Corn, Cotton, Cactus understanding GMO's and GE's:
What does this mean for our future?

The project Corn Cotton Cactus, began with a sketch of a cactus. I was inspired by The cactus project: C-lab which used Genetic engineering to produce a cactus with human hair. They call projects like these Bio-art which is the collaboration of art, technology, science, and nature. This was started in 2002 as a collaborative project of Laura Cinti and Howard Boland. (Les mutants,2013)I came across this article in 2013 and was astounded that biotechnology has already advanced to the stage that we are able to reproduce organisms simply by cutting and pasting desired gene traits to create a new kind of organism. This prompted me to explore and get more informed about transgenic work. What the difference actually is between Genetically engineering and genetically modifying crops. Truthfully I really didn't know.

I discovered that Genetically modifying organisms with methods of simple selection and crossbreeding is something that we have been doing since 7,800 B.C. It includes almost everything we eat including corn, squash, tomatoes, carrots, etc. The specific corn, Maize was domesticated when ancient Mexican farmers chose to save desired kernels process of selection; from tastier easier to grind crops from the harvest. By selecting the desired characteristic they were able to evolve and yield the most desirable Maize. Corn as we know it today came from a species of tall grass called teosinte. Carrots through genetic modification were not orange until the 1700's, and tomatoes were about the size of marbles. (agbiotech.ces.ncsu.edu) Through this method of selection and crossbreeding we have been able to genetically modify organisms that share similar characteristics to achieve desirable results. Genetic engineering differs in this way because it is the direct manipulation of an organism's genome using biotechnology. However technically it is a type of Genetic modification and that's why it is so confusing. There are several biotech methods of manipulating genes and most people think that it is moving genes from one species to another which fits the bill but it can also be moving genes within a species or from a closely related species(same breedable gene pool) this genetically modified result that is produced is referred to as cisgenic..

Gene editing is another method of manipulating DNA (Genetically modified); different processes include: zin finger nucleases(ZFNs),

transcription activator-like effector nucleases(TALENs), and clustered regularly interspersed short palindromic repeats (CRISPR)/Cas systems. Gene editing can involve deletion, insertion, silencing or repression. The resulting organism from gene editing is called subgenic. However, the most probably most well-known result is transgenic where an organism that contains genetic material into which DNA from an unrelated organism is artificially introduced.(agbiotech, Edmisten)
Gene Splicing is a post- transcription modification method where a single gene can code for multiple proteins. It was used for the first time in the food industry in 1990 and by 1995 67% of cheese produced in the U.S. was being genetically modified using this method. The GMO FDA approved strain is called Rennet, it was used to curdle milk to form curds and whey.
(https://livinghistoryfarm.org/farminginthe70s/crops_10.html)

There three methods used for genetically engineering are plasmid method, vector method and the biolistic method.
Plasmid Method is usually used for altering microorganisms such as bacteria. Plasmids are formed with random pieces of DNA offering more variability but make results harder to predict.
Vector method uses similar techniques to the plasmid method but uses small carrier molecules normally being viruses. The vector method uses a specific gene to get specific result.
Biolistic Method is also called gene gun method. It is mainly used for the engineering of plants but now also engineering of animals currently. They take metals that have extremely small particles like tungsten, gold or silver coated with DNA that was first made sticky under specific conditions. These particles are then fire with gun at the target and The DNA is effectively introduced to the cells.
(https://mrlloyder.weebly.com/methods-of-genetic-engineering.html)

Why I thought this was important to know is to understand a bit of the science methods of how scientist genetically engineer to make it easier to understand what genetically modifying and genetically engineering is in relation to each other . After understanding the more “hairy” scientific methods I looked into techniques of Genetic modification and genetic engineering. After understanding these varying techniques the idea of what these two alien terms are started to come together. In my findings I discovered that most techniques are not as “unnatural” as we might think. (https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/intergeneric-hybridization)

These are all methods other than genetic engineering…basis for genetic modification

