Science of Food Biotechnology

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PROFESSOR AND CHAIR
Genetically engineered

GE

Genetically Modified Organism

GMO
Genetics

1866 Gregor Mendel showed traits pass from parent to offspring
  ◦ Mendelian inheritance
1928 Frederick Griffin showed that genes could be transferred
1941 Beadle and Tatum developed ‘one gene, one enzyme’ hypothesis
1953 Watson and Crick defined the chemical structure of DNA

Central dogma of molecular biology
  ◦ DNA – RNA - Protein
Hybrid corn
(conventional genetic manipulation)

1920s Research on corn breeding

1930s Commercial production began

1960 95% of corn in US was hybrid varieties
  ◦ Hybrid sorghum, soybeans and cotton
  ◦ Hybrids of onions, spinach, tomatoes and cabbage

Source: Agricultural Statistics, NASS, USDA, various years.
Molecular biology

Study of genes and gene replication, mutation and expression

**Genome** is the collection of all base pairs within the cell

Human Genome project started in 1980s
- Humans have 20-25,000 genes
- Mice have 24,174 genes
- Rice has 32-50,000 genes
- Human and pumpkin genomes are 75% similar

**Genes that express a desired protein could be identified – isolated – inserted - expressed**
Transgenic Technology

1. Insertion of gene into plasmid using restriction enzyme and DNA ligase
2. Introduction into plant cells in culture
3. Regeneration of plant

Plant with new trait
Genetic engineering

Recombinant DNA technique
- Selection of DNA sequence using restriction enzymes
- Insertion of sequence into plasmid DNA using ligase enzymes
- Introduce recombinant DNA to host cell
- DNA encodes for protein that is expressed in the cell

Gene silencing
- Antisense and RNAi
- Block translation of RNA to protein

Gene knockout
- Inserted DNA sequence disrupts gene expression

Gene editing – CRISPR technology
- Selective removal of DNA sequences
## What does GMO do?

<table>
<thead>
<tr>
<th>Benefits</th>
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<tbody>
<tr>
<td>Herbicide tolerance</td>
</tr>
<tr>
<td>Insect resistance</td>
</tr>
<tr>
<td>Virus resistance</td>
</tr>
<tr>
<td>Ripening delayed</td>
</tr>
<tr>
<td>Amino acid composition</td>
</tr>
<tr>
<td>Fatty acid composition</td>
</tr>
<tr>
<td>Modified color</td>
</tr>
<tr>
<td>Nicotine reduced</td>
</tr>
<tr>
<td>Plant quality</td>
</tr>
<tr>
<td>Starch hydrolysis</td>
</tr>
<tr>
<td>Increase yield</td>
</tr>
<tr>
<td>Increase quality</td>
</tr>
<tr>
<td>Reduce use of chemicals</td>
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<tr>
<td>Reduce waste</td>
</tr>
<tr>
<td>Nutrition improvement</td>
</tr>
<tr>
<td>Reduce toxic compounds</td>
</tr>
</tbody>
</table>

[www.cera-gmc.org](http://www.cera-gmc.org)
Two examples of GMO crops

<table>
<thead>
<tr>
<th><strong>ROUNDUP® READY</strong></th>
<th><strong>BACILLUS THURINGIENSIS (Bt)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RoundUp® is glyphosate</strong></td>
<td>Bt toxin approved as natural pesticide since 1960s</td>
</tr>
<tr>
<td>◦ Inhibits shikimate pathway</td>
<td></td>
</tr>
<tr>
<td>Made by Monsanto</td>
<td>Bt gene inserted into plant</td>
</tr>
<tr>
<td>Gene from <em>Agrobacterium tumefaciens</em> inserted into plant</td>
<td>Plant produces Bt pro-toxin that kills corn borer insect</td>
</tr>
<tr>
<td>Allows plant to survive exposure to glyphosate</td>
<td>Bt pro-toxin has no effect on humans</td>
</tr>
<tr>
<td>◦ Herbicide tolerant</td>
<td>◦ Pest resistant</td>
</tr>
</tbody>
</table>
Food sources of GMO

Currently in the food supply
- Corn
- Soybean
- Canola
- Sugar beets
- Papaya
- Squash

Approved – coming soon
- Apples
- Rice
- Eggplant
- Salmon
- Melon
- Sweet pepper
- Plum
- Tomato
- Potato
Evidence of safety

1. FDA considers technology equivalent to conventional plant breeding
2. Study of 100 billion animals fed conventional compared to GMO feed for 25 years found no health risks
3. No human disease or illness ever linked to GMO food
4. Most scientific organizations approve safety of GMO
   - American Medical Association
   - American Academy of Pediatrics
   - American Association for the Advancement of Science
   - Center for Science in the Public Interest
   - European Commission
   - Union of German Academies of Science and Humanities
   - French Academy of Sciences
   - World Health Organization
5. National Academy of Sciences report
Reliable information

GMO Answers  www.gmoanswers.com
Best Food Facts  www.bestfoodfacts.org
USDA Biotechnology  www.ers.usda.gov
FDA  http://www.fda.gov