Science on Your Plate:
Consumer perceptions of food biotechnology

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PROFESSOR AND CHAIR

Learning Objectives

- Define the history of biotechnology in the food system
- Describe the types of foods that are genetically modified
- Describe the scientific evidence for safety of biotechnology in food
- Describe the motivations for public discord relative to food biotechnology

Nutrition and food are in the news and in government policy more than any time in history

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What drives decisions?

Scientific evidence – facts

Perceptions – beliefs

"*Everyone is entitled to his own opinion, but not to his own facts*"

Daniel Patrick Moynihan

Disconnect

55% of population is trying to lose weight

85% do not know their calorie requirement

77% do not meet DHHS activity recommendations

IFIC Foundation, Food and Health Survey, 2012

72% of consumers stated they know nothing or very little about farming

70% said purchasing decisions were affected by how food is grown and raised

National Farmers and Ranchers Alliance survey, 2011

Science and facts have less influence

"I'm part of a moms group. When there is a big consensus, I think 'There's something here.' You don't need doctors or scientists confirming it when you have hundreds of moms."

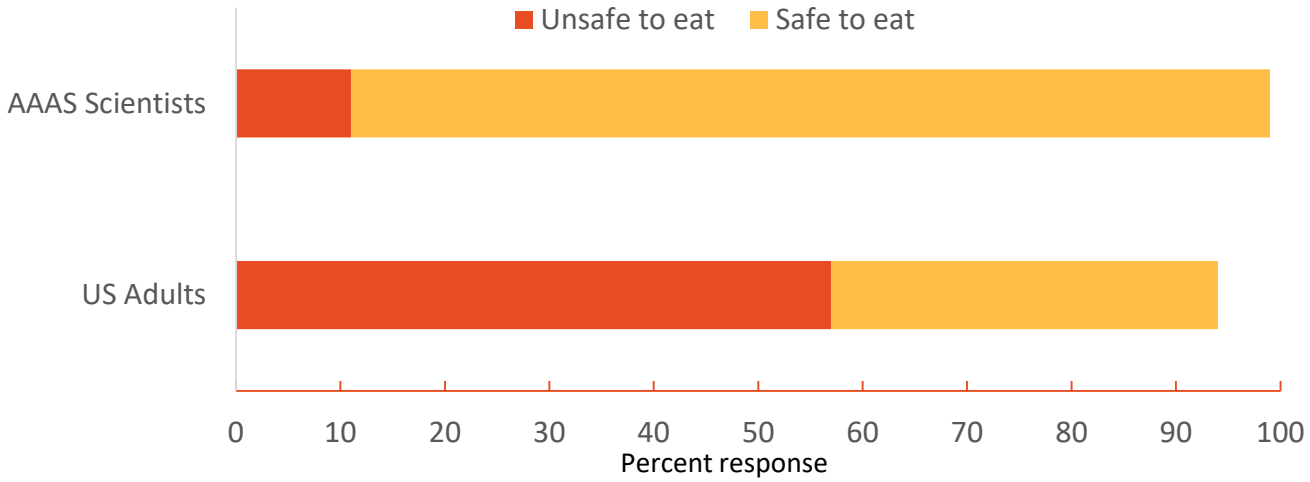
Heidi, CFI Moms panel on GMOs, Orlando, April 2013

Center for Food Integrity 2014 Consumer Trust Research

Conflict

88% of scientists think eating GMO foods is safe

37% of public believe that they are safe



https://www.geneticliteracyproject.org/2015/01/29/pewaaas-study-scientific-consensus-on-gmo-safety-stronger-than-for-global-warming/

Can we ever prove ‘safe’ ?

The FDA, USDA and EPA have defined chronic reference dose (RfD) for pesticide residues in food.

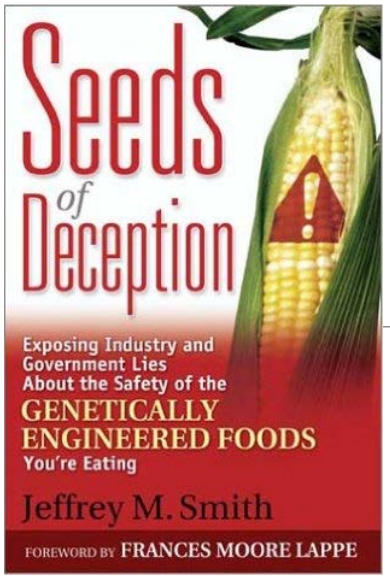
“*Chronic dietary exposure to pesticides….continue to be at levels far below those of health concern*.”

