

# Agricultural Biotechnology

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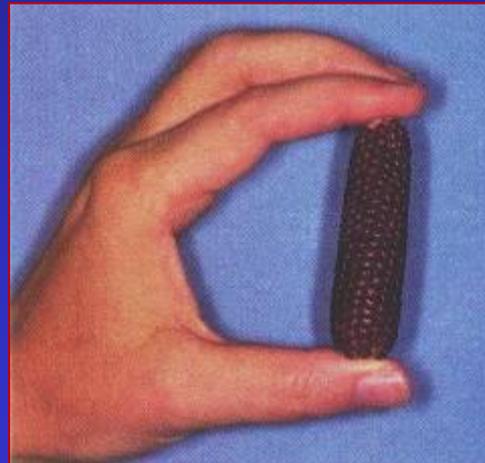
# Domestication: The Original Crop Biotechnology

*Humans have made dramatic changes in plants during the process of domestication that have resulted in the crops that we rely on today.*

*The majority of these changes had already occurred before scientific breeding began.*



Teosinte and early progenitors of corn



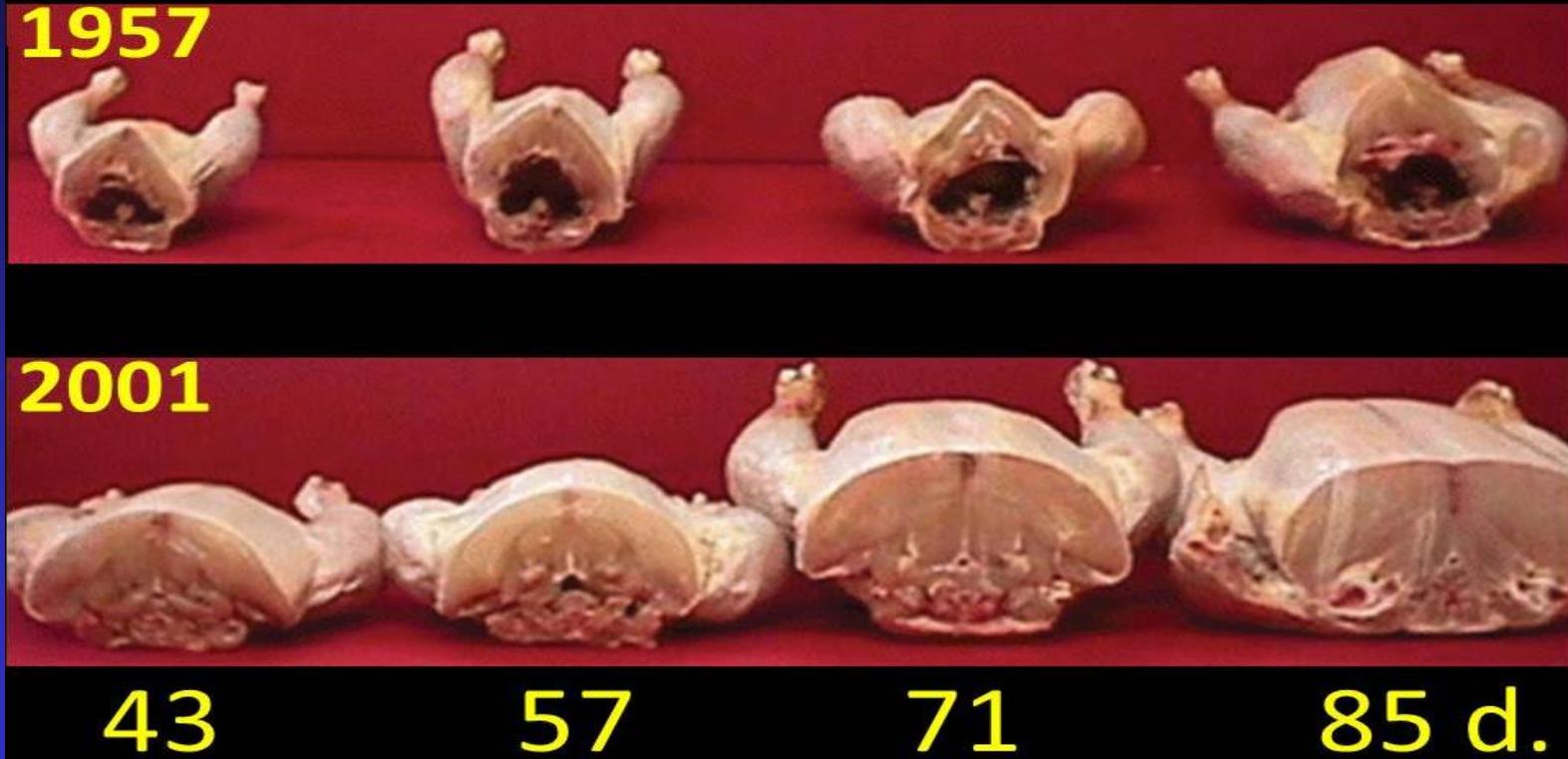
