	Argentina, Canada, Chile, Hong Kong, Kenya, Philippines, South Africa, USA		Peru

But other nations have specific mandatory labeling laws for GE, although the rules and enforcement vary dramatically among countries, making international trade difficult

SOURCE: Marchant, G.E., Cardineau, G.A. and Redick, T.P. 2010. Thwarting Consumer Choice. The Case against Mandatory Labeling for Genetically Modified Foods. American Entreprise Institute, p. 71.

What is the U.S. regulatory process that governs these engineered plants?

U.S. Regulatory Agencies

Lemaux

USDA	FDA	EPA
• Field testing -Permits -Notifications • Determination of non-regulated status	• Food safety • Feed safety	• Pesticidal plants -tolerance exemption -registrations • Herbicide registration
Plant pest?	Danger to people?	Risk to environment?

APHIS Determines Nonregulated Status – 86 granted

(8-11-2012)

Once nonregulated, organism no longer requires APHIS review for movement or release in U.S.

✓ Alfalfa – HT –removed, reinstated
✓ Corn - HT, IR, AP
✓ Cotton - HT, IR
✓ Soybean - HT, PQ
❖ Potato - IR, VR
❖ Tomato - PQ
Squash - VR
✓ Canola – HT

Papaya - VR
❖ Rice - HT
Rapeseed - HT, AP, PQ
✓ Sugar beet - HT
❖ Flax - HT
Chicorium - AP
Tobacco – PQ
Rose - PQ

✓Large-scale production
❖Not on market

Lemaux

(http://www.aphis.usda.gov/brs/not_reg.html)

Why Doesn't FDA Have a Labeling Policy for GM Foods?

Actually it does…

Foods produced through biotechnology are subject to same labeling laws as all other foods and food ingredients

Govt-mandated label information relates to composition or food attributes not agricultural or manufacturing practices

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

GM food must be labeled if:

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

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

	Jan. 2001	Apr. 2003	July 2006	Apr. 2010
Packaging	27%	15%	15%	5%
→ Food Handling/Preparation	23%	41%	35%	33%
Other	19%	9%	4%	4%
→ Disease/Contamination	16%	28%	36%	38%
Chemicals/Pesticides in Food	10%	7%	16%	10%
→ Altered/Engineered Food	2%	1%	3%	2%
Nothing	9%	5%	--	--

SOURCE: IFIC, April 2010.
http://www.foodinsight.org/Resources/Detail.aspx?topic=2010_Consumer_Perceptions_of_Food_Technology_Survey

WHOLE FOODS MARKET

The New York Times

March 8, 2013

Major Grocer to Label Foods With Gene-Modified Content

By STEPHANIE STROM

Whole Foods Market, the grocery chain, on Friday became the first retailer in the United States to require labeling of all genetically modified foods sold in its stores, a move that some experts said could radically alter the food industry.

