How Genetics Affects the Plants We Grow and the Foods We Eat

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Agriculture was the Driving Force in Development of Civilization

Egyptian tomb mural ~ 4200 BP

Changing Man From a Forager to a More Sedentary Life Style

Indians cultivating maize
From small farms to...
...large farms with higher yields!
U.S. Cultivated Land

Acreage Needed at 1929 Production Levels
Tour d'Onion
Dividing cell

Chromosomes
How is a new wheat variety created by classical breeding?

_Triticum aestivum_  
Modern bread variety

_Triticum monococcum_  
Ancient variety
Information in the wheat genome
Chemical units represented by alphabetic letters
...CTGACCTAATGCCGTA...

1700 books
1000 pages each

1700 books
(or 1.7 million pages)
Hybridization or cross breeding of wheat

Random retention of information from each parent

1700 books (or 1.7 million pages)

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1700 books (or 1.7 million pages)
Table of contents for genes in wheat

...CTGACCTAATGCGGTA...

Genomics

1700 books (or 1.7 million pages)
MAS For Quality Traits In Wheat

Selection of Hard and Soft Wheat

5' A AAC AAC ATT GAA AAC ATG AAG ACC TTA TTC CTC CTA GCT
CTC CTT GCT CTT GTA GCG AGC ACA ACC TTC GCG CAA TAC TCA
GAA GTT GGC GGC TGG TAC AAT GAA GTT GGC GGA GGA GGT GGT
TCT CAA CAA TGT CCG CAG GAG CGG CCG CAG CTA AGC TCT TGC
AAG GAT TAC GTG ATG GAG CGA TGT TTC ACA ATG AAG GAT TTT

CCA GTC ACC TGG CCC ACA AAA TGG TGG AAG GCC GCC TGG GGC
Gly

Soft allele
Hard allele

Hard allele: cut
Soft allele: uncut

PCR amplification of puroindoline b

Digested with Bsr-BI

Homozygous soft
Heterozygote

GAG CGG: Bsr-BI restriction site.

Adapted and modified from http://maswheat.ucdavis.edu/
Genetic Engineering Methods

1700 books (or 1.7 million pages) + one-half page equivalent to a gene → 1700 books (or 1.7 million pages)

Inserts randomly in genome

Inserted gene(s)
<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMO</td>
<td>Genetically Modified Organism</td>
</tr>
<tr>
<td>GEO</td>
<td>Genetically Engineered Organism</td>
</tr>
<tr>
<td>LMO</td>
<td>Living Modified Organism</td>
</tr>
<tr>
<td>rDNA</td>
<td>Recombinant DNA</td>
</tr>
<tr>
<td>Biotechnology</td>
<td></td>
</tr>
</tbody>
</table>
What Does the Introduced, Recombinant DNA Construct Look Like?

Gene of interest: herbicide, stress or disease tolerance

Marker gene: antibiotic or herbicide resistance
Process of Genetic Engineering of Plants

- Create rDNA with gene from same or different organism
- Transfer DNA to plant cell; plant cells divide under selection
- Cue cells to reform plant - every cell will have new DNA
- Confirm introduced DNA and expression of foreign protein in plants
<table>
<thead>
<tr>
<th>Classical Breeding</th>
<th>Genetic Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uses plant machinery in plant</td>
<td>Uses plant machinery in laboratory</td>
</tr>
<tr>
<td>Gene exchange is random involving entire genome</td>
<td>Gene exchange is specific, single or a few genes</td>
</tr>
<tr>
<td>When/where genes expressed not controlled by breeder</td>
<td>When/where gene expressed can be controlled precisely</td>
</tr>
<tr>
<td>Only between closely related or within species</td>
<td>Source of gene from any organism</td>
</tr>
</tbody>
</table>
GLOBAL AREA OF BIOTECH CROPS
Million Hectares (1996 to 2005)

Increase of 11%, 9.0 million hectares or 22 million acres, between 2004 and 2005.

Source: Clive James, 2005
Estimated 75% of Processed Foods Have GE Ingredients
Insect-Resistant Cotton (Bt)

+ Increases yields; profits variable
+ Decreased pesticide use
+ Reduced tillage

- Can result in Bt-resistant insects
- Produces insect toxin throughout plant
- Can transfer Bt gene to wild relatives
WHAT’S IN THE PIPELINE?
Drought tolerant wheat
(using DREB1A gene from Arabidopsis)
GE Grape Root Stocks Field Tested in Northern France for Fanleaf Virus Protection that Can Reduce Yields by 80%
Mitigating food allergies through genetic engineering
A new variety of sweet potato in Peru is rich in β-carotene and could help prevent millions of cases for blindness and disease among children in Africa.

