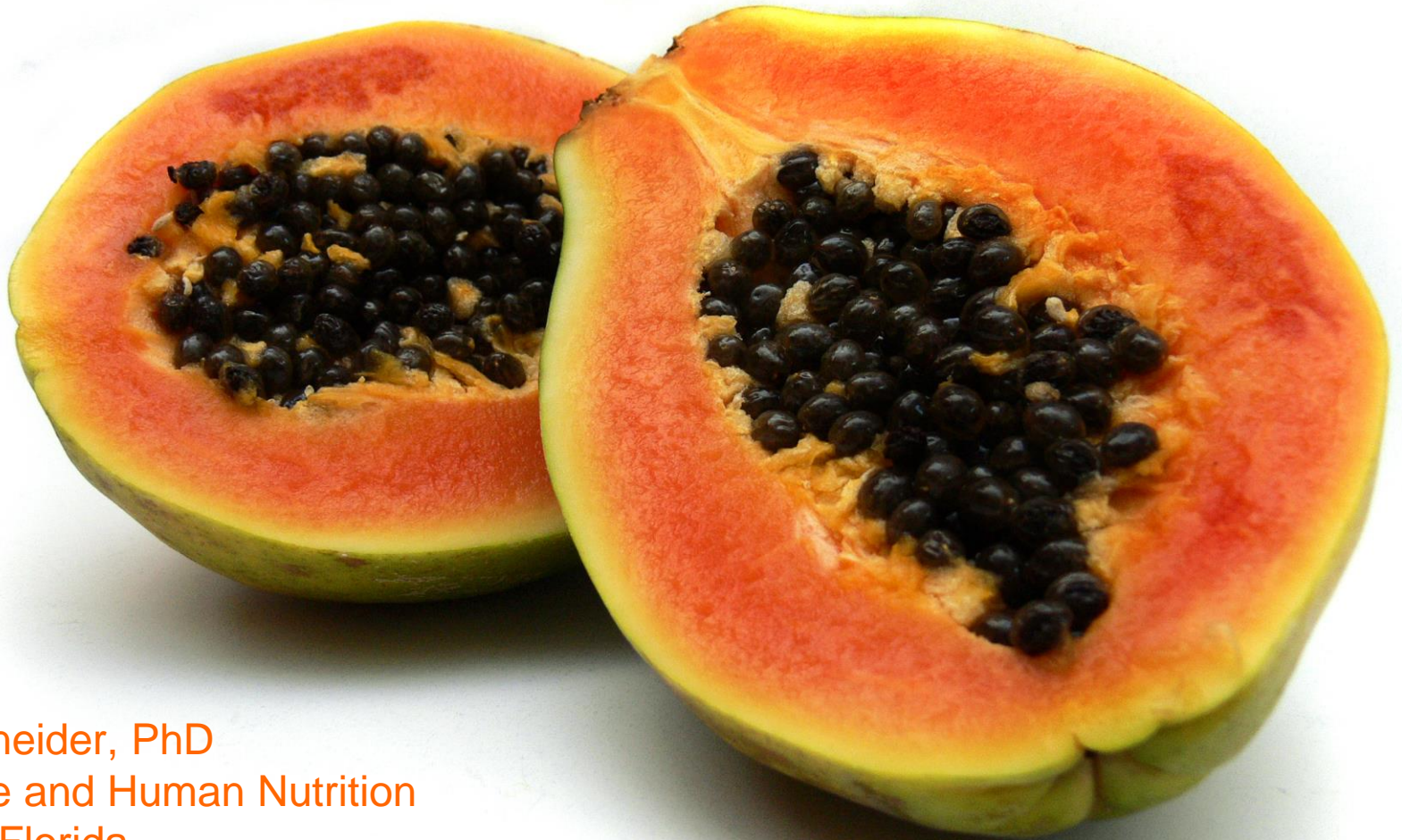


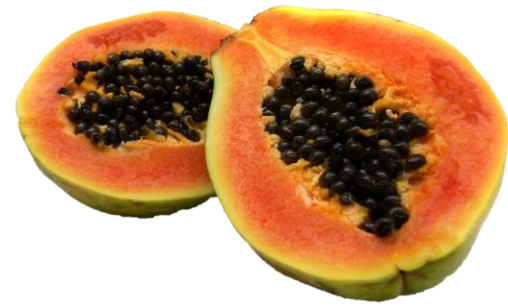
# What are GM foods and how are they produced?



Keith R. Schneider, PhD  
Food Science and Human Nutrition  
University of Florida  
May 15, 2014

# Introduction

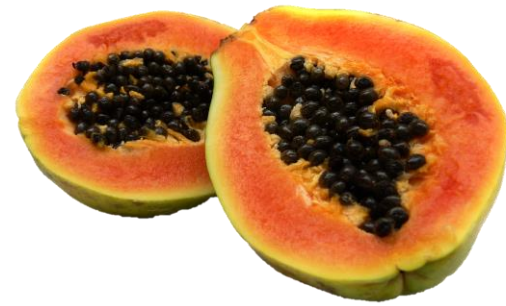
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- What is a GMO?
  - “Genetically Modified Organism (GMO)” means an organism in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination

# Genetically Modified Foods

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- Genetically Modified Organisms (GMO) or GM foods have been around for many years, not only in vegetables, but also in livestock and horticulture. Controversy has risen from the practice of gene splicing, rather than the traditional selective breeding.

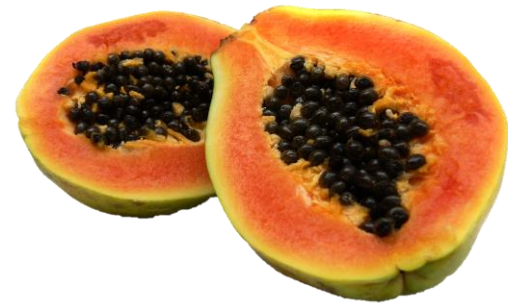
People are afraid their food is becoming.....