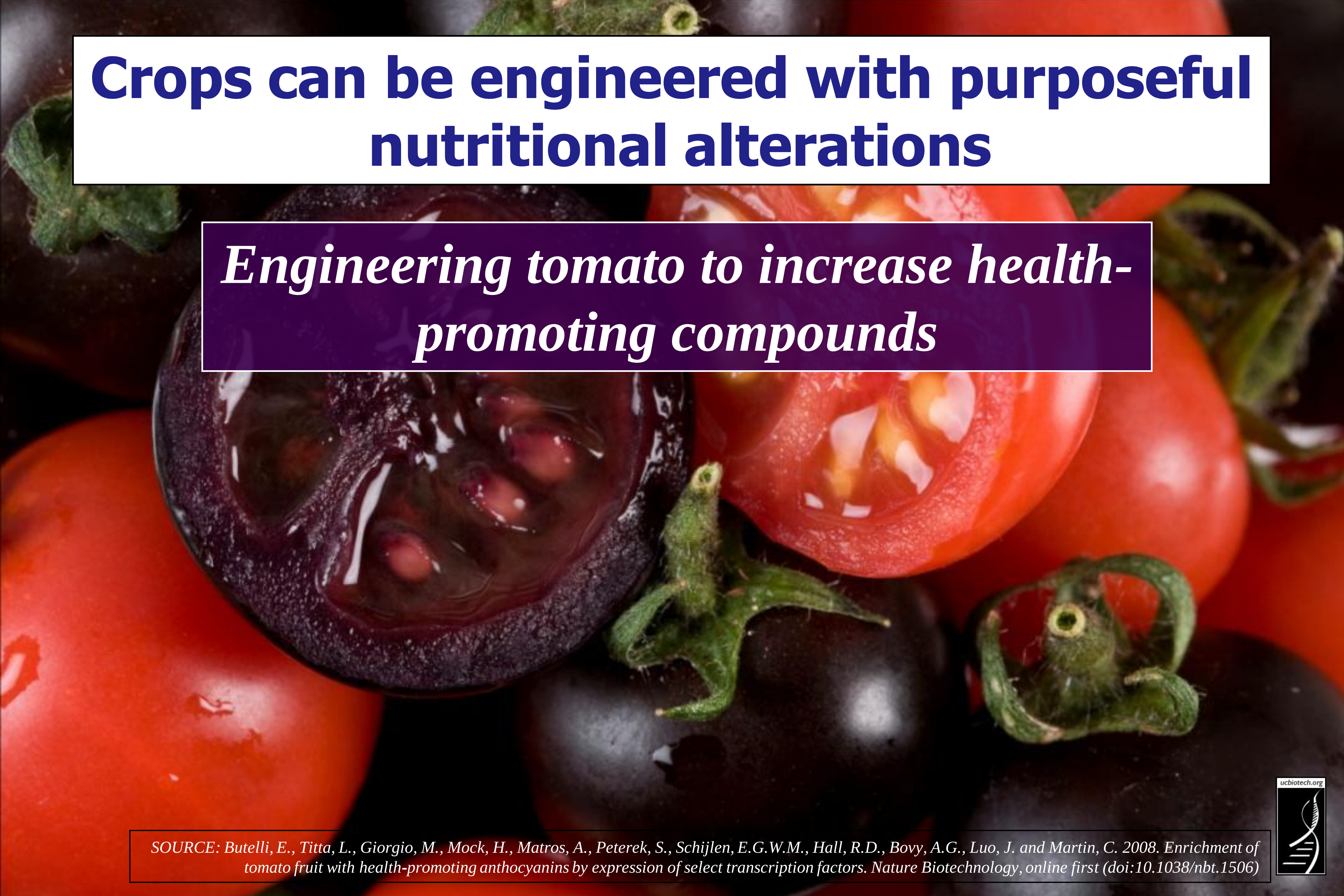
Not only are states entering into the labeling arena, but a variety of companies are becoming involved in different ways.

By 2018, all products in U.S. and Canadian stores must be labeled to indicate whether they contain genetically modified organisms (GMOs)

SOURCE: "Major Grocer to Label Fodos With Gene-Modified Content", New York Times, 3/8/13
http://www.nytimes.com/2013/03/09/business/grocery-chain-to-require-labels-for-genetically-modified-food.html?ref=opinion&_r=0

ucbiotech.org

Crops can be engineered with purposeful nutritional alterations



Engineering tomato to increase health-promoting compounds

SOURCE: Butelli, E., Titta, L., Giorgio, M., Mock, H., Matros, A., Peterek, S., Schijlen, E.G.W.M., Hall, R.D., Bovy, A.G., Luo, J. and Martin, C. 2008. Enrichment of tomato fruit with health-promoting anthocyanins by expression of select transcription factors. Nature Biotechnology, online first (doi:10.1038/nbt.1506)

Pollen Flow Distances for Crop Species of Interest

Crop Type	Mode of Pollination	Means of Movement	Fdn Seed Prod Isolation Distance	Measure Pollen Movemnt Dstance
Alfalfa	Self-sterile; obligate outcrossing	Bees	900 ft (0.17 mi)	2000 ft (0.48 mi)
Bentgrass	Clonal (stolons); type outcrossing dep on environment	Wind	900 ft (98%purity) (0.17 mi)	13.05 mi
Canola	Predom. selfing; 30% outcrossing	Wind/insects	>1320 ft (0.25 mi)	1.9 mi
Corn	Almost exclusively outcrossing	Wind	660 ft (0.125 mi)	~2 mi
Cotton	Predom. Seslfing; outcrossing with insects	Insects	>1320 ft (0.25 mi)	n.a.
Rice	Self-pollinating (99.5%); pollen viable 3-15 min	Physical touching/wind	10 ft	30 ft
Squash	Obligate outcrossing	Insects (predom. bees)	1320 ft (0.25 mi)	0.8 mi
Soybean	Self-pollinating (99%)	Physical touching/wind	5 ft	n.a.
Wheat	Self-pollinating (99.9%)	Physical touching/wind	5 ft	>160 ft

ucbiotech.org

What Are Some of the Issues?

Lemaux

What are some **food safety** issues?

