GMO Salmon – Part 2

AquAdvantage Salmon by AquaBounty Technologies

AquaBounty Technologies has created the world's first approved genetically engineered animal for human consumption

AquAdvantage Salmon can grow twice as fast as its non-GE counterpart

The Famous Fish

- Recombinant DNA technology
  - Genes transferred from Chinook Salmon and Ocean Pout
- "Feminized" population made infertile
- May reach harvest size in 200 days
- Male-like progenitors for sperm production

FDA

- Food & Drug Administration - founded June 30th 1906
- US Federal Agency responsible for "safety, efficacy and security of human & veterinary drugs, biological products, medical devices, our nation's food supply, cosmetics, and products that emit radiation"
- FDA approved AquAdvantage Salmon in November 2015
- Food & Drug Act (FDA) of Canada

FDA Requirements

- Land-Based Housing Facilities with multiple and redundant barriers against escape
- Sterile, all Female Production Population
- No additional "GMO" labelling required

Health/Safety & Environmental FDA verdict:

- No Significant Impact

Raising AquAdvantage Salmon

- A breeding stock raised in Prince Edward Island
  - "Feminizing" process consistently achieves 99.8% infertility, with variability between batches ranging from 98.9% to 100%.77
  - Batches are tested for a minimum of 95% infertility

AquAdvantage Salmon Population

The production stock of AquAdvantage Salmon raised in Panama are all sterile females

Is it really ethical to create a population of non-breeding animals for the sole purpose of food?

Risk of Hybridization

Is it worth gambling the risk of potentially creating a hybrid species of AquAdvantage Salmon and Brown Trout?

There's another side to GMO's

Scientific Literacy

- Main public concerns stem from scientific illiteracy and inability to comprehend complex procedures and safeguards of GM food.
- While a multitude of literature is available online – at times they can be confusing to the general public.

Google search: "GMOs"

NON GMO Project VERIFIED

GMOs in the eyes of Mom and Dad

Two sides to the debate:

MONSANTO
BIOTECHNOLOGY
innovation – collaboration – speed

GMOs and Society

- Main concerns addressed in this section will cover:
  - Ethics.
  - Politics.
  - Global economic concerns of GM production and use.

Monsanto

Concerns of Scientists

- Efficient gene modification
- Implementing safeguards
- Profitability

Public Concern

- Fairness to local markets
  - Global trade
- No contamination

Monsanto Revisited

- Monsanto prides itself on being "dedicated to providing farmers the broadest choice of products and services that will help them produce more, conserve more and lead improved lives".
- They offer:
  - high-yielding conventional and biotech seeds.
  - advanced traits and technologies that enable more nutritious and durable crops.
  - safe and effective crop protection solutions.

Monsanto Revisited

Seeds and Traits

- Large acre crops:

Corn, cotton, alfalfa, sourghum, sugarbeets, wheat, and oilseeds.

Crop Protection Products

- Agricultural and industrial, herbicide products.

Economics

- From 1996 to 2010, biotechnology crop production area has increased from 1.7 million hectares to 148 million hectares.
- 92% of global biotech agriculture occurs in 6 countries (2010).
  - 45% in the U.S (66.8 hectares).
  - Other countries(Brazil, Argentina, India).
- Monsanto, DuPont and Sygenta
  - 47% of the global proprietary seed market.

Monsanto 2016

Quarterly report:
- 2.2 billion dollars in sales:
- $253 million profit.
- 123% from 2015.

Sygenta not far behind.

The "Friendly" Giant

Politics

- Local markets that are economically ill-equipped to compete with quickly developing strategies employed by biotech companies see GM as a threat.
- For many developing countries searching autonomy the fact that Monsanto continues to expand its global footprint.
- Monsanto partners with many global markets but main footprint in developing nations in Africa and South America.

Politics

- Monsanto and other biotech companies often market their genetically modified seed to countries in the global south as a solution to world hunger.
- Short-comings of golden rice.

Monsanto's attack on local farmers…

- In 1998 Monsanto brought legal action against Percy Schmeiser.
- Canola Farmer in Saskatchewan.
- Patent infringement of transgenic canola seeds.
- Involuntary contamination of his crops…

Monsanto's attack on local farmers…

- The Court ruled that Schmeiser deprived Monsanto of its monopoly on the special canola plant by storing and planting the Roundup Ready canola seeds
- Patent infringement?
  - Schmeiser knew of the contamination.
  - Only brought up the issue of contamination when he was dealt with a lawsuit.
- Result: No actual repercussion.

