GENETIC ENGINEERING AND GENETICALLY MODIFIED ORGANISMS IN PERSPECTIVE

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A. The Science of Genetic Engineering and Conventional Cross-breeding Aided by Marker Assisted Selection (show outline)

To evaluate all the controversies around genetically modified organisms (GMO's), we need to make a sharp distinction between the *science of genetic engineering (GE)* in general and *its use in breeding certain agricultural crops*.

GE has proven to be a very helpful laboratory technique in medical research, manufacturing and agriculture. Under very strict and contained conditions in medical research, for example, GE has been successfully used in the diagnosis of diseases, the manufacture of drugs, viruses for somatic gene therapy, and many other applications. In plant breeding it is being used in the laboratory to identify specific genes to study their functions and proteins under normal and disease conditions. In industry it is used in fermentation processes, as sources of enzymes for manufacturing processed foods, making biofuels, cleaning up oil spills, detecting arsenic in drinking water, and a host of other uses. In all those instances every precaution needs to be taken so that genetically modified living organisms, especially viruses and bacteria, as well as new proteins, cannot escape into the environment where they could reproduce and spread or have unexpected reactions.

Even under carefully controlled conditions, gene manipulation raises many ethical questions, especially in medical research, because we are dealing with the very secret of life, the DNA of living organisms. Do we know what we are doing when we change or interfere with the genetic code of plants or animals? Do we know what the long-range consequences may be? For millennia the evolutionary process of 'natural selection' and the 'survival of the fittest' has guided the reproduction of life. Are we sure we can enhance or improve on that process? Are there boundaries to our interventions? We ought to at least ask these kinds of questions when a new genetic procedure is being considered and a genetically new kind of plant is introduced into the environment.

When 32 weeds in the world have become resistant to herbicides, the so-called superweeds, we need to ask ourselves, what have we done wrong? Did we not realize that some of the fittest of these weeds would survive even multiple herbicides and multiply in fields without competitors? Each year, or couple of years, some more of these herbicide resistant weeds are added, not to mention insects. Presently there are 5 of these weeds in Canada and 14 in the US and they are spreading and multiplying rapidly. So far the only response has been to increase and vary the pesticides and rotate crops more often, and, if all else fails....pull weeds by hand, or, as in the US, abandon large tracts of land. About 60 million acres of American farmland are infested with super weeds.

Genetic engineering is not just a matter of technical ingenuity and know-how; it is about *the role we give* to technology in life and for *what purpose*. Do we look to technological innovations to solve the world's problems, like climate change or world hunger and 'overpopulation'? The core question about engineering is always, does the use of any technology enhance life and provide well-being for everyone, or is the technology used primarily for the benefit of the few and leave the majority impoverished? Human pride and arrogance can tempt us to ignore these larger contexts, but only to our detriment. We are not masters of the universe. On the contrary, we are an inseparable part of the integral unity of life and the inter-connectedness of all creatures.

In talking about genetic engineering this morning and the way it is applied to some key agricultural crops, I want to carefully evaluate *the use that is made of GE*. Are some uses too risky, irresponsible or even unethical? I think we can all appreciate what GE has done, especially in medical applications, including for some of us here. We just need to be alert to any *reductionistic view of science* that reduces life to biochemical processes without regard for the larger context. In medicine this means, without regard for the whole person in his or her context and cultural setting. We also need to oppose any *over-estimation* of science, "*in science and technology is our trust",* regardless of threats to our health, climate change and social decline. Scientific facts cannot be separated from values as is done in the prevalent fact-value dualism. Even some of the authors of the best evaluations of GMO's find it necessary to explain or defend that they are providing *both* scientific evidence *and* value judgements, as if you can separate those two. Science is not a value free, context free, a-historical, a-cultural enterprise. On the contrary, *ultimate values determine the nature, scope and kind of research* that is undertaken, as the history of science illustrates. The industrial development and promotion of GMO's is one example of how the corporate profit motive determines and controls how the science of genetic engineering is conducted and applied. We will come back to this in a moment.

Proponents of GE and GMO's claim that there is 'no substantial difference' between genetically engineered new varieties of corn, soy beans, rape seed (canola) and cotton and new varieties obtained by traditional cross-breeding. They claim that these two kinds of new varieties are 'substantially equivalent'; that GMO's are 'natural' and are equivalent to plants that are not genetically modified.

Those who oppose GMO's in our food are often portrayed as being opposed to science and technology, or worse, that they don't understand science, are ignorant, or are over-zealous environmentalists. Such controversies about GE and GMO's often become muddled and prevent honest discussions. The many articles and reports by independent scientists and researchers make it clear that those who oppose genetically engineered crops and GMO's in our food are not against science and technology. On the contrary, they want better, longer term scientific studies and safer technology. A brief overview of genetic engineering in staple crops will allow us to take a little distance to all the controversies about GE crops and GMO's in our food.