Early corn



Modern corn

# Chicken Genetic Improvement: 1957 to 2001

## 1957 vs. 2001 chickens



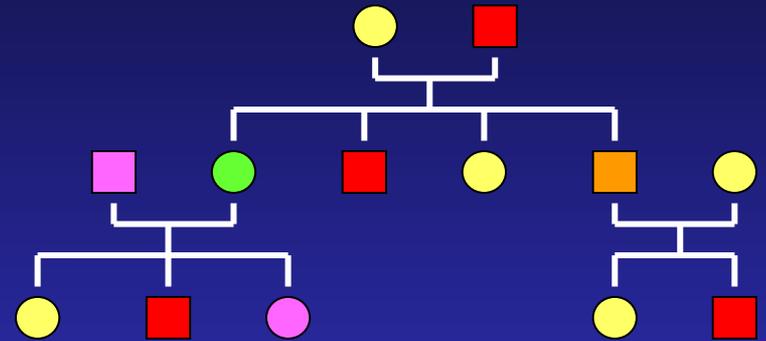
The 8-week old body weight of broiler (meat) chickens has increased from 0.81 kg to 3.14 kg over the period 1957 to 2001, and approximately 80% of this four-fold increase has been the result of genetic selection.

Havenstein et al. (2003). *Poultry Science* 82, 1500-1508.

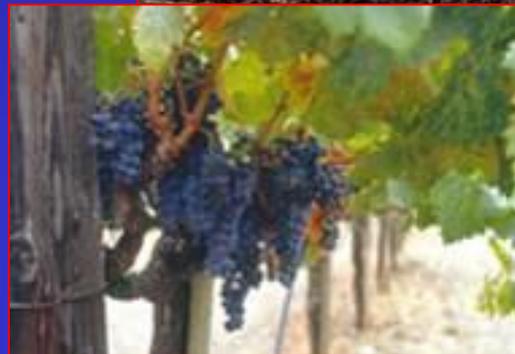
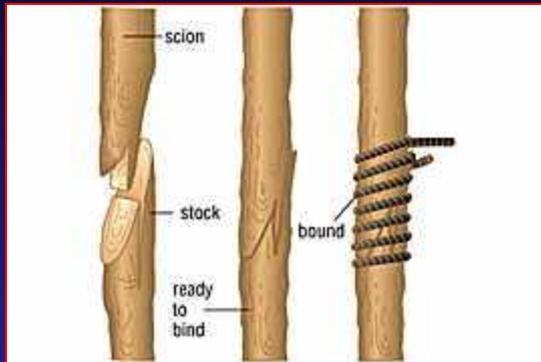