Ethics

- Monsanto – on a quest for global seed production domination.
- Can't argue that they aren't taking necessary precautions (safeguards).
- They also try to provide alternative crops for non GM supporters.
- DroughtGuard® hybrid crops – marketed to anti-GM european farmers.

However it is hard to overlook certain contributions of leading biotech companies…

Agent Orange

- Deadly herbicide used to put an end to the Malayan Emergency and Vietnamese war.
- Destroyed bushes, food crops, and trees.
- Deprivation of food and cover.

Agent Orange

- In actuality Britain was the first nation to employ the use of this herbicide – but U.S often held in the spotlight.
- Exposure to Agent Orange by U.S war veterans and members of the Vietnamese population left a horrifying impression of the power of GM on public psyche.

40 years later the web is still flooded with pictures of AO victims

Agent Orange Continued

- Although Monsanto was not the only company involved in the production of agent orange they played a major role.
- Sparked world-wide debate on ethical considerations of biotech companies: "If they can use this technology to kill innocent people.."
- Anti-GMO activists often capitalize on this incident:
  biotech companies involvement in Agent orange can be
  a reason to distrust motive.
- Often neglect to consider this a question of poor political
  judgement of U.S government.

Agent Orange – according to Monsanto

"From 1965 to 1969, the former Monsanto Company manufactured Agent Orange for the U.S. military as a wartime government contractor. The current Monsanto Company has maintained responsibility for this product since we were spun-off as a separate, independent agricultural company in 2002."

GMOs and Corporate Patenting

GMOs and the Corporate Patenting of Living Organisms

The Big Question: Has the patent system truly become a vehicle for big corporations to monopolize the market?

Why are GMO Companies granted patents?

The purpose of the patent system is to give inventors a period of exclusivity for commercial development of products thereby encou

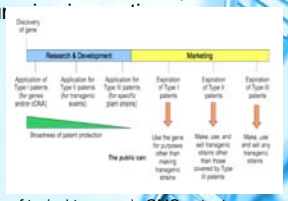
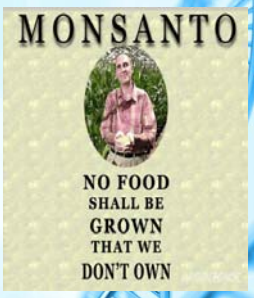


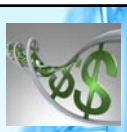
Figure 1: The timeline of typical transgenic GMO patents

History of Patenting System

- For nearly all of its history the United States Patent and Trademark Office had refused to grant patents on seeds, viewing them as life-forms with too many variables to be patented.
- But in 1980 the U.S. Supreme Court, in a five-to-four decision, extended patent law to cover "a live human-made microorganism." A *Pseudomonas* bacterium developed by a General Electric scientist to clean up oil spills.
- Monsanto took advantage of this. Since the 1980s, Monsanto has become the world leader in genetic modification of seeds and has won 674 biotechnology patents, more than any other company in the US.



Problems with GMO Patents



- Monsanto portrays its move into genetically modifies seeds as a giant leap for mankind.
- Monsanto buys conventional-seed companies. $1.4 billion for Seminis, $300 million for Emergent Genetics. It's estimated that Monsanto seeds now account for 90% of the US production of soybeans.
- Roundup Ready seeds. Farmers who buy Monsanto's patented Roundup Ready seeds are required to sign an agreement promising not to save the seed produced after each harvest for re-planting or to sell the seed to other farmers.
- Vernon Hugh Bowman vs Monsanto.

Future of the Patent System

The US is a leading country in biotechnological innovation and the number of biotech patents issued in the US has been steadily increasing over the past few years.

A new legal reform: The American Invent Act (2013). This Act also changed the US patent system.

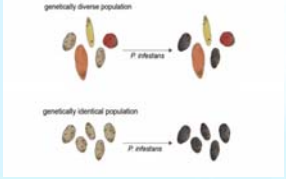
- First-to-invent to first-to-file, extensive options for post-grant proceedings that allow third parties to challenge the validity of patents more easily.

Whoever provides the world's seeds controls the world's food supply.

GMOs and Genetic Diversity

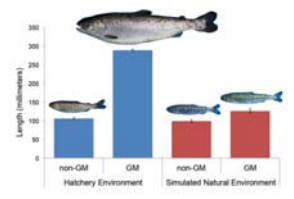
How GMOs Influence Genetic Diversity

- Despite the benefits of GMOs, it is important to understand the risks before introducing them into the wild.
- It is assumed that genetically engineered modifications may affect genetic diversity through crossbreeding or uncontrolled growth.
- Maintaining genetic diversity is very important for the environment and agriculture.
- The potato famine of the mid-1800s in Ireland.