- Lack of peer-reviewed food safety tests
- Creation of allergens or activation of toxins
- Pharma crops contaminating food supply
- Labeling
- Gene flow from food to intestinal bacteria increasing antibiotic resistance

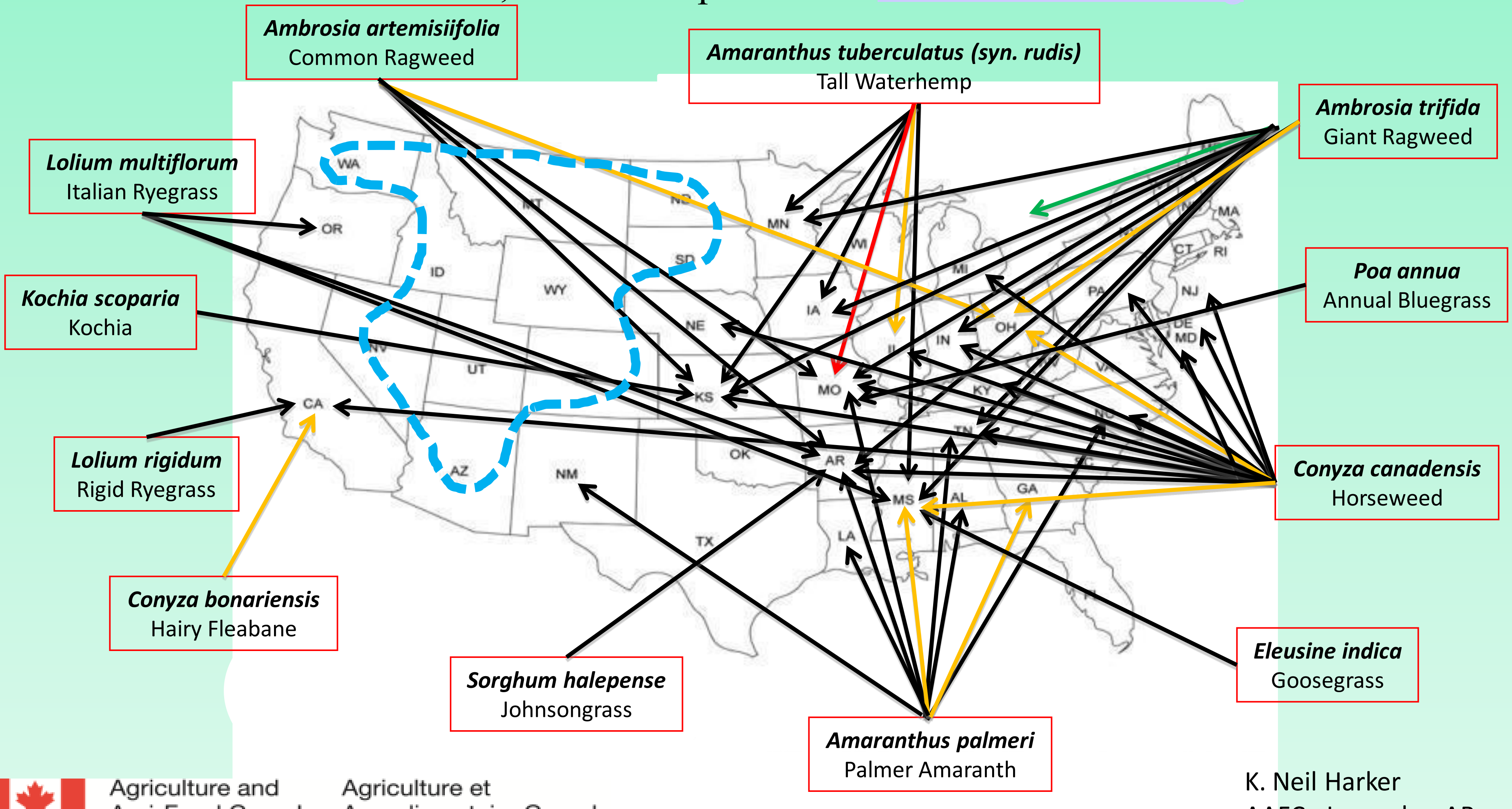
What are some **environmental** issues?

- Transfer of engineered genes to non-GMO/organic crops?
- Development of herbicide-tolerant weeds or pesticide-resistant insects
- Spread of pharmaceutical genes into commercial crops?
- Loss of genetic diversity?
- Property rights (gene patents)?

ucbiotech.org

Glyphosate- Resistant Weeds – USA

December 13, 2010 – adapted from: www.weedscience.org



Agriculture and Agri-Food Canada Agriculture et Agroalimentaire Canada

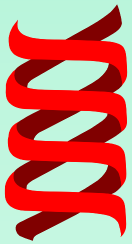
K. Neil Harker
AAFC - Lacombe, AB

Can Organic Agriculture Coexist with GE Crops?