1. The role of genes   (image of a double helix DNA molecule)

In order to understand the genetic engineering process we first need to look at the role *genes* play in the functioning of every cell. A cell is the smallest structural unit of all living organisms that is able to grow and reproduce independently. The nucleus of each cell contains the *DNA or double helix molecule,* one from each parent that provides all the genetic information, both structural and functional, that cells need to develop into a particular organism. Within the DNA molecule are small *segments of genes*, which can number into the thousands. Together these gene segments form the *genome* which is the total genetic blueprint for each organism. When cells multiply and reproduce themselves, the total genome is duplicated and passed on to the daughter cells before the cells divide.

The gene segments are organised both in a *specific linear sequence* (the genetic code or alphabet) on the double helix, and they are *interconnected in a complex multi-layered network of interactions*. The organisation of genes within a genome is not random. Genes are not isolated units or segments of information, but they are interconnected with other genes and groups of genes elsewhere in an organism's DNA. Many of these complex interrelationships and functions are still unknown. Gene organisation consists of a finely balanced, highly complex network of interactions, which scientists are only beginning to understand.

Likewise with regard to the total genome of any species, we still only know a fraction of what there is to be known about the genetic, biochemical and cellular functioning of our crop species. A single disturbance in the functioning of one gene can have serious repercussions for the entire gene system, and have unexpected consequences for the whole cellular function and health of an organism. Changing or interfering with a plant's or an animal's genetic make-up is a delicate issue with many unknowns.

2. Genetic engineering: how it works (GE, 101)

How does genetic engineering (GE) actually work? Following is a simplified picture of *genetic engineering (GE) as it is applied in particular agricultural crops*. GE involves inserting a gene, often from a totally different organism, or a newly made-up gene, into the DNA of another organism. This process is done in a laboratory in a tissue culture. Engineering a particular corn variety like Bt corn, for example, involves inserting a gene(s) from soil bacteria into a selected species of corn, which makes the plant poisonous to certain pests. The corn plants develop a kind of built-in pesticide. The first step in the process of gene transfer is relatively easy. It involves isolating two different DNA gene sequences, putting them together in the lab in a tissue culture to form a new gene combination, a so-called *transgene.* The next steps are more difficult to do.

To introduce this new sequence or transgene in a specific place in the genome of the host plant by means of 'bombardment' by a 'gene gun' or infecting them with a bacterium that carries the transgene ('a taxi') is a very random process. These techniques insert new genetic materials randomly, because the sites in the genome cannot be precisely chosen or predicted. Such bombardment or insertions takes many (unsuccessful) trials. Controlling how many intact parts of the modified sequence will actually be integrated in the host organism' genome is nearly impossible. It has been even harder to avoid unwanted interactions between these new sequences of the inserted gene and the host's other genes. There is no control over how these inserted transgenes will behave or disperse in their new location. Basically it is a gamble, a very random process that requires numerous trials and errors, and, as a consequence, a lot of time and research money.

Because of this difficulty of controlling what happens to or how the transgene will behave, it is impossible to predict what the impact of transgenes will be on genetically modified organisms and on the environments in which they are released. The GE process can disrupt the host organism's genetic functioning in unexpected ways, which can result in unpredictable and unintended changes in the function and structure of the GMO's. It can give rise to toxins, allergens, altered nutritional value, or have harmful effects on the environment, animals and humans. At every step in the process unwanted and harmful *mutations* can take place as the report *Genome Scrambling – Myth or Reality?* (2004) makes clear.

Of course there is nothing wrong with developing new varieties of plants. The criticisms of genetic engineering as applied to agricultural crops are not a campaign against the science of genetic manipulation in general. Rather it is a critique of a biotechnology that does not respect the intricate complexities of nature and that does not take adequate precautions and follow strict regulations. As it is, regulations, especially in the US and Canada, are very weak, not enforced, or non-existent. There are no long-term independent studies of the effects of genetically changed plants on the environment, animals and people's health. The regulations are mainly based on the selective, short-term test results of the multinational seed and chemical companies themselves with little transparency. These studies cannot be duplicated by independent researchers. They are not provided with genetically engineered seeds unless they sign a contract and have their research and results approved by Monsanto and other seed and chemical companies.

3. GE applied to agricultural crops: an unpredictable, risky and 'outdated' science

When genetic engineering was first beginning to be applied to agricultural crops during the mid-1990's, it was assumed that *each gene had a single, unique and independent function*. It was assumed that when a gene was moved from another organism to a host plant, it would function in exactly the same way as in the original organism, regardless of where it was placed in the host's genome. Many geneticists were convinced that they were dealing with a straight forward one-to-one process, including *Agriculture Canada.* They described genes as the basic unit of heredity and that each gene is responsible for one particular trait. However, already at that time, twenty years ago, some geneticists pointed out that they were oversimplifying the complex ways genes function and interrelate, and that they were ignoring other factors that affects the regulation of gene functioning or expression. Since then it has become known that a single gene can influence two or more unrelated traits, or it can take several genes to trigger or create one single trait. There is no 'one to one' relationship between one gene and one trait, which makes gene transfer and developing new traits such a complicated endeavor.