# Breeding Is Genetic Modification

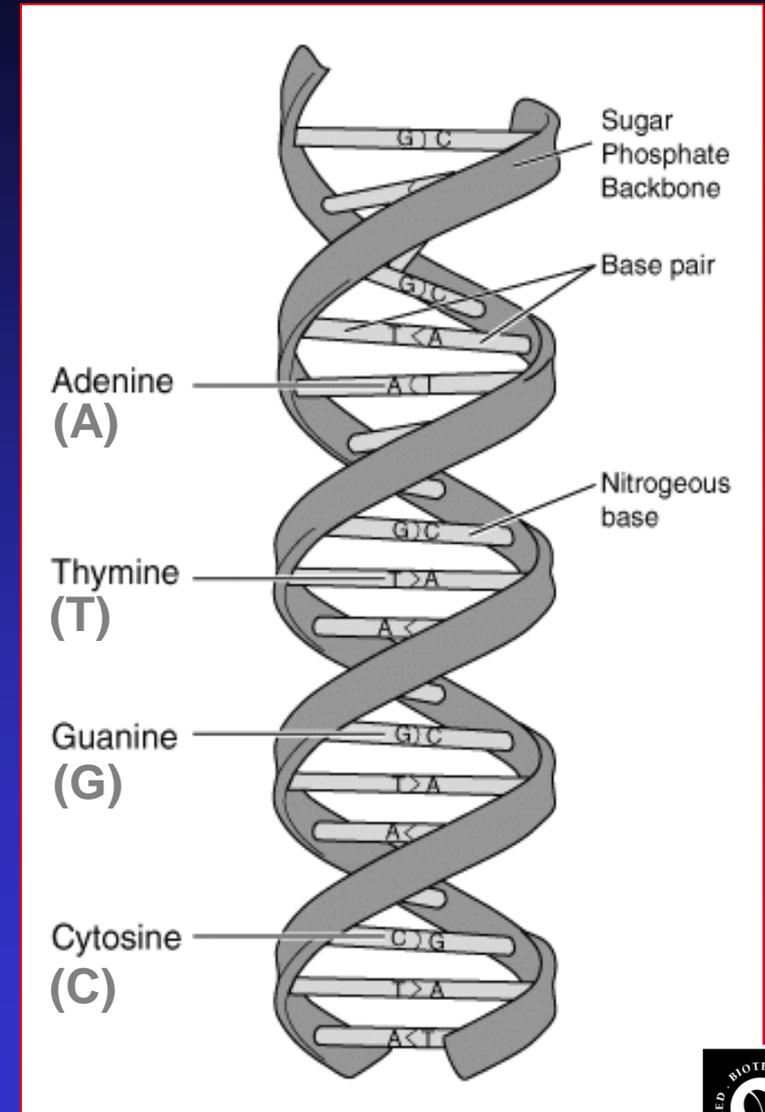
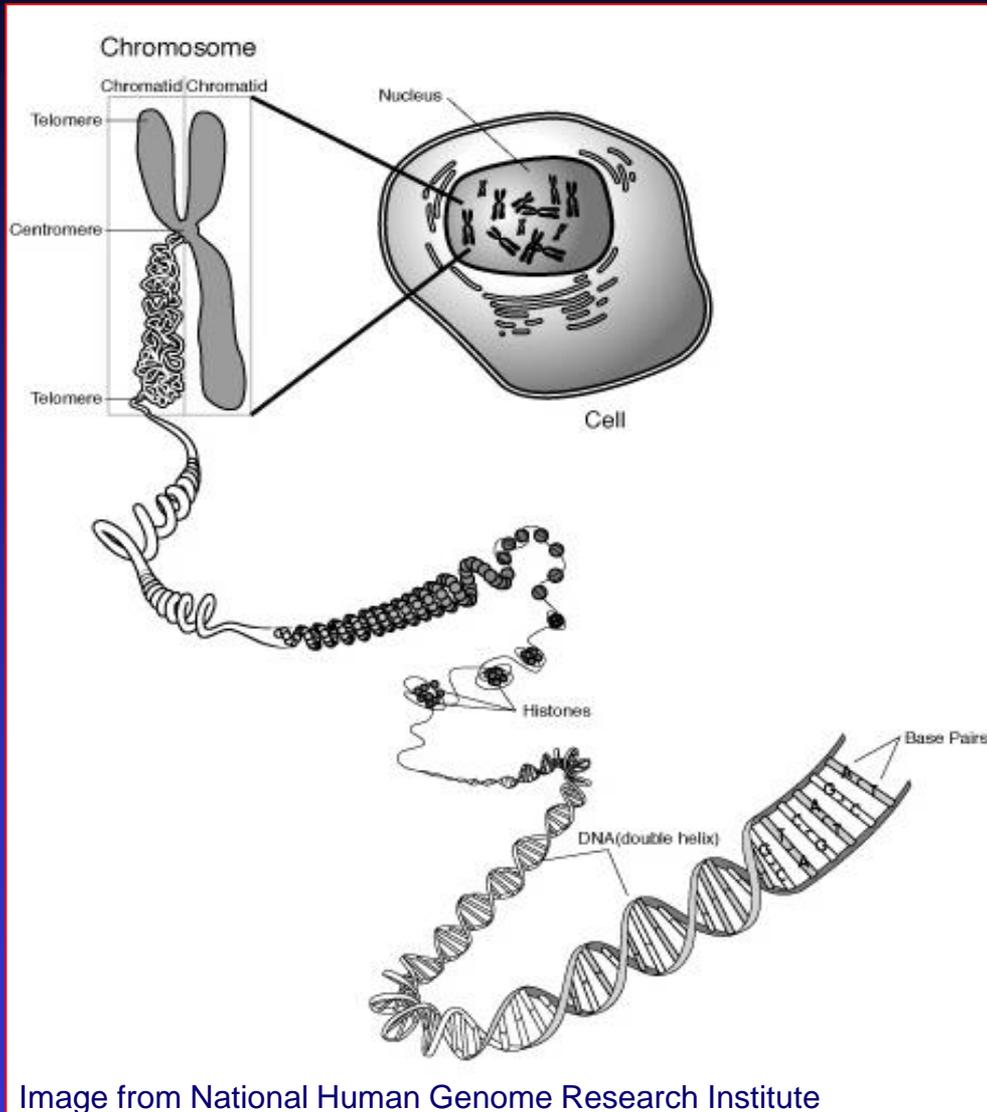
Through the application of genetics, breeders have directed changes in the genetic characteristics of plants and animals to achieve desired results.