**Frankenfood!!!**



# Commonly Used Terms

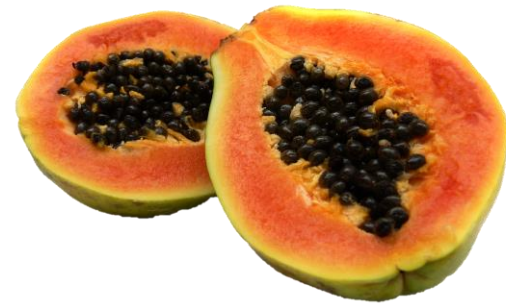
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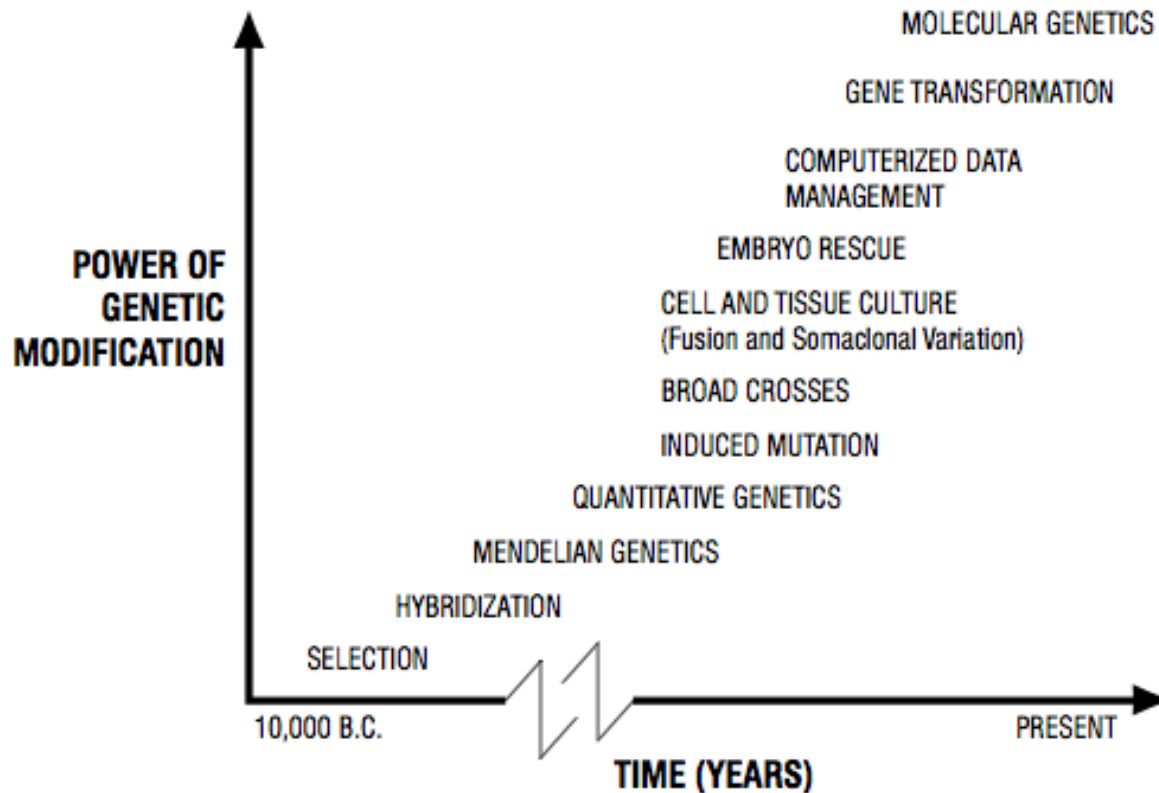
- **Genetically modified (GM):** An organism is considered genetically modified if its genetic material has been altered through any method. A "GMO" is a genetically modified organism.
- **Genetically engineered (GE):** An organism is considered genetically engineered if it was modified using techniques that permit the direct transfer or removal of genes in that organism. Such techniques are also called recombinant DNA or rDNA techniques.
- **Transgenic** organisms have a gene from another organism moved into them. For example, the plant product known as "Bt. corn" is a transgenic plant because it has a gene from the bacterium *Bacillus thuringiensis*



# GMO Timeline



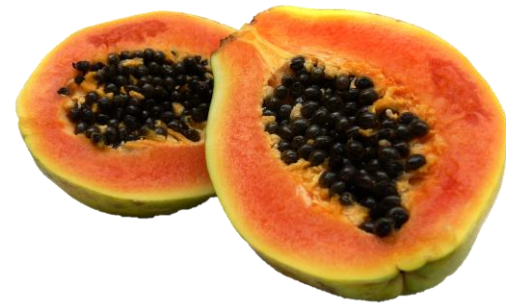
**Fig. 1—Increase in power of genetic modification over time. Adapted from NRC (1989)**





# History

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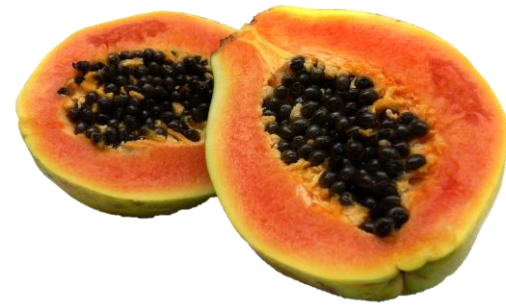
## Example: Wheat and Barley

- Wild traits:
  - Bear their seeds on top of a stalk that spontaneously shatters, dropping the seeds to the ground where they can germinate.
  - Difficult for humans to gather.
  - An occasional single-gene mutation that prevents shattering is lethal in the wild (because the seeds fail to drop), but conveniently concentrates the seeds for human gatherers.
- *Domestication*:
  - Once people started harvesting those wild cereal seeds, bringing them back to camp, accidentally spilling some, and eventually planting others, seeds with a non-shattering mutation became unconsciously selected for rather than against.



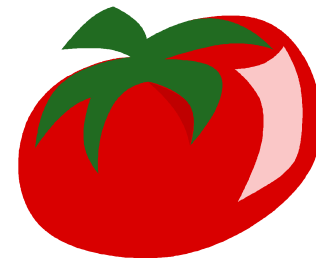
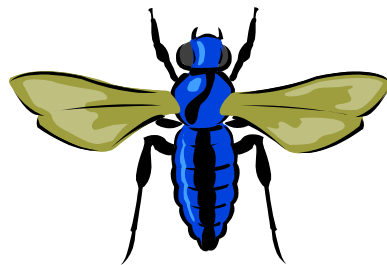
# Genetically Modified Foods

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Since the last century, humans have crossbred plants to make them tastier or hardier. Who can forget our first genetics course and the stories of Gregor Mendel crossing round peas with wrinkled peas in the 1860's...pure genius (Where would we be today without wrinkled peas?).