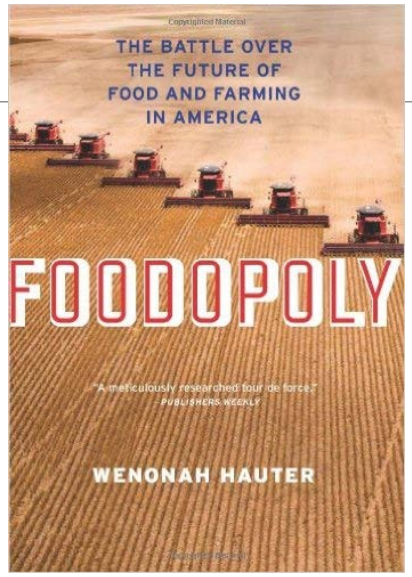
(Winter, C. 2015, Int J Food Contamination)

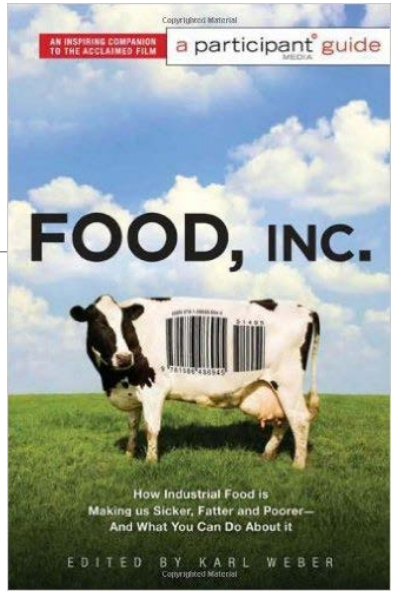
“*But some scientists say there is little to no data to back up that claim, stating that regulators do not have sufficient comprehensive research regarding how consumption of residues of multiple types of pesticides impact human health over the long term, and government assurances of safety are simply false*.”

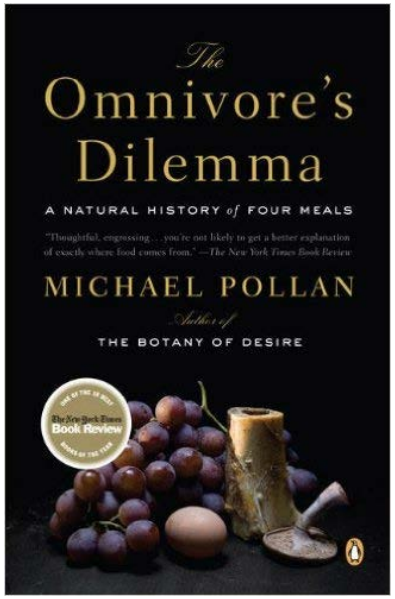
(EcoWatch: http://www.ecowatch.com/usda-pesticide-exposure-2105041546.html)

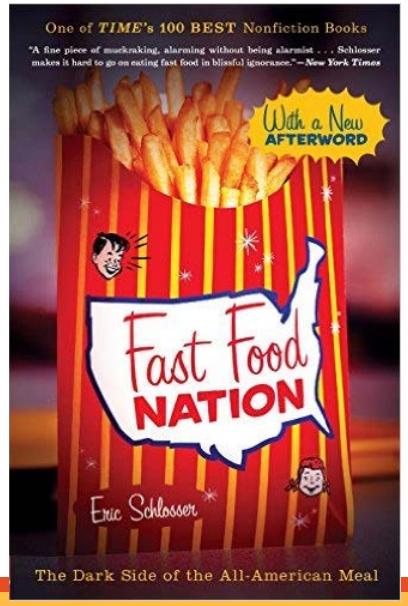
Popular press











Defining GMO

Definition of GMO

Genetic engineering: 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 techniques.

Genetically engineered organism (GEO): An organism produced through genetic engineering.

Genetic modification: The production of heritable improvements in plants or animals for specific uses, via either genetic engineering or other more traditional methods. Some countries other than the United States use this term to refer specifically to genetic engineering.