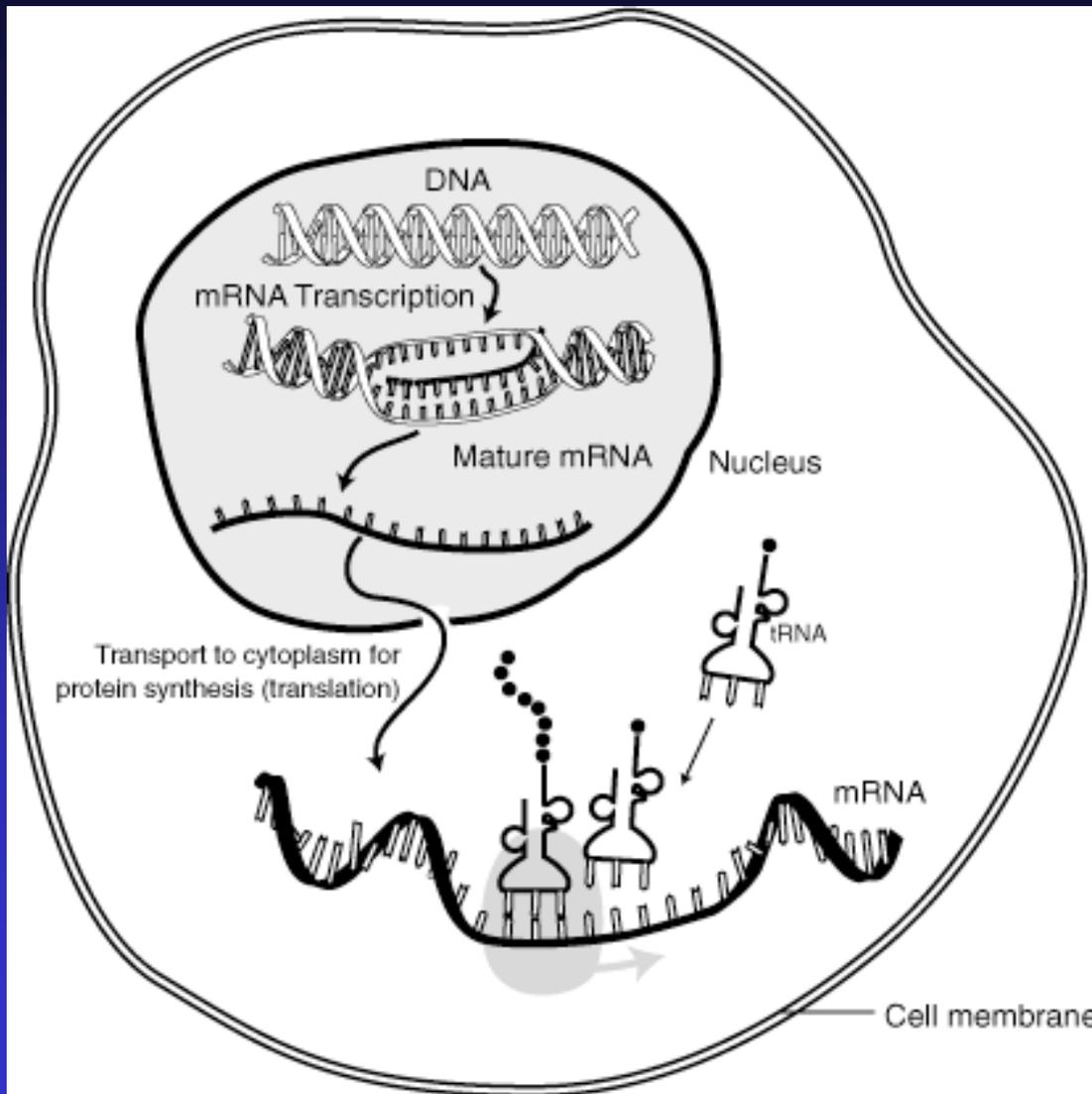
# Plant Species Are Combined by Grafting