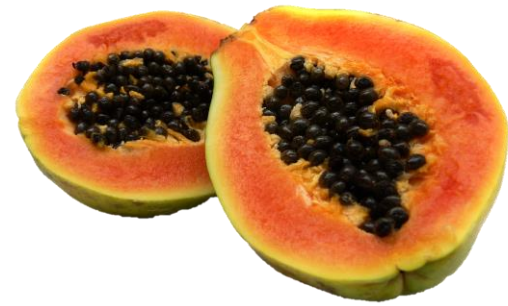
With the advent of new gene-splicing technology researchers are now able to remove individual genes from one species and insert them into another. This is called “**transgenic.**” A gene from a fish or a gene from a soil bacterium can be put into a tomato.



# How do you Genetically Engineer Something?

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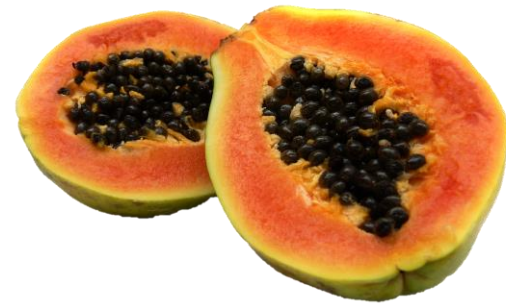


A GMO is a result of recombinant DNA biotechnological procedures that allows genes of one organisms to be modified by the incorporation of genes from another.

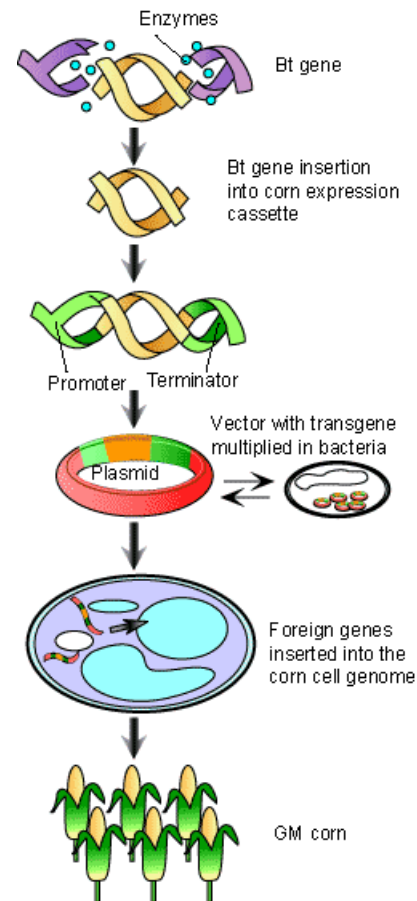




# How You Make a GM Food

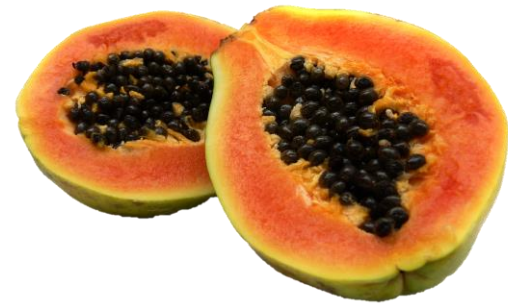


- Excise desired gene with restriction enzymes (RE).
- Use the same RE to open a space in target DNA.
- Once foreign gene is inserted it will produce the desired trait and pass that along to its offspring.



# Why Modify at All?

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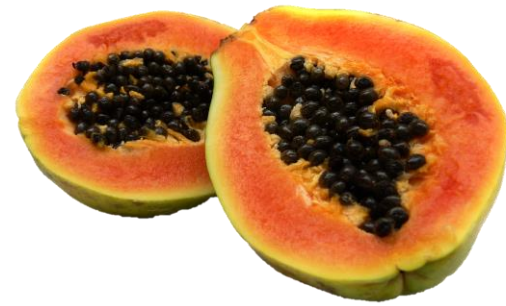


- Other than the widely popular wrinkled pea market, why mess around with Mother Nature in the first place?



# Genetically Modified Foods

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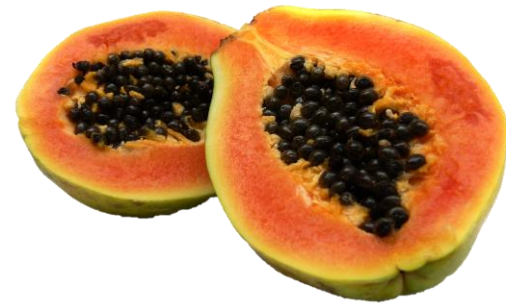


- One of the earliest uses of genetic modification was the insertion of a gene that made plants glyphosate-resistant
- Monsanto brought this herbicide to market in the 1970s under the trade name Roundup
- By inserting a gene that made crops resistant to Roundup, farmers could spray herbicides, control weeds, increase yields



# What's out there?

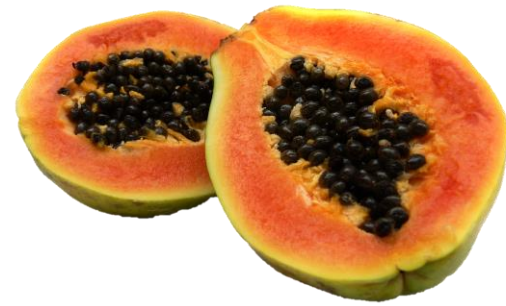
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- The number of releases: 4 in 1985 grew to 1,194 in 2002
- Averaged around 800 per year thereafter. However, while the number of releases peaked in 2002, other measures of research and development activity have increased very rapidly since 2005.
- Releases of GE varieties with agronomic properties (like drought resistance) jumped from 1,043 in 2005 to 5,190 in 2013.
- As of September 2013, about 7,800 releases were approved for GE corn, more than 2,200 for GE soybeans, more than 1,100 for GE cotton, and about 900 for GE potatoes.