SOURCE: British Medical Journal, September 30, 2000
Production of Omega-3 and Omega-6 Oils in Plants

SOURCE: “Transgenic plants produce omega-3 and omega-6 fatty acids”, Baoxiu Qi, ISB News Report July 2004
Japanese scientists create blue rose from blue pigments in pansies
Moonglow carnation
Available in cut form from Australia
Slow grow grass
Genetically engineered pollen reduces allergy symptoms in sufferers

“Production of specific vaccines for lymphoma in tobacco”

After eating potato-based vaccine for Hepatitis B, 60% of humans show immunological response

Green glowing pigs used to study human disease
Step your way to Nicotine Free!

new Quest

1. Low Nicotine
2. Extra Low Nicotine
3. Nicotine Free

Genetic engineering used to improve breakdown of global wastepaper glut

Yellow poplar bioremediation
Green algae have a switch that can change metabolic processes and produce hydrogen gas - potentially providing a renewable, clean fuel source.
The **HORROR** of Genetically Engineered Food

**IT** Came from the Grocery Store

You Can't Avoid It Because It's **NOT LABELED!**

GREENPEACE

From the **LABS** of Monsanto to YOUR TABLE!

A **NEW LIFE FORM** Released into the World!
“In human gene therapy, studies have verified that insertion mutation can lead to leukemia in children...In plants the disruptions may be similarly dangerous, producing unpredicted toxins.”

“Turning genes on or off is another form of Russian roulette. Whether the process creates new toxins, allergens, cancers or nutritional changes is anyone’s guess.”

“Genes can influence each other. Proteins can influence each other. With each change, a new interaction can begin setting off yet more changes. This type of unpredicted chain reaction” may have caused the ‘deadly’ tryptophan epidemic
Some food safety concerns with genetically engineered foods

- Adverse change/improvement in nutritional content
- Creation/removal of allergen
- Activation/removal of toxin
- Horizontal gene flow from food to intestinal flora
- Increase in antibiotic resistance
- Labeling
Plant Biotech Products Have Continuous Regulatory Oversight

Discovery → Product Development → Commercialization

NIH Guidelines

USDA

EPA

FDA
“In fact at various stages of the field test process…weaknesses in APHIS regulations and internal management controls increase the risk that regulated genetically engineered organisms (GEO) will inadvertently persist in the environment before they are deemed safe to grow without regulation.”

Excerpt from USDA Audit
Toxicity Assessment: Roundup Ready/CP4 EPSPS protein

No deleterious effects at highest dose (572mg/kg)
Hierarchical metabolomics demonstrates substantial compositional similarity between genetically modified and conventional potato crops.

“…apart from targeted changes, these GM potatoes in this study appear substantially equivalent to traditional cultivars.”

Kraft Food recalls all taco shells sold nationwide under Taco Bell Brand

Percentage of Positive Starlink Tests

Week ending:

- November 25, 2000 12.05%
- November 30, 2002 1.19%
- November 1, 2003 0.26%
- November 27, 2004 0.00%
- April 16, 2005 0.19%
- May, 2005 0.00%
- June, 2005 0.00%
- July, 2005 0.00%
- August, 2005 0.00%
- October, 2005 0.00%
- November, 2005 0.00%
- December, 2005 0.00%
Kiwi Allergies
Some environmental concerns with genetically engineered crops

- Transgene movement via pollen flow
- Transfer of transgenes to non-GMO / organic crops
- Generation of "superweeds" (transfer of herbicide-tolerance to wild/weedy species)
- Spread of pharmaceutical genes to edible crops
- Loss of genetic diversity
- Property rights (gene patents)
Movement of genes between crop species and wild relatives

Charlock  Canola  Wild radish

Buchan weed  Canola  Brassica tournefortii
Example - Gene flow from rice to weedy red rice
WORLD: 'Suicide Seeds' Could Spell Death of Peasant Agriculture, UN Meeting Told

by Haider Rizvi, OneWorld.net
January 26th, 2006

Groups fighting for the rights of peasant communities are stepping up pressure on governments to ban the use of genetically modified "suicide seeds" at UN-sponsored talks on biodiversity in Spain this week.

Genetically modified crops offer the promise of fat profits for their developers, marketers, and political supporters while threatening farmers with lean times and consumers with ill-health.

"This technology is an assault on the traditional knowledge, innovation, and practices of local and indigenous communities," said Debra Harry, executive director of the U.S.-based Indigenous Peoples Council on Biocolonialism.

The group is among organizations urging United Nations experts to recommend that governments adopt tough laws against field testing and selling Terminator technology, which refers to plants that have had their genes altered so that they render sterile seeds at harvest. Because of this trait, some activists call Terminator products "suicide seeds."

Developed by multinational agribusinesses and the U.S. government, Terminator has the effect of preventing farmers from saving or replanting seeds from one growing season to the next.

The product is being tested in greenhouses throughout the United States. Opponents fear it is likely to be marketed soon unless governments impose a ban.

"Terminator seeds will become a commercial reality unless governments take action to prevent it," said Hope Shand of the Canada-based Action Group on Erosion, Technology, and Concentration (ETC Group).

