The Genetic Modification of Food

by

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The Chairman of the meeting was Mr. David Curtain QC.

I am going to tell you about the advantages and possibly the problems that may face you in the genetically engineered world. I'm going to turn first to a slide which will tell you about the history of the change in genetic information. In 1928 Griffith injected a mouse with a killed Type III pneumococcus along with a live, virulent pneumococcus Type II. He showed the material from the dead cells of Type III had transformed the live Type II pneumococcus into a Type III virulent pneumococcus. 1928 - that's a long time ago. Nobody knew why, but it could be repeated and it was clearly a real observation. In 1944 Avery took an extract from the killed cells and found that the substance that really caused the change was the DNA and not the protein.

When I was a student, which is roughly around about that time, we were still arguing the toss as to whether DNA that only had four variables could possibly make a baboon and a banker and a bureaucrat and all other things different from each other, with just those four possible variables. Clearly, this was not correct. DNA was it. Everybody was then after the structure and in 1953 the structure was proposed by Watson and Crick. I always feel that Roslyn Franklin got a bit of a poor deal out of that. I'm sure many of you have read the "Double Helix." If you haven't - read it. It's a marvellous "warts and all" job on how these two got together and developed the model for the structure of the DNA molecule - and I think you'll discern a certain amount of ego.

In the 1960s the amino acid/DNA code was discovered and this was a very exciting time. Whoever would have thought that this triplet of bases coding for each amino acid was in part redundant. One codon was unique, some amino acids had four codons, and one had six. This was an extraordinarily complicated way of using these four variables, uncovered in the 1960s; papers were coming out all the time as to whether "my codon coded for say, lysine, or whether it didn't."

The next thing that was really critical in the 1970s was discovery of the restriction endonucleases. These are the genetic scissors which cut DNA specifically and the ligases are the scotch tape to put the bits together again. In other words, you chop up DNA specifically and recombine the pieces. Hence, if you cut the DNA from two different organisms with the same specific endonuclease and mix the DNA from the two along with a ligase, maybe you could make a recombined DNA molecule. And that was done in 1972 in a bacterial system. Of course, scientists were excited about the possibilities and then it was proposed that a gene from SV40 (an oncogenic mouse virus) should be

put into E.coli and everybody said, "Good God, we're going to produce cancerous coli." Questions were then asked, "Does a single gene when put into a non-pathogenic organism cause it to become pathogenic and oncogenic"? Then they called a conference at Asilomar in California, 1975, and as a result of that, guidelines from the National Institutes of Health and similar ones in UK were developed. We had two Australian academicians go across, Jim Pittard and Jim Peacock. When they came back they said, "Look, we need some guidelines for this work, it is absolutely fantastic stuff, it gives us tools we never had previously. We can ask questions we would love to ask and couldn't do before, but we need to be careful, we need guidelines."

So they published the Australian Academy of Science Guidelines (ASCORD). By the 1980s it was clear that the horror scenarios which had been suggested earlier had not eventuated. It was clear as a result of NIH experiments on risk assessment that single virulence factors which came from, say, the SV40 type of experiment were insufficient to provide the necessary set of characteristics which make something pathogenic.

Remember, at that time work on the rec-DNA and restriction endonucleases was done by biochemists and physical or organic chemists who had absolutely no understanding of virulence and epidemiology and knew no pathology, so they had no feeling at all for what is required to make something virulent. It is not surprising that the furore in the 1970s was not in fact supported in the real world, when it was tested experimentally in the 1980s. By the 1980s it was clear that useful things would come from this, so the Commonwealth government decided to take it over (and probably tax it). The Recombinant DNA Monitoring Committee (RDMC) became a creature with a five-year life span. At the end of five years it was decided that we needed to continue surveillance but the name was changed to the Genetic Manipulation Advisory Committee (GMAC) because the technology had expanded so that you could actually shoot DNA into a cell without having to use the recombinant technology per se.

Up to December 2000 we had a non-statutory system which had worked extremely well, but there were people who were uncomfortable with this system. The government passed the Gene Technology Bill, in December 2000; this becomes operational as a law on June 22 2001.

You've asked me to talk about GM food. The first thing I'd like to do is to remind you that we've been manipulating the gene pool of plants forever. If you were given an apple as it once was, you wouldn't eat it.