# What's out there?

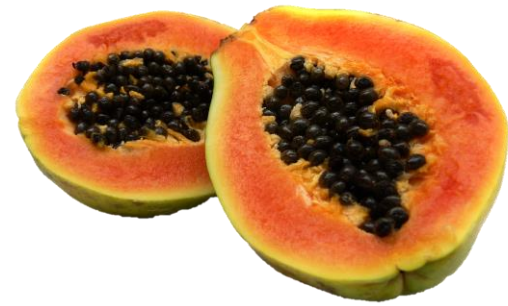
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- Herbicide tolerance - 6,772 releases
- Insect resistance - 4,809
- Product quality such as flavor or nutrition - 4,896
- Agronomic properties like drought resistance - 5,190
- Virus/fungal resistance (2,616).
- The institutions with the most authorized field releases include Monsanto (6,782), Pioneer/DuPont (1,405), Syngenta (565), and lastly USDA's Agricultural Research Service (370).

# What's out there?

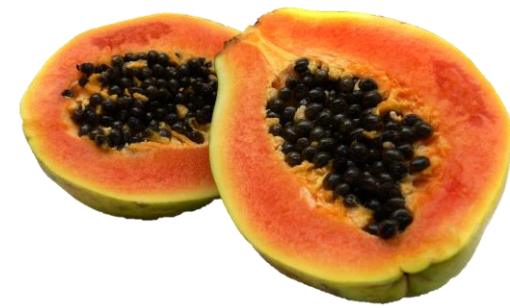
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- As of September 2013, APHIS (Animal and Plant Health Inspection Service) had received 145 petitions for deregulation (allowing GE seeds to be sold)
- Approved 96 petitions: corn (30); cotton (15); tomatoes (11); soybeans (12); rapeseed/canola (8); potatoes (5); sugarbeets (3); papaya (2), rice (2), and squash (2); and 1 each for alfalfa, plum, rose, tobacco, flax, and chicory.

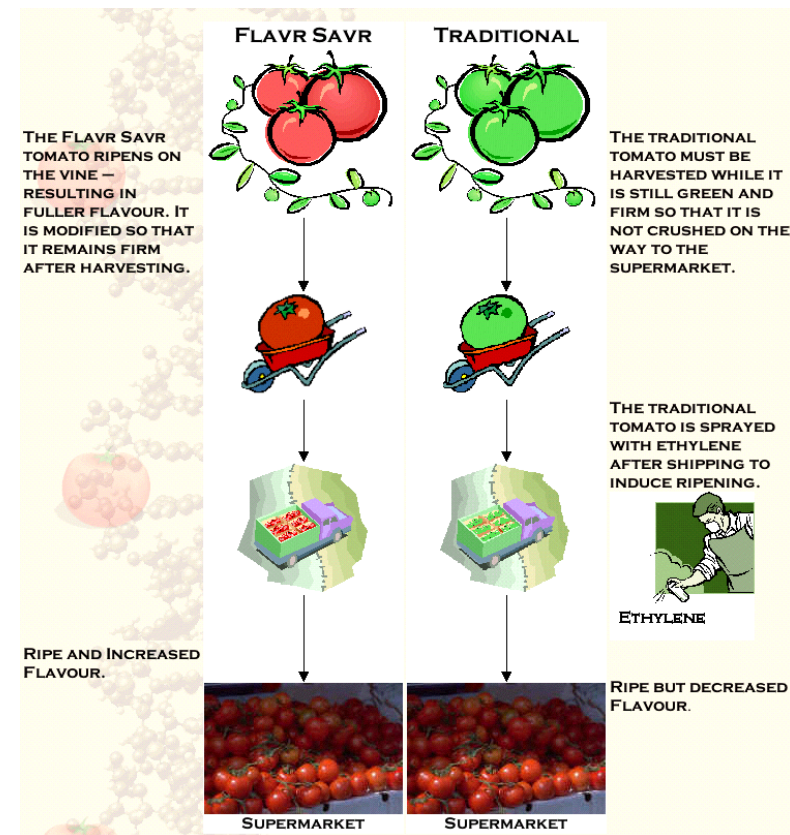


# Genetically Modified Foods



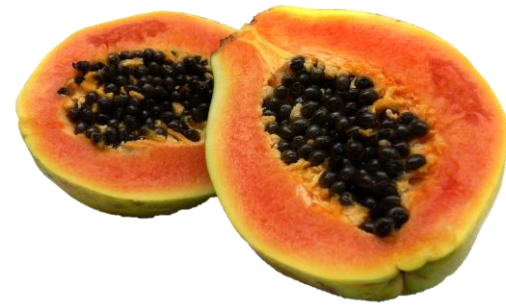
The first genetically modified crop to hit the supermarkets was the Flavr-Savr™ tomato. In 1993 the FDA approved this product by Calgene. It went on sale one year later, but in 1997, due to rising public concerns, and the need for specialized transportation equipment, production ceased.

The objectives of Calgene, (bought out by Monsanto) was to create a Tomato that would have a ripened taste, yet survive shipping. What they created was a controversy still being debated a decade later.



# Pros and Cons of GMOs

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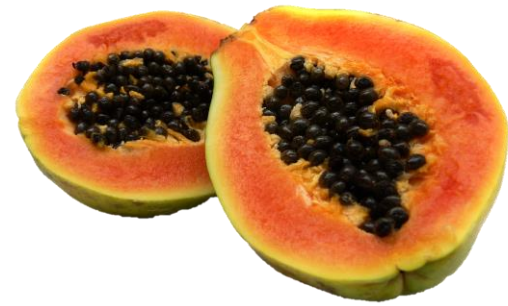
## Consumers

- Most consumer surveys and studies indicate a concern about foods containing GE components.
- This concern has had little effect on US markets.
- GE-free labels not widely used in the US.
- Manufacturers have been active in the creation of GE-free foods.



