DO YOU KNOW WHAT YOU'RE EATING?

John Vanderstoep

First of all, thank you to the Study Centre for the invitation to take part in this program on genetic engineering, specifically on genetically modified foods.

Introduction

When first approached about taking part in this program, I initially thought the task better left to others more qualified. Not that I did not have any acquaintance with the subject, nor that I did not have some thoughts on it. Being an agrologist, and more specifically a food scientist, it is impossible to avoid this issue. Upon some reflection on the challenge, I decided to accept the invitation. I think that I might be able to add something to the discussion, and hopefully, to the understanding of this somewhat controversial topic.

I deliberately say controversial, because there are several, strongly argued sides to the debate about genetically modified foods. As a consequence, the consumer is left with conflicting information, unanswered questions and resulting confusion. To guide me in the preparation of my remarks, the Study Centre committee suggested a fairly lengthy list of questions.

During the next 35 to 40 minutes I will try to address most of these issues. On the one hand, this is an impossible task – there are many, many scientists, public policy makers (nationally and internationally), consumer educators and special interest groups involved in the debate. The information on it is extensive. In fact, as I started mentally to prepare for the task, I put aside relevant reports, comments and articles. I now have a stack of paper measuring well over a foot. On the other hand, I think it is necessary, and hopefully possible, to clarify some of the issues surrounding this matter. Included in the debate is much rhetoric and what frankly, I would label as misinformation.

I would like to structure my talk as follows:

- Define genetically modified (GM)
  - What is it?
  - What is meant by it?
- Why modify food (organisms)?
- What are the results?
- Are there risks?
- Are there checks and balances?
- Are we over-stepping our God-given role?

Genetic Modification

What is it?

A 1999 Angus Reid study (Ontario Agri-Food Technologies 1999) concerning consumer knowledge about biotechnology in foods, found that only 64% of Canadians had seen, read or heard anything about genetically modified foods. Unprompted, top-of mind concerns about foods related to a wide range of issues – including having healthy foods, the cost of food, how food is produced (including genetic modification), the

availability of food, and its taste and flavour. Having healthy, nutritious foods was mentioned first by most people – but only by 13%. Genetic modification was mentioned first by only 9%. The study also indicated that the majority of people (84%; in Ontario and Quebec) considered food crops altered by inserting genes from another plant species to be genetic engineering. In addition, nearly three-quarters (71%) also consider radiation/chemical mutation and traditional cross breeding to be genetic engineering. Just over one-half (60%) also consider crops sprayed with hormonal agents or chemicals to be genetically engineered. Fewer, but still a sizable portion (42%) consider irradiated foods as genetically engineered.

There are a number of terms that need clarification. In the broadest sense, the technology we are talking about is agricultural or food biotechnology. This is the "application of science and engineering in the direct or indirect use of living organisms, or parts or products of living organisms, in their natural or modified forms" (Canadian Environmental Protection Act). A rather legalistic description! It means using biology to make new products, and in our context, new food products. Many traditional methods and familiar foods fit into this basic definition. Grafting plants, breeding animals for desirable traits, and using enzymes to make cheese, and yeast to make bread rise and to ferment wine, are all examples of biotechnology.

Modern biotechnology as we are able to practice it today, however, is a giant leap in scientific capability. Genetic engineering, for example, helps scientists do what was once thought impossible: move genes, the hereditary units of living things, from one species to another. It is even possible to transfer genetic material between species that would otherwise never breed. At this level we are coming much closer to what might be termed transgenics. A more meaningful term to describe what is at issue is

genetic modification or gene technology. This describes a series of techniques used to transfer genes (genetic material) from one organism to another, *or* to alter the expression of an organism's genes.

Let's back up for a moment. Biotechnology is rooted in the disciplines of biology, genetics, biochemistry, microbiology, environmental science and applied technology. Peering through a microscope, the first things we can see are cells. All living things – plants, animals, and bacteria – are made of cells. Each cell has the ability to breathe, use energy and replicate. At the centre of a cell is the nucleus and inside the nucleus are rod-shaped structures called chromosomes, the carriers of heredity that do the replication work. If we could magnify further and do some unraveling, we could see that each chromosome is made up of a tightly packed and spooled string of a complex chemical called DNA. DNA has the set of instructions, or software, to build proteins – the compounds of which all life is made. A gene – the smallest part of the chromosome containing enough information to replicate itself – is no more than a section of the DNA ladder. One gene has the information for one specific protein. The DNA has the ability to reproduce itself, forming two separate DNA ladders. This recombined DNA can then continue the procedure and work with other compounds to create protein – for living tissue or for other functions such as enzymes (Consumers' Association of Canada 1999).

I just said that the replication of the DNA molecule was an integral part in the creation of proteins (used here in a scientific sense). As a scientist, I have always been in awe of the complexity, but at the same time, the magnificence and beauty of creation. The replication and creation that we speak of in scientific terms is impossible without the guiding hand of our heavenly Creator.

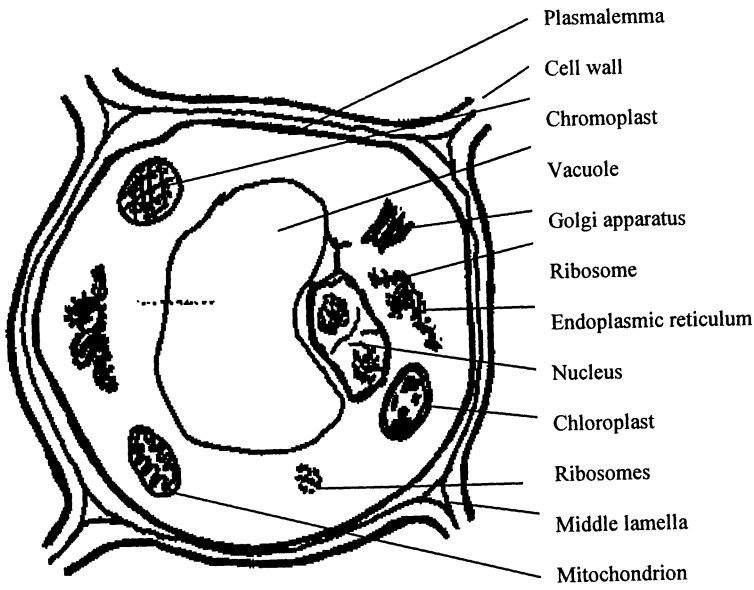

Fig. 1. Diagram of a typical plant cell

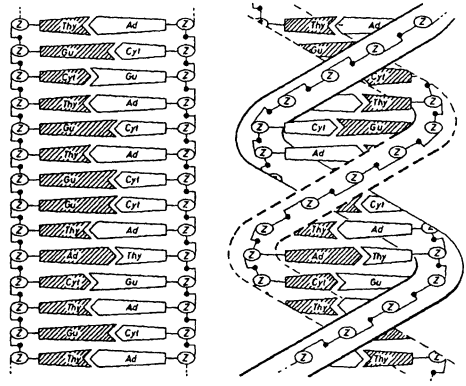

Fig. 2. Structure of DNA Strand (from Karlson 1965)

Humankind is able to do marvelous things with and in the created world, but it is only with and in his good pleasure. At the same time, we, that is humankind, have a considerable propensity to misuse the talents given us, particularly when it comes to technology.

What is meant by it?

Because of the complexity of gene technology applied to agri-food products, it is critically important that we have well-defined, precise, commonly accepted and well-understood terminology. Consistent codes of practices for labels that indicate either the presence or absence of foods from biotechnology (gene technology) are essential to ensure truthful and accurate information for the public. Both internationally and in Canada, regulatory agencies and others are engaged in defining the terminology to be used in labeling and marketing of products of gene technology. In Canada, the Canadian Council of Grocery Distributors, with support from the Canadian Food Inspection Agency, has initiated a process for developing such terminology for the voluntary labeling of foods obtained through genetic modification. A committee, representing over 100 stakeholder groups, including farmers, food manufacturers and retailers, dieticians, consumer organizations and environmental groups are using the Canadian General Standards Board process to develop such standards. At the time of preparing this talk, it was anticipated that these would be ready by early fall of this year.

