- 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.
GMO - Similar terms

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

HOW THEY COMPARE

GM salmon
Length: 24ins
Weight: 6.6lb

Farm salmon
Length: 13ins
Weight: 2.8lb

*Both fish are 18 months
Tour d’Onion

Or what makes an onion, an onion?

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

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

http://www.genome.gov/10000202

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

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
≠
```
The History of Genetic Modification in Crops

10,000 years ago
Humans begin crop domestication using selective breeding.

1700s
Farmers and scientists begin cross-breeding plants within a species.

1940s and 1950s
Breeders and researchers seek out additional means to introduce genetic variation into the gene pool of plants.

1980s
Researchers develop the more precise and controllable methods of genetic engineering to create plants with desirable traits.

1990s
The first GMOs are introduced to the marketplace.

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**
Number of different commercially available GE crops is limited

**GE Cotton**
- 90% of 2013 acreage
- Source: USDA-ERS, 2012
- (Insect Resistant: 8%, Herbicide tolerant: 15%, Stacked gene: 67%)

**GE Canola**
- 88% of 2010 acreage
- Source: ISAAA, 2011

**GE Soybean**
- 93% of 2013 acreage
- (Herbicide resistant: 93%)
- Source: USDA-ERS, 2012

**GE Corn**
- 90% of 2013 acreage
- Source: USDA-ERS, 2012
- (Insect Resistant: 5%, Herbicide resistant: 14%, Stacked gene: 71%)

**GE Sugarbeet**
- 96% of 2010 acreage
- Source: ISAAA, 2011

**GE Alfalfa**
- 20% of 2012 acreage
- Source: Dan Putnam, UC ANR, 2013

**GE Sugarbeet**
- 96% of 2010 acreage
- Source: ISAAA, 2011

**GE Alfalfa**
- 20% of 2012 acreage
- Source: Dan Putnam, UC ANR, 2013
Only a few whole foods on the market are genetically engineered

**GE Squash**
10% of 2004 acreage

**GE Papaya**
≥77% of 2009 acreage from Hawaii

**GE Sweet Corn**

Source: ISAAA, 2004

Source: USDA, Hilo, HI, 9/2011

Lemaux
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

Improved visual appeal to reduce waste
Example:
Apple varieties that have been enhanced through biotechnology so they don't brown

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

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.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Genetic Traits</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FIELD CORN</strong></td>
<td><strong>Genetic Traits</strong></td>
<td>- Livestock and poultry feed</td>
</tr>
<tr>
<td></td>
<td><strong>Insect Resistance</strong></td>
<td>- Fuel ethanol</td>
</tr>
<tr>
<td></td>
<td><strong>Herbicide Tolerance</strong></td>
<td>- High-fructose corn syrup and other sweeteners</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Corn oil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Starch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Cereal and other food ingredients</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Alcohol</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Industrial uses</td>
</tr>
<tr>
<td><strong>SOYBEAN</strong></td>
<td><strong>Genetic Traits</strong></td>
<td>- Livestock and poultry feed</td>
</tr>
<tr>
<td></td>
<td><strong>Insect Resistance</strong></td>
<td>- Aquaculture</td>
</tr>
<tr>
<td></td>
<td><strong>Herbicide Tolerance</strong></td>
<td>- Soybean oil (vegetable oil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- High oleic acid (monounsaturated fatty acid)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Biodiesel fuel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Soymilk, soy sauce, tofu, other food uses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Lecithin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Pet food</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Adhesives and building materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Printing ink</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Other industrial uses</td>
</tr>
<tr>
<td><strong>COTTON</strong></td>
<td><strong>Genetic Traits</strong></td>
<td>- Fiber</td>
</tr>
<tr>
<td></td>
<td><strong>Insect Resistance</strong></td>
<td>- Animal feed</td>
</tr>
<tr>
<td></td>
<td><strong>Herbicide Tolerance</strong></td>
<td>- Cottonseed oil</td>
</tr>
<tr>
<td><strong>SUGAR BEETS</strong></td>