# GE Foods and Labels

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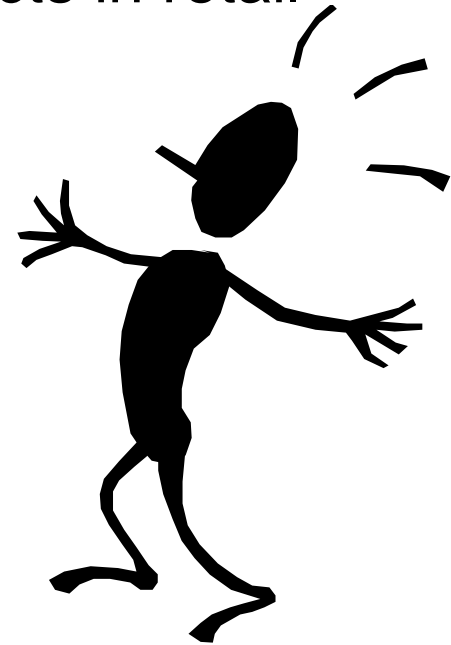


FDA does not require labeling. Food deemed to be “substantially equivalent” to their non-GE counterparts.

What is the estimated percentage of food products in retail stores already containing GMOs?

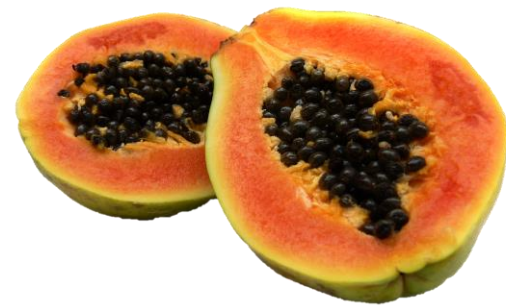
Anyone want to guess?

**60-70%**



# Genetically Modified Foods

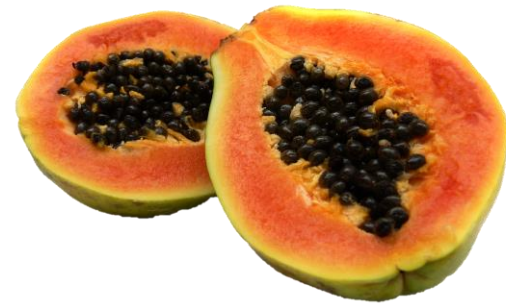
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Another example is GM product being used in production is chymosin (or rennin is a protease found in rennet), used in the manufacture of cheese. Approximately 90% of the hard cheeses made use GM produced chymosin.



# Unintended Consequences



What is your definition of healthy and nutrition?

<b>Total Carbohydrate</b>	45g	15%	17%
Dietary Fiber	3g	13%	13%
Sugars	15g		
Other Carbohydrate	27g		
<b>Protein</b>	5g		
Vitamin A		0%	4%
Vitamin C		0%	2%
Calcium		2%	15%
Iron		8%	8%
Vitamin D		0%	10%
Thiamin		4%	8%
Riboflavin		2%	10%
Phosphorus		10%	25%
Magnesium		10%	10%
Zinc		6%	8%

\* Amount in cereal. A serving of cereal plus skim milk provides 6g total fat, less than 5mg cholesterol, 170mg sodium, 350mg potassium, 51g total carbohydrate (21g sugars), and 9g protein.

\*\* Percent Daily Values are based on a 2,000 calorie diet. Your daily values 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
Potassium		3,500mg	3,500mg

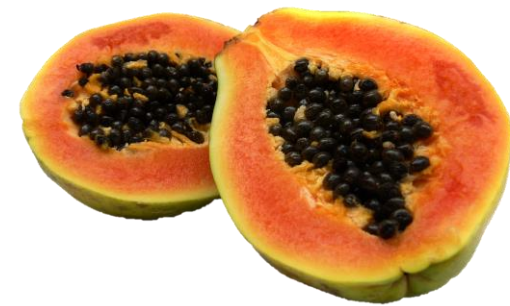
Sugars	9g		
Other Carbohydrate	12g		
<b>Protein</b>	1g		
Vitamin A		10%	15%
Vitamin C		25%	25%
Calcium		10%	25%
Iron		25%	25%
Vitamin D		10%	25%
Thiamin		25%	30%
Riboflavin		25%	35%
Niacin		25%	25%
Vitamin B <sub>6</sub>		25%	25%
Folic Acid		50%	50%
Vitamin B <sub>12</sub>		25%	35%
Phosphorus		6%	20%
Magnesium		2%	4%
Zinc		25%	30%

\* Amount in cereal. A serving of cereal plus skim milk provides 1.5g total fat, less than 5mg cholesterol, 200mg sodium, 260mg potassium, 29g total carbohydrate (14g sugars, 13g other carbohydrate), and 6g protein.

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



# Approved Microbes



**Table 2** GMOs approved for use in food processing<sup>a</sup>

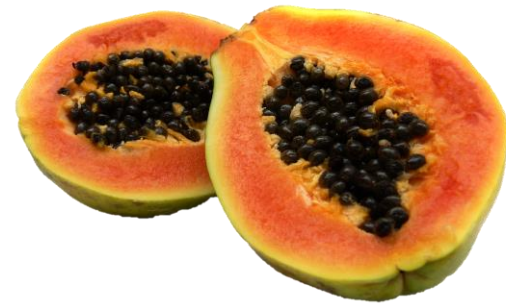
Microorganism	Function/benefit	Genetic modification
<i>Saccharomyces</i> (Bakers yeast)	Gas production in sweet, high-sugar dough	Switched promoter elements to allow constant expression of enzymes necessary for maltose fermentation
<i>Saccharomyces cerevisiae</i> (Brewers yeast)	Manufacture of low-calorie beer—starch degradation	Introduction of glucoamylase for degradation of dextran and production of fermentable glucose
<i>Lactococcus lactis</i>	Phage resistance, lactose metabolism, proteolytic activity, bacteriocin production	Conjugal transfer of naturally occurring plasmids into industrial dairy starter cultures

<sup>a</sup>Compiled from Hill and Ross (1999) and Roller and Goodenough (1999)



# GMOs in Biotechnology

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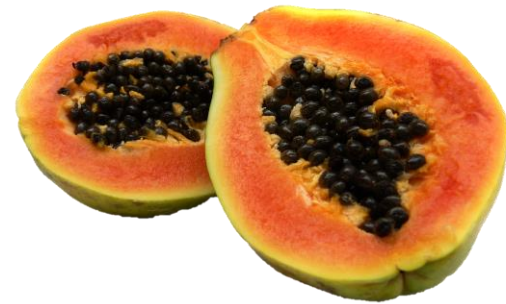
## Production of Insulin

Bacteria cells can be genetically modified to produce hormones such as insulin for treating diabetes.