- **Simple Selection**: (Darwinism, evolution) Self-replicating systems growing over time(evolution) or artificially selected example (corn).
-**Crossing**: Mendel, cross breeding of individual with a phenotypically recessive individuals, varieties, or species.
-**Interspecies Crossing**: Interbreeding between two animals or plants of different biological group(taxa). Hybrids between different species within same group are sometimes known as interspecific hybrids or crosses. Example Mule (male donkey & female horse).
-**Embryo Rescue**: In vitro technique that allows development of interspecific , intergeneric food (example: sweet orange), Ornamental plant crop hybrids. It's often used to create interspecific and intergenic crosses that would normally produce seeds which are aborted. It can also be used to promote development of an immature or weak embryo into a viable plant. For instance when failure of endosperm to properly develop (part of seed that usually contains starch with protein and other nutrients.)
-**Somatic Hybridization**: A technique which allows manipulation of cellular genomes to modify two distinct species of plants to fuse a new hybrid plant, with the characteristics of both.
-**Somaclonal Variation**: Is used as a valuable tool to quickly produce crops with novel traits. This plant breeding where variation in tissue culture regenerates plants from somatic cells(example: skin, organs, etc.) clonal variations in number and structure of chromosomes. Regenerated plants usually show altered changes in leaf sharp and color, growth rate and habit, as well as sexual fertility. Essentially, it has uncontrolled heritable mutations that normally persist in plant population even after plantation.

-**Mutation Breeding/ Variation breeding**: Is the process of exposing seeds to chemicals or radiation in order to generate mutants with desirable traits to be bred with other cultivated variety.

-**Cell selection**: Has been used to develop a myriad of commercial crops including varieties of soybeans, canola, etc. The process involves isolating cells with desired phenotypic variation (observable characteristics or traits; such as size color, behaviors etc.) may then be selected and regenerated into a whole plant. In theory, one can then create a so-called "elite plant" with superior agricultural characteristics (example: cells expressing herbicide resistance). After regeneration of

whole plant with desired progeny cell line it is tested to ensure that the phenotypic trait is stable. Although, in practice breeders cannot select for increased yield in cell cultures because of cellular mechanisms for this specific trait are unknown.(Genetically engineered Food, 2018)

If you can still remember; Genetic engineering is technically a type of genetic modification that involves the intended desirable or targeted change in a plant or animal gene sequence.

These different types of techniques include:

Microbial Vectors: Agrobacterium is a naturally occurring soil microbe known for causing gall disease on susceptible plant species. This unusual pathogen transfers a portion of its own DNA when it infects a house into the plant cell, the plant then reads and expresses the transferred genes as if they were its own. Among these substances is another nonprotein amino acid, called opines. Opines are translocated throughout the plant. In the early 1980's strains of Agrobacterium were developed that didn't possess this disease-causing gene but maintained the ability to attach to susceptible plant cells and transfer DNA. Agrobacterium is a naturally occurring genetic engineering agent and is responsible for the majority of the genetically engineered plants in commercial circulation.

Electroporation: This technique involves protoplasts taking up macromolecules from the plants surrounding fluid, this is made possible through electric impulses. Cells that are growing in a culture medium are stripped from their protective walls, resulting in protoplasts(living plant or bacterial cell wall being removed). The DNA is then supplied to the culture medium and then by applying electrical pulse the cell membrane becomes destabilized allowing said DNA to enter the cell. Transformed cells can then regenerate their cell walls and regenerate further into transgenic plants. Unfortunately most plants tend not to stabilize and regenerate.

Microinjection: This technique involves DNA being directly injected into anchored cells. Some part of these cells survive and integrate into the injected DNA. This process happens to be very labor intensive in comparison to other methods.

Transposons/ Transposable Elements: Probably the most promising extensively researched technique, especially to study mutagenesis (genetic mutations). These type of genes of most plants and some animals (e.g., insects and fish) carry transposons which are naturally occurring pieces of DNA with the ability to move from one location to another within the genome. This phenomena was discovered by Barbara McClintock in 1950's where elements of this were discovered in corn plants. Unfortunately, scientists have not been able to harness novel genetic information to improve commercial crops using this technique.

Nontransgenic Molecular Methods of Manipulation: This technique is done without insertion into plants or animals organism's native genome. DNA of interest is delivered to a plant cell, which then expresses a new protein and therefore new trait without becoming integrated into the host's cell DNA. However, because the host is able to replicate and thrive without integrating into the host genome. Which puts the new desired trait at risk to be lost during meiosis(when single cell divides twice to produce for cells containing half the amount of information a.k.a. sex cells);preventing the new desired trait from being expressed. (NCBI, 2004)

Here are some of the pros and cons of genetic modification and engineering;

Pros

- The world populations has doubled over the past 50 years and continues to grow by roughly 100 million people each year. Though this is estimation the population will likely reach 11 billion by 2100. GMO show promise to produce increased yields and can be designed to be more resistant to environmental stressors.

- Modifying genomes could eliminate world hunger by engineering crops with longer shelf life.

- Genetically modified crops that are herbicide-resistant crops are able to withstand weed killers allowing for less reliance on chemical pesticides.