In this standard, gene technology is taken to refer to techniques by which the genetic material (DNA or RNA) of an organism is changed in a way that does not occur naturally by multiplication and/or natural combination (Canadian General Standards Board Committee 2001), including:

- recombinant DNA (rDNA) techniques that use vector systems
- techniques involving the direct introduction into the organism of hereditary material prepared outside of the organism
- cell fusion or hybridization techniques that overcome natural physiological, reproductive, or recombination barriers, where the donor cells/protoplasts do not fall within the same taxonomic family.

However, the term is taken to exclude a number of other techniques such as:

- in vitro fertilization
- conjugation, transduction, transformation, or any other natural process
- polyploidal induction

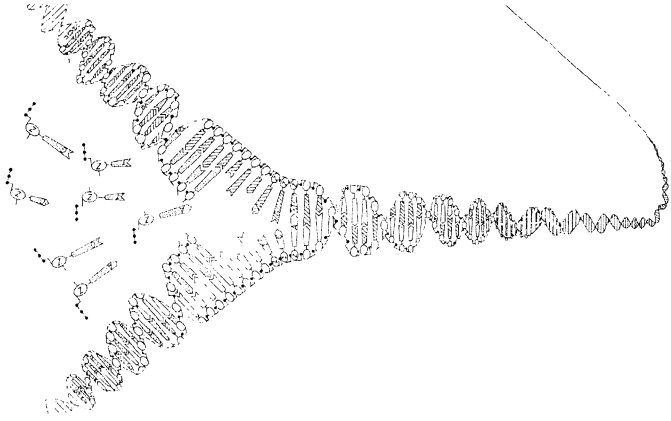

Fig. 3. DNA strand replicating itself (from Karlson 1965)

- cell fusion or hybridization techniques where the donor cells fall within the same taxonomic family, and
- mutagenesis, which is the introduction of genetic mutation through chemical, physical or radiation treatment, causing nucleotides of the exposed organism's DNA to be altered.

Mutagenesis occurs naturally at a very low rate but can be accelerated with in vitro methods. This breeding tool has been in use for well over 40 years, resulting in thousands of crop cultivars all over the world developed through this process. It does not introduce DNA. Virtually all of our common vegetable, fruit and grain crops have benefited from this technology. The sugar you will put into your coffee later tonight will likely have been extracted from a sugar cane variety that has benefited from breeding programs that included mutagenesis as one tool in the mix of tools used to make variety improvements. The excluded techniques certainly can and do modify the genetic material, but do not introduce "foreign" DNA.

These are complex matters - the realm of scientists, but not necessarily of the average consumer. As such the topic of genetically modified foods engenders concern, worry and even fear. Is this justified?

Why modify foods?

Many generations ago, when food was produced on small farm holdings, or even in individual family gardens, there was always the need or desire to improve the plants and animals used. Selecting varieties, or even individual plants or animals that had better production or yielded products with desirable traits, might have been the tool. Initially this was done very much by trial and error. Later, after the science of genetics became better understood,

it was done by selective breeding. This technique was and still is used to bring about an exchange of genetic material between two parent plants to produce offspring having desired traits such as increased yields, disease resistance and enhanced product quality. The exchange of genetic material through conventional breeding requires that the two plants being crossed (or bred) be of the same, or closely related species. Such active plant breeding has led to the development of superior plant varieties far more rapidly than would have occurred in the wild due to random mating. However, these traditional methods of gene exchange are limited to crosses between the same or very closely related species. It can take considerable time to achieve desired results, and frequently, characteristics of interest do not exist in any related species. I think

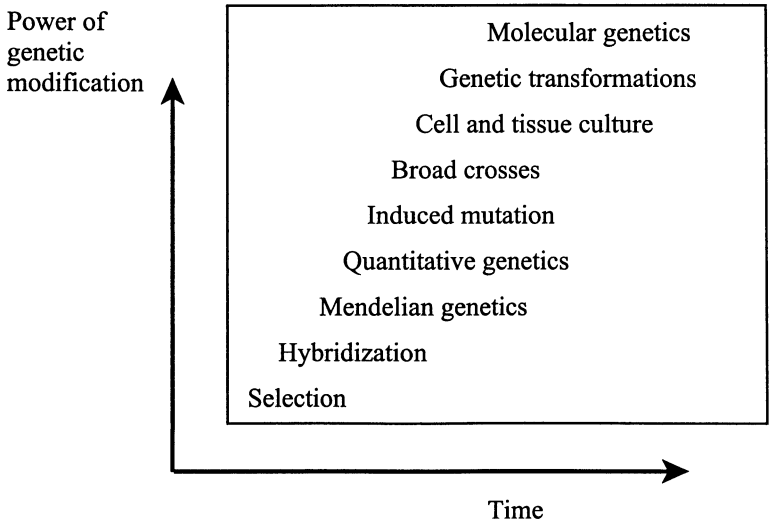

Fig. 4. Increasing power of genetic modification techniques over time. (Adapted from ITP 2000b)

all of us are aware of the improvements that have been made in resistance to disease of grain crops, vegetable crops and ornamental flowers.

In the 1970's, through some advances in the field of molecular biology, it became possible to readily move DNA between more distantly related organisms. This recombinant DNA technology, as a means to facilitate the genetic exchange in crops, is far more precise because only a single specific gene (or at most, a few) that has been identified as providing a useful trait, is being transferred to the recipient plant. As a result, there is no inclusion of ancillary, unwanted traits that need to be eliminated in subsequent generations, as often happens with traditional plant breeding (Council for Agricultural Science and Technology 1999). Even so, the technique is only another tool to create new genetic variability, which is then used by breeders to select new varieties.

What are the results?

How has this technological capability been used? Canadian food safety approvals have been granted for at least 45 plants with novel traits. A number of these illustrate some of the (early) goals of biotechnology (Consumers' Association of Canada 1999).

a. Herbicide resistance. Both corn and soybean are very versatile crops that are found in thousands of food and consumer products. Weeds are their major adversary, competing for space, moisture and nutrients. The development of broad-spectrum herbicides now allows growers to control a wider range of weeds in a single spray. With the help of biotechnology, plants have been developed that tolerate these herbicides. This gives farmers one more tool to control weeds in their fields and help improve both environmental

sustainability and crop yield and quality.

b. Pesticides. The Colorado potato beetle has been devastating to potato crops in North America for many years, but farmers now have another approach available to them to control this pest. The NatureMark™ or NewLeaf™ potato has been modified to produce a leaf protein that acts as a natural insecticide to the Colorado beetle, but does not harm animals or humans. This change means that farmers don't have to use insecticides to control the beetle, and this benefits farmers and consumers, and the environment. Farmers who decide to plant NatureMark™ potatoes also are required to plant a small area of traditional potato varieties nearby. This practice is used to reduce the development of resistance in the beetles and to help maintain a balance in the surrounding ecosystem.

c. The FlavrSavr™ tomato, although approved, is not currently sold in Canada. This tomato was developed to stay fresh longer, by identifying the gene responsible for ripening, removing it and re-inserting into the tomato backwards. This change did keep the tomato in a ripe, firm shape for a longer period of time. However, after market trial, researchers returned to the product development stage to try the technology in other tomato varieties.

d. Chymosin. To turn milk into curd, cheese-makers have traditionally used an enzyme called rennet, which is taken from calves. Researchers developed a synthetic replacement for rennet called chymosin. Chymosin produced from recombinant *E. coli* is identical to its conventional counterpart. It has several advantages over rennet. It's purer, less expensive, and does not use animals. Chymosin is now used in the majority of cheese manufactured in Canada.