<td><strong>Genetic Traits</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Herbicide Tolerance</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SWEET CORN</strong></td>
<td><strong>Genetic Traits</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Herbicide Tolerance</strong></td>
<td></td>
</tr>
<tr>
<td><strong>ALFALFA</strong></td>
<td><strong>Genetic Traits</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Herbicide Tolerance</strong></td>
<td></td>
</tr>
<tr>
<td><strong>RAINFALL PAPAYA</strong></td>
<td><strong>Genetic Traits</strong></td>
<td><strong>Disease resistance</strong></td>
</tr>
<tr>
<td><strong>SUNFLOWER</strong></td>
<td><strong>Genetic Traits</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Herbicide Tolerance</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SUMMER SQUASH</strong></td>
<td><strong>Genetic Traits</strong></td>
<td><strong>Disease resistance</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**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
- 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
- Sugar
- Animal feed
- Cottonseed oil
- Food
- Food
- Food
- Food
- Food
- Food
- Food
- Food
- Food
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.

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
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.

<table>
<thead>
<tr>
<th>FAMILY</th>
<th>GENUS</th>
<th>SPECIES</th>
<th>VARIETY OR COMMON NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cucurbitaceae</td>
<td>Cucurbita</td>
<td>pepo*</td>
<td>'Buttercup' squash 'Connecticut Field' pumpkin 'Acorn' or 'Table Queen' squash</td>
</tr>
<tr>
<td></td>
<td></td>
<td>moschata*</td>
<td>'Kentucky Field' pumpkin 'Dickinson' pumpkin 'Sweetmeat' squash</td>
</tr>
<tr>
<td></td>
<td></td>
<td>maxima*</td>
<td>'Marblehead' squash 'Turk's Turban' squash</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ficifolia</td>
<td>Malabar gourd</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mixta*</td>
<td>'Green Striped Cushaw' pumpkin 'White Cushaw' pumpkin</td>
</tr>
<tr>
<td>Lagenaria</td>
<td>siceraria</td>
<td></td>
<td>Bottle or White Flowered gourd</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cucuzzi</td>
</tr>
<tr>
<td>Luffa</td>
<td>cylindrica</td>
<td></td>
<td>Dishrag gourd</td>
</tr>
<tr>
<td>Momordica</td>
<td>balsamina</td>
<td></td>
<td>Balsam apple</td>
</tr>
<tr>
<td></td>
<td>charantia</td>
<td></td>
<td>Balsam pear</td>
</tr>
<tr>
<td></td>
<td>edule</td>
<td></td>
<td>Chayote</td>
</tr>
<tr>
<td>Sechium</td>
<td>hispida</td>
<td></td>
<td>Chinese Preserving melon or White Gourd of India</td>
</tr>
<tr>
<td>Benincasa</td>
<td>melo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cucumis</td>
<td>sativus</td>
<td></td>
<td>Cucumber, all varieties</td>
</tr>
<tr>
<td></td>
<td>anguria</td>
<td></td>
<td>West Indian Gherkin</td>
</tr>
<tr>
<td>Citrullus</td>
<td></td>
<td></td>
<td>Watermelon, all varieties</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Citron</td>
</tr>
<tr>
<td>Trichosanthes</td>
<td>anguina</td>
<td></td>
<td>Snake or Serpent gourd</td>
</tr>
</tbody>
</table>

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

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
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

Source: Clive James, 2010.
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.

Seminis Vegetable Seed
<table>
<thead>
<tr>
<th>Variety</th>
<th>Description</th>
<th>Height</th>
<th>Growth Habit</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold Rush</td>
<td>Deep gold on a rich green stem</td>
<td>7-8 in.</td>
<td>Upright. Open habit</td>
<td>49</td>
</tr>
<tr>
<td>Greyzini</td>
<td>Light green w/ grey mottling and faint stripes</td>
<td>5-6 in.</td>
<td>Compact bush, open habit</td>
<td>47</td>
</tr>
<tr>
<td>Independence II</td>
<td>Light to medium green, Large specks</td>
<td>7-8 in.</td>
<td>Strongly vigorous bush</td>
<td>41</td>
</tr>
<tr>
<td>Judgement III</td>
<td>Medium green</td>
<td>5-6 in.</td>
<td>Compact bush</td>
<td>Intermediate resistance to ZYMV</td>
</tr>
<tr>
<td>Justice III</td>
<td>Medium-dark green, Wavy appearance</td>
<td>7-8 in.</td>
<td>Upright</td>
<td>Transgenic high resistance to WMV</td>
</tr>
</tbody>
</table>

- **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.
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’s sure to be a hit at roadside stands and local retail stores.

Primus