It's rotten. I don't mean it's rotten in the sense of it's spoilt, but it is bitter, full of tannin. I was sucked in as a student when I did my PhD on cider. Wasn't it a splendid thing to do it on? I did it in Somerset and they gave me a cider apple. They look gorgeous. They're red, and they shine them on their pants and say, "Have a go at this" - ugh - it was awful. They are the most unpleasant things you've ever eaten.

Most apples or any other fruit or cereal or anything you eat is going to be very, very unpleasant in its first wild form. What has been done since that time is to select desirable parents, cross them and amongst the offspring select the very good ones, discard the ones that aren't good and repeat the process. You gradually, in a sort of Brownian movement, ease your way to a better product. In this way we have moved from being a hunter/gatherer to being cultivators of plants and animals which we wish to husband. But that's a very slow process and a very imprecise one. You may even have observed the experiment yourselves amongst your offspring. Highly desirable parents though you are, all your children are, of course, highly superior. Well, it doesn't always work.

With the new technology we are able to take a defined piece of DNA from a host in which this property is clearly defined and insert it in the background of a highly desirable plant. Most of the technology has been directed at plants rather than animals because people - and again this is something that I think is present in many of us as a population – feel more comfortable about using a modified plant than eating a modified animal. And I think at the back of the head it says, "Pigs today, us tomorrow." So be that as it may, the likelihood is that almost all of the foods that are modified by the novel technology at the present time are modified plants or modified bacteria rather than modified animals. Most of what I will be speaking of this evening will relate to plants rather than to animals though in principle exactly the same philosophy could apply.

We've selected plants with superior properties and, clearly, as these are inherited, we're talking about changing their genome but we've done it in a random fashion in the past. Today we have a tool which offers us the opportunity to take a highly developed plant with the properties we want for agriculture in our climate, and place the gene we want into that background. The one piece of serendipity about this technology is where that gene goes. We cannot at present target the site in the plant genome where the gene will be inserted. So there's a degree of uncertainty as to whether we might, in inserting the new gene, cause

what's technically called a pleiotropic effect. In other words, you stuff it in here, what the hell does it do to Bloggs down there? That's one of the reasons why the technology is under surveillance by a committee such as the one I've just mentioned.

I'd like to say something now about the technology as it is currently regulated. We have the Office of the Gene Technology Regulator. Isn't it a splendid title? Wouldn't you love to be the Gene Technology Regulator? At the present time the Regulator doesn't exist but we have a real office. This office is going to have a number of statutory activities and it is going to produce regulations, guidelines and codes of practice and it's going to monitor whether or not people do what they should be doing and it's going to provide public information. The Gene Technology Regulator will receive advice on policy principles and ethics from a Ministerial Council, a Community Consultative Group and an Ethics Committee. A fourth committee, the Gene Technology Technical Advisory Committee (GTTAC) is like the old committee GMAC which offered technical advice on all proposals. The other committees will not look at individual proposals. The technical assessment will come from part-time scientists.

Our surveillance process in the past has been produced by practising molecular biologists, scientists, medicos or ethicists. They have been people who are doing another job out there, which means they're up-to-date workers in the field and that's a very important part of a good regulatory system. If you have people step out of this type of science for say, five years, they are just so far behind the eight ball that they may not be well equipped to consider the things which are coming forward at the current cutting edge of research which is what this committee will be handling. I think it is a very important principle that we stick to having a technical committee of part-time people who are active in the field. I hope that that structure will continue under the new Act.

In the future, a "notifiable low risk dealing" in a contained laboratory can go ahead in an accredited place or organisation such as a division of CSIRO, a university or a hospital. They will establish a bio-safety committee (IBC) which will look at the proposal and if they agree it's of low risk, it's not going to be any trouble to anyone, and it's going to be contained within the laboratory, they will give permission for the work to go ahead. They will simply send a copy of the proposal to OGTR, the GTTAC will take a look at it, and if they agree, the whole thing will proceed. We do something very like that at the present time; it has worked very well and it's relatively unbureaucratic.