With the exception of the tomato example, most of the

applications (as indicated by the examples) have been the exploration of agronomic traits, i.e, traits that concern the growing and husbanding of the agricultural crops, or the processing of foods. While these have some benefits to consumers, they are not always readily identifiable. In part, it has been this "separation" between what the technology can do and what it means to me personally, that has resulted in the skepticism among consumers. However, the next wave of applications are likely to be more relevant to the day-to-day consumer. A few examples (Consumers' Association of Canada 1999) will hopefully illustrate this.

a. Canola was developed by Canadian plant breeders through traditional plant breeding techniques, specifically for its nutritional qualities. The seeds are crushed to obtain canola oil for human consumption and the remainder is processed into canola meal, which is used as livestock feed. Already recognized for its health benefits, research on canola, including the use of gene technology, is now being done to further improve on canola's nutritional profile. On the research agenda are things like: adjusting the levels of oleic and linoleic acids, and laurate and myristic acids which are important fatty acids in plant oils.
b. A gene encoding beta carotene/vitamin A formation has been incorporated experimentally into rice. This could enhance the diets of 180 million children who suffer from vitamin A deficiency that leads to 2 million deaths annually. Similarly, introducing genes that increase the availability of iron levels in rice three-fold is a potential remedy for iron deficiency that affects more than 2 billion people and causes anemia in about one-half that number.
c. Research on milk products is exploring the removal of ingredients such as lactose, to which some people are sensitive,

and the elimination of allergy-causing proteins. Other research is trying to add ingredients that milk lacks, such as lactoferin or other immuno-proteins. Lactoferrin, an essential form of iron, is found in human milk but not in cow's milk.

d. In many countries, cholera and other diarrheal diseases are the leading cause of death. By introducing the cholera gene into potatoes, researchers in California have developed what might be a simple, nutritious, and effective way to deliver a vaccine against cholera. Initial results suggested that eating one transgenic potato per month, with periodic boosters, could provide sufficient immunity. Similar research is underway in Australia, where researchers have developed the world's first plant-derived oral vaccine for measles.

In addition to classical nutrients, other plant components (i.e. phytochemicals) are now recognized for their contributions to improved health and the prevention of some degenerative diseases. Scientists predict that in the near future rDNA biotechnology derived foods with improved levels of phytochemicals will be developed. Some have predicted that these and other health products will be well received by health-conscious consumers who, it is estimated, spend more that $6 billion annually on over-the-counter food supplements (IFT 2000c).

This kind of consumer behaviour I find extremely interesting. People, often totally oblivious of the origin of the products, or of how they were produced, or even of how they may or may not work, spend inordinate amounts of money on these "health promoting" products, without even so much as batting an eye. By the way, I suspect, no, I know, that some of these health promoting products were produced by biotechnological procedures. However, about well researched, very extensively regulated

products such as the approved genetically modified foods, consumers have very firm convictions that they are evil!

In the broader animal and human healthcare arena, biotechnology is producing drugs to treat cancers, Aids, diabetes, hormonal disorders and other diseases; vaccines, antibiotics, interferon, insulin and growth hormones. Furthermore, diagnostic products to help doctors identify disease, screen blood and perform other life-saving tests are benefitting from this technology.

Are There Risks?

Is biotechnology the answer to all the world's food and nutrition problems? Are there no downsides, no risks? The answer to the first question is a definite no and to the second a definite yes. The report by the Council for Agricultural Science and Technology (1999), suggests that in making judgements about risks and benefits, it is important to distinguish between technology-inherent risks and technology-transcending risks. The former include risks associated with food safety and the behaviours of a biotechnology-based product in the environment. The technology-transcending risks emanate from the political and social context in which the technology is used and how these uses may benefit and or harm the interests of different groups in society. The concerns or risks fall into several categories.

Safety

The first of these that I want to address is safety. It is probably the uppermost in most people's minds. Changes to our foods have always produced public concerns. This was the case for hybrid corn, introduction of margarine, pasteurization of milk,

microwave cooking, irradiation of foods and is the case for genetically modified foods.

Safety Evaluation Process

The initial safety evaluation by regulatory agencies of rDNA biotechnology derived foods must address both short-term and long-term potential food safety issues. Specifically though, the inadequate assessment of long-term safety is often cited as a major concern. Long-term human safety was considered by a recent consultation of the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO). It concluded that the possibility of long term effects being specifically attributable to genetically modified foods is highly unlikely (IFT 2000c). I quote as follows:

> .....the consultation noted that very little is known about the long term effects of any foods. In many cases, this is further confounded by wide genetic variability in the population, such that some individuals have a greater disposition to food related effects. In the context, the consultation acknowledged that for genetically modified foods, the premarketing assessment already gives assurance that the food is as safe as its conventional counterpart. Furthermore, it was recognized that observational epidemiological studies would be unlikely to identify any such effects against the background of undesirable effects of conventional foods.

To unequivocally declare any product as absolutely safe is simply impossible. Life processes are so complex that an adverse effect can never be ruled out totally.

Nonnatural Foods

The allegation has been made that the insertion of a microbial gene into a plant's DNA, makes this an unnatural creature – a "bacterial plant." Or, the theoretical insertion of a gene from a cold-water fish into a tomato plant to infer frost resistance makes this no longer a plant – making it fishy. There is really no such thing as an "animal gene" or a "plant gene." In fact, many genetic traits for common metabolic processes have been conserved through time in microbes, plants and animals. Although a few proteins from an organism may be unique to it, many plant and animal proteins have the same or closely related functions. For example, both the human brain and the rice plant carry the same genetic material for the production of an enzyme called lysozyme. In nature, genetic material does transfer across sexual boundaries. For example, strains of the crown gall bacterium carry genes that can transfer to and be expressed in plant cells. These bacteria transfer their genes to plant cells, which then make compounds that feed the bacteria (IFT 2000a).

Going back to the mission-oriented breeding of plants (using natural methods), in many instances the process was in fact a forced merging of genetic material that would not have happened in that way if left to the natural process. Yes, the modern process is more advanced, and does have the potential for overstepping what we may consider natural boundaries. Unfortunately, that is the potential of almost all technologies that man has "discovered", and emphasizes the more the great stewardship responsibility that we all must exercise.

A question posed to me for tonight was "should we stay away from genetically modified foods and stick to "natural" foods? Unfortunately, while recombinant DNA technology is the specific lightning rod in the current debate, the genetic modifications that

we have been making to our food-producing plants and animals over the years, makes it virtually impossible to stick to "natural" foods. I am not sure what "natural" really means. Of course, if one wishes to avoid foods produced by gene technology, then we need to identify these foods clearly. But is avoidance logical, is it required of us?

Allergenicity

Food allergies involve "abnormal" immunological responses to substances in food, usually naturally occurring proteins. The majority of food allergies are traced to eight commonly allergic food groups: milk, eggs, fish, crustacea, peanuts, soybeans, tree nuts and wheat; although other sources of genetic material can posses genes encoding for environmental allergens such as pollen allergens. Virtually all food allergens are proteins, although only a small fraction of the proteins found in nature (and in foods) are allergenic. Since genetic modifications involve the introduction of new genes into the recipient plant (or animal) and since these genes would produce new proteins in the resulting (modified) variety, the potential allergenicity of foods developed through gene technology has been and should be of some concern.

Despite the concerns, no unique allergic reactions have yet occurred through any of the foods derived through rDNA biotechnology. Of course a consumer with an allergy to soybeans, is likely to be reactive to a rDNA soybean as well. But no new and novel allergens have been introduced through rDNA biotechnology (IFT 2000c).

The potential allergenicity of gene technology derived foods is assessed as part of the extensive safety evaluation required before approval is granted. The strategy for this assessment is to

focus on the source of the gene(s), the sequence homology of the newly introduced protein(s) to known allergens, the immunochemical reactivity of the newly introduced protein(s) with immunoglobulin E (IgE) antibodies from the blood serum of individuals with known allergies to the source from which the genetic material was obtained, and the physicochemical properties (ie. digestive stability) of the introduced protein (IFT 2000c).

If genes are obtained from known allergenic sources, the possibility of transfer of a known allergen must be carefully examined. The potential hazards are illustrated by the often-cited case of a soybean variety constructed to correct an inherent methionine deficiency in soybeans. A high-methionine protein was introduced into the soybeans using a gene from Brazil nuts. Brazil nuts are known to be allergenic, but, at the time of this development, the allergens from Brazil nuts had not been fully identified.

Naturally Occurring Toxicants

The great majority of food plants, and many animals used as food, produce or carry naturally occurring toxic substances - the only exception being cereal grains and domestic animals (even here an exception must be made for milk). The absence of toxicants from these foods is almost entirely due to man's interference with "nature" – many centuries of selective breeding and careful husbandry. Most naturally occurring toxicants are endogenous, i.e., they are produced by normal metabolic processes of the organism that is the food source. Given the near ubiquity and occasionally demonstrated harm from toxicants that are naturally and unavoidably present in most traditional food sources, it is entirely rational to take every reasonable precaution to assure that breeding – by traditional or rDNA biotechnology methods – does not result

in an increase in risk, or if possible to reduce the risk.