- First in a series of new TripleSweet Plus varieties from Syngenta
- Marries the next generation of superior eating quality
- Exceptional flavor and sweet, a superior standard TripleSweet varieties and bring a cornier back for more
- Tender and extra sweet broccoli kernels, long ears and matted row hair
- Prime for culinary, local market and speciality markets
- High resistance to southern corn leaf blight and intermediate resistance to common rust and Stewart’s wilt
- Approximately 81 days to maturity

WH-0809
- This TripleSweet has high-quality large ears and outstanding eating quality, making it a favorite for roadside markets
- Produces exceptional taste quality
- Well-suited for local and roadside markets in the Midwest and Northeast
- A white BC 005-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
- 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 corn and attractive flag leaves
- Approximately 77 days to maturity

GH0851
- Ideal for roadside and local markets
- Excellent rust resistance package
- Approximately 77 days to maturity

BC 0805
- An industry standard for reliability of high yield 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
- Approximately 82 days to maturity

Honey Select
- Exceptional tenderness
- Medium-grain kernels and good flavor
- Produces large, high-quality ears
- 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 90 days to maturity

Silver King
- This white ear has a delicious flavor and tender mess for local market sales and home gardeners
- Tight husk cover helps prevent bird damage
- Optimal placement makes for an easy harvest
- Approximately 92 days to maturity

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

Legion
- Legion is a high-yielding bicolor shipper corn with a robust disease package and strong agronomic characteristics.
- Well-suited for the eastern shipper market
- Excellent husk cover and attractive flag leaves
- Reliable high yields
- Approximately 75 days to maturity

Munition
- This is a high-yielding white supersweet hybrid that produces a large shipper ear with uniform size, protected by a robust disease package.
- Excellent tip fill appeals to fresh market customers
- Ideal ear size for eating in shipper markets
- Especially well adapted for regions from south Florida to New York
- High resistance to common rot and intermediate resistance to Sclerotinia wilt, southern corn leaf blight, and maize dwarf mosaic
- Approximately 78 days to maturity

GSS 096
- Main-season yellow shipper corn with good eating quality.
- Well-filled ears with excellent husk cover.
- Consistent performance.
- Approximately 76 days to maturity

WSS 0987
- A consistent performing white for the fresh shipper market.
- High resistance to common rot and intermediate resistance to southern corn leaf blight.
- Approximately 81 days to maturity
But other nations have specific mandatory labeling laws for GE, although the rules and enforcement vary dramatically among countries, making international trade difficult.

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

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

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

FDA
- Food safety
- Feed safety

EPA
- 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

(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?

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaging</td>
<td>27%</td>
<td>15%</td>
<td>15%</td>
<td>5%</td>
</tr>
<tr>
<td>Food Handling/Preparation</td>
<td>23%</td>
<td>41%</td>
<td>35%</td>
<td>33%</td>
</tr>
<tr>
<td>Other</td>
<td>19%</td>
<td>9%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Disease/Contamination</td>
<td>16%</td>
<td>28%</td>
<td>36%</td>
<td>38%</td>
</tr>
<tr>
<td>Chemicals/Pesticides in Food</td>
<td>10%</td>
<td>7%</td>
<td>16%</td>
<td>10%</td>
</tr>
<tr>
<td>Altered/Engineered Food</td>
<td>2%</td>
<td>1%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Nothing</td>
<td>9%</td>
<td>5%</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**SOURCE:** IFIC, April 2010.

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

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

http://www.nytimes.com/2013/03/09/business/grocery-chain-to-require-labels-for-genetically-modified-food.html?ref=opinion&_r=0
Crops can be engineered with purposeful nutritional alterations

**Engineering tomato to increase health-promoting compounds**

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Mode of Pollination</th>