If the proposal is something which the GTR believes has a higher risk but is still within the laboratory, the IBC where the work is to be done sends the proposal into the OGTR, it's sent to GTTAC for advice, this goes back to the GTR and a decision is sent to the accredited organisation. Again, it is a fairly simple process if the organism will be contained because all of our rules relate to keeping the organism within the closed system. On the other hand, if we want to release it live into the environment we have another set of difficulties because the people out there cannot have any say - this organism is going to live out where they are and the public can't do very much about that. Contained work is kept indoors, so that the worker and the organisation where the work takes place have total responsibility. When the organism is put out in the field, there's a whole range of other constraints. What will it do to the environment? What will it do to other plants? What will it do to animals? What will it do to other people? And if I don't like it because I have some adverse feeling about it, what are my rights in this matter? So release produces an entirely new set of concerns.

The legislation requires the Regulator to consult on the initial application with all of the States, the Commonwealth agencies, local government, the public, community and environmental groups. Anyone who wants to be on the mailing list can receive a copy of the proposal. It will be put on the Web so that if you want to look it up you can do so. Any concerns which these people express go back to the Regulator.

All this material is considered by the GTTAC, which advises the GTR, which develops a draft risk assessment. This draft risk assessment is sent to the same group of people as above for their advice. So you have two loops. The first is to develop the concerns that might exist out there. The risk is assessed and a second loop takes place, advice goes back to the GTR and then a decision is made. If it is approved, conditions may be stipulated. That is the process which the new legislation will have in place by mid-June.

Having said all that, I remind you of the steps which any new release to the environment must undergo before it reaches the commercial stage. First of all it's contained because you have to make your new construct, tissue culture or whatever else and then you have to reconstitute your tissue culture as a plant and grow it in a glasshouse so that it doesn't turn out to be a trifid. This is all done in containment and until it gets a tick there, it doesn't come into the planned release regulations. When it is satisfactory in containment you then grow the plants in an open plant house or in a small plot in a field at an

agriculture department, CSIRO, or university. Small plots are needed to make sure that they can grow well in the open. If it succeeds here it moves to the larger plots and multiple sites and this may take four or five seasons before it is regarded as satisfactory. If it goes through those tests well, you need a seed increase, demonstration-sized areas and then a general release and commercialisation may follow. That process can take anything from five to ten years. So you can dismiss the idea that these plants are released as food plants just as if they've moved into the mind of some scientist in a laboratory and they're on your plate tomorrow morning. It's really not the way it works. You have a process here which enables a very large number of plants to go through their reproduction cycles in many millions before you get to the point where it becomes a commercial reality.

I've talked about the process, what are the risks associated with this? GTTAC undertakes risk assessment. This requires you to identify potential hazards, to say to yourself, "How likely is this hazard to actually appear? What's the probability with which it will happen? How absolutely horrendous would it be if it did" and then "What measures can you take to minimise or control it"? Of course, you have to be satisfied there are some benefits. Whether you accept that risk or not is whether you believe the benefits outweigh the risks. Medicos face this all the time - somebody is terminally ill, here is the wonder drug that's going to protect them from this difficulty but they're going to have nausea, pregnancy, dandruff and every other thing, along with the protection that this drug will give them. If you're in extremis you may take the drug. It doesn't say there's no risk; what it does say is that you believe the benefit outweighs the risk.

Now if I said to you that those are the sorts of risks you'd expect in your food I think you'd tell me to get lost. But I would give you this little chart. This is horizontal scale is your age from 0 to 100 years and this is the probability on a log scale that you will die within a year. So this is 1 in a 1,000 chance, 1 in a million chance that you'll be dead within the year. I want to focus your attention first on this graph, remembering that we're at 20 years here, at 40, 60 et cetera to 100. Being born is slightly hazardous. It gets better until you're a teenager and then it's all downhill. When you're my age, it's not l good and you blokes are worse off than I am. So I'm saying to you, I'm off the twig with a 1 in 50 chance next year. So that's the risk you accept by merely being alive. Okay, what will you die from? Well, here are some probabilities. These, incidentally, are insurance figures which I pinched