Environmental Issues

There are issues related to the environment that are also very much a part of the public debate. I do not mean to say these are not important, but time does not permit me to deal with them in detail.

Among the potential ecological risks is increased weediness, due to cross-pollination whereby pollen from genetically modified crops spreads to non-genetically modified crops in nearby fields. This may allow the spread of traits such as herbicide-resistance from genetically modified plants to non-target plants, with the latter potentially developing into weeds. This needs to be carefully evaluated and monitored when approval for release of a new variety is approved (Council for Agricultural Science and Technology 1999).

Other risks stem from the wide-spread use of genetically modified corn and cotton with insecticidal genes from *Bacillus thurigiensis* (the Bt genes). This may lead to the development of resistance to Bt in insect populations exposed to genetically modified crops. There may also be a risk to non-target species, such as birds and butterflies, from plants with Bt genes. Again the monitoring of these effects of new transgenic crops in the environment and devising effective risk management approaches are essential components of further research in risk management (Council for Agricultural Science and Technology 1999).

Other Concerns

Technology-transcending risks include the social and ethical concerns that modern biotechnology may increase the prosperity gap between the rich and the poor, both internationally

and within individual societies and increase the monopolization in agribusiness. There are also ethical concerns as to the moral dimensions of patenting living organisms and the cross-species movement of genes. And of course, the question of whether this activity oversteps our God-given role is very much part of this. These risks relate to the *use* of the technology, not to the technology itself. The management of these risks requires policies and practices that give consumers choices while also promoting environmentally sustainable development through the judicious use of new development in science and technology. This is the role of the scientific and regulatory/political world we live in (Council for Agricultural Science and Technology 1999).

That brings me to the last two questions, namely "Are there checks and balances?" and "Are we overstepping our God-given role"?

Checks and Balances

Evaluation

For crop varieties developed through conventional breeding, the testing required for new genotypes being considered for commercial release is long and rigorous. Likewise, a genetically modified product may undergo assessment by several agencies, but the Canadian Food Inspection Agency (CFIA) plays the lead role. It has the direct responsibility for any necessary field trials for crop plants, and for approval of any genetically modified feed for animals. Health Canada has the responsibility for assessment of food safety. It is done under a category of "novel foods." Novel foods include:

- Those that have not previously been used as food
- Foods resulting from genetic modification, and

- Foods modified from traditional products using new processes or microorganisms not previously used

These agencies assess products of biotechnology on a case-by-case basis.

The Royal Society of Canada sponsored report *Elements of Precaution: Recommendations for the Regulation of Food Biotechnology in Canada* (The Royal Society of Canada 2001), released in February of this year, suggests that the evaluation and regulatory processes need to be more rigorous and transparent. However, it also concludes that the identifiable but relatively uncertain risks associated with the products of biotechnology can be managed by labeling, beyond what is already required by current regulation.

Labeling

Genetically modified foods are treated exactly the same as other new foods seeking entrance into the market place. If the product is different from its traditional counterpart, in either nutritional or other compositional aspects, or there are safety concerns, such as the presence of an allergen, it must be labeled. This is mandatory. Some opponents to biotechnology would have genetically modified foods labeled as such, even when rigorous scientific assessment determines there is no health or safety concern and the food is essentially equivalent to its conventionally produced counterpart. There is much debate about the usefulness of labeling as a means to educate consumers about genetic modification. However, a strong wish and significant pressure is being voiced by the consuming public that it has a right to know what is in its food or how it was produced.

Food manufacturers do have the option of using voluntary labeling to promote the fact or to inform consumers that they have

modified, or not modified the food product through genetic engineering. However, such labeling must be understandable, truthful and not be misleading. This is the exercise that is currently underway through the Canadian General Standards Board, to which I made reference earlier. It is this desire to make such statements understandable, truthful and not misleading, and not open to abuse, that is the challenge.

Acceptable and Safe

Not that pronouncements such as these are necessarily valid, it is noteworthy that many agencies and organizations have indicated that the *safety* of food derived from genetically modified material is adequately assured by the science-based procedures effectively used by the plant breeders and regulatory agencies and that this technology responsibly used is a legitimate tool for a more sustainable future.

Are We Playing God?

The last question then is, "Are we over-stepping our God-given role in the use of this technology"; "Are we playing God?" I left this very important and central question till the end intentionally. For me personally, it is not a difficult one, but I fully appreciate that it can be for many individuals. Whether it is or not, is predicated on some understanding about what biotechnology is and about how this powerful tool is used. The answer is also moderated by the scope of the topic or issue to which we apply the question. As we will undoubtedly hear tomorrow, this same fundamental technology can be applied to the area of human cloning. Here the answer is very clear to me. But how about when using it as I have tried to explain this evening, in the modification

of plants, microorganism and possibly animals as a means of making new and better foods?

Technology in itself is rarely the issue. It is the manner in which it is used and to what end. Technology and all of science, for that matter, are tools given to us by God, the creator of all things. We, as the creatures he placed in the creation, were mandated to:

> "…..Be fruitful and increase in number; fill the earth and subdue it. Rule over the fish of the sea and the birds of the air and over every living creature that moves on the earth. … I give you every seed-bearing plant on the face of the whole earth and every tree that has fruit with seed in it. They will be yours for food." (Gen 1:28-29)

That was before the fall of man. Sin came into the creation of which God had declared: "it is very good" (Gen 1:30). After the fall and because of it, God said to Adam, and through him to us all:

> "Cursed is the ground because of you; through painful toil you will eat of it all the days of your life. It will produce thorns and thistles for you, and you will eat the plants of the field. By the sweat of your brow you will eat your food until you return to the ground, since from it you were taken; for dust you are and to dust you will return." (Gen 3:17b-19).

The once perfect creation now shows the signs of imperfection, disease, pain and sorrow. Yet God has not left us to our own devices. He enables, yes, demands of us that we manage his creation. He provides many tools. He has permitted many scientific discoveries to be used by us. He has permitted tremendous medical advances, enabling us to support life even beyond what might realistically be called living. When we go to these lengths, using God-given technologies to go beyond what God has intended, then we are no longer the image-bearing

stewards that God demands us to be.

I was recently alerted to a 1998 article by David Tyler, published by the Biblical Creation Society on its web-site (Tyler 1998). In it he reported on the disdain expressed by HRH the Prince of Wales about the increasing proliferation of genetically modified foods in Britain. The prince had supposedly proclaimed that this kind of activity "takes mankind into the realms that belong to God and to God alone." He is quoted as having written: "The fundamental difference between traditional and genetically modified plant breeding is that, in the latter, genetic material from one species of plant, bacteria, virus, animal or fish is literally inserted into another species, with which they could never breed." He goes on to say: "I happen to believe that this kind of genetic modification takes mankind into realms that belong to God, and to God alone. Apart from certain beneficial and specific medical applications, do we have the right to experiment with, and commercialize, the building blocks of life? We live in an age of rights and it seems to me that it is time our Creator had some rights too."

Now, far be it from me to discredit His Royal Highness, but a scientific expert he is not. (In fact, I often question his moral ethics, as well!) However, his comments illustrate the power of blanket, partial truths, especially when uttered by highly visible public figures. His first statement, while on the surface correct, is a gross simplification of what in actual fact is the situation. His second suggestion that for certain specific medical applications it is OK to experiment with the "blocks of life", illustrates the dilemma that even Christians face. What is acceptable and what is not? In my mind, I have a number of serious questions about the ethics of organ transplantation. God has given the technology that enables us to do so, but is it proper stewardship to utilize this

"unnatural" exchange of fundamental, life-sustaining organs to prolong life that within this spoiled creation is subject to disease, decay and death? How far can we go in altering this God-given process? Remember the words of Gen. 3:19, "for dust you are and to dust you will return."

I think the comment by Tyler sums up the thesis that I have tried to develop this evening: "Some plant and animal breeders proceed in the belief that there is an innate variability in organisms, and that desirable traits can be developed by a process of artificial selection. All this is consistent with the thought that God has created organisms with the potential to vary, and that selective breeding is a justifiable expression of stewardship." I might modify the statement here to read "this can be a justifiable expression of *appropriate* stewardship." He goes on to say, "This is not to imply that all selective breeding programs are acceptable – some appear to have lost the links with the concept of stewardship. If this argument is accepted, then it is possible to interpret genetic engineering, involving the introduction of genes from other organisms, as an extension of the breeding process with man acting as an intelligent designer" (Tyler 1998). And, I would add "a responsible steward."