Genetically modified organism (GMO): An organism produced through genetic modification.

https://www.usda.gov/wps/portal/usda/usdahome?contentid=biotech_glossary.html

Genetics

Molecular Structure of Nucleic Acids (1953) Nature 171; 737-738

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

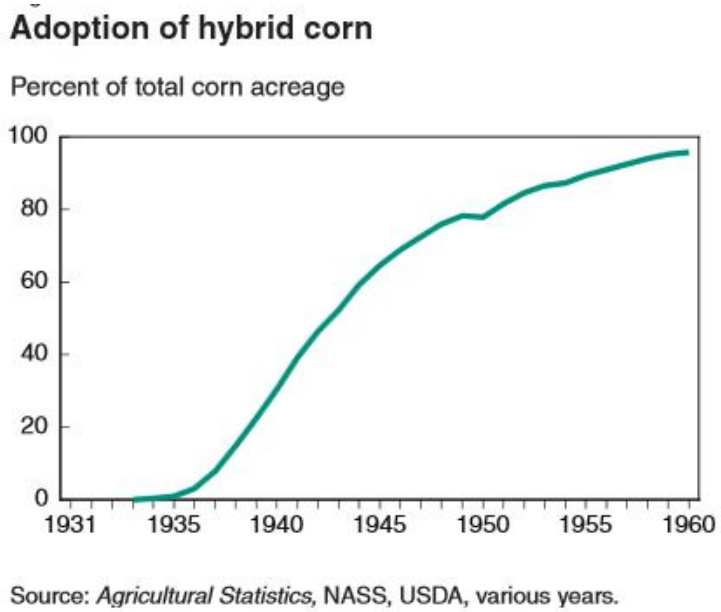
Hybrid corn
(conventional genetic manipulation)

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



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

- Rice has 32-50,000 genes
- Mice have 24,174 genes
- Humans have 20-25,000 genes

Human and pumpkin genomes are 75% similar

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 or editing of DNA sequences

Definition of Agricultural Biotechnology

Agricultural biotechnology is the application of scientific techniques, including genetic engineering, to create, improve or modify plants, animals and microorganisms.

Agricultural biotechnology improves upon conventional techniques, such as selective breeding, by enabling scientists to move genes and the desirable traits that they express with greater efficiency and precision.

USDA, 2003

Two examples of GMO crops

ROUNDUP® READY

RoundUp® is glyphosate

- Inhibits shikimate pathway

Made by Monsanto

Gene from *Agrobacterium tumefaciens* inserted into plant

Allows plant to survive exposure to glyphosate

- Herbicide tolerant

BACILLUS THURINGIENSIS (Bt)