Lemaux

...And What Genetic Modification Input Methods Are PROHIBITED?
(§ 205.2 National Organic Program)

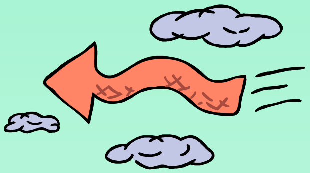
- **"A variety of methods...are not considered compatible with organic production. Such methods include cell fusion, micro- and macro-encapsulation, & recombinant DNA technology (including gene deletion, gene doubling, introducing a foreign gene, & changing the positions of genes when achieved by recombinant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



F.J. Chip Sundstrom CCIA

There are tolerances for pesticides but not for GM content

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



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

WHAT'S IN THE PIPELINE?

Lema

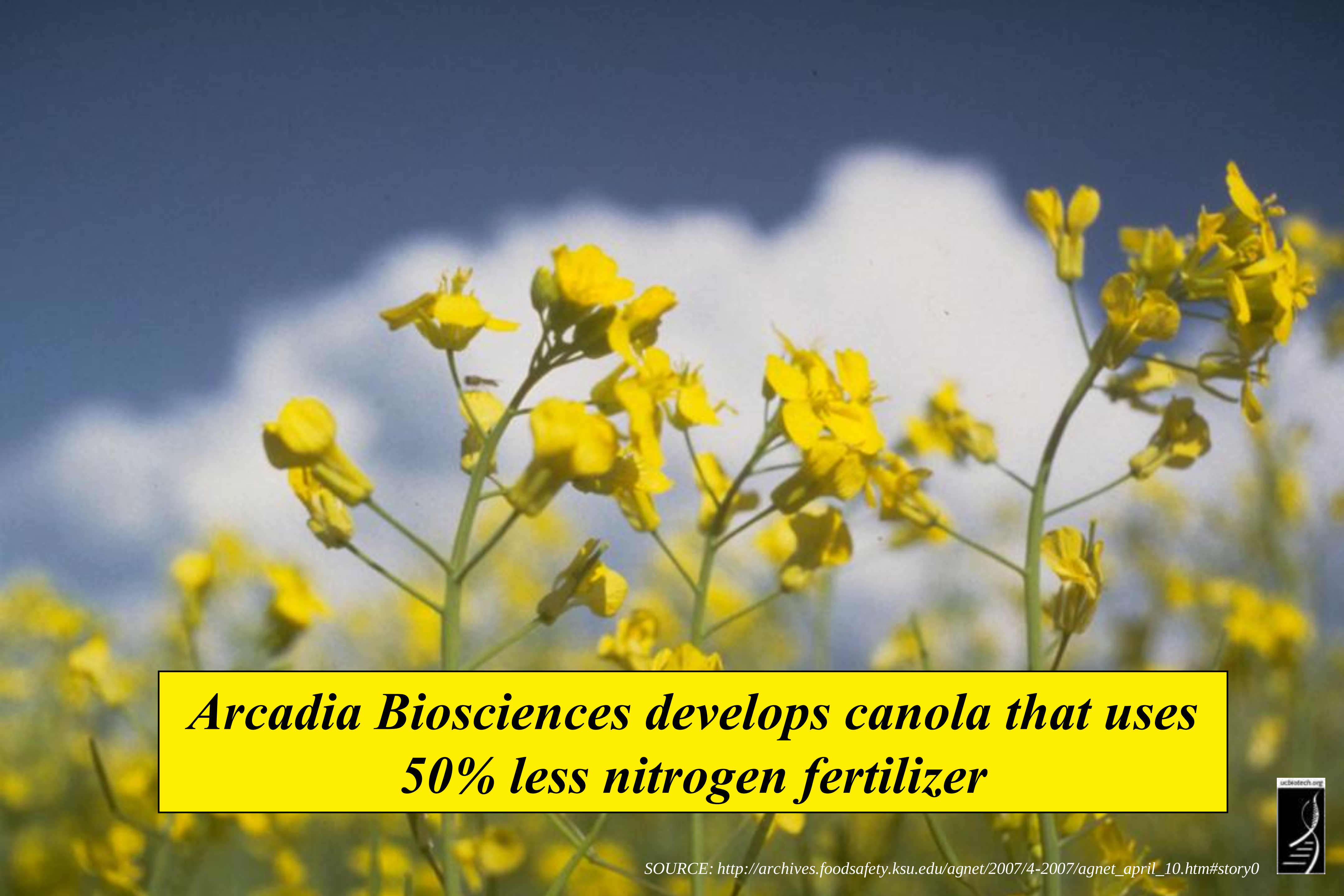
Field Trials Conducted in California with Grape Root Stocks Engineered for Resistance to Fanleaf Virus

SOURCE: http://www.democratandchronicle.com/apps/pbcs.dll/article?AID=/20080806/BUSINESS/808060336/1001

Australian researchers identify grape genes that provide resistance to powdery mildew

SOURCE: Western Farm Press, volume 26, number 16

Arcadia Biosciences develops canola that uses 50% less nitrogen fertilizer



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

There are two new approaches to introducing GE whole foods into the market.