Conclusion

The final question that was suggested to me was "Are there perils to this science?" Although the word "perils" creates a very negative tone, I would need to say, that there are serious issues that could be raised by and come out of biotechnology. It is potentially very powerful and if improperly used could certainly be perilous. However, I am convinced that the technology as it is currently used to modify plants, and potentially animals, for the production of

high quality food is beneficial. The issue is not one of safety! Again, we can be irresponsible stewards, but that in itself does not make the technology by which we practice, wrong or improper.

Thank you for your attention and interest.

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RESPONSE

Nelson D. Kloosterman

As we reflect together on issues relating to genetic manipulation and biotechnology, we need to remember that these questions must be placed within the context of a worldview (Kuhn 1974; Payne 1985, 1-32). There exist a number of competing worldviews available for understanding this ethical issue.

One popular worldview is the *ecocentric* worldview, which places ecology and questions of natural balance, primitive beauty, and primordial innocence at the center. Within this worldview, human well being and the interests of the human race are often viewed as competitors to the interests of the ecosystem. Planet earth is the center of this worldview and earth's well being is the highest good from which all other values are to be derived.

A popular alternative to this worldview is a standpoint to which we might be attracted in response, namely, the *anthropocentric* worldview where human beings exercise dominion and sovereignty over the earth. Here, man is the center and his well being is the highest good from which all other values are to be derived.

A third worldview, perhaps the dominant one in connection with the issue of genetic manipulation, is the paradigm of *scientism* or *technologism*. Science and technology come to be pursued as goods in themselves. Technology possesses an inherent momentum and scientific experimentation is seen as self-justifying. Often questions that non-scientists raise with regard to value and

meaning, and with regard to morality and moral good, are viewed as threats to "pure" science, or as attempts to control scientific inquiry, or merely as the inhibitions of the ignorant.

None of these alternatives fully comports with the biblical worldview. The biblical worldview appropriate to issues of genetic manipulation and biotechnology is the *covenantal* worldview. This view considers each human being as living in four relationships: first, to God, second, to our neighbour, third, to ourselves, and fourth, to the creation (Douma 1999, 329-358. Douma has even added a fifth dimension, namely the relationship to creational structures. pp. 343-348). Although we do not have the space to discuss each of these four relationships, it is useful to see that all our questions relating to biotechnology and bioethics involve each one of them. However, we should observe that their relative order - God, neighbour, self, and creation - is an important feature of this covenantal worldview.

As we seek to identify the issues and explain the principles involved in this arena, one of the first problems we face is that of terminology. Have you noticed that in discussions of biotechnology, we are tending to employ mechanistic language which views nature as a mechanism? We speak of a DNA *code*, of gene *splicing*, of genetic *engineering*, and of *reproduction* rather than *procreation*. All these terms have embedded within them a mechanistic view of nature (Rifkin 1998, 227; Kass 1985, 48; Kilner 2000, 138-139).

But let me move to the heart of my response to Dr. Vanderstoep's excellent presentation by indicating that the Bible provides no direct guidance or prohibitions in this area. Thus we need to rely on principles derived from the Bible, principles that provide direction and orientation. Such principles shape our motives, help us identify consequences, and the like. I would like

to describe a matrix of those principles under the theme of stewardship. This matrix has three dimensions or coordinates (Douma 1997, 168-171).

First, biblical stewardship requires that we *cultivate* creation. Part of this cultivation, as we learn from Genesis 1, involves rule and dominion. The first coordinate in this matrix is that God has entrusted us with the calling to pursue creation's secrets. That pursuit always involves risk. The nature whose secrets we pursue is created nature, not autonomous nature. The nature with which we are working was created by God and possesses a structure that must be respected. The ethical problems here are the same, in principle, as with other discoveries and inventions. All of us have heard of people in earlier generations quipping about flying and space travel to the effect that if God wanted man to fly, he would have created us with wings. Well, that same kind of logic can also operate in the field of genetic manipulation in our generation. The argument would be that if God had wanted us to do this kind of manipulation and this kind of discovery, then he would have given us clearer instructions. Without those instructions, we had better keep our hands off. I'm suggesting that the same principles that obtain in other areas with regard to discoveries and inventions obtain in this sector as well.

The second coordinate is that man's work with creation is *curative*. Here, we face the effects of the fall. We face brokenness in creation so that as we work in the sector of biotechnology, our primary goal is curative, not creative. Curative, not cosmetic. Curative, in the sense of dealing with the consequences of the fall in the plant and animal world.

The third coordinate or dimension of this matrix is that our work with the creation must be *conservative*. That is to say: we must keep intact the diversity existing in plant and animal life. This

is not to be equated with maintaining a kind of paradise, as if the plants and animals we see today are genetically identical to those that existed in paradise. We don't know that. As a matter of fact, it's quite likely that forms and processes of evolution have occurred within the completed creation over the millennia.

Now the challenge in this field of biotechnology arises at the intersection of these coordinates of cultivation, of curing, and of conservation. It arises, for example, where the drive for cultivation collides with the need for conservation, or where unleashing creation's curative powers conflicts with conserving creation's diversity. But these challenges are not new. Rather, what is new are the scope and breadth of our decisions, as well as our capacity to affect creation by altering its structure, while not being altogether sure of the long-term consequences of our scientific, biotechnological decisions. In that light, I would like us to understand what we were taught tonight. This whole business of modifying plants and animals has been going on for thousands of years. What are new are the precision and the speed with which changes can be brought about in plants and animals.

Let me, therefore, leave you with these two suggestions, two ethical burdens with regard to this area of research and development. The first is that those working in fields related to biotechnology need to develop a *predictive ecology*, formulating risk assessment standards and procedures (Rifkin 1998,77-81). Molecular biologists and biotech companies ought to be required, as part of any approval or patent process, to present the results of field tests performed on a large scale among various ecosystems. Predictability and certainty are the most necessary qualities in the outcome of any scientific experiment, and they are the most lacking in the current biotech industry. Years, even decades, are required to test hypotheses, to experiment, and to assess consequences.

Finally, as biotechnology develops, western nations need to enable *global participation* in assessing economic and environmental consequences. This technology has the capacity for creating a new form of imperialism - not geographic or political, but economic imperialism. More developed nations could, with little trouble, blackmail third world countries economically by inventing a substitute for a third world product on which local third world economies depend. For most of us, motorized vehicles have become essential to our way of life so that we might be delighted if biotech engineers found a substitute for rubber. (See Considine 1983 regarding industrial uses of rubber, including the production of tires.) But in southeast Asia, twenty-two million jobs would be affected by such a discovery. Admittedly, market forces of supply and demand would provide new economic incentives in such countries. A persuasive study has even illustrated how such market forces enhance biodiversity (Schap and Young). But, enabling global participation in evaluating consequences would demonstrate a national, industrial moral integrity that would foster worldwide harmony and long-term cooperation.

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DISCUSSION

After the main address by Dr. John Vanderstoep and the response by Dr. Nelson D. Kloosterman, an opportunity was given to the audience to ask questions. The moderator or chair was Mr. Herman Faber.

1. *I would like to ask Dr. Vanderstoep who is in fact the beneficial party of all this new biochemical technology, the farmer who has to work more acres to get the same income or the large companies who are selling for instance the spray to grow healthy beans?*

Vanderstoep: That is certainly a valid question and one that is posed many times. Certainly today with respect to genetically modified foods in the agri-food sector, most of the benefits have not been very obvious or clear to the consumers. Does the farmer really benefit from all this? I am not a practising farmer, but my understanding is that certainly with the opportunity of minimizing the use of pesticides and herbicides there is a possibility of increased profit margins. The farmers are, to the best of my knowledge, adopting this technology. They are not being forced into using the genetically modified seeds but they are in fact doing so in general. They would not do this if there was no benefit in it for them.

There is no question that the multinational corporations are making money with this biotechnology. That is their main reason

for being in this business, although they do claim to be altruistic and to have additional purposes in life as well. But they indeed do make money, there is no question about it! But let's not forget either that bringing any of these new developments to market costs many, many millions of dollars. So, yes in the long run they are going to make some money. And yes, they are multinationals - perhaps Dr. Kloosterman may wish to comment on this too! But don't forget that these multinationals are in fact owned by many, many shareholders.