Bt toxin approved as natural pesticide since 1960s

Bt gene inserted into plant

Plant produces Bt pro-toxin that kills corn borer insect

Bt pro-toxin has no effect on humans

- Pest resistant

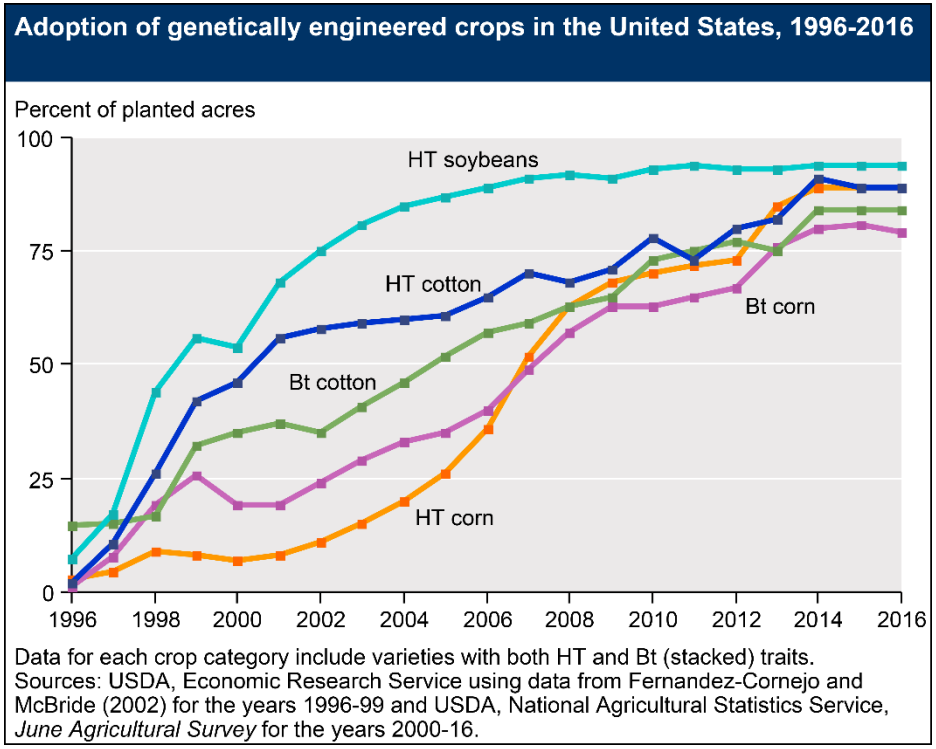
Path to GMO crops

Bacterial genes inserted into plants 1983

Technology advanced during 1990s

Entered the US food supply in 1996

Herbicide tolerant (HT) soybeans, cotton and corn and pest resistant (Bt) cotton and corn quickly adopted



Advantages of GMO

Save plant variety from disease – papaya

Higher yields – less competition from pests

Higher quality crops – less insect and disease damage

Lower inputs – less pesticides, herbicides; less fuel use

Able to use no-till practices – reduced release of carbon and greenhouse gases; less topsoil loss

Faster more efficient growth – salmon

Enhanced nutrient composition – Golden Rice and oilseeds

Less food waste – apples

Reduced plant toxins - potatoes

Criticisms of GMO

Loss of plant diversity – monoculture in agriculture

Increased use of a few chemicals, risks to humans and environment

Weed resistance

Seed ownership and patents by big companies

Ethical concerns about determining nature

Environmental damage from genetic drift

Risks to human and animal health

Lack of transparency in food production

Application of GMO

Herbicide tolerance

Insect resistance

Virus resistance

Ripening delayed

Amino acid composition

Fatty acid composition

Modified color

Nicotine reduced

Plant quality

Starch hydrolysis

Increase yield

Increase quality

Reduce use of chemicals

Reduce waste

Nutrition improvement

NONE OF THESE ARE IMPORTANT TO CONSUMERS

Until the benefits of GM technology to consumers outweigh any perceived risk, acceptance will be challenging to attain.

Conventional – Organic – Natural – Genetically Modified: Which is which?

Food sources of GMO

Currently in the food supply

Corn

Soybean

Canola

Sugar beets

Papaya

Squash

Approved – coming soon

Apples

Eggplant

Melon

Plum

Potato

Rice

Salmon

Sweet pepper

Tomato

“70-80% of processed foods have GMO”

Corn
- Sweeteners (HFCS)
- Corn starch
- Corn oil
- *Animal feed*

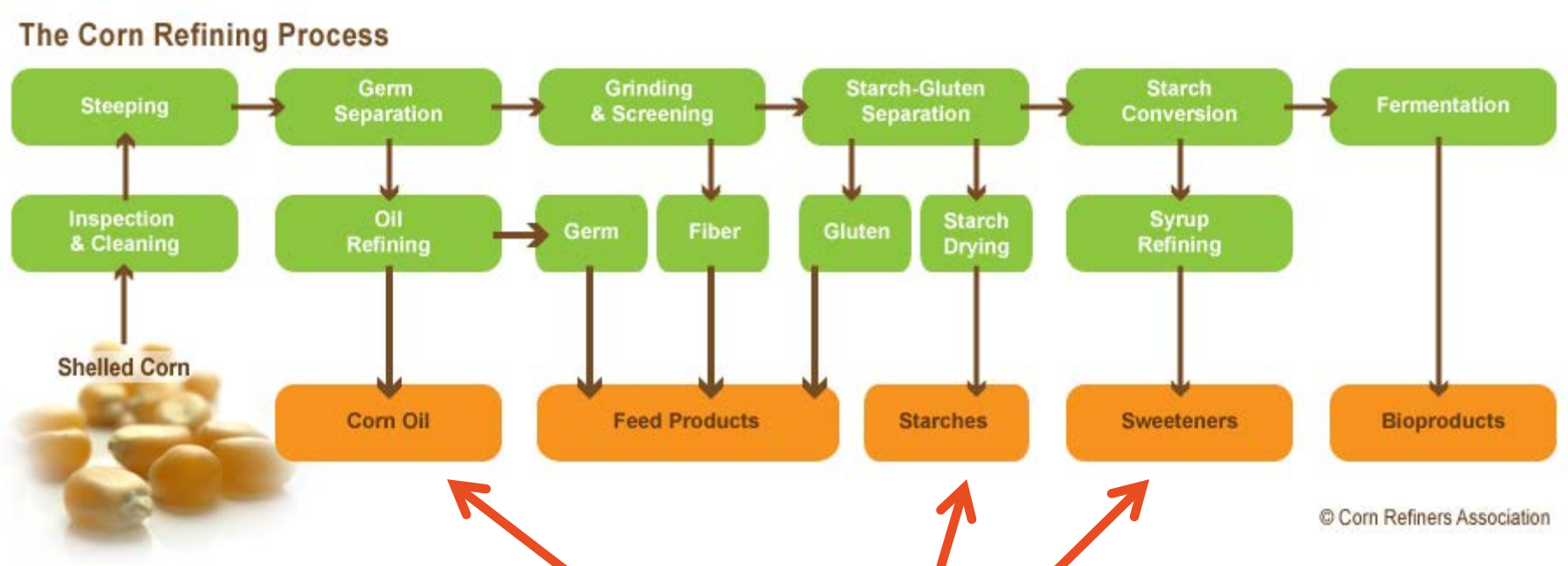
Soybean
- Soy flour - proteins
- Soy oil
- *Animal feed*