Given the many difficulties and uncertainties about the way genes actually behave in living organisms, it is not surprising that many researchers conclude that GE applied to staple crops is a very imprecise, risky and inefficient method with unpredictable and unstable outcomes. In reality genes behave very differently than what was, and still is, assumed by some genetic engineers. The DNA molecule may be stable in the tissue culture in the lab, but not in fields of reproducing plants, in living systems. DNA is modified by mutations, gene flow, recombination, natural selection and environmental influences. GE in the lab involves a very limited understanding of genetic processes. We can study it, but we must take into account the limits of the fluidity and interactions of genome physiology. Altering an organism with a piece of another organism, or even with a piece of its own DNA, affects its entire physiology. As Professor Goodwin put it (as quoted in *Seeds of Destruction*, p.169), "Genes are defined by context. Genes are not stable bits of information that can be shunted around and express themselves independently of context... If you change the context, you change the activity of the gene".

Corporations selling GM seeds and chemicals wrongly maintain that the GE technique is a precise, safe, and predictable process, and that the results are equivalent to conventional breeding methods. As David Suzuki already said in 1999, any politician or scientist who tells you these genetically modified organisms are safe is either stupid or lying because there is no way of knowing. That is still true today. Many critics consider it irresponsible to release these GMO's into nature without credible or predictable criteria. They feel that given the many unknowns, it violates the precautionary principle.

Several major reports have pointed out that the old approach is based on the classic notion of the gene as *the basic unit or part of a rigid genome sequence.* The assumption is that each of the parts can be isolated, recombined and manipulated at will and without consequences. *It is a predictable machine-like picture, in which one part can be substituted with another part, like parts of a car motor.* This static, linear view is outdated. Although there have been many advances and refinements in GE techniques, like targeted genome editing, a rapid trait development system (RTDS), and others, the basic approach has not changed. In modern genetics genes are no longer *ontologically defined, that is, as entities in themselves like so many discrete building blocks;* rather they are considered *part of a relational complexity* that defies classical hierarchical linearity. Because of the fluidity of the genome, genes respond to many signals from within and outside cells to form each plant variety. Epigenetic research has highlighted how environmental factors like pollutants and toxins can alter some of functions of a plant, animal or person's DNA. In their view even the DNA molecule in all its complexity and interrelationships is not the basic building block of any organism. Rather a plant's or animal's genetic code too is part of a total system of interaction and can be influenced by environmental factors.

4. Science and technology in the service of industrial agriculture; from a Utopian dream to a ugly nightmare. (image of 'Basic Perspective')

Many authors consider this conception of plant engineering a mechanistic and reductionistic view, in which any organism can be reduced to its basic elements and understood in terms of these building blocks. Only in the computer and laboratory can complex living systems be reduced to simple, deterministic and predictable models and parts. Living organisms are seen as machines whose only goal is genetic replication, a question of biochemistry and statistics. The infinite complexities of life are reduced to simple, deterministic and predictable models. In this view plants no longer form an integral unity that grow and flourish in a particular environment and are dependent on internal and external triggers and cues for their development. It is this sense of the integral unity and complexity of plants and their inseparable intertwinement with their environment that is lost in this approach. When plants are reduced to genes, then they have no inherent nature or unity; then they can be manipulated at will.. It involves an extreme reductionism, plants like machines that can be reduced to their individual parts.

This viewpoint has deep roots in Western civilization and goes back to the Enlightenment and the Age of Reason. It reflects a deep faith in Progress and unlimited growth; in human mastery over nature. It is a utopian vision of control over and manipulation of nature, including human nature. It is a Utopian ideal of a trouble free society based on mastery of nature's laws and scientific technological progress. In science is our trust and technology can solve any problems that may arise, whether climate change or population growth. The new spirit of freedom, equality, tolerance, brotherhood, and scientific exploration has brought us many good things over the centuries. However, it is tragic to see where this new faith in Progress by means of rational scientific insight and new technologies has brought Western civilization today: the degradation of our environment and the decline of human society. What started out as a new freedom to investigate and experiment, deteriorated over time into a pragmatic and reductionistic scientism that is primarily in the service of corporate economic development. Exciting new technological advances changed to a narrow technology driven and financed by economic interests. It started out so promising. It was like a beautiful dream that is ending in an ugly nightmare, which brings us where we are today.

There is a direct relation between this kind of reductionist scientific thought and the ideology of neoliberalism. International seed and chemical companies have created an artifice of a science to legitimize the procedures used for genetic modification, disregarding uncertainties, risks, the complexities of genomes, and the impacts of GMO's on nature and human health. It removes transgenesis from the realm of science to that of profit-making speculation. For the political and economic context you can read *Seeds of Destruction; the hidden agenda of genetic manipulation,* (2007) by William Engdahl. It reads like a conspiracy theory, but it is well-documented and has had thoughtful reviews. It is a story of manipulation of the world food supply (as well as human population; eugenics) by the Rockefeller brothers and the Rockefeller Foundation. They have financed many research labs around the world and sponsored the education of numerous geneticists. This 'genetic colonialism' as it has been called purposely ignores current knowledge in order to justify genome manipulation. Gene manipulation and the creation of new species touches upon the secret of the creation of organic life. It defies the integrity of ecosystems and puts human beings at risk. It not only disregards ancient and current peasant and farmer knowledge, but it also conflicts with the most advanced scientific views of biological complexity.