# GMOs in Biotechnology

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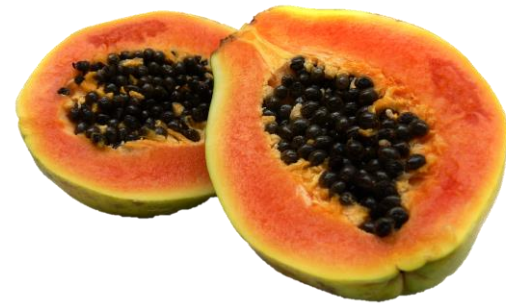
## Production of bio-plastics

### Bacterial Polyester Fermentation

The sugar of harvested plants, such as corn, fuel the cellular processes of bacteria called *Ralstonia eutropha* or other suitable bacterial species. The by-product of these cellular processes is the polymer which can be separated from the bacterial cells to produce plastic products.

# Pros and Cons of GMOs

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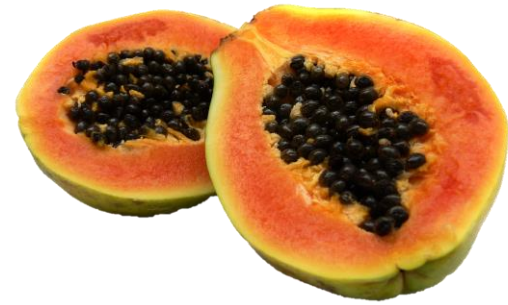


- First off, don't believe everything you read!
- The internet is flooded with research and commentary and sometimes its hard to decide which is which.
- These range from analytical, antidotal, speculative, to outright “I think this is the way it is, so that is the way I'm going to present it!”



# Pros of GMOs

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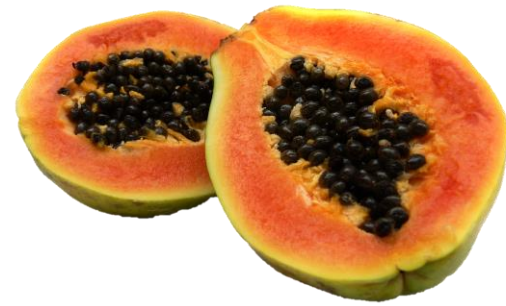
- Pros
  - Reduced production costs
  - Reduced pesticide use
  - Increased yield
  - Increased shelf-life
  - Enhanced nutrition

Golden Rice, a source of beta-carotene, beneficial in preventing childhood blindness

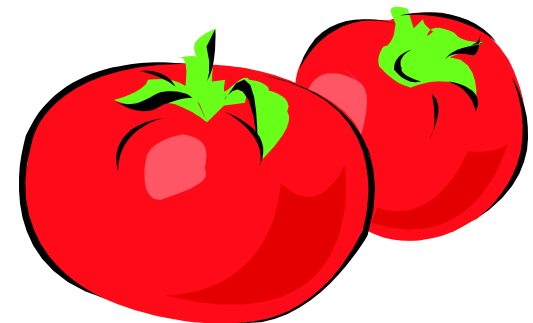
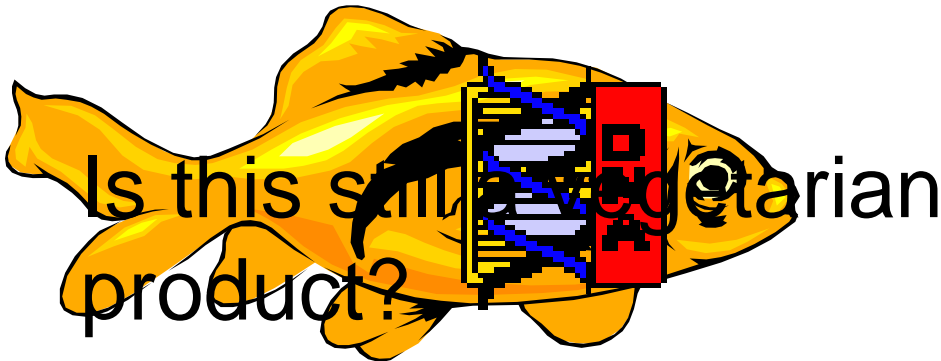


# Pros and Cons of GMOs

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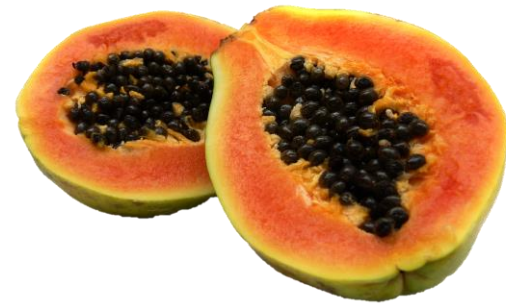


- Cons
  - Possible introduction of allergens
  - Insects can become resistant to pesticides
  - Religious and ethical implications



# Genetic Pollution?

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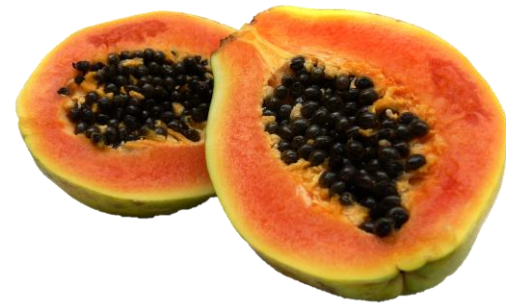
- Genetic engineering enables scientists to create plants, animals and micro-organisms by manipulating genes in a way that does not occur naturally.
- These genetically modified organisms (GMO) can spread through nature and interbreed with natural organisms, thereby contaminating non 'GE' environments.
- Thus '**genetic pollution**' is a major concern because the 'gene' cannot be recalled once released into the environment.