from an insurance company. If you are struck by lightning it's a little better than 1 in 2 or 3 million. Well, that's our population in Melbourne and about once a year some unfortunate person is struck by lightning and killed. Motorcars, where are they? They're up here, at about 1 in 8,000 - 10,000. How many of us have come in a motorcar today? And if I offered you a cream bun with a probability that it would kill you, you wouldn't be awfully thrilled. So it's a very personal matter. If you accept the risk because it's something you want to do and it's personally beneficial to you, you'll take all sorts of risks. But if it's somebody else putting something on you, the "oughta" syndrome takes over - they ought to do something about it.I'm saying to you that risk is a very, very subjective matter, very difficult. I just put that before you to remind you of what we're dealing with, not that everybody has the same perception about all risks. You just don't. So how do we go about deciding what is the risk in growing a GM plant? What we try to do is identify the hazard components. There can be hazards associated with the parent organism, the source of the introduced DNA, and with a vector used to introduce the DNA into the plant. There may be, of course, problems with the resulting GMO and there will be attributes of the environment which may make the novel organism more or less successful. So we try to look at attributes which relate to each of those properties and ask, "Do we need to be more or less careful, give greater scrutiny to these attributes?" We ask, is it a crop, free-living or a weed? If it's a crop we're less concerned than if it's free-living or a weed. Of course, if somebody said, "Look, here's capeweed and I want to put herbicide resistance into it", we'd tell them to go away. On the other hand, if we're talking about a crop plant which is something you have to plant every year, it is not likely to go up the hills and over the mountains, then we're less concerned. Does it produce fertile pollen? You can get male sterility in plants or you can get ones in which the stamens are so hidden they do not shed pollen - carnations are a good example of that. We ask how does the pollen get about? Is it by wind, insect or whatever? Does the plant self- or out-cross? Some plants are entirely self-fertile; others out-cross widely. We are more concerned, of course, about the out-crosses than those that are self-fertile. You can imagine we have a long list of questions about all the other components of the construct. Now on the basis of that process we offer a risk assessment which says we believe it's safe or unsafe, or that is appropriate to grow it but you must do this, this and this in order to use it as safely as possible. Now this doesn't mean that there is no risk. We don't live in a risk free

society and GM food is no different from anything else.

One of the things that I am concerned about is management of GMOs once they get out into commerce on the farm. I believe our process does give us reasonable control up to the point where there is a commercial release and I believe our task is to ensure that farmers understand that this is a new tool and I draw an analogy with antibiotics in 1945. We did not take the care we should, as a result we over-prescribed and over-used. We are now drowned in antibiotics. We have resistant organisms everywhere and we have lost the tremendous benefit that antibiotics gave us in the early days. Resistance was something we did not know about at the time. We now do. And if we make the same mistake here we're bloody idiots, along with the drunk drivers. It really is criminal if we fail to understand that we have a tool here which is new and we should use it carefully and properly. Management on the farm, I think, is almost our most significant challenge in the use of this material. I do feel that very strongly.

In the past we've had, as I said, a non-statutory approach. We now have the law and the benefits are that there is increasing representation in the way the process works because of all of the consultative groups and ethics committees. We have increased transparency because we're putting more things on the Web, we're informing more widely than we did before, there is increased monitoring to see whether people are actually doing what they're supposed to do and there's more detail provided in risk determination. The risk determination is no different in its rigour but people are told in greater detail why we arrived at the decisions. Of course, the one that pleases many people is the power to prosecute those who fail to keep the rules. At present we can't prosecute, unless you use common law power after the GM has caused damage to you. But we do not want to be in a position where we must wait till damage happening. We want to stop damage from happening.

In my observation of people's concern about genetic engineering, there is little concern about diagnostic kits and reagents; nobody worries about them. They are very happy to be able to tell whether or not some particular disease is present or perhaps whether a gene in a family is likely to occur in a particular offspring. The topical application of GM agents is not a difficulty. Injected material is of no concern; nobody minds insulin, nobody minds having growth factor, nobody minds factor 8/factor 9 being used. Injected DNA as vaccines is not a problem. Even whole live GM organisms are not a problem. But

eating GMOs, they go bananas. They've been eating pork chops forever without getting pointed ears and a curly tail but suddenly this stuff really turns them off. And I find that very interesting. I can understand gene therapy. In this country gene therapy involving germline cells is against the law. But somatic gene therapy is possible; it is controlled by a sub-committee of the National Health & Medical Research Council (GTRAP). Our part in that exercise comes at the laboratory level where the researchers are identifying the gene, studying it in an animal model, making sure that it does code for what it wanted. When it comes to putting it into people then the National Health people take over. So this sensitivity to food is quite interesting, I think.