# DNA in the Chromosomes Carries Biological Information



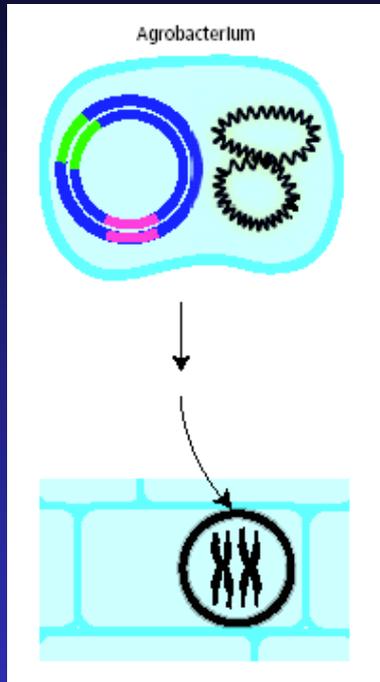
# DNA $\Rightarrow$ RNA $\Rightarrow$ Protein



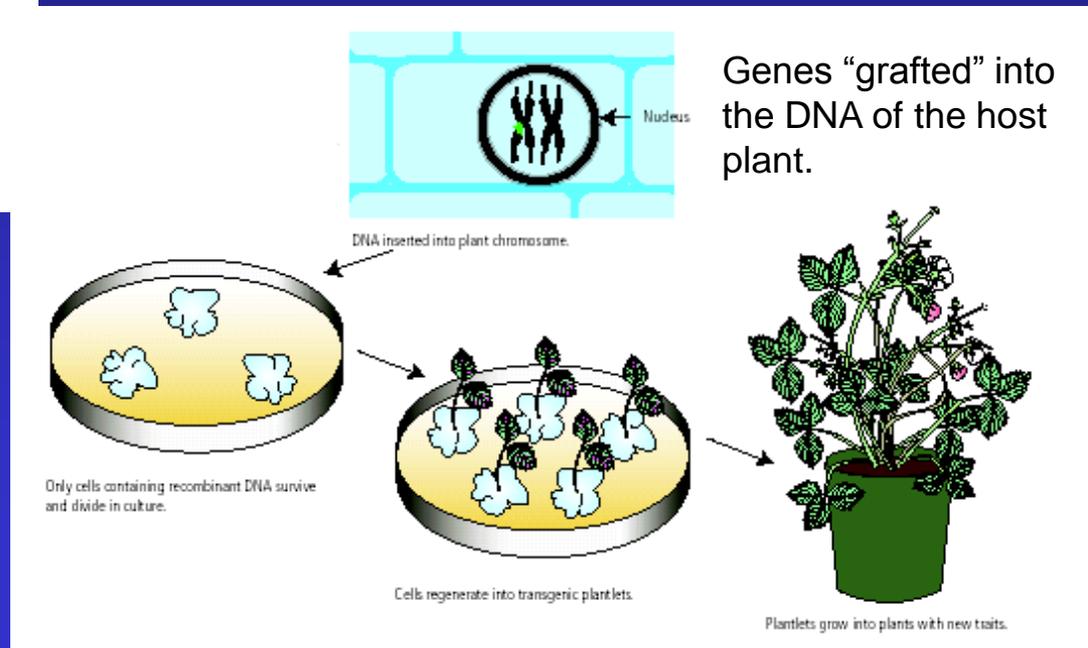
The fundamental concept of molecular biology is that the information in the DNA sequence is **transcribed** into mRNA, which is then **translated** into proteins.

Proteins are large molecules that are the enzymes and structural components of living cells.