So my conclusion is that it is hard to be definitive as to who the main beneficiary of all this is. I do think that the new wave of biotechnology will have more direct benefit to the consumer. Due to this technology new properties can be built into our foods and that will be beneficial for everybody. It produces a more nutritious food supply and a food supply that has components in it that in fact can be beneficial for our health in terms of alleviating diseases.

As is the case with many technologies we are not able to articulate exactly the savings it brings but it is certain that there are savings to the consumer. I am certain that the processing areas I am familiar with, simply by applying a new process and preserving the food product, brings the price of that food product down. But if you ask me to demonstrate that difference between today and tomorrow to the consumer, I would argue that is very difficult.

Kloosterman: I am not sure that I will be able to satisfy any question with regard to the market forces and dynamics of multinational corporations as to who benefits - the grower, the seller, the multinational? That being said, I would like to observe that in this field there are often loud cries for government prevention, regulation, and subsidy. I am committed to the premise

that the market and economic laws that the Lord has put in place will assist in ironing out these matters of regulation, honesty in labelling and serving the broadest public. I think we need to recognize that multinational corporations are multinational corporations for an economic reason. Part of that reason is that they need the labour supply and the resources which have been priced out of their reach locally and made their local industry unprofitable. In other words, I don't think that "multinational" is a bad word or a pejorative term. I think such companies have great promise to assist in what I pleaded for earlier in my remarks, namely, global participation in the application and use of biotechnology.

2. *Dr. Kloosterman you mentioned that this biotechnical knowledge would produce a form of possible imperialism. Is not the greatest danger of imperialism that biotech inventors will become the new landlords of the world adding to further political imbalance in the world? In other words, could you say something about the global impact of having these companies possibly control our food supply?*

Kloosterman: The short answer is: yes, that danger exists! I think a study of history will show that whenever major changes occur in economic or political systems there are those who for a time profit from that change. You may think of the "land barons," people who controlled transportation, or companies which controlled the acquisition, parcelling and selling of land at the time when the West of the United States or Canada was being developed. I think that danger of imperialism indeed does exist!

However, the impulse in the face of such a danger is equally perilous. And that impulse is to stop, if possible, any advancement, to stop or retard any development, using tactics like

public opinion or fear, which thrives on illiteracy and ignorance.

The proper response to avoid the danger of imperialism, wherever the power is consolidated in the hands of a few, is to make the market as free and open as is possible for competition. By the interaction of the consumer and the producer, by the invitation and participation of everybody involved - I am now speaking globally – we can prevent the consolidation of power in the hands of a few. I would hope that would be an ideal.

How can we guarantee, how can we enable global participation in order to prevent that imperialism? I believe that multinational corporations are a good vehicle just for that kind of enabling so that people who are involved in the application of the techniques can get around the table and can help shape policies - policies that are respecting not only the needs of a developed industrialized West but also the needs of an underdeveloped or developing third world. Multinational corporations, it seems to me, are properly poised to help us enable that kind of participation and prevent the kind of imperialism I was speaking about.

Faber: I wonder to what extent we are also influenced by the media in terms of the things that we see on television or read in the newspaper or hear about when world trade organizations meet and the protesters are there and concerns are raised. To what extent does all that affect our thinking on these issues?

3. *Dr. Kloosterman, you mentioned that in addition to a need to enable a global participation, we also need what you call "predictive ecology". I gather that you mean that we should demand that these products be extensively tested so that we will be able to assess whether they are ecologically safe or not. You started your comments by saying that we are dealing here really*

with conflicts in worldview. My question or comment is whether this assessment of what is considered ecologically safe is not based on, or is not dependent on whether you come from an ecology-centric or a man-centric point of view? I was wondering how we can get out of this dilemma. Or is this simply a matter of two worldviews coming into conflict with an issue like this?

Faber: *In other words, can we trust those who test to come with a fair assessment? Is it based on principles we can accept?*

Questioner: *That is what I mean! Whether you consider something ecologically safe or not depends on your principles. I would argue that someone with an ecology centered worldview would say a product is not safe because there are environmental risks associated with it. However, someone else may say of that same product, look this is for the benefit of mankind. This product will improve people's health and nutrition and so it is fine! What do you do when two assessments conflict with one another: the one says "yes", the other "no"?*

Faber: *I would also like to hear Dr. Vanderstoep explain a bit more what kind of testing is really available and being done. For there is here a sort of underlying assumption that some of these tests are not being done properly or to the extent that they should be done.*

Kloosterman: And when Dr. Vanderstoep is finished with that, I would like to hear a lawyer on this in terms of product liability!

Let me use an analogy in my answer to your question. Precisely the analogy of product liability. Take something like a table saw. People will declare a table saw unsafe if it is at all possible to cut your finger off with the saw. Such a declaration of

unsafety does indeed involve a worldview, since value judgments assigned to the degree of safety and risk are directly related to someone's worldview. We live in a culture which by and large, because it is secularized, is terrified; it is afraid of so many things. People demand infallibility and perfection as well, in terms of products, processes, techniques and so forth. I think, however, that the standards for safety are empirical although they are in a certain sense contextualized with value. We can point to a table saw in terms of reasonable use and reasonable use standards that help define safety. But, here is where I need a lawyer to help me.

How do we get out of this? I think by applying to biotechnology the same questions, the same kind of safety processes and analyses that we apply to other areas such as product development.

I am interested of course in the worldview questions underlying our modern litigious quest for safety. But I think the way out of it is to let reality take over. In other words, people have to use saws and we will have to educate people on the proper use of saws so that they can use them without the manufacturer being afraid of a lawsuit every other week. And so it is the same in the biotechnology industry. We have to educate people as we put before them choices and decisions regarding responsible and reasonable use of processes and techniques made possible by biotechnology.

Vanderstoep: I am not sure what I can add to this but I could say something in answer to the specific question the chairman posed: what sort of testing is being done? I have to qualify that by saying that there is lots of testing being done but the question always is: what is enough? And this is where it ties in with what Dr. Kloosterman just mentioned. It has also to do with a

previous comment made that long term consequences must be evaluated. I agree, they certainly must be! But here again the question is what constitutes "long term" and what constitutes "satisfactory answers"? This is where we have the difficulty. Partially because we come from different perspectives. My perspective is food safety. And then I am satisfied that the genetically modified foods we have available today are safe. The kind of testing that is done on these products is to evaluate them in terms of their composition, and in terms of where it has come from.

In other words, if we insert into product "X" a small gene from a very closely related plant species, genetics and the biology will tell us that we are not likely to expect very significant changes in characteristics. This is the kind of evaluation that is done: "what kind of compositional differences are there, if any?"

If there are likely to be allergenic properties because the parent materials have the likelihood of being allergenic, then we need to be very careful and very diligent about evaluating the resulting product for its allergenicities. You have to look at allergenicity from the point of view of what protein is causing that allergenicity. How susceptible is it to degradation in the gut, and so on and so forth.

To be precise in my response is totally impossible, but from the safety point of view I am convinced that the evaluations are extensive and adequate. The principle that is used is the substantially equivalent one. In other words, the end product that we are approving is substantially equivalent to the product that it is replacing. I do acknowledge that the equivalence is always a matter of degree.

With regard to other testing that is done with respect to ecological impact, I am much less qualified. I know that there is a debate going on, but there is indeed lots of testing being done. The

question is again: "when is it enough?" I can also add to this that today it is generally acknowledged that the regulatory process is adequate but it is not transparent enough. That shortcoming certainly came to light when the Canadian Biotechnology Advisory Committee had hearings across Canada this past spring. In other words, you and I, unless we are insiders, do not necessarily know, or have access to, the information that the evaluators and the regulators evaluate. The Canadian government and other jurisdictions are intent on implementing more transparency so that the process is more obvious. Then we don't have to simply go by the word of the regulator: "Believe me, I have told you it is OK", but you can make that decision yourself.

Now that is a problem as well! I have had thirty years in food science and there have been a number of technologies that have come along that have echoed in many respects that of biotechnology in terms of nonacceptance, fear and so on. And one can argue that, if you put all the information on the table you can make the decision. Still that is not true. We can not! I mean I may be able to make that decision when it concerns food science but if you ask me to evaluate the safety of a car, I have to rely on someone else. I am not capable!