What happens in this approach of creating new varieties of plants with new traits is that it breaks the role of biological or evolutionary time. It bypasses sexual reproduction and the barriers between species. Historically improvements and new varieties have been brought about not by a single change in the DNA of a plant, but by patient cross-breeding of promising plants and varieties. In this process of 'natural selection' aided by human observation and selection, the consolidation of a new trait comes about by an adjustment in the *entire* genome and structure of the DNA of the new plant. It is a process that respects nature's own restrictions to re-combinations. Thus a new variety represents an integral improvement of the entire phenotype. In speeding up this process of 'natural selection' fine epigenetic adjustments take place in the entire organism. This does not mean we cannot intervene in the evolutionary process or speed up the process of breeding new varieties. Rather it means that we must not blindly rush ahead without fully understanding what we are doing and without taking adequate precautions.

5. An alternative to genetic engineering of agricultural crops: fast-track plant breeding by means of MAS

While the controversies around genetic engineering continue on, a silent transformation in conventional breeding methods has taken place during the last decade. It is a non-invasive biotechnological alternative to genetic engineering. It is called marker assisted breeding (MAS), which is essentially a conventional breeding process assisted by genetic marker technology. There are several of these molecular marker-assisted techniques. By means of these methods specific genes can be marked and traced throughout the breeding process to create new crop varieties. A simple DNA test at each step of the selection process can determine whether the genes for a particular trait are present. The organisms that do not have the trait can be discarded. The researchers do not have to wait until the plants are full-grown. They can immediately proceed with the organisms that have the trait. DNA markers have enormous potential to improve the efficiency and precision of conventional plant breeding via marker assisted selection. It saves a great deal of time and is much cheaper than the development of GMO's.

Complex traits such as drought tolerance and many others are much more difficult to determine for the breeder than a simple trait like sugar content or size. By using genetic markers that are linked to a specific trait, like drought tolerance, they can identify the genetic sequence that is always linked to drought resistance. In this way they can avoid testing every single plant, which is a very time-consuming process. They just need to look for the marker with a rapid DNA test. In this process no DNA is altered and no new genes are introduced. It is smart breeding assisted by molecular help. Because of the speed and accuracy of MAS, it dramatically speeds up the entire breeding process. It has been effectively applied to a broad range of crop species, among them several crops that are important for food security such as barley, beans, cassava, chickpeas, cowpeas, groundnut, maize, potato, rice, sorghum, and wheat.

Conventional cross-breeding methods aided by molecular assisted selection is out-performing genetic engineering of new crop varieties. Breeders have developed varieties that are resistant to insects, viruses, fungi, bacteria, nematodes and parasites. They have developed high-yielding varieties in soybeans, rice and tomatoes, as well as tolerance to salt, drought, flooding, and acid soils. It is an impressive list. "Examples of the success of MAS are tackling bacterial leaf blight, one of the most serious threats to rice in irrigated and rain-fed systems, across China, India and Indonesia. Rice blast is estimated to cause loses of 10-30% of annual rice harvest, but MAS has successfully tackled it through the breeding of resistant varieties in Thailand and Korea. MAS has extended the lifespan of a popular and effective pearl millet variety in Northern India by breeding in downy mildew resistance – the varieties are used across approximately 900,000 hectares. In Sudan, it has helped deal with striga (known locally as witchweed) in sorghum, and is expected to be used in other African countries soon. Cassava, a staple food for 200 million people in sub-Saharan Africa, has been bred with MAS to provide resistance to cassava mosaic disease – which can deliver yield losses of 20-90% at times – in Nigeria and Tanzania. MAS has brought fungal resistance to North American wheat farmers. Other successes include flood and drought tolerant rice. MAS has proven its potential to control biotic stresses in a range of crops, and current markers even tackle some of the biggest constraints worldwide such as bacterial blight and blast in rice, rusts in wheat, common bacterial blight in beans, striga in sorghum and cassava mosaic virus in cassava." (*Smart Breeding; the next generation*, 2014, pp. 4, 5). Because of these resistant varieties there is little or no need for the use of chemicals.

One other important and crucial advantage of this marker assisted selection breeding is that it lends itself to *farmer participation* and allows *region-specific breeding*. Farmers can share their observations and experiences with specific varieties of plants in their particular climate and soil region. It gives breeders a head-start in selecting promising varieties. At the same time farmers can let them know what traits they are looking for and need in their specific region and circumstances. It provides farmers with more suitable, locally adapted varieties rather than centralized breeding crops. It ensures that local, genetic, climatic and cultural variations can be taken into account and it is an acceptable method in organic farming. It is the opposite of the standardized and homogenized varieties promoted by biotech companies. The full benefit of this local and regional approach will only become apparent if it remains an open source technology without associated patents on the techniques. Open source means that it is freely available to all independent research institutes and remains in the public domain. Headway is also being made in the mapping of entire genome sequences that remain in the public domain.

In a change-over from industrial agriculture to an ecologically sustainable form of growing food, cross-breeding aided by MAS is not the ultimate solution. It can make a very significant contribution, especially in view of climate change with its many regional different impacts. For a genuine reform in agriculture many other changes are needed, like: land tenure reforms, securing property rights and land access, halting land and water grabbing by big investors, eliminating chemical farming and deforestation for growing more monoculture crops, eliminating patents on living organisms, establishing the right to preserve seeds, fostering social equality, changing unequal power relations, having access to technical knowledge, eliminating high farmers' debt level, equitable food availability, lowering meat consumption in developed countries, development and maintenance of rural communities and infra-structure, etc.