Simplot has created a low acrylamide, low sugar, bruising-resistant potato engineered with only potato DNA – under consideration for deregulation

SOURCE: "Comment period opens on biotech potato", Truth About Trade & Technology, 5/2/13
http://www.truthabouttrade.org/2013/05/03/comment-period-opens-on-biotech-potato/

ucbiotech.org

About 80% of tomatoes under certain conditions suffer blossom end rot. Tomatoes engineered for high solids resist the disease

SOURCE: "Transgenic processing tomato also resists blossom end rot", The Grower, 5/24/12
http://www.thegrower.com/e-newsletters/fresh-from-the-field/Transgenic-processing-tomato-also-resists-blossom-end-rot-152327065.html

Non-browning GE apple to be labeled and marketed in U.S.

SOURCE: "Stop Genetically Engineered Apples!", Organic Consumers Association, 3/24/11.
http://www.organicconsumers.org/bytes/ob269.htm#SEC3

Tear-free onion developed by turning off tear-inducing enzyme

The key is not to introduce a foreign gene but to silence one using a phenomenon called RNA interference. By stopping sulphur compounds from being converted to the tearing agent and redirecting them into compounds responsible for flavour and health, the process could even improve the onion.

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

Japanese scientists create blue rose with blue pigments from pansies

In 2009, after nearly two decades
research and developmental work
of the blue rose began for the firs

SOURCE: http://www.japantimes.co.jp/cgi-bin/getarticle.pl5?nn20040701a2.htm

Slow-Mow grass addresses watering, maintenance and weed problems

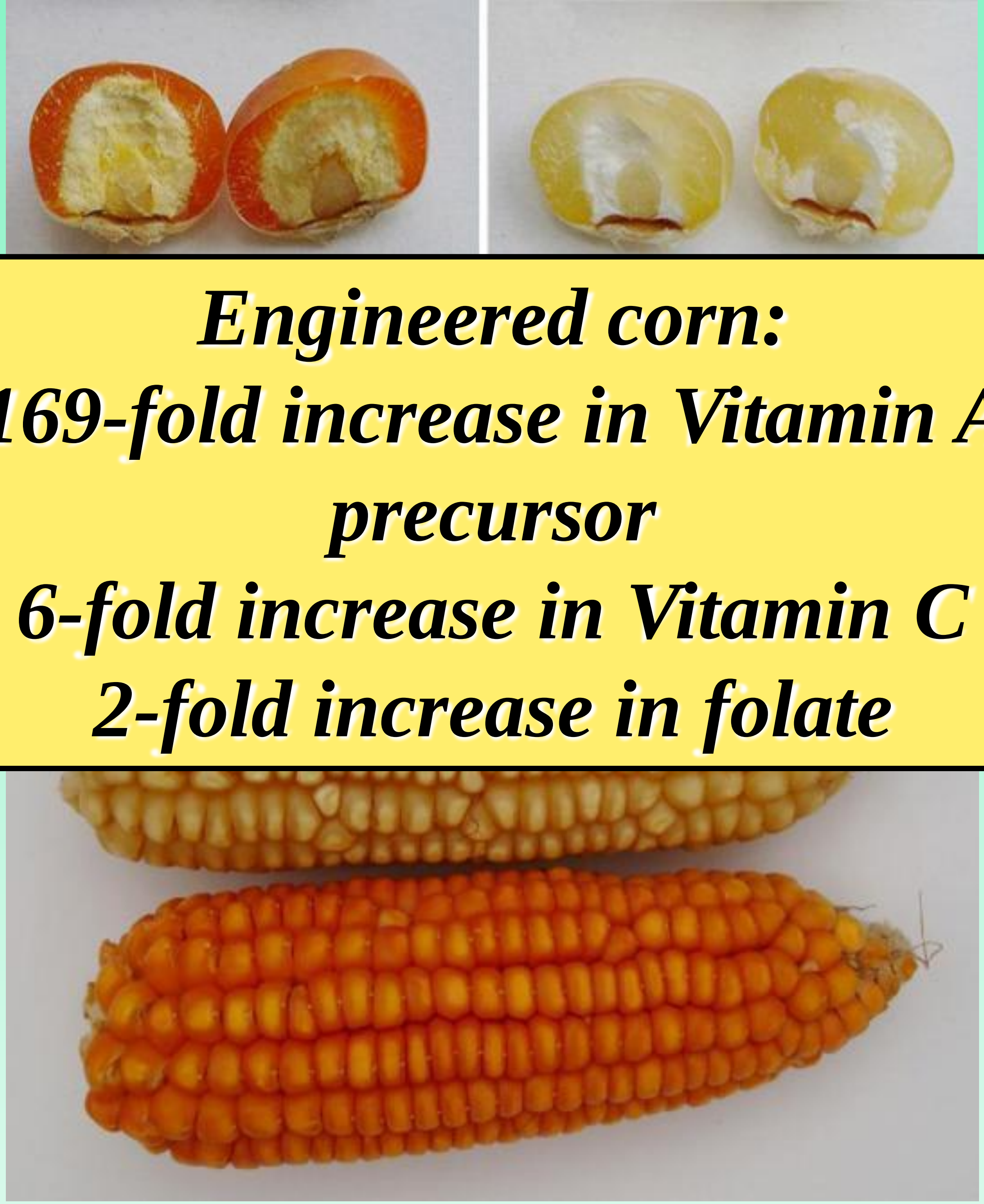
SOURCE: "Engineering a mow-less lawn", New York Times, 4/22/06
http://www.nytimes.com/2006/04/22/business/22offline.html?_r=1&oref=slogin