Some concerns relate to religious or lifestyle preference or are of a socio-economic type. Some people believe it transgresses natural laws, nature's laws, or God's laws and that worries some people; they have moral or religious feelings and that's a difficulty for them. It may offend those who want "organic" food. The fact that it's organic in any chemical sense of the word is not at issue, it's the philosophical organic that I'm speaking of here (which is why I put it in quotes because I don't ordinarily eat the tin). GM foods will offend those folk. It may also offend those wanting small cottage farming because they prefer that lifestyle.

Perhaps the issue that concerns a very large number of people relates to genes which are of interest to agriculture. These are owned by multi-nationals and often, if the plant contains a herbicide-resistance gene, the company not only owns the gene but the chemical as well and they are worried that the multi-nationals will have an undue influence on the whole agricultural scene. None of these concerns has anything to do with efficacy or safety, but that doesn't mean they're unimportant. They're very important, because unless people are satisfied over these issues they will not use the material. I'm not wishing to dismiss them at all but to recognise them as something that has nothing to do with safety but is nonetheless important.

There are, however, hazards which are genuinely addressable. You could make a novel pest or pathogen by putting in something which changed your original host organism to something that is undesirable. That is something that you can test for and these are exactly the things that our whole regulatory system is addressing. Here we are addressing hazards which we can test for and eliminate. We might make a novel pest or pathogen and our testing procedures are such that we hope that we won't miss any such potential.

The spread of antibiotic resistance genes is often raised as an issue. When people are constructing plants they often link an antibiotic resistance marker gene to the wanted gene and then put them both into the host organism. Amongst the offspring they are looking for antibiotic resistant cells because they can wipe out the rest of the population and then amongst the survivors they look for the wanted gene. But that will often mean that both genes are present in the final product. Our concern is does that constitute a serious public health problem? If you choose the right antibiotics as markers, it does not. If you use an antibiotic like hygromycin, it has never been used on anything, people or animals. It is a perfectly good selectable marker in this context. The one, however, that is most commonly used is kanamycin. I don't know how many of you medicos have prescribed kanamycin for anything in ten years, twenty years. Anybody ever prescribed it? Not a one. And that is my experience of asking any medical group that I've ever talked to. It is an early antibiotic and it is not used today in human therapy. I believe the veterinarians do use it sometimes but it is a very, very unusual antibiotic to prescribe. Why would a resistance marker be important if you're not going to use the antibiotic? The answer is it will be unimportant because antibiotic resistance to kanamycin is very common. If you pick up a teaspoon of soil, I'll guarantee that you'll find kanamycin resistance amongst those organisms. I believe that if you choose the right antibiotic it is not a hazard that you need be worried about. It's a manageable risk.

Herbicide resistance genes spreading to weeds is something to which we give a lot of attention. If one is dealing with cereals such as wheat we have no concern. We do not have wild relatives of wheat present as weeds in Australia. So the chances of it crossing with a weed are zero. Canola, on the other hand, is another story. We have radishes, we have wild radish, we have other types of Brassica weeds with which canola can cross and canola has about a third out-crossing capability. So it is a potential problem and is the worst of the scenarios that we have to deal with. It is a real possibility. Our task is to ensure that the rotation of crops - and this is where I'm talking about management on the farm - has to be seriously looked at in order to reduce the capability and likelihood of the gene moving out into a weed population. This is a really serious issue to which we give a lot of attention.

We can test for production of allergens, cancers, deformities, and toxins. Allergens are the most difficult to identify because people vary so much in their sensitivities to allergens. But our experience has

been that if there's no history of allergenicity in the host, no history of allergenicity in the donor, there is very little probability that the resulting GMO will be allergenic. But you'll hear that discussion very frequently. Poor nutrition and digestibility are perfectly testable and so you can determine whether the GM product is different.