B. GMO's+ (plus: synthetic fertilizers, pesticides and herbicides)

6. The limitations of GM crops (map of countries with GM crops)

Almost 20 years of genetically modified crops and what have we gained? Very little. They have resulted primarily in 2 simple traits, herbicide tolerance and insect resistance, which have been applied to 4 main crops: maize, cotton, rape seed (canola), and soybeans. These 4 crops account for 99% of the total area (millions of hectares) grown with GM crops. The remaining 1% consists of: herbicide tolerant sugarbeets and alfalfa; drought tolerant maize; and virus resistant papayas and squash. These crops have been grown primarily in ten countries, who account for 98% of all GM crops grown. This means that the great majority of countries do not grow GM crops. In terms of breeding these are very disappointing results. These crops produce less per hectare than the seeds that are already available on the market. The yield potential has not increased. Moreover GM crops are turning out to be less nutritious than naturally bred crops. Because of the over-emphasis on genetic manipulation, new and advanced techniques have been discovered, but these advances have not led to any major improvements or changes in genetic engineered plant breeding.

Because GM seeds are a package deal; they either have a built-in insecticide or are resistant to herbicide applications, particularly Roundup. Rather than reducing the use of pesticides, it has led to an *exponential increase in the use of insecticides and herbicides*, and, as a result, the development of superbugs and superweeds. These pests and weeds have become serious problems in the US and increasingly in Canada. Loss of natural or biological pest control requires more and more insecticides and herbicides. President Obama wants to allocate 1.2 billion dollars just to slow the emergence of resistant bacteria and prevent the spread of infections that no longer respond to antibiotics. It is estimated that in the US alone 'superbugs' are linked to 23,000 human deaths and 2 million illnesses annually, costing the American health care system 20 million dollars a year (Lorraine Chow, "Obama unveils $1.2 billion plan to fight superbug crisis, but is it enough?", *EcoWatch*, March 27, 2015). Because of the direct consequences – no antibiotics for a loved one - superbugs are of more immediate concern than superweeds. Doubling and tripling the use of herbicides that encourages the development of superweeds may lead to many chronic diseases, but this connection is not immediately evident to the public.

GM seeds put a strain on food security and food sovereignty when traditional crop varieties are displaced by GM varieties or contaminated by their pollen. They perpetuate and increase the development of mono cultures and chemical based industrial agriculture, including high energy use. The combination of GM crops and patent protection has resulted in a concentration of industrial control over seed. GE research is expensive and takes money away from public research laboratories using conventional breeding methods aided by genetic marker selection. Economically GE crops have had very limited or mixed benefits for small-scale and family farms. They have primarily benefitted large industrial farms. For consumers GM foods have not become cheaper, tastier, fresher, more nutritious, or more environmentally friendly, on the contrary. On all scores GMO's have not lived up to its promises. Just this brief summary illustrates that GE crops cannot just be evaluated from a purely biotechnical perspective, but must be looked at from all angles, including environmental and social aspects.

7. The effects on the environment

GM crops compromise and harm *soil quality*, *disrupt ecosystems*, and *reduce crop genetic biodiversity*. They increase *disease susceptibility* and *vulnerability* to environmental change and offer no solution to climate change. The current increase in industrial crop production is happening in the context of mounting water scarcity, decreasing area and degradation of arable land, increasing pollution, inevitable rise of new pests and diseases and the adverse effect of climate change. The increased use of synthetic chemicals has led to the on-going accumulation of CO_2 and other gasses in the atmosphere, leading to more global warming. Chemical agriculture is a major contributor to climate change and leads to more and more change in land use and deforestation. Without a fundamental change in agricultural policies and practices global warming cannot be stabilized. Regrettably, the need for a radical change in agricultural policies and practices is not center stage for the Paris climate negotiations, even though its impact is equally destructive as the exploration and burning of fossil fuels. Because of its impact on the environment and climate change industrial agriculture deserves equal attention as the phasing out of non-renewable energy in order to reduce greenhouse gasses.

8. The effects on animal and human health

The increased use of *GMO's plus*, that is, *plus* built-in insecticides, Roundup Ready resistance, or other stacked chemicals, have a serious impact on public health in every country where they have been grown on a large scale. GM crops can be toxic, allergenic and less nutritious than their natural counterparts. As the evidence multiplies, especially in animal studies, and, in spite of claims to the contrary, it is becoming increasingly apparent that GM feeds are not without risks for farm animals and that processed foods containing GMO's may have long-term effects on human health. Just handling pesticides can affect the health of farm workers. Government statistics in the US indicate that every year between 10,000 and 20,000 farm workers experience acute pesticide poisoning. The World Health Organization reviewed the health effects of the herbicide glyphosate, the key ingredient in Roundup, and decided it should be classified as 'probably cancerous', meaning animal studies have indicated a definite link between cancer and exposure to glyphosate. Antibiotic resistant marker genes pose special risks because GM food could transfer antibiotic resistance to human gut bacteria.