Scotts announced that employees will be testing a Roundup Ready Kentucky bluegrass grass seed at their homes with an eye toward commercial production next year and introduction into the consumer market by 2016.
http://www.fool.com/investing/general/2014/02/10/scotts-miracle-gro-mows-down-gmo-worries.aspx

Delayed senescence Moonshadow™ carnation

Over the last 24 years Florigene and Suntory have developed, patented and refined technology and are now regarded as a world-leader in the genetic modification of flowers

http://www.florigene.com/products/products.php?product_name=moonshadow



Engineered corn:
169-fold increase in Vitamin A precursor
6-fold increase in Vitamin C
2-fold increase in folate

SOURCE: Naqvi et al. 2009. Transgenic multivitamin corn through biofortification of endosperm with three vitamins representing three distinct metabolic pathways. Proceedings of the National Academy of Sciences USA, doi: 10.1073/pnas.0901412106.

"In a globalized economy, the control of fruit ripening is of strategic importance because excessive softening limits shelf life."

Engineered tomatoes have ~30 day extension of shelf life

SOURCE: Meli, V.S., Ghosh, S., Prabha, T.N., Chakraborty, N., Chakraborty, S., and Datta, A. 2010. Enhancement of fruit shelf life by suppressing N-glycan processing enzymes. Proceedings of the National Academy of Sciences USA, doi/10.1073/pnas.0909329107.

Salt-tolerant Tomatoes

Engineered ***Control***

The company was lately acquired by Syngenta

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

Classical Breeding	**compared to**	***Genetic Engineering***
Gene exchange is random involving whole genome		Gene exchange is specific involving single or few genes
When/where gene expressed not controlled by breeder		When/where gene expressed controlled precisely
Source of gene primarily within genera – not between kingdoms like plants & bacteria		Source of gene from any organism

How is the genetic information in a plant manipulated to create a new plant variety… by classical breeding?

X

Tangerine **Orange**

ucbiotech.org

The New York Times

December 21, 2012

Engineered Fish Moves a Step Closer to Approval

By ANDREW POLLACK

Government regulators moved a big step closer on Friday to allowing the first genetically engineered animal — a fast-growing salmon — to enter the nation's food supply.

The Food and Drug Administration said it had concluded that the salmon would have "no

Engineered salmon has been awaiting approval after submitting its first request for approval to FDA in 1995!
FDA's preliminary finding: this product, under the specific conditions proposed in the application, would not have a significant impact on the U.S. environment. But it still awaits approval

The AquAdvantage salmon, as it is called, is an Atlantic salmon that contains a growth hormone gene from the Chinook salmon and a genetic switch from the ocean pout, an eel-like creature. The switch keeps the gene on so that the salmon produces growth hormone year round, rather than only during warm weather. The fish reach market weight in about 18 months instead of three years.

SOURCE: "Engineered Fish Moves a Step Closer to Approval", New York Times, 12/21/12
http://www.nytimes.com/2012/12/22/business/gene-altered-fish-moves-closer-to-federal-approval.html?_r=2&

handout

Will Human Genes Be Spliced into Food for People?

by Don Fitz, Gateway Green Alliance

"If you want to protect your seed, if you want to protect your food, join the movement of the Center for Food Safety"

-Vandana Shiva

Internationally renowned Indian environmental activist, founder of Navdanya, and prolific author.