SOURCE: http://www.corpwatch.org/article.php?id=13178
Consequences of gene flow from GE crops to organic crops in the field
Will an organic farmer automatically lose accreditation if his/her crop is found contaminated with a GE crop?

No.

“As long as an organic operation has not used excluded methods and takes reasonable steps to avoid contact with the products of excluded methods, as detailed in their approved organic system plan, the unintentional presence of the products of excluded methods should not affect the status of an organic product or operation.”
Communicate to avoid pesticide drift, winemaker says

By MATEUSZ PERKOWSKI  
Freelance Writer

Fifteen years ago, David Adelsheim received some bad news. His vineyard manager had noticed that a section of his vineyard, located near Newberg, Ore., was producing vines with badly distorted leaves.

"Instead of being a full leaf shape, they might have been only half a leaf shape, or they were smaller and fanned together," said Adelsheim. All the symptoms pointed to one thing: the plants had been damaged by an herbicide.

As it turned out, a neighbor had sprayed half an acre of his land that was overgrown with blackberry bushes with a growth regulator herbicide containing 2,4-D. Aside from killing the blackberries, some of the herbicide had drifted onto the rows of grapevines growing only 15 feet away.

Roughly five acres were affected by the drift, which was about a third of Adelsheim Vineyards at the time. The first several rows were the most badly damaged, but even grapevines 30 rows down were showing some deformation. Because the neighbor had sprayed in mid-spring—after the grape bud break but prior to bloom—much of the year's crop had been aborted, and the remaining vines were too damaged to ripen any grapes.

In the decade and a half since then, Adelsheim Vineyards has managed to overcome the injury caused by the incident—the company has expanded to 180 acres, and the five acres ravaged by the herbicide have largely recovered. Nonetheless, Adelsheim said the effects of the
European Commission project aimed at co-existence of GE and non-GE crops

This website, part of the University of California Division of Agricultural and Natural Resources Statewide Biotechnology Workgroup, provides science-based information to the public on issues relating to the application of biotechnology to crops. For the scientific community, educational tools and an extensive database of pertinent scientific literature are available to promote participation in the dialogue. Teaching aids for students and teachers are provided.
FOOD FIGHTS IN CALIFORNIA

County GMO Ordinances

Visible images include logos and text for "GrowGmoFree.ORG," "No On "D" Families & Farmers For A Healthy Environment," and "NO on Q It's Bad for Farmers. YES Q Healthy Farms and Families."
March 2004 MENDOCINO
MEASURE H - 2,579 signatures obtained

- “unlawful for any person, firm, or corporation to propagate, cultivate, raise, or grow genetically modified organisms in Mendocino County” (excludes microorganisms)

- The ban does not pertain to properties within city limits, or lands managed by State, Tribal and Federal agencies.

- At election time, no GE organisms were known to be in production in Mendocino County.
November 2004, Fresno
Passed: Board of Supervisors 5 For; 0 Against

- Whereas, biotechnology has the potential to greatly improve the health, nutrition and...
- Whereas, biotechnology can make the food we eat safer, more nutritious and free from all allergens, and...
- Whereas, the University of California and the California State University systems are world leaders in biotechnology research recognizing that science is the driving force behind innovation and technology advancement and has been a key driver for California’s agricultural success; and...
- Whereas, patchwork county-by-county regulation of biotechnology suppresses important scientific developments, dismantles California’s leading research and development infrastructure, undermines the farmer’s choice and flexibility to meet market and environmental demands, and is unnecessary given the coordinated federal framework for regulating biotechnology; and...
- Therefore, be it resolved that the County of Fresno affirms that the right for farmers and ranchers to choose to utilize the widest range of technologies available to produce a safe, healthy, abundant and affordable food supply, and that the safe, federally regulated use of biotechnology is a promising component of progressive agricultural production.

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Nonexhaustive List of Issues with GMO Foods

**Food Safety Issues**

- Create new allergens
- Activate naturally occurring toxins or create new ones
- Removal of existing allergens and antinutritionals

- Adversely affect the nutritional quality of foods
- Enhance the nutritional quality of foods

- Vegetarian and religious issues with GMOs
- Labeling
- Increased antibiotic resistance in intestinal flora
- Horizontal transfer of DNA from plants to humans through foods
- Unknown, unanticipated risks from GMO consumption
- Trust in regulatory agencies
Nonexhaustive List of Issues with GMO Foods

**Environmental Issues**

- Unintended adverse consequences for beneficial insects
- Unintended beneficial consequences for beneficial insects

- Soil residuals of bio-engineered pesticides
- Soil residuals of nonengineered pesticides used in the absence of engineered varieties

- Degradation of the environment because of GMOs, *e.g.*, residuals, chemical dependence
- Degradation of the environment because of current agricultural practices, *e.g.*, tilling, fertilizers, pesticides
- Improved environmental situation with GMOs, *e.g.*, reduced phytic acid, phyto and bioremediation

- Herbicide-resistant weeds as a result of GMOs, “superweeds”
- Herbicide-resistant weeds from conventional practices in absence of GMOs