Pesticides may cause chronic health effects that may occur even after years of minimal exposure. They have been linked to a range of cancers from leukemia, non-Hodgkins, lymphoma, to ovarian, prostate, testicular, and liver cancer. There is mounting evidence that exposure to pesticides disrupts the endocrine system, regulation of hormones, reproductive system and embryonic development. Endocrine disruption can produce infertility, a variety of birth defects, impaired brain development, and behavioral disorders. Viewing the chemistry of glyphosate as explained by Dr Thierry Vrain on YouTube and the dangerous effects of glyphosate alone should be sufficient to ban the product for agricultural use. We don't need to wait for long-term scientific studies for affirmation that it is detrimental for the environment and our health. Science is not the final arbitrator in this case; that is giving science too much authority. Such long-term studies may be good for other purposes, but there is enough evidence to take action now and ban these products for weed control.

GM crops are not adequately regulated to ensure safety. Using the environment and human diet as a laboratory is an unacceptable experiment. Genetic engineering is not merely an extension of natural breeding. It is an unpredictable and risky method that needs to be strictly confined to the laboratory and carefully regulated. Since there are readily available safe alternatives to genetic engineering, we really do not need GM crops. Conventional plant breeding aided by safe modern technologies like gene mapping and marker assisted selection continues to outperform GM crops in terms of varieties developed. They produce high-yield, drought-tolerant, and pest and disease-resistant crops that can meet our present and future food needs and the impact of climate change.

9. A package deal plus royalties

Given the evidence and alternatives, why do farmers use GM+ seeds? GM seeds plus chemicals have led to a large increase in corporate control over every aspect of agriculture. GM seeds are a package deal, pesticides included and yearly patent payments. The one does not come without the other. Six transnational companies control all the GM crops commercially grown in the world. These same six corporations are the largest manufactures of agrochemicals. Since agrochemicals generate the most profit, about 85% of GM crops are engineered to resist large doses of herbicides and insecticides and the rest have built-in pesticides.

Farmers in the global North, except for corporate agribusinesses, are squeezed between economic pressures and good farming practices; between increased expenses and smaller profits. What is a farmer to do? For small family farms there are few options. With rising expenses and lower incomes there are few economic benefits. They either accommodate to the prevailing agricultural policies and practices, find some specialty niche or make a radical change to organic farming; or, as a last resort, stop farming. As it is, many farmers have to have another part-time job to survive and depend on different government grants and subsidies. Propaganda, indoctrination, and pressure from large seed and chemical companies are intense. You can read about the extent of propaganda, indoctrination, misinformation by front groups, slanted materials for the media, schools, members of parliament, etc. in the report, *Spinning Food,* (2015). It is a sordid story that rivals the manipulations of the tobacco, asbestos and uranium companies and others. Monsanto, Syngenta, Dupont, Dow Chemical and the major food companies spend millions and millions of dollars each year to "enhance US consumer trust in modern food production". We can ask Gerald what pressures and indoctrination farmers are subjected to on a local level. The challenges farmers face are formidable and they can't be solved by them alone, or even collectively. To change agricultural policies and practices requires the support and actions of many citizens and alternative organizations. Farmers are not the only ones that face these kinds of economic and ethical dilemmas. Most of us who are strongly hemmed in by neoliberal guidelines and regulations in our work face similar ethical conflicts. Teachers, for example, to mention just one group, are mandated to teach our children the neoliberal conditioned curriculum introduced by Harris in 2000 and indoctrinate our children in the neoliberal ideology. What are they to do if they are aware of this dilemma and many are, be subversive, try to get a job at an alternative school, or quite teaching? (See, *Backward into the Future*, available on line at Heathwood Press, UK.)

Farmers in the global South suffer the most from GM industrial crop production. For small-hold farmers large-scale industrial corn, soya, or cotton production often result in bankruptcies, buy-outs, displacements, forced and violent dispossession, loss of food and seed sovereignty. Mexico, Brazil, Argentina, Paraguay, and many other countries are distressing examples of the devastating effects of large-scale industrial farming. Modern agricultural practices foster social injustice throughout the global South. GM crop cultivation has accelerated the decline and impoverishment of small and mid-sized farmers. In Argentina, for example, 80% of farmed land is now in the hands of 4,000 investment funds, which is a perfect set-up for land, water and commodity speculation. The corporate aim is to incorporate all small-hold farmers world-wide into the global food production and make them into the new bonded labourers or modern slaves. The promotion and growing of GMO's in the global South is considered by many 'complicity in crimes against humanity'.

To add injury to hurt *corporate agriculture is not the answer to world hunger and poverty* either as many would have us believe. That is the myth, or rather the lie. The large segment of peasant farmers, local fishers, small-scale vegetable and fruit growers, and small family farmers provide between 50 to 80 percent of the world's food, depending on the location and country. In contrast, industrial agriculture provides food for only 30 percent of the world's population, but they use a disproportionate percent of the world's arable land, water and fuel for agricultural use. Part of the reason is that 85% of GM corn and soy crops are used to feed animals (cattle, pigs, sheep, chickens, pets, etc.) and cars (45% for animal feed and 40% for ethanol production).