# Genes Can be Transferred by Recombinant DNA

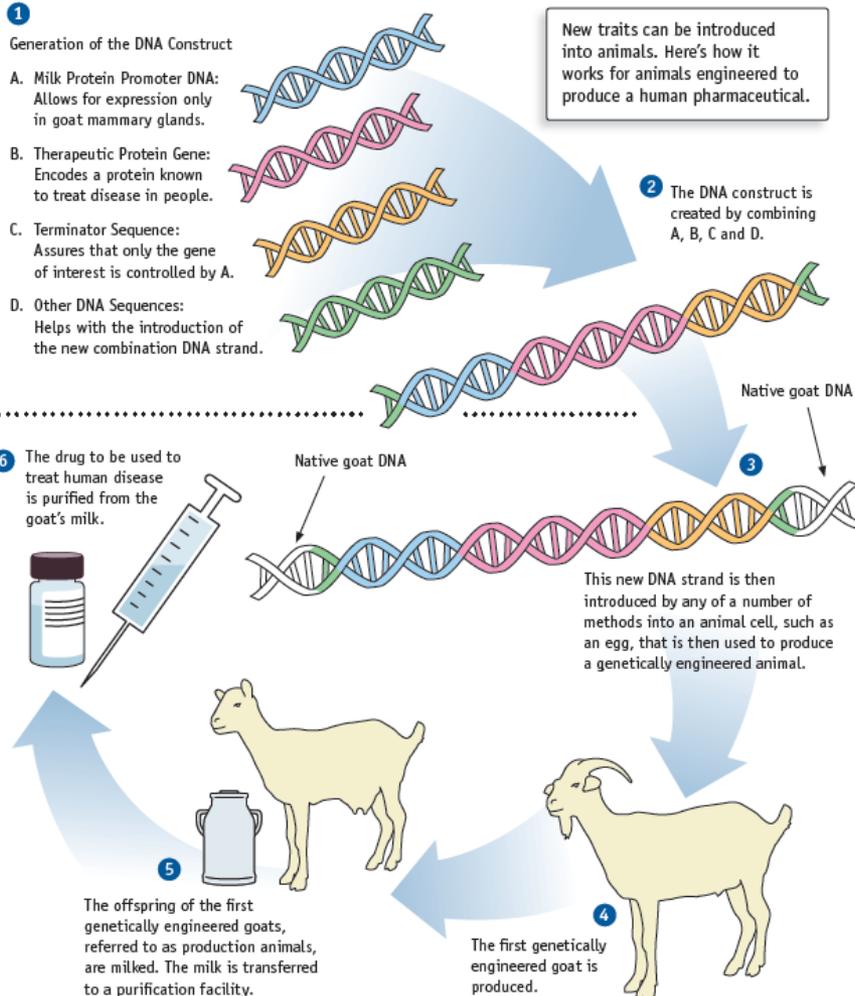


Recombinant DNA techniques can now be used to transfer specific genes among organisms. Crop plants, for example, can be “transformed” by transferring a desired gene into the plant cells and then regenerating those cells into an entire plant. Essentially, individual genes can be “grafted” into the chromosomes of another plant.



# Genes Can be Transferred by Recombinant DNA

## Genetically Engineered Animals



Similar methods can be used to transfer DNA among animals.

This might be used to produce therapeutic proteins for humans or enhance animal health.

Enhanced lysozyme in milk is effective in reducing diarrhea in young animals, for example.



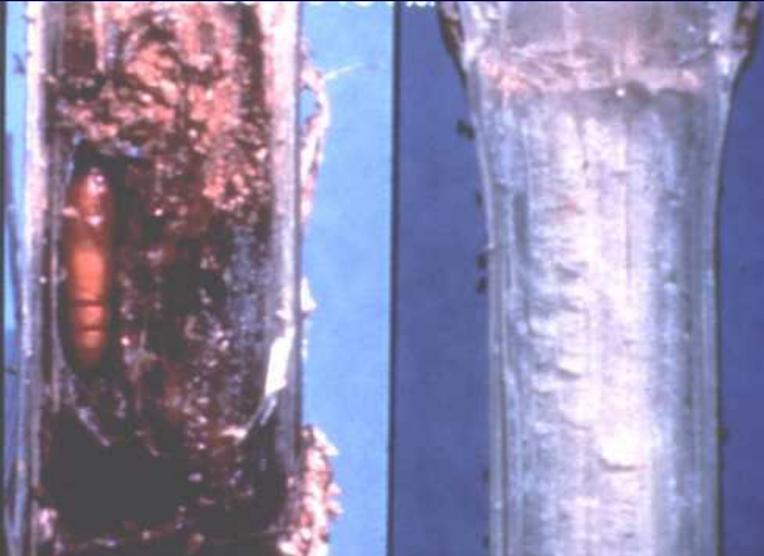
# What Is Genetic Engineering?