How GMOs Influence Genetic Diversity

- A major concern: Can GMOs cause reduced genetic diversity of plants and animals in the environment?
- When GM plants are in close proximity with wild plants, they can cross pollinate producing a hybrid version of the two. This could impart a fitness advantage to the hybrid species allowing it to better reproduce.
- Genetically engineered traits may be too advantageous e.g AquAdvantage Salmon.



Ecological Consequences of Potential Escape, Establishment and Spread

Process	Potential Ecological Consequences
GE organisms persist without cultivation	GE organisms that are able to spread and maintain self-sustaining populations could disrupt biotic communities and ecosystems, leading to a loss of biological diversity.
GE organisms interbreed with related taxa	Incorporation of transgenes could result in greater invasiveness or loss of biodiversity, depending upon the amount of gene flow from generation to generation and the transgenic trait(s).
Horizontal gene flow	The transfer of genes through nonsexual means is common in some microbes but rare in plants and animals. Ecological consequences would depend on amount of gene flow and the transgenic trait(s).
Changes in viral disease	In GE virus-resistant organisms, recombination between viral transgenes and invading viruses could lead to increased virulence of a disease and undesirable effects on wild hosts in natural habitats.
Non-target and indirect effects	Loss of biodiversity, including species of conservation concern, may occur, as well as altered community or ecosystem function, including reduced biological pest control, reduced pollination, altered soil carbon and nitrogen cycling, and secondary pest outbreaks.
Evolution of resistance	Resistance to pesticides (including pesticide-producing plants) can lead to greater reliance on chemicals and other pest control methods that are damaging to the environment, including unregistered pesticides under emergency exemptions. This applies to insects, weeds, and other pests.

The Ecological Society of America has identified six major environmental concerns associated with genetically engineered organisms and their potential ecological consequences.

These consequences remain largely undocumented to date because few genetically engineered organisms have been released into the

Protecting Genetic Diversity

- Researchers are investigating how to better prevent crossbreeding and spreading of GMOs.
- Physical and Biological Containment Strategies used for AquaBounty's Salmon.
- Methods which make the second generation of seeds sterile or dependent on a chemical for fertility.
- Other approaches include: requiring that two GMO plants be crossed in order for the offspring to contain the advantageous trait, recoding the genome of crops to include synthetic amino acids that are not present in the wild.
- It is important that researchers continue to study the impact of GMOs and agricultural practices on genetic diversity in order to discover new ways to minimize their influence on biodiversity.

GMOs and Religion

GMOs and Religion

- Must take into consideration whether GMO's are permissible for consumption under religious laws.
- Religions such as Judaism and Islam have certain rulings on the types of foods allowed for consumption.
- Jews are only allowed to eat foods considered Kosher.
- Muslims are only allowed to eat foods considered halal.
- There are also rulings on the type of foods allowed for consumption in Christianity.

Kosher Foods

- What is Kosher?
  - Foods considered "pure" or suitable according to the Torah (Kashrut Laws)
  - This has specific rulings for different categories of foods:
    - All plants are kosher, some exceptions
    - Seafood: Only fish with fins and scales may be eaten, shellfish are forbidden
    - Meats:
      - Meat allowed for consumption must be cattle and game with "cloven hooves" that must "chew the cud" Meat must be slaughtered by a ritual slaughterer and the animal must be slaughtered in a way that does not cause any harm to animals
      - Goose, duck, chicken and turkey are the only kosher birds
      - Kosher dairy products must be derived from

Are GMOs considered kosher?

- No general consensus between religious leaders.
- Some believe food that does not contains genes from Non-kosher sources is not kosher.
- Others argue that even with genetic material from non-kosher animals, GMO's can be considered Kosher because genetic material is not considered "food", has no taste and is of negligible quantity of the host species.
- Can not change physical appearance of animals to consider them kosher – i.e pigs that have cloven hooves via genetic modification are still not kosher.

Halal Foods

- What are halal foods?
  - Foods permissible or lawful under Islamic Sharia Law
  - Most foods are halal with the exception of foods that include:
    - Alcohol
    - Meat or any product from a forbidden animal (including pigs and any carnivorous animals or birds of prey)
    - Meats (of allowed animals) that is not slaughtered in the correct manner in the name of God by a Muslim – correct manner entails drawing out the blood
- Muslims are allowed to eat foods not considered halal if it is a matter of survival

Are GMOS considered Halal?