Feeding the world requires a diversity of seeds in the hands of millions of peasants and small and mid-sized farmers. They feed the poorest populations of the world. With the advancement of the industrialisation of the entire food chain since 1996, the number of undernourished and obese people and food related illnesses have only increased, which is now synonymous with poverty. As prof. Latham put it, "The commercial purpose of GMOs is not to feed the world or improve farming. Rather, they exist to gain intellectual patent rights over seeds and plant breeding and to drive agriculture in directions that benefit agribusiness" (*Growing Doubt: a Scientist's Experience of GMOs*, 2015). In Europe 19 member states out of 28 have rejected or restricted growing GM crops in their country. As opposition to GMO grows, profits decline, and law suits multiply, Monsanto, Syngenta, and others may be moving away from GMOs and start a new round of patents to try to control conventional breeding methods assisted by MAS. At the same time the big seed, chemical, and food companies are seeking to develop industrial-size organic farming and gain control over organic food products.

10. Our options: buy organic and support local efforts and the NFU

We can only conclude that GE as applied to food crops ought to be rejected as a risky and unpredictable technique and GMO's in our food ought to be banned since they pose an unacceptable risk to our health. Even if they are labelled, we all pay for the long-term increase in health costs. Moreover GM crops are destructive to our environment, our soil, water, and the biodiversity of our crops, and create untold suffering and injustice in the global South. Most important of all, monocultures of GM crops have as great an effect on climate change and global warming as burning fossil fuels. Without a radical transformation in growing our food, climate change cannot be stabilized.

Rather than being discouraged by the present state of affairs, we can nevertheless take heart, because we can all learn to change our shopping habits and buy as much organic, non-GMO and fair trade foods as we are able to. Whether or not GMO foods get labelled, we can vote with our feet. Instead of the one-stop supermarket shopping, we can learn to change our shopping habits, item by item. We are fortunate in our area that so much ecologically grown food is available. It is an impressive list of what is available locally and regionally (see wall chart). It will cost a little more, not because organic food is more expensive, but because processed food is heavily subsidized. Organics are actually cheaper than processed foods if you take the environmental, health and social costs into account. What we are not told is that between 10 to 30 percent of processed food is subsidized by our tax money through a range of government subsidies, tax breaks, reduced interest rates, interest free loans for large equipment, infra-structure accommodation (roads, railways, harbours), research and development subsidies, and countless other advantages. *It is called the private appropriation of public money.* They have estimated that every time we go to the supermarket and spend $100.-, we are really paying between $110.- to $130.- The ten to thirty dollars extra money comes out of our taxes. Meanwhile the price of food keeps going up year after year.

All this does not count the ecological price we all pay for climate change and global warming and the costs of increasing health expenses as a result of unhealthy, processed food with excess sugar, salt and fat, countless additives and trace chemicals. Along with mining, forestry, and fishing, industrial agriculture and food processing is one of the most polluting industries. It creates large amounts of greenhouse gasses and chemical pollution; uses up a disproportionate percentage of arable land and fresh water. The Ontario and Canadian government are both deeply committed to expanding industrial agriculture and food production for export. It is doubtful whether the new government will make any radical changes in this regard. They will find it hard to oppose or undo the many trade agreements and the new ones in the works. The implication of these policies is that through their taxes Canadian citizens will continue to contribute to more climate change, increased CO_2 and methane gas in the atmosphere, a further rise in sea level, an increase in the acidity of the oceans and micro plastic particles, more deforestation in our boreal forests, more massive land and water grabs by large investment companies, and food speculation. Corporate power and money will have a very large presence at the climate talks in Paris just like in Copenhagen in 2009, when 800 delegates walked out because of corporate lobbying, including Elizabeth May. There will be a lot of rhetoric and window dressing, but limited substance and many non-legally binding international agreements, or binding agreements but without financial commitments. It will be the legacy we are leaving our grand children.

What can we do about Paris? Apart from committing ourselves to buy as much non-processed, non-GM food as we are able to, we can all have a voice in Paris or even several voices. First of all we can become an associate member of the *National Farmers Union,* regardless of whether we are farmers. They speak on behalf of all of us with regard to all the major agricultural and food issues. They *give us a provincial, national, and international voice* and they will be present in Paris. The internet activist group *AVAAZ* and others like it will also speak up and protest for us. If you are Roman Catholic, Pope Francis' delegates will be there. If you are a protestant, the WCC and your ecumenical councils will be there to represent you. If you are a Buddhist, the Dalai Lama has already spoken out strongly. If you are a Green Party member, Elizabeth May will testify on behalf of us all. Large delegations of peasant farmers from the global South

(La Via Campesina and many others) will be there and so will David Suzuki, Friends of the Earth and dozens and dozens of other radical environmental groups. It is our witness and protest that counts regardless of the outcome. Whatever happens, we can say to our children, we were there, testified and we protested. Meanwhile we can all support many local efforts, from the Headwaters Food and Farming Alliance (HFFA) and their Farm-to-School program, to local growers, dairies, farmers markets, health food stores, and so on. Food Link shows us the way. Meanwhile we can buy as many ecologically sustainable products as we can. We are all on the way to Paris, to testify with our sustainable practices and our many voices, for the sake of our children and grandchildren...