Canola
- Canola oil

Sugar beets
- Sugar

Alfalfa
- *Animal feed*

Where goes the GMO?



No DNA or protein
in products for human food – so
are these still GMO??

Digestion basics…

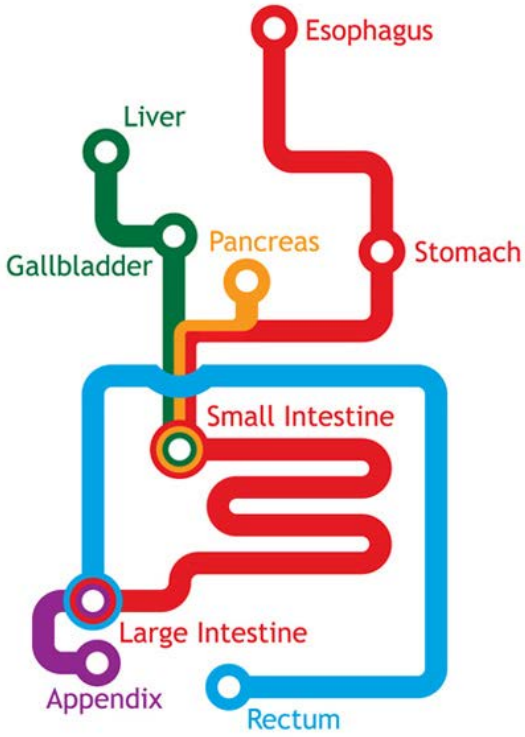
All plant and animal foods have DNA and proteins

Consumed food is digested into basic units:
- DNA → nucleotides
- Proteins → amino acids

The basic units are absorbed into the body and used to make *human* DNA and proteins

Intact DNA or protein from food is NOT absorbed directly into our bodies

GMO DNA and protein is digested like all other sources



BUT is GMO safe?

FDA policy

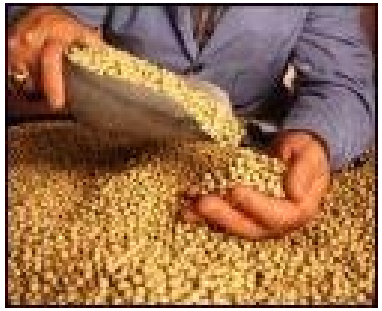
In the 1992 policy, FDA also addresses the labeling of foods derived from new plant varieties, including plants developed by bioengineering.

The 1992 policy does not establish special labeling requirements for bioengineered foods as a class of foods.