- No general Consensus:
  - No laws within Islam which stop the genetic modification of food crops and animals.
  - Muslim countries like Egypt and Indonesia are actively manipulating plant genes in a variety of ways.
  - BUT, many believe according to Islamic law that any components of non-halal sources added to foods would make them not halal.

  I.E if genetic components are obtained from pigs and added to plant material, that plant is not considered halal.

Christian views of Genetically Modified Foods

- Most Christian denominations lack specific requirements for food.
- The Catholic Church supports genetic modification of food as an answer to world starvation and malnutrition under the belief that progress in science was part of the divine plan.

Importance of labelling

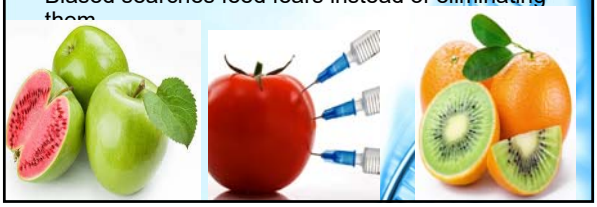
- Important for religious purposes but also for main informed choices.
- Foods should be labelled with the host species in order for religious followers to decide whether its genetic modification source is kosher
- Eg. In one study of plant tolerance to herbicide makes use of pig genes to produce herbicide-tolerant plants and to confirm the metabolic activities of the cytochrome P450 (Study was for testing purposes)

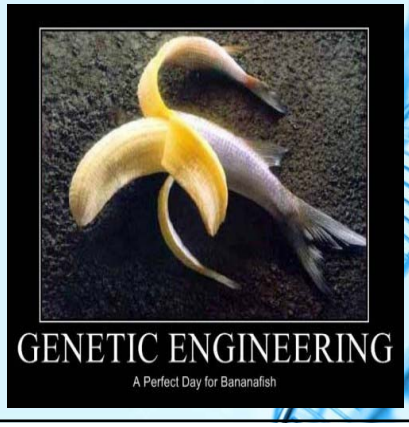
Religious ethical concerns of GMO's

- The production of non-natural substances does not follow religious guidelines on preserving God's naturalness.
- Consider mixing different organisms to create new species as 'Taking on the role of God'.
- Muslims believe in *Fitra* – The preservation of God-given naturalness.
- In Jewish belief, God prohibits the mixing of species, as proofs that God made "distinctions in the natural world.
- Taking on the role of God is the main religious concern with genetic engineering.

Scientific Illiteracy

- Controversy due to the lack of understanding of GMO's – People fear what they don't understand.
- The general public turns to the internet for easy access to information, an unreliable source.
- Biased searches feed fears instead of eliminating them





Increasing Public Knowledge

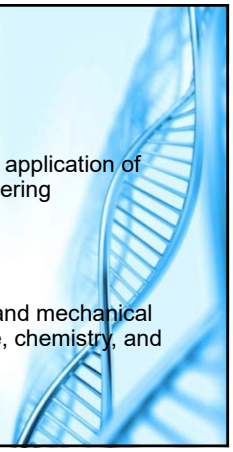
- News interviews with scientists with relevant background knowledge
- Teaching youth about GMO's in science class
- Adding informative labels to GMO foods
- Allowing public access to peer reviewed articles
- Free post secondary education

Bioengineering

Bioengineering

Definition: “biological or medical application of engineering principles or engineering equipment”.

- Relatively new field.
- Include elements of electrical and mechanical engineering, computer science, chemistry, and biology.



GMO Timeline

Non-GMO Project is Founded:

- In 2005.
- A standardized definition of non-GMO is created for the U.S. and Canada.
- Testing criteria implemented.
- In 2013, non-GMO verified products reached over 7 billion dollars.

GMOs – Fear or Fact?

GMOs – Fear or Fact?

Why are people so afraid?

- Lack of understanding of basic scientific principles.
- It's not "natural".
- Non-GMO Project and the organic food industry.
- Conspiracy theories.
- Potential health risks.

Lack of scientific understanding

Chemistry:

- The fear of chemicals!
  - Everything is a chemical!
- Complicated scientific names and nomenclature.
  - Says nothing about its toxicity.
- Chemicals are toxic!
  - Dose determines toxicity!
- Misunderstanding elements within compounds.
  - No there is not chlorine in your table salt!
- Your body will know the difference between a natural and synthetic molecule!
  - If it's chemical structure is identical, your body doesn't know the difference.

It's not natural?

- Actually, bioengineering occurs in the environment naturally! (ie., Angrobacterium).
- We have been doing it for thousands of years! (ie., agriculture, and animal domestication).