# The StarLink™ Incident

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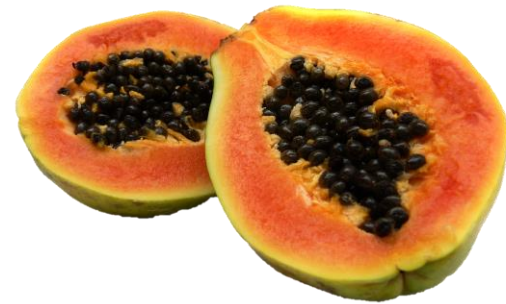


- The discovery of StarLink corn in human food was a major event in the evolving response of the American public to agricultural biotechnology.
- StarLink is the trademark for a variety of corn that had been genetically modified to produce its own pesticidal protein, Cry9C. This protein, was effective in controlling certain insects and thus can substitute for chemical insecticidal sprays.



# The StarLink™ Incident

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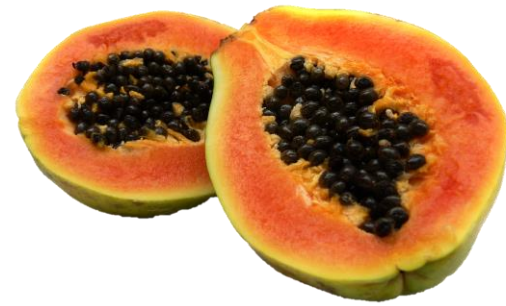
- Issues surrounding questions about the potential human allergenicity of the Cry9C protein, the EPA only approved StarLink in 1998 for use in animal feed and other industrial, nonfood uses.
- In September 2000, StarLink corn was found in the human food supply, first in corn tortillas but later in other processed foods.
- This event triggered extensive publicity and increased public awareness of the presence of GM-derived foods in the American food supply.



- **Estimates suggested it found its way into more than 50% of the US corn supply**

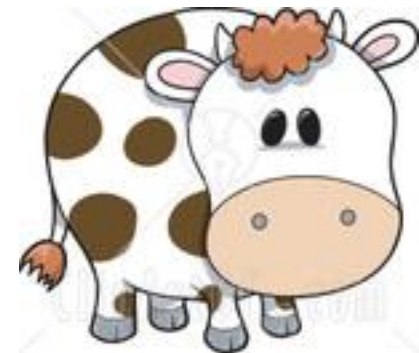
# Ethics

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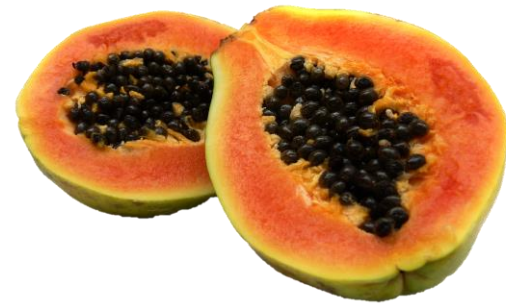
## Vegetarian vs. Organic

- Here's an ethical dilemma, you're a vegetarian and you like to eat organically produced food. You like cheese. Opps, remember we said the much of what we eat is derived from GE sources? Several slides ago we talked about GM derived Chymosin?
- So what do you do. Eat GE cheese or get your cheese made with Chymosin from the stomach of a slaughtered calf?



# Tough Decisions

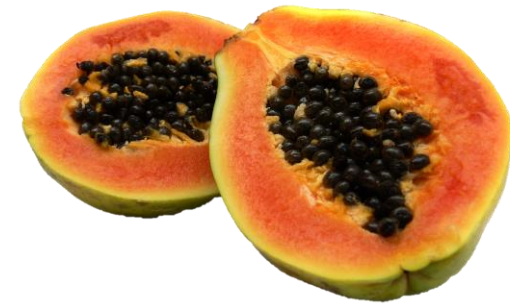
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## **Hungry nations balk at gene-altered food (8/23/02)**

- UNITED NATIONS - Across southern Africa, an estimated 13 million people face the threat of severe hunger. Yet much of the UN emergency food aid shipped to the region this summer was slowed by a raging public debate over the genetically modified grain it contained.
- “We would rather starve than get something toxic,”  
Zambian president Levy Mwanawasa told Sky News recently, The UN estimates that 1.75 million people face starvation in Zambia.

# Latest Published Reports



United States  
Department  
of Agriculture




Economic  
Research  
Service

Economic  
Information  
Bulletin  
Number 11

April 2006

## The First Decade of Genetically Engineered Crops in the United States

Jorge Fernandez-Cornejo  
Margriet Caswell

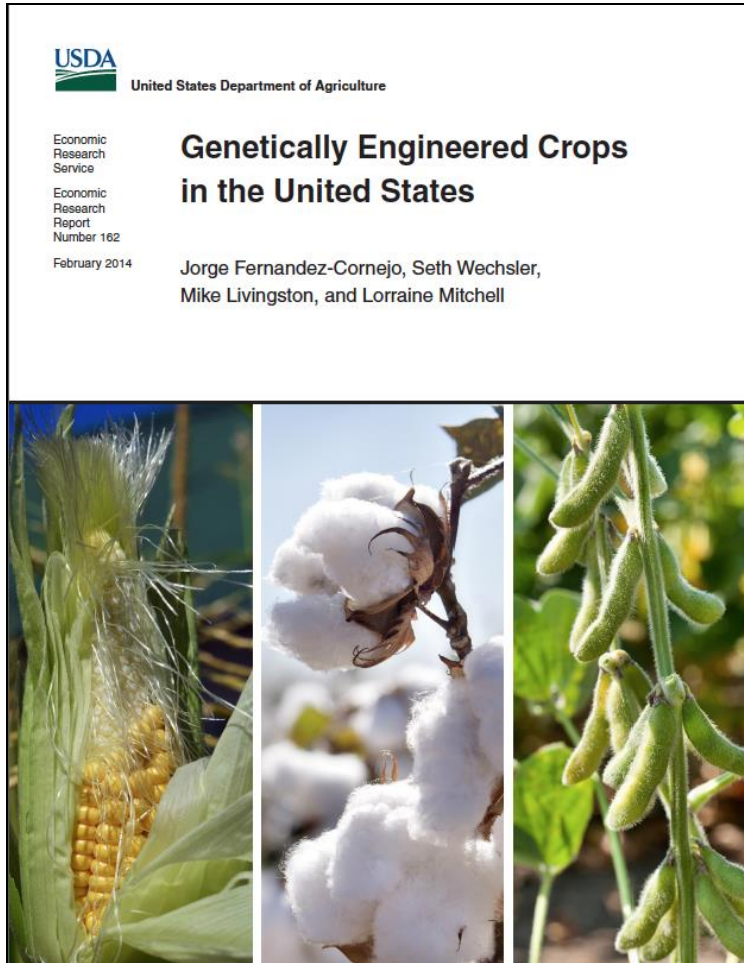
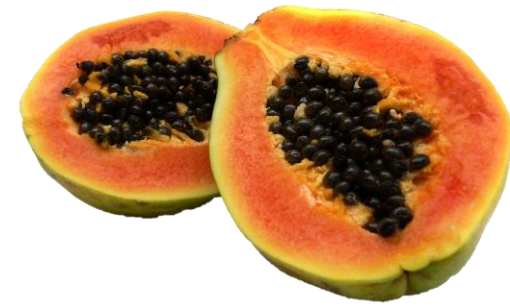