The policy states that FDA has no basis for concluding that bioengineered foods differ from other foods in any meaningful or uniform way, or that, as a class, foods developed by the new techniques present any different or greater safety concern than foods developed by traditional plant breeding

http://www.fda.gov/food/guidanceregulation/guidancedocumentsregulatoryinformation/ucm059098.htm

Safety testing

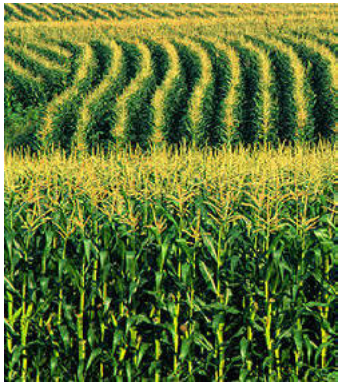


Safety assessments begin with concept of product

No variety is released without substantial safety evidence

Research on safety

- Nutrient and chemistry same as non-GMO
- No inadvertent compounds – no allergens
- Transfer and/or breakdown of trait
- Environmental safety



Independent researchers

- Animal studies
- Environmental studies

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

National Academies of Sciences report 2016

"…the committee found no differences that implicate a higher risk to human health from GE foods than from their non-GE counterparts."

National Academies of Sciences, Engineering, and Medicine. 2016. Genetically Engineered Crops: Experiences and Prospects. Washington, DC: The National Academies Press. doi:10.17226/23395.

Defining ‘Safe’

Risk-Benefit (no risk?)

Exposure – dose

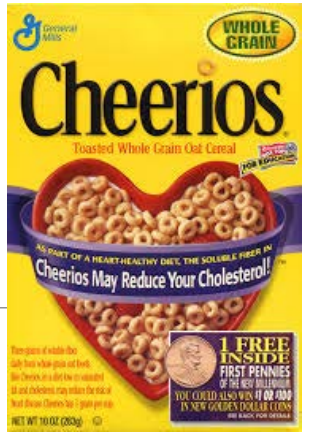
Long term vs short term

Safe to who-what-when?

When it comes to food, people want no risk!
Which is not achievable….

Mandatory GMO labeling

Purpose of food labeling



Regulated by FDA

Standard of identity

Quantity (weight/volume)

Food composition and ingredients

Manufacturer name and address

Nutrition facts panel

Allergens

- (eggs, fish and seafood, milk and lactose, peanuts and tree nuts, soy, wheat and gluten)

Nutrition Facts

Serving Size 2/3 cup (55g)
Servings Per Container About 8

Amount Per Serving	
Calories 230	Calories from Fat 72
	% Daily Value*
Total Fat 8g	**12%**
Saturated Fat 1g	**5%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 160mg	**7%**
Total Carbohydrate 37g	**12%**
Dietary Fiber 4g	**16%**
Sugars 1g	
Protein 3g	
Vitamin A	10%
Vitamin C	8%
Calcium	20%
Iron	45%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily value may be higher or lower depending on your calorie needs.

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Current GMO labeling policy

Signed by President Obama in July 2016 – *National Bioengineered Food Disclosure Standard*

Requires USDA to define how the bill (S.764) will be implemented

Three options for labels

- Label on the food package
- USDA symbol on the package (to be created)
- Electronic access – either a QR code, website or toll-free phone number

Defines GMO food as: "(Food) *that has been modified through in vitro recombinant deoxyribonucleic acid techniques; and for which the modification could not otherwise be obtained through conventional breeding or found in nature.*"

Labeling requires monitoring

USDA now needs to define levels of GMO, ingredient tracking and industry regulations – to implement the bill

Industry tracking of ingredients and production methods will add to food costs

More inspectors needed to educate and monitor industry

Shift in the commodity markets to generate more non-GMO ingredients

Foods will cost more – with no added safety to consumers

The future is changing…

Ancient times – Cross breeding and selection created new plant and animal varieties

1940s – Mutation breeding used carcinogens, mutagens and radiation to induce random genetic changes in plants

1990s – Genetic engineering used highly controlled gene insertion to induce genetic changes in plants and animals

2010s - Advances in molecular biology, such as CRISPR technology allow gene editing of plants and animals

Take home messages

Consumers make decisions based on perceived risk and benefits

No evidence that GMO foods have negative effects on health

Organically produced foods are not inherently safer or more nutritious than conventionally or GMO produced foods

Trends to eliminate food additives and GMO are more about marketing than health

Economics drives decisions for producers and manufacturers

Government policy decisions must be based on sound science

Research is essential – more funding is needed

Helpful websites

GMO Answers www.gmoanswers.com

Center for Food Integrity www.foodintegrity.org

Genetic Literacy Project www.geneticliteracyproject.org

IFIC www.foodsafetynews.com

Allow golden rice now www.allowgoldenricenow.org

Biology fortified www.biofortified.org