The only difference between doing it in a lab is that it is more efficient and accurate!

Non-GMO Project and Organic Industry

Non-GMO and Organic food, is it better?

- It has NOT been shown to be:
  - More nutritious.
  - More safe for consumption.
  - More cost-effective (in fact, less so).
  - More environmentally friendly (in fact, less so).
- Organic farms use 40 different non-synthetic pesticides
  - Can be more toxic (carcinogenic).
  - Not as effective as synthetic and need more application.
- They are making a lot of money!
  - >7 billion dollar industry (Non-GMO project).
  - 27 billion dollar industry (Organic).
- Negative environmental impacts.

GMO Conspiracy Theories

- Monsanto has hidden data that GMOs are harmful!
- Monsanto deliberately causes food shortages to force the use of GM foods!
- Monsanto is in cahoots with the FDA!
- Monsanto's GM mosquitoes caused Zika virus!?
- GM companies are sabotaging Chipotle for no longer using GMOs!

Fear or Fact?: Potential Health Risks

Claims: “GMO proteins have properties of known allergens”.

- All this statement means is that GMOs retain the allergenicity of the “natural” organism.

Claims: “GMOs can cause disease”.

- WHO has over 1100 peer-reviewed articles with scientific evidence debunking this claim and pointing to the safety of GMOs.

Fear or Fact?: Potential Health Risks

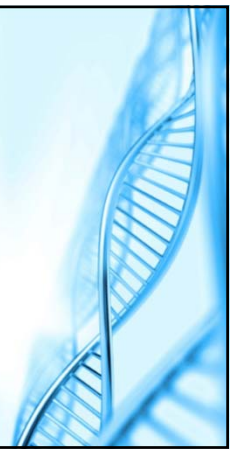
Do GMOs pose a health risk?

- Short term, no.
- Long term, only time will tell!
  - However, there is no scientific evidence to support that GMOs will pose long term health risks.

How can scientists ease fears?

- Education
  - In school.
  - Access to scientific articles.
- Discouraging misinformation.
- Show the benefits to the consumers.
  - Disease-resistant plants (ie., papaya).
  - Insect resistance plants (ie., corn).
  - Potatoes and apples that don’t bruise!
- Sustainable agriculture.
  - Feeding a world growing at an alarming rate.
- Less negative environmental impacts.
  - Not using pesticides and herbicides.
  - GMO salmon allows the wild salmon to re-populate

GMO Labeling



GMO Labeling – Recent Events

"Just Label It" Petition:

- March 27th, 2012.
- 1 million people sign a petition to the FDA, requiring the mandatory labeling of GMOs.

Proposition 37:

- November 5th, 2012.
- California citizens vote to pass prop 37 to label GMOs.
- Donations and endorsements raise 45.6 million dollars.
- Vote did not pass!

Campbell's Company:

- In 2015 announced they would label products containing GMOs.
- To educate population that GMOs are safe!

GMO Labeling

Some believe labeling GMOs insinuates they are not safe!

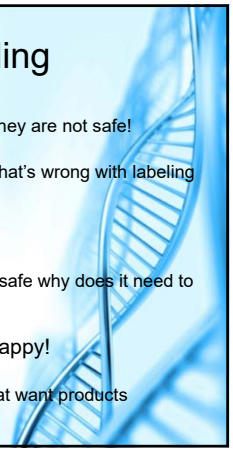
Though, others will say if they are safe, what's wrong with labeling them?

BUT….

Once labeled we will probably hear "if it's safe why does it need to be labeled?"

Really, there's no making anyone happy!

….Let's keep in mind these are people that want products containing DNA to be labelled…



No GMOs?

… what a wonderful world?

Our World Without Genetic Modification

Genetic Modification is responsible for many modern day foods we consume!

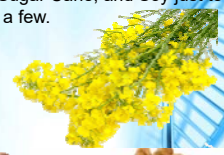
Our World Without Genetic Modification

"SunUp" and "Rainbow" Ringspot Virus Resistant Papaya.

Zucchinis and many other Squash varieties are disease resistant due to genetic engineering.

Our World Without Genetic Modification

Many Herbicide and Insecticide-Resistant, even Insect-Resistant, strains of common cash crops have been engineered; Corn, Canola, Sugar Cane, and Soy just to name a few.

Our World Without Genetic Modification

"Arctic" Golden Delicious & "Arctic" Granny Smith Apples are bruise-resistant and non-browning.

Rennet is used for making most varieties of cheese

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How do you feel about GMOs?