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- The USDA's current definition of genetic engineering is “manipulation of an organism's genes by introducing, eliminating or rearranging specific genes using the methods of modern molecular biology, particularly those techniques referred to as recombinant DNA (rDNA) techniques.”
- Also known as genetically modified, GMO, transgenic, bioengineered, biotech, made with modern biotechnology, etc.



# *Insect-resistant Bt Corn and Cotton*



*Regular maize*

*Bt maize*



*Regular cotton*

*Bt cotton*

Council for Biotechnology Information

Corn borer

Bollworm

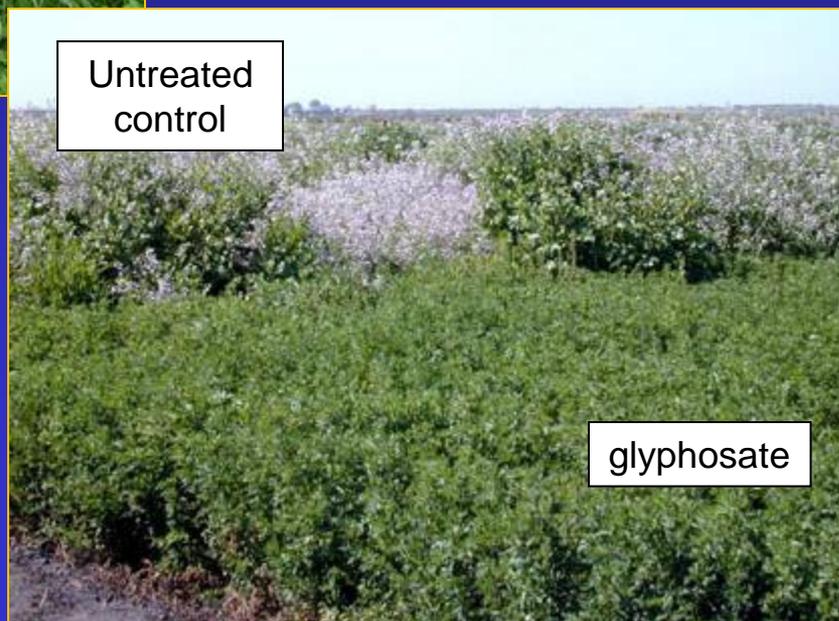
Grafting of a single gene from a bacterium into maize and cotton enables them to resist insect attack without insecticides. This has greatly reduced the use of chemical insecticides in these crops.



# Herbicide-Tolerant Crops Improve Crop Establishment



Herbicide-tolerant alfalfa allows the establishment of weed-free crops, which results in, higher yields and better forage quality.



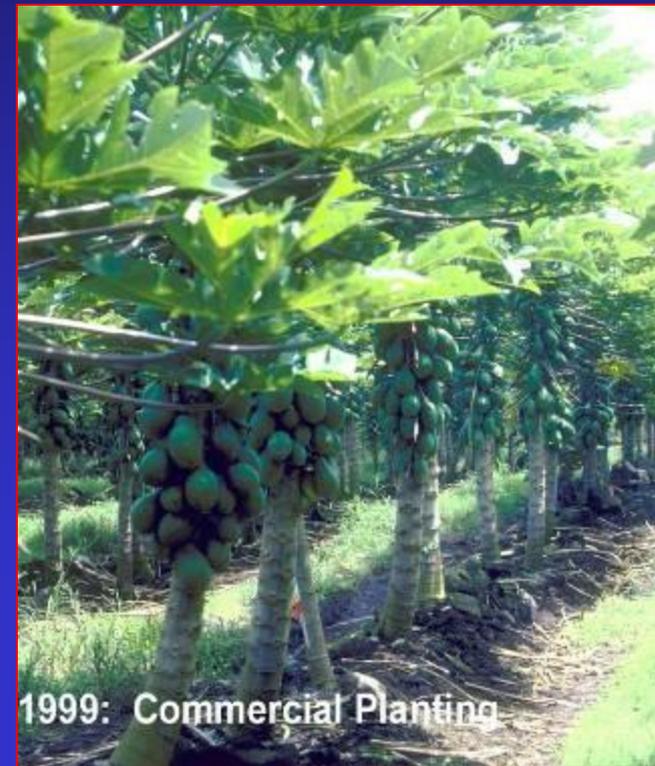
Van Deynze et al. 2004. ANR  
Publication 8153  
<http://anrcatalog.ucdavis.edu>



# Virus-resistant Crops



By 1995, Papaya ringspot virus had devastated the Hawaiian papaya industry.