USDA Approves Applications to Grow Rice With Human Genes on 270 Acres in North Carolina, Missouri

June 30th, 2005

The U.S. Department of Agriculture has quietly approved controversial proposals by genetic engineering firm Ventria Biosciences to grow rice containing human genes on 270 acres in North Carolina and Missouri. The rice is engineered to produce two pharmaceutical compounds, lactoferrin and lysozyme, derived from human genes. When grown in rice, the compounds present unresolved toxicity and allergenic risks and have not yet received approval from the Food and Drug Administration.

"With this approval, USDA has signaled that it thinks it's okay to grow drug-producing crops near food crops of the same type, despite the threat of contamination," said Doug Gurian-Sherman, senior scientist at Center for Food Safety. "There have already been numerous examples of contamination of food crops by biotech crops, including pharmaceutical crops. Over time, such contamination of our food is virtually inevitable under the conditions allowed by USDA."

USDA Asked to Bring Organic Food Regulations Into Compliance with 1990 Law
READ MORE

First-Ever U.S. Labeling Law for Genetically Engineered Food Passes in Alaska
READ MORE

Recall Urged for Illegal Biotech Corn
READ MORE

- Ventria has developed three varieties of rice, each endowed with a different human gene that makes the plants produce one of three human proteins. Two of them -- lactoferrin and lysozyme -- are bacteria-fighting compounds found in breast milk and saliva.
- Ventria's rice produces two human proteins found in mother's milk, saliva and tears, which help people hydrate and lessen the severity and duration of diarrhea attacks, a top killer of children in developing countries..
- The proteins are extracted for use as an anti-diarrhea medicine and might be added to health foods such as yogurt and granola bars.
- "We can really help children with diarrhea get better faster.

And how was the possible introduction of the "Artic Apple" into the market treated in the media by the New York Daily News?

turns down the expression of the apple PPO (polyphenol oxidase) genes in a process called gene silencing, which utilizes low-PPO genes <u>from other apples.</u>

GMO 'botox apples' that do not bruise or brown could soon be in stores

The genetically modified apples are produced by Canadian company Okanagan Specialty Fruits, have been under review by U.S. regulatory agencies since 2010. If approved, they would become the second GMO fruit to be allowed in the country.

Comments (6)

BY DAVID KNOWLES / NEW YORK DAILY NEWS

FRIDAY, MAY 10, 2013, 6:18 PM

668 56 3 +1

FLICKR/GETTY IMAGES

Developed by scientists at Okanagan Specialty Fruits, the new, genetically modified apples do not bruise or brown.

Capital Press
Agriculture Newspaper

'We intend to label our Arctic apples as genetically modified'

APPLE from Page 1

prohibition that barred the state Legislature from modifying it unless it was made more stringent. Opponents, including Monsanto, DuPont, food companies and grocery stores, spent $45 million against the proposition.

Carter believes he is about six months away from gaining USDA and U.S. Food and Drug Administration approval to grow and sell genetically modified apples in the United States. He is also seeking Canadian government approval.

His Arctic brand Golden Delicious and Arctic Granny Smith apples have been modified by switching off a gene, so they won't brown when sliced. That could benefit the sliced apple bu[illegible] expens[illegible] ments [illegible] brownin[illegible] apples i[illegible] service[illegible] all appl[illegible]

"As a company, labeling

Dan Wheat/Capital Press

Joel Brooks, marketing communications specialist for Okanagan Specialty Fruits, of Summerland, British Columbia, talks to people about

netically modified. We want

ing because it undermines the credibility of the FDA, which does its review. It has standards for food safety. This is mandating labeling of something that has no risk. I don't agree with that. It becomes too much negative marketing."

The battle isn't as much about food safety as it is about market share between the organic and natural food side versus big, biotech corporations, Carter said.

"We're a small company," he said. "We can't engage in that."

The recession shrank the organic industry, which "wants [illegible] people into buying organic," he said. [illegible] motivation, he said, and it should be about food safety.

we're not for mandatory label-

Biotech foods have been around for 15 years, fed 4 trillion people and never been a single health risk, yet nine people died from organic bean sprouts in Germany last year," he said. "Organics can kill people with E.coli."

But the Pacific Northwest apple industry, fearing negative public reaction, is on the record against USDA approval of genetically engineered apples.

The Northwest Horticultural Council in Yakima, Wash., representing tree fruit growers and packers in Washington, Oregon and Idaho, sent USDA [illegible] a letter in 2011 asking him to reject [illegible] application for non-regulated status of his two genetically engineered apples.

"While we do not think any

place," Chris Schlect, hort coun-

cil president wrote in the letter.

Todd Fryhover, president of the Washington Apple Commission, has said genetic modification raises public concerns and doesn't seem to fit with the image of apples as healthy and nutritious.

Carter and other representatives of Okanagan Specialty Fruits early this month, for the [illegible] time, had booths to display and talk about Arctic apples at the [illegible] of the Washington State Horticultural Association and the Great Lakes Fruit, Vegetable and Farm Market Expo in Michigan.