So, indeed we can make it more transparent. We can also make the information available so that you and I can evaluate it and make our own decision. But in the end that decision is limited by our ability to understand what is being put before us. So, there are limits here too! Yes, lots of testing is being done on the ecological side and the economic side. I know all kind of protocols that Canadian food inspection agencies have with respect to how many field trials need to be done, replications and all that sort of thing. Are they adequate? From my perspective, I think they are. But that's from my perspective. Somebody else coming from another

angle would probably say that they are not.

Faber: Just as an aside, when we are talking about this transparency or making the consumer more aware, you might have heard that just yesterday the Canadian Parliament voted down a bill to label food products as to whether they are genetically modified or not. The bill did not pass in the House of Commons.

So, there are lots of political and other issues that play a role here too. The issue of safety and the problem whether we can really trust this new technology is certainly on the mind of people here who handed in questions. One of them reads as follows.

4. *Has genetically modified food contributed to an increase in attention deficit disorder? What can we expect? Will the food that we eat possibly cause more people to have this disorder?*

A related question. In the last few years, we have begun to see a negative impact of soya based infant formula. Certain phytosterols at high levels are becoming associated with male sterility and puberty starting at a much younger age. It is being banned in New Zealand, and research groups in other countries are also expressing concerns.

Vanderstoep: I am not sure that I have answers to these specific questions. I would comment, however, that the conditions that are referred, attention deficit disorder, the consumption of soya based infant formula, and the impact that this has on basically the balance of sex hormones in developing children, are issues related to food supply. I don't think it is fair to lay that at the doorstep of genetically modified foods. It is not really my field, but do we know what the cause of attention deficit disorder s? To suggest that the greater prevalence of modified foods and the increase in

attention deficit disorder are related is not necessarily an accurate reflection of what is going on. I really do not know!

The problem with assessing and evaluating safety is that it is not always clear what the relationship is, if there is any, between different factors. In my classes I like to demonstrate that point by showing our increased reliance on certain electrical appliances and the increase of certain diseases. Yes, both of them are increasing, but are they associated? There are many events that happen side by side that are nevertheless not related at all.

With regard to soya based products, there is definitely a greater reliance on them today than there was in the past. I think this is in part – and here I will be controversial – where biotechnology may have a positive impact. Today we can more closely mimic the replacements that we are trying to use. Soya is being used as a replacement for mother's milk. There are lots of things that are missing from soya as there are things missing from cow's milk which are in mother's milk. I think there are opportunities for biotechnology to put some of those things into these products so that we have less of the current problems! But these are, I agree, only some very general comments. I am not sure that they are answering the question.

5. *I do not have a question , but I am somewhat confused and concerned about what I heard so far tonight. I just heard one of the speakers say that mother's milk can perhaps be replaced by soya milk. I think there is nothing better than mother's milk. Nobody can ever duplicate that! We need to go back to nature. I am not a scientist but I do know that what goes into my mouth on a daily basis does have impact. It is generally recognized that our industrialized world is affected by what we eat. Genetically modified food is a small part of that. But the food we eat today is*

toxic and makes us sick. Most cancers are directly related. Type two diabetes is cancer related. We have to be very careful here! I have done a lot of reading and research on this topic. I think we should not allow ourselves to be used as guinea pigs. Our physical health is too important and there is a lot at stake here.

Vanderstoep: I would like to make only one comment. I certainly don't disagree with you that there is nothing better than mother's milk. When I was suggesting that we can modify some of our products to replace mother's milk, I am also thinking of those situations where mothers are unable to produce milk to feed their children. For it's true, mother milk is perfect. It was intended to be! We should indeed not tinker with that! But there are oftentimes situations when that is not adequate.

Kloosterman: In addition, I would point to my comment about using this technology for a *curative* rather than a *creative* purpose. With that I mean that technology at its best repairs and remedies what is defective and deficient in what is natural. Many of us are thankful for prosthetics because of a lost limb. The description of Dr. Vanderstoep about mother's milk is another example albeit in a different field.

As Christians, therefore, I think we have to be careful with regard to identifying and defining what is "natural." After all, what I am doing here tonight for you right now is quite unnatural in the sense that all of us are enjoying a device that amplifies my voice. We make use of unnatural things all the time in life! So, I think that the concept of "natural" is far from clear. And to make policy decisions such as "we need to go back to nature," is not at all clear in my judgment.

6. *Dr. Kloosterman I noticed that you did not really clarify the origin of the three worldviews that you discussed, the egocentric, anthropocentric and the covenantal view. I was rather surprised when you were discussing the covenantal view to hear you say that our food source has evolved. I have great difficulty with a worldview that includes evolution and not creation. That is creation as God intended it because when you say that our technology has a curative function you are implying that there is a devolution in the world's food supply, not an evolution. I think that when you are talking evolution you must be consistent. Could you clarify how our food sources are evolving?*

Faber: *I have a related written question which I like to tie in. Dr. Kloosterman, could you elaborate somewhat on man's work as being curative. What does that mean?*

Kloosterman: Well, I apologize that I was not clear with the use of the word evolution. I did not mean to speak of the origin of the world. In fact this is what I said if I look at the comments I have written down here. "Forms and processes of evolution have occurred *within that completed creation.*"

All I mean to suggest is that throughout the millennia things have changed in the plant and animal kingdom. A study of the history of botany can verify that. Indeed, I now used the word "changed." But I don't mind using the word "evolved" because I do not invest that with the meaning of "improved." I do not invest the word evolution with the value of improvement. In this context, I simply mean with the word evolution, "changed." So, I want everybody here to be clear that God created the world out of nothing , by the power of his Word. The world did not come into being through aeons of processes.

Now with respect to this covenantal worldview, I believe

that it arises from the Scriptures, from the creation itself and the record of that creation in Genesis 1 that we read tonight. Also Genesis 9 and other portions of Scripture assign to man a role in that creation.

Let me also speak for a moment about this curative role of technology. What do I mean? I simply mean that man's working with God's creation always occurs in the context of man's fall into sin and the consequences thereof. Earlier tonight we read some verses from Genesis 3 that spoke of thorns and thistles, of pain in childbearing, and of the results of sin in creation with which we contend every day. Dr. Vanderstoep mentioned that many foods and food sources in earlier years were toxic, but as a result of our selective breeding we have removed that toxicity so that we can enjoy these food products. So with curative I mean the orientation of man's work in creation to the brokenness and the effects of the fall into sin. In no sense does man thereby become co-redeemer with Christ, because the world will groan in travail until the revelation of the Lord Jesus Christ at the end of history. But we still have a calling to ease pain, to relieve suffering and undo and overcome these many, many effects of the fall.

7. *Dr. Kloosterman, why do you think we have to keep the rubber industry alive in third world countries if a new material is invented and developed? Things change over time. Inventions and new products become useful or they die because of technological developments.*

Kloosterman: I wanted to use this simply as an illustration of taking into account long term effects of biotechnology. As we consider the long term consequences of discovering or inventing synthetic substitutes for some of the products upon which third

world countries depend, we should engage them in this development. We look ahead with them to the effects of such developments for their economy and help them create, generate and provide substitutes for their economies.

Someone asked about consolidating too much power into the hands of a few. I believe that we have to avoid that and we can do so by international policy commissions and studies which can be done, initiated or led by the business sector as well as by the consumers. Here is an opportunity for Christians to exercise the kind of transnational integrity and responsibility towards others in identifying and evaluating long term consequences.

In principle, I have nothing against finding a substitute for rubber. But I would like us to assist countries that depend on rubber production to find an alternate product for their local economic sustenance.

8. *My question concerns biodiversity. It seems to me that biotechnology inherently results in minimizing biodiversity. As different strains are developed, others are lost. That has been the result since man has been selecting and breeding plants and animals. I wonder, though, whether the present biotechnology does not accelerate that process so that the number of species are limited. Is there not a risk that we lose the diversity that we have today?*

Vanderstoep: This is certainly not my area of specialization but I would agree that one of the risks or perils associated with biotechnology is the consolidation of the genetic material in fewer and fewer strains, or increasingly fewer lines, if you like. And the risk is losing biodiversity.

However, to enable biotechnology we need to have

available to us a rich biodiversity. I think it is incumbent upon us to maintain that biodiversity. That is probably a national and international responsibility. Although I am not familiar with the details, I do know that there are considerable discussions going on right now in the context of this biotechnology which try to maintain the biodiversity. This is important both for present as well as future biotechnology. To the best of my knowledge this is certainly a concern of those who are in the business of regulating these things.