Arnold De Graaff, November 7, 2015

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A BASIC PERSPECTIVE ON GENETIC ENGINEERING AND GMO's

THE ENLIGHTENMENT OR THE AGE OF REASON

Utopian Dream: Faith in Progress and Unlimited Development; the End of History
Enlightened Rationality would do away with superstition, ignorance, blind faith
Enlightenment Ideals: freedom for all, democracy, rule of law, equality, tolerance

IN SCIENCE AND TECHNOLOGY IS OUR TRUST

Industrial Revolution and *Utilitarianism*:
primary value of material goods and services; consumerism

neo-liberal ideology

free trade

eliminate tariffs

electronic communication

financialization and speculation

GENETIC ENGINEERED CROPS

4 crops,
with 2 traits,
in 27 countries;
requiring more and more pesticides and herbicides;
results in superbugs and superweeds;
little or no increase in yields;
reduction in crop biodiversity;
increase in mono-cultures;
endangers animal and human health;
adds a large percentage to climate change and global warming;
corporate control over agriculture and global food system;
only feeds around 30% of the world population;
not the answer to world hunger

increase in profits

expansion of markets and corporate power

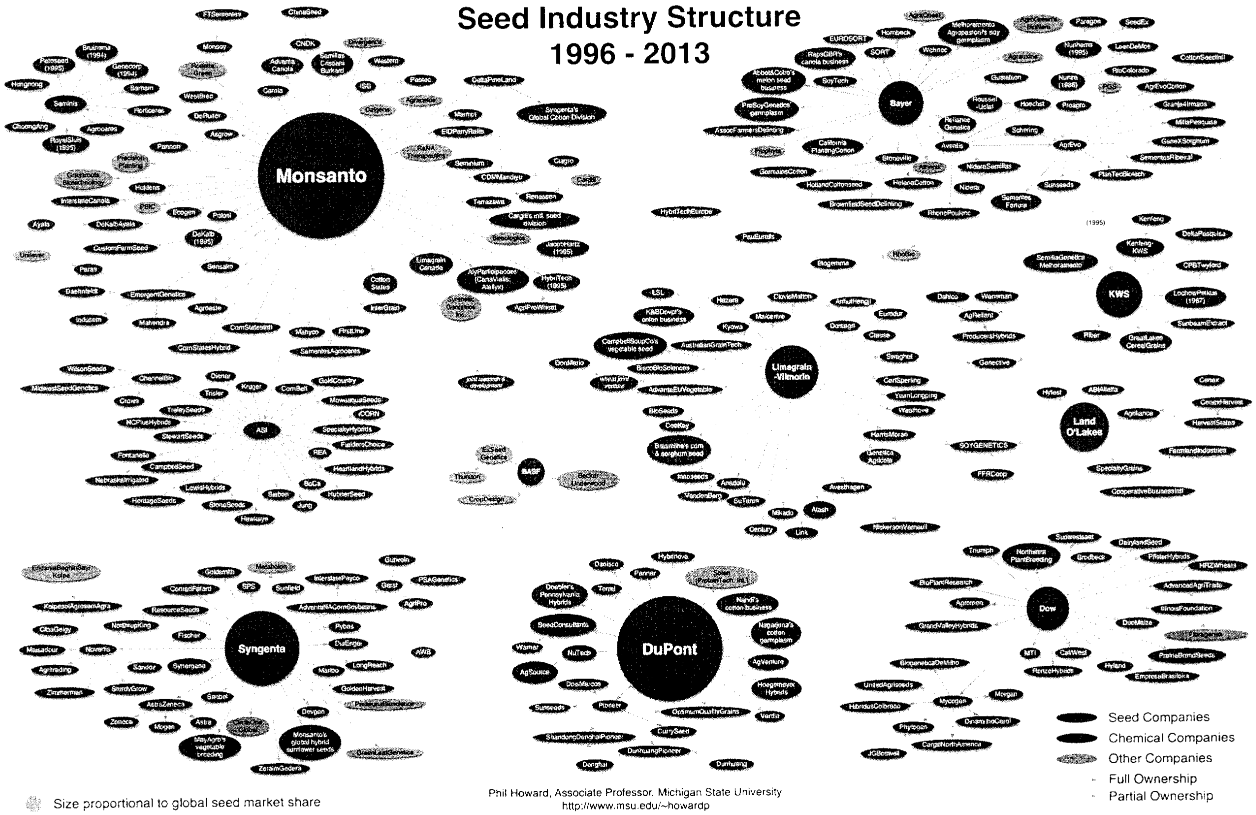
IMF, W.B. structural adjustment

austerity programs

market regulates itself; the morality of the market;
no government interference; voluntary regulations

A beautiful dream that is turning into an ugly nightmare:
disintegration of our environment: climate change and global warming;
social injustice and widespread inequality; complicity in crimes against humanity;
neo-colonialism: plundering of the global south's resources;
corporate control of global markets; propaganda, manipulation, corruption

Seed Industry Structure
1996 - 2013



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