- Underdeveloped regions see fewer food shortages through crop yields increased due to GE crops.

- Development of drought-resistant crops would prevent higher prices in food in areas affected by extreme droughts like California.

- An innovation in a new strain of rice has allowed this crop of GM rice to produces 43% more grain and emits up to 97% less methane than conventional rice. In fact, 17% of global methane emissions are emitted due to rice paddies so if the GM rice crop was adopted on a larger scale this would have major benefits for consumers and for the environment. Not available to farmers yet as test trials continue.

- Insulin taken by diabetics is a product created by GE modification that allows diabetics to have a balanced and normalized sugar intake.

- GE technology with CRISPR allows for simpler gene editing, which in turn, this technology could expedite the development of useful GE crops (as sometimes not able to pin-point what gene expresses a specific trait) so this could also facilitate disease elimination.

- Nutritional content can be improved serving a denser nutritional profile so that future generations are able to gain the same nutrition from lower levels of food consumption. For instance The UN Food and Agricultural Organization notes that rice has been genetically modified to produce higher levels of Vitamin A, have inherently helped worldwide deficiencies.

- Animals through modification insertion can produce better milk, eggs, and meat these animals are expected to have a higher resistance to disease and an overall better health.

- With GE tech soon it will be possible to produce certain proteins and vaccines, along with other pharmaceutical goods. This “pharming” technique would offer cheaper methods of improving personal heath and could change how certain medications are administered.

- GMO foods can be changed in color to look more appealing to eat, apparently deeper colors in foods changes how the brain perceives the taste of what is being eaten. According to Spoon University study subject perceived foods as sweeter with deeper colors of red even though they are not.

Cons

- GMO crops may cause antibiotic resistance. The crop that are modified to include antibiotics and other components that kill germs and pest reduce the effectiveness of an antibiotic or other medication when it is needed in a traditional sense. When consumed because the foods contain trace amounts of antibiotics these organisms are affected with an immunity to these antibiotics, making it more difficult to cure certain illness.

- Farmers growing genetically modified foods have greater legal liability. Many of the crops and seeds that produce GMO are patented so when cross pollination occurs with non-GMO crops farmers can face liabilities for letting their GMO seeds go into other fields or allowing cross-pollination to occur. Also farmers that have non-GMO crops and follow specific farming practices are effected when cross-pollination occurs because the patented crop can be claimed losing them yield of the crops and future yields as it becomes the ownership of the companies patented crop.

- It is possible that genes with herbicide resistant crop transfer to other plants for instance the weeds they are designed to kill. Interactions at cellular level could create unforeseen complications to the future of crop growth. Dozens if weed species are already resistant to atrazine.

- Independent research of genetically modified food is not allowed, 6 companies control most of the genetically modified foods market at the core. While most GMO foods are made from crops like corn, wheat and soybeans even food manufacturers that use the crops have not control over the preferences of these modifications. More than 50% of the seed producers in GMO market have prohibited independent research on final crops as an effort to protect their patents and profits.

- Genetically modified foods may present a carcinogen exposure risk. Studies have shown that long-term exposure to small amounts of chemical pesticides still unclear exactly what chemicals cause this but have been linked a variety of chronic health condition such as diabetes, cancer, and neurological defects (according to EPA).

Now after explaining the different processes, methods of genetic modification and the different techniques used to genetically engineer there are certain techniques where the safety of how healthy they are can definitely be questioned. The pros and cons can also be debated, do the pros outweigh the cons? This is why this remains such a controversial subject and one of the reasons genetic modification or genetically engineering is perceived to be so dangerous as certain methods that are currently been used to produce crops have only been around for 50 odd years. Unfortunately, many of these new methods or techniques were developed between 1980 and 1990 so with GE crops and food we simply lack the research to conclude how healthy these new techniques/methods are and what these manipulated crops actually do to you over time; there have been little research done on the affects in human as this is normal tested in animals. Not to mention, the studies that have raised health concerns linking these new methods used to create these GMO crops with underlying health conditions. This has been done previously with linking health concerns with eating from plastic, pollution, and other environmental factors and inventions. There are definitely risks to genetically engineered crops as well as great benefits. What would it mean for the future if we were to label all GE and GMO crops? Would it only raise the price of food extremely ? What would it mean if some GE and GMO techniques if they were banned? A shortage in food supply? In the future, I think there need to be regulations put in place by governments on mandatory research of genetically engineered seeds and crops. As well as more funding to develop useful Biotech and gene editing techniques. Just like any technological advancements for example, the internet; there will always be pros and cons but what we make out of it is up to us.

Sources

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