Virus resistance introduced via rDNA techniques re-established the industry in Hawaii.

Photos by D. Gonsalves

# Where is rDNA used in Animal Agriculture?

GE products are used in animal feed, vaccines (chickens, pigs, horses, dogs, cats), pharmaceuticals and food processing aids.

Feed



Vaccines  
rBST



Food &  
ingredients



GE rennin (chymosin made in fungi or bacteria) and other food processing aids

# Is GE Food Safe? YES

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## 600+ published safety assessments

An estimated 2 trillion meals containing GM ingredients have been eaten around the world over the last 18 years without a single substantiated case of ill-health due to GE.

### Some summary statements of leading science organizations include:

- “No effects on human health have been shown as a result of the consumption of such foods by the general population in the countries where they have been approved.” **(World Health Organization)**
- “No adverse health effects attributed to genetic engineering have been documented in the human population.” **(US National Academy of Sciences)**
- “The science is quite clear: crop improvement by the modern molecular techniques of biotechnology is safe.” **(American Association for the Advancement of Science)**
- “No scientific evidence associating GMOs with higher risks for the environment or for food and feed safety than conventional plants and organisms.” **(European Commission)**

# Labelling of GE Foods

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- A number of states (29) have proposed legislation to require mandatory labeling of foods produced from GE plants or animals.
- Initiatives have been defeated narrowly in California and Washington. Legislation has been passed in Vermont.
- Most refer to the consumers' right to know what is in their food.
- FDA and courts have ruled that simply a desire to know information not directly related to the composition of the food should not be sufficient to require mandatory labeling.
- Additional food costs (\$200 to \$400 per year per family) would be associated with mandatory labeling.
- Alternatives to mandatory labeling already exist, including voluntary non-GMO labels and organically certified foods.



# Exemptions for Labelling of GE Foods

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Food containing ingredients derived from GE plants will have to be labeled unless....

## **EXEMPTIONS**

- Food consisting entirely of, or derived entirely from, an animal that has not itself been genetically engineered, regardless of whether the animal has been fed or injected with any food produced with GE or any GE drug.
- Any processed food made with GE processing aids.  
[This exempts GM chymosin used in cheese production.]
- Until July 1, 2019, any processed food that would be subject to this section solely because it includes one or more materials produced by genetic engineering, provided that the engineered materials do not account for >0.9% (0.5% in CA Prop 37) of the total weight of the processed food.
- Food that has been lawfully certified to be labeled, marketed, and offered for sale as “organic”.



# Labelling of GE Foods

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## Some statements of leading science organizations on labelling:

- “There is no scientific justification for special labeling of bioengineered foods. Bioengineered foods have been consumed for close to 20 years, and during that time, no overt consequences on human health have been reported and/or substantiated in the peer-reviewed literature.” (**American Medical Association**)
- “The World Health Organization, the American Medical Association, the U.S. National Academy of Sciences, the British Royal Society, and every other respected organization that has examined the evidence has come to the same conclusion: consuming foods containing ingredients derived from GM crops is no riskier than consuming the same foods containing ingredients from crop plants modified by conventional plant improvement techniques.

The FDA does not require labeling of a food based on the specific genetic modification procedure used in the development of its input crops. Legally mandating such a label can only serve to mislead and falsely alarm consumers.” (**American Association for the Advancement of Science**)

# *Why Use Agricultural Biotechnology?*

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## Because agricultural biotechnology:

- extends a proven biological method (genetic improvement) that has been remarkably successful in increasing crop and animal productivity and quality;
- enables the use of traits from diverse sources;
- can reduce pesticide use and preserve soils;
- can improve nutritional content and improve health;
- can make food production more efficient so that land can be preserved for wildlife and biodiversity.



## ***For More Information***

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<http://www.ucbiotech.org> -- University of California Biotechnology Education

<http://sbc.ucdavis.edu> -- Seed Biotechnology Center, UC Davis

<http://biofortified.org> -- Biology Fortified, Inc.

<http://gmoanswers.com> – Council for Biotechnology Information