9. *My question goes back to Leviticus 19:19 and similar verses in the Old Testament that speak about "kind" or "sort." It forbids the breeding of different "kinds" of animals. Is this not some kind of normative rule for us? Should there not be a boundary or limit beyond which we cannot go so that we respect the different species?*

Kloosterman: That is an excellent question not least because it refers to the Bible and how we are to use the Bible responsibly in this discussion. The passage you refer to, Leviticus 19:19 states: "Keep My decrees. Do not mate different kinds of animals. Do not plant your field with two kinds of seeds. Do not wear clothing woven of two kinds of material …."

What do we make of these laws? If we would start with today and say, "Do not wear any clothes woven of two kinds of material," I think most of us here tonight would be in violation of such a principle. If we say, "Do not plant your field with two kinds of seed," I think that some of us do that in terms of maximizing our product yield and our use of our land.

I happen to believe that these laws were given to Israel by God to teach Israel at every moment of every day that she was a

different people, different in every way, all the way to the clothes she wore on her back. She was not to be intermingled with the nations but was to remain absolutely separate from those nations - spiritually, ceremonially and morally. That is the function of these laws. And that determines their meaning and application. Therefore, I think that their relevance to the issue of biotechnology is limited.

Vanderstoep: Keeping that perspective in mind I am going to go out on a bit of a limb by saying that one should be careful equating what is done in biotechnology with intermingling of species.

I tried to point out that when we are excising a piece of DNA from one species or even from one strain of species and implant it into another, that piece of DNA which is just a small portion of the total, does not *make* that species or does not *make* that plant. The technology we are using today is to use a very small portion of the genetic material, one, possibly two or three genes, which in itself is not the character or the essence of that species. When we are using that to modify the genetic material of another species, I don't think we are in the realm of "intermingling species" or "intermingling genetic material from species." I think we have to make that distinction.

I know that this does not answer all questions and does not bring us to a point where we can say ,"Okay, now we have got the answer and there is no question about it!" I don't say that but I honestly think that it is not "intermingling of species." Think of the example that I used of a "fishy tomato." People who are opposed to biotechnology, come up with that one all the time! But it is a fallacy! It is not a "fishy tomato." It is a tomato that potentially has some genetic material from another species in it. I

hope that this answers the question.

10. *I have a question about the use of antibiotics. Is the over-use of antibiotics to help, for example, production on the farm not problematic? In the health industry we find that we now have very resistant bacteria.*

Vanderstoep: In terms of bacteria resistance, I fully agree with you and I think you will find that there is a concerted effort being made in Canada and elsewhere to decrease the use of antibiotics for enhancing growth and fighting infections. Indeed, the use of antibiotics has diminished significantly in Canada, in part because it has been recognized that we are in fact creating, if you like, a race of superbugs that are not susceptible to these antibiotics.

I think we have another case right now where during the last couple of days news reports tell us that many people are buying antibiotics because of the anthrax scare. That is another very good example of a potentially harmful situation where widespread use of antibiotics can be detrimental. Where there really is an anthrax case, the use of these antibiotics is certainly justified. But if there isn't such a case, we are just encouraging the bugs to become resistant and therefore we are going to have problems with it.

11. *How long is too long in research? I ask this in relation to soya infant formula because it has now been twenty-five to thirty years that we have discovered the side effects of the high estrogen levels in instant soya. This is being implicated in causing early puberty as well as sterility in males. New Zealand has virtually banned it and the American Association for Pediatrics is asking that its use be reduced. But you go on to say that we may have to genetically modify soya or put long chain of fatty acids in formula*

so that it is more easily assimilable for infants. But when we know from research that 95% of mothers can breastfeed, why is it then that in Canada at three months we only have a 46% rate of breastfeeding when God made this simple food so wonderful for us. It does not only have implications for infants but it has implications for mothers as well, in terms of their fertility and long term cancers of the uterus or the breast.

Vanderstoep: With respect to the mother's milk, I don't disagree with you at all! I think Western society has in fact gotten to the point that the natural process of the mother feeding her infant has been shunned. I am not necessarily saying that this is indeed the way to go. Far be it for me to do that!

What I was alluding to in my speech in terms of modifying soya was also for the benefit of adults where we know that certain fatty acids are better for us. We have been hearing from dieticians that we should be increasing our consumption of unsaturated fatty acids. I think we can modify some of our other food sources to increase that intake. That was what I was alluding to, not necessarily to modify the infant formula.

One other quick comment I would like to make is concerning the time required to do research. It is unfortunate, but the biological process is extremely complex. It is virtually impossible to cover all fronts and to cover all tracks in a research setting in order to access and evaluate all the aspects of a biological process. Yes, we are going to make some mistakes and I would argue that we cannot, even with predictive ecological testing, test to the point that we are satisfied that there are no risks anymore. It simply does not work!

12. *Dr. Vanderstoep, why do Britain and the European*

countries take a much stronger stand against genetically modified foods?

Vanderstoep: Again a very good question! Certainly the media would suggest that the European countries are much stronger in their opposition to genetically modified foods. I was in Europe about ten days ago for four weeks and I must admit I did not notice it but maybe that was because I was not looking for it.

Let me just relate to you one bit of information that I learned a few months ago. That was about the backlash against genetically modified food in Britain. The United Kingdom has stores that explicitly say "no" to genetically modified ingredients and genetically modified foods. In such stores, you do not even have the option of buying genetically modified food. Why is that? It is mostly a matter of market force. There was namely one large retailer which decided not to stock any genetically modified food because of the sentiments that genetically modified food is bad. Their market share (and stocks) started to creep up. That was seen as a positive thing and everybody jumped on the bandwagon. I have it from very good sources that that was the only reason! It was just simply a matter of economics!

Now having said that, I must admit that the European community appears to have more stringent regulations in place or at least proposed. Many are on paper but have not actually been implemented. And they are going to have considerable difficulties in trying to actually make them work. There is the issue of how do you detect genetically modified food. If you say a product cannot be labelled free of genetic modification if it has more than one percent genetically modified material, the question is: how do you determine that? The testing procedures are not that well worked out. They are faced with problems of false positives and false

negatives.

So, the answer is: yes, strict regulations appear to be in place in Europe. But my latest reading on it is that many of these regulations have not actually been tested in terms of how well they are going to work. That is not to say that they are not going to work but it needs some time.

I think that we should not forget that Canada also has regulations in place. If I did not already do so in my presentation, I would like to say now that if food is genetically modified and it causes changes, then it has to be identified and has to be labelled as such. That is mandatory in Canada. If the product is not different, it does not have to be labelled, which of course raises the question how you can tell without question whether it is, or is not different! But it is a fact that in Canada if genetical modification causes changes from the traditional or the normal counterpart, it is mandatory that it be clearly indicated and labelled. So, we are not really that different from Europe! The degree to which the regulations are in place in Europe may be a little bit further than here, but the intent is essentially the same.

Concluding Comments

Herman Faber

I would like to bring the discussion to a close. First of all, a hearty thank you to our speakers of tonight for sharing their time and expertise. We have learned that this issue is a complex one and we have just scratched the surface. There is here a lot of food for thought here.

Tomorrow night we would like to turn up the heat a notch when we will address the topic of engineering humans. Some of the issues will be the same, some will be different. We are very fortunate and thankful that Dr. Tony Jelsma will join us tomorrow evening and Dr. Kloosterman will then be speaking as well. I invite you all to come back!

When I am now trying to pull together a couple of points which were relevant tonight, then I think that this entire issue should be seen under the heading of stewardship.

Our stewardship includes our responsibility, and we heard Dr. Kloosterman stress the covenantal aspect of that responsibility. God has given us promises, but also demands. And we have to deal with both of these.

In our stewardship lies also a challenge, a challenge to subdue this creation God has put us in. I think Dr. Vanderstoep has shown us how in various ways we are subduing this creation, also countering some of the effects of the fall into sin as it applies to food. Dr. Kloosterman spoke in that context about the curative aspect of our covenantal mandate.

And so I think that the biblical notion of stewardship

should be our guide. I hope that tomorrow night we will get some further insights in these topics. We invite you to come again!