<th>Means of Movement</th>
<th>Fdn Seed Prod Isolation Distance</th>
<th>Measure Pollen Movemnt Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>Self-sterile; obligate outcrossing</td>
<td>Bees</td>
<td>900 ft (0.17 mi)</td>
<td>2000 ft (0.48 mi)</td>
</tr>
<tr>
<td>Bentgrass</td>
<td>Clonal (stolons); type outcrossing dep on environment</td>
<td>Wind</td>
<td>900 ft (98%purity) (0.17 mi)</td>
<td>13.05 mi</td>
</tr>
<tr>
<td>Canola</td>
<td>Predom. selfing; 30% outcrossing</td>
<td>Wind/insects</td>
<td>&gt;1320 ft (0.25 mi)</td>
<td>1.9 mi</td>
</tr>
<tr>
<td>Corn</td>
<td>Almost exclusively outcrossing</td>
<td>Wind</td>
<td>660 ft (0.125 mi)</td>
<td>~2 mi</td>
</tr>
<tr>
<td>Cotton</td>
<td>Predom. Selffing; outcrossing with insects</td>
<td>Insects</td>
<td>&gt;1320 ft (0.25 mi)</td>
<td>n.a.</td>
</tr>
<tr>
<td>Rice</td>
<td>Self-pollinating (99.5%); pollen viable 3-15 min</td>
<td>Physical touching/wind</td>
<td>10 ft</td>
<td>30 ft</td>
</tr>
<tr>
<td>Squash</td>
<td>Obligate outcrossing</td>
<td>Insects</td>
<td>1320 ft (0.25 mi)</td>
<td>0.8 mi</td>
</tr>
<tr>
<td>Soybean</td>
<td>Self-pollinating (99%)</td>
<td>Physical touching/wind</td>
<td>5 ft</td>
<td>n.a.</td>
</tr>
<tr>
<td>Wheat</td>
<td>Self-pollinating (99.9%)</td>
<td>Physical touching/wind</td>
<td>5 ft</td>
<td>&gt;160 ft</td>
</tr>
</tbody>
</table>
What Are Some of the Issues?
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)?
Glyphosate- Resistant Weeds – USA

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

K. Neil Harker
AAFC - Lacombe, AB
Can Organic Agriculture Coexist with GE Crops?
"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).”
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?
Field Trials Conducted in California with Grape Root Stocks Engineered for Resistance to Fanleaf Virus
Australian researchers identify grape genes that provide resistance to powdery mildew
Arcadia Biosciences develops canola that uses 50% less nitrogen fertilizer

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.
About 80% of tomatoes under certain conditions suffer blossom end rot. Tomatoes engineered for high solids resist the disease.
Non-browning GE apple to be labeled and marketed in U.S.

http://www.organicconsumers.org/bytes/ob269.htm#SEC3
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.
Japanese scientists create blue rose with blue pigments from pansies

In 2009, after nearly two decades of research and developmental work, sales of the blue rose began for the first time.
**Slow-Mow grass addresses watering, maintenance and weed problems**

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.

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

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

“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**
Salt-tolerant Tomatoes

The company was lately acquired by Syngenta

SOURCE: Zeraim Gedera L.T.D., Israel
<table>
<thead>
<tr>
<th>Classical Breeding</th>
<th>compared to</th>
<th>Genetic Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gene exchange is random involving whole genome</td>
<td>Gene exchange is specific involving single or few genes</td>
<td></td>
</tr>
<tr>
<td>When/where gene expressed not controlled by breeder</td>
<td>When/where gene expressed controlled precisely</td>
<td></td>
</tr>
<tr>
<td>Source of gene primarily within genera – not between kingdoms like plants &amp; bacteria</td>
<td>Source of gene from any organism</td>
<td></td>
</tr>
</tbody>
</table>
How is the genetic information in a plant manipulated to create a new plant variety... by classical breeding?

Tangerine  X  Orange
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.
Will Human Genes Be Spliced into Food for People?

by Don Fitz, Gateway Green Alliance
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 allergic 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."
• 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 from other apples.
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
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
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.

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
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 **whether or not they could** that they **didn't stop to think if they should**
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

- 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