It was an educational outreach with lots of grower questions answered, he said.

Contacts were made for potentially more grower testing,

[illegible]ower in Washing-[illegible]ed about 10 acres [illegible]nd quality, Carter [illegible]nting should pro-[illegible]t in 2014, w[illegible] apples shou[illegible] deregulated, he said.

McDonald's, Gerber:
No Plans to Use GMO Apple

http://www.foodsafetynews.com/2013/11/mcdonalds-gerber-reject-gmo-apple/#.UwwgT4W8ZD4

Okanagen Specialty Fruits has decided to voluntarily label their GE apples.

http://www.arcticapples.com/arctic-apples-story/how-we-keep-apples-from-turning-brown

ucbiotech.org

Reps. Tara Sad and Bob Haefner: Why labeling GMO foods makes no sense

First, there has been no credible scientific study that proves that there is any material difference between GMO and non-GMO foods. No nutritional difference. No health safety difference. In fact, we have all been eating foods made with genetic engineering for more than 20 years.

Second, many legal experts tell us that this labeling bill is unconstitutional.

Third, the bill is unenforceable.

Finally, product labeling is a federal - not a state - responsibility.

Names in Bio Tech industry

- Three of the world's largest agrochemical companies (DuPont, Syngenta, and Agrigenetics Inc., a company affiliated with the Dow AgroSciences) have filed a lawsuit in Hawaii to block a law enacted on the island of Kauai in November to limit the planting of biotech crops and the use of pesticides.

http://www.agweek.com/event/article/id/22506/

But there are other ways to create new varieties using the modern tools of genetics

ucbiotech.org

Monsanto's Newest Veggies Are High-Tech – But They Aren't GMO

There's the onion that won't make you cry, the better-for-you broccoli, and the melon that won't spoil when it's ripe. But these aren't the genetically-modified plants Monsanto has made its name on. Instead, biologists there are taking a high-tech approach to a very ancient kind of crop modification: crossbreeding.

These new technological tricks allow Monsanto to speed up the process of breeding better plants— by identifying the genes responsible for desirable traits and then scanning millions of seeds to select only the genetically-promising ones to plant and breed in the next generation.

http://blogs.discovermagazine.com/d-brief/2014/01/28/monsantos-push-for-non-gmo-vegetables/#.Uwk7VYW8ZD5

Senate Bill Proposes GE Labeling in California

2014

- Despite defeats in California and Washington, GE labeling has passed elsewhere. Legislatures in Connecticut and Maine have passed laws that require GE food labeling once certain conditions are met.

- For the Connecticut law to go into effect, four other states (including at least one border state) with a combined population of at least 20 million must pass GE labeling laws.

- For Maine's law to go into effect, four other states contiguous with Maine must pass GE labeling laws.

http://www.foodsafetynews.com/2014/02/senate-bill-once-again-proposes-gmo-labeling-in-california/#.UwzlOIW8ZD4

Summary

A useful website for you that lists engineered crops and their descriptions is:

http://www.cera-gmc.org/?action=gm_crop_database

- Nothing on the market has animal genes inserted into plants
- Most foods on the market have been engineered with two primary genes: one from a naturally occurring bacterium, Bacillus thuringiensis (BT, for insect resistance), and the other, also from a naturally occurring bacterium called Agrobacterium, protects plants from Roundup herbicide

❖ In the case of virus resistant plants like squash and papaya, they were actually modified by using a part of the virus genetic information itself engineered in such a way as to shut off the replication of the virus. Squash and papaya are the only small acreage crops that are GE and are available on the commercial market.

❖ Is it a Black or White issue?

❖ Is it a Yes for it or no against it?

❖ Or is there a middle of the road?

❖ Moral ?

❖ Ethical ?

❖ Biblical ?

Jurassic Park(1993)

- Dr. Ian Malcolm: Yeah, yeah, but your scientists were so preoccupied with <u>whether or not they could</u> that they <u>didn't stop to think if they should</u>

Where to get more information on GE issues?

http://ucbiotech.org

Some of the powerpoint slides
Thanks to UC Biotech
Peggy G. Lemaux, Ph.D.

Other resources

- http://www.aces.uiuc.edu/vista/html_pubs/irspsm91/transfor.html
- Animal and Plant Transformation: The Application of Transgenic Organisms in Agriculture

- http://cls.casa.colostate.edu/transgeniccrops/how.html
- http://cls.casa.colostate.edu/transgeniccrops/faqpopup.html
- http://www.nongmoproject.org/learn-more/what-is-gmo/*******
- http://www.genome.gov/10000202   *****
- http://agbiosafety.unl.edu/food_safety.shtml