Electronic  
Report

- In April 2006, the USDA published a review of first ten years of GM foods in the US. Can be found online at:

<http://www.ers.usda.gov/publications/eib11/eib11.pdf>

# Latest Published Reports



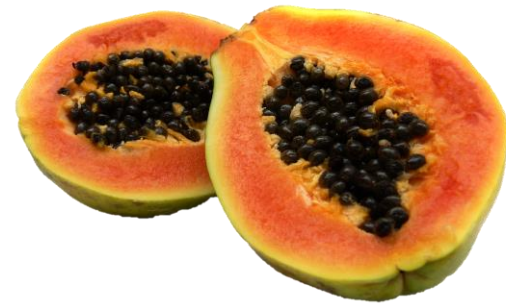
- Most recent published report, February 2014, published by USDA Economic Research Service. Can be found online at:

<http://www.ers.usda.gov/publications/err-economic-research-report/err162.aspx#.U3O8TV6UCSM>



# Take Home Points

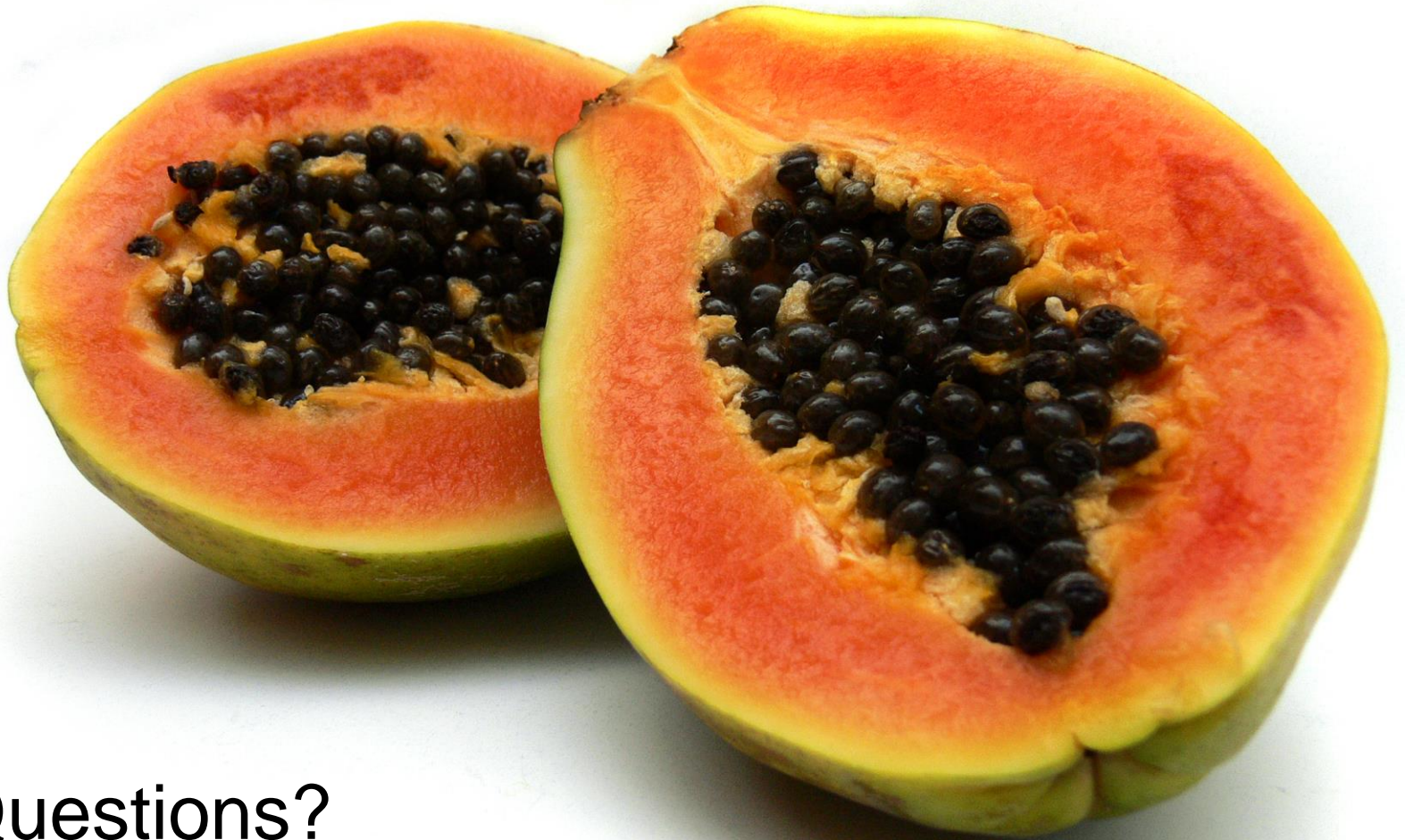
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- Genetic modification involves the insertion of gene that has some beneficial effect.
- Some countries allow GM foods (with strict regulations like the US) and some country don't allow any (e.g., New Zealand).
- The future of GM foods is debatable, benefits can be numerable, consumer acceptance is still in question.



Thank you



Questions?