Reduce bio-diversity. This is one that moves into the less easily quantifiable area. My view personally is that the bio-diverse horse has long since bolted. It bolted about 1940 when we moved from small-scale agriculture to large monoculture. This is when bio-diversity was lost. I don't believe that the GMO has in any way been the cause of the loss of bio-diversity. It is the method of agricultural production which has been the prime cause. Now I'm not going to suggest that it hasn't contributed, it may have done, but I don't believe that's the prime cause at all.

Increased problems of management. I've discussed this and I believe that's a serious challenge to which we should give a lot of attention.

QUESTION: DR COURT. I'm John Court and I'm a physician. I wonder if you'd like to explore a little further the cost benefits in modified foods because you've talked about risks.

PROFESSOR MILLIS. An example of the benefits is in cotton production. Cotton is particularly sensitive to lepidopterous insects - caterpillar munching - and in the course of production conventional cotton may be sprayed as many as 15 times within a season and this is both expensive in labour and chemicals and, of course, environmentally is very undesirable. With BT cotton - BT stands for Bacillus thuringiensis - and this is a bacterial toxin which is specific for Lepidoptera (for caterpillars), it does not attack other insects. If that gene can be placed in the cotton plant genome, the cotton plant produces the toxin and, of course, the caterpillar on eating the cotton leaf is knocked off. The only problem is that, early in the growing season the plant produces a good yield of toxin. As the plant matures and makes cotton balls, it makes less protein and as a result you get a fall off in the BT level in the cotton plant towards the end of the season, so you have to be ready to spray at the appropriate time to prevent caterpillars from doing their worst with the plant.

These are the data that will assist us in seeing the benefit. In a survey in New South Wales and Queensland from 1999 to 2000 there were 780 conventional growers and 700 BT growers. So, roughly, equal groups. Only 2 per cent of the BT growers were not satisfied. Incidentally, there's a higher price to pay for BT seed compared with conventional

seed so they have to be satisfied with the benefit they got from paying the extra price for the seed, and only 2 per cent were dissatisfied. The average reduction in sprays was 7.2 per season. So, environmentally there is a big advantage there and most growers were satisfied. There were 36 growers amongst that 700 who did not reduce the number of sprays. In other words, they did not have the benefit that BT was supposed to confer and it was believed that this was due to a very high pest pressure and the wrong variety or poor development in those particular plants.

The other data that I have from Western Australia, as distinct from New South Wales, is at Kununurra. They had an average of 40 sprays in the final years of cotton grown conventionally in 1970s. You may remember that the whole of the cotton industry collapsed totally in the 1970s because the caterpillars just ate them out of house and home - they couldn't spray fast enough - so that the whole industry died. So now they're trying to use BT cotton to deal with that and, as you can see, they've reduced the number of sprays from the conventional 13 to 15 sprays. So I think there are real benefits both environmental and financially. One may be confident that farmers are not going to buy expensive seed if the outcome is not satisfactory.

The other one that I'd like to quote for you, though I don't know that I can actually give you data on this, is virus infection of plants. Like ourselves, we have no attack weapons once a host is infected with a virus. There's not a thing you can do about it, but hope the plants don't die on you. Plants viruses often reduce the yield by 15 to 20 per cent. They now know that by taking a viral gene and incorporating it into the plant they can reduce the attack by virus to zero.

This probably works at the level of DNA expression. Exact mechanism is unsure but the effect is to give very good protection to the plant against virus attack. Now that's a tremendous benefit because at the present time the only thing we can do is to try and control an insect vector, if the virus is vector borne, or use virus free seed, but neither of them helps you if the virus actually gets in. So I think there are real benefits there.

QUESTION: MR CURTAIN. If we have seeds patented by a company and they take over the agriculture in a certain area, what constraints does Australia have to protect consumers from the patent-holder dominating the market and selecting the price it wishes to charge the farmers for those seeds? That seems to me to be a concern that a lot of people have expressed.

PROFESSOR MILLIS. Yes, they have expressed this. I'd be very interested to hear from this group how different the ethical principles are in that particular situation from that which applies in oil, motorcars, Mr Software Man, or whomsoever else.

QUESTION: MR CURTAIN. I'm not sure that you've picked good examples. I don't think there are too many fans of the oil companies here. If they want to put up their hands I'm sure they will. As I understand it, the US Attorney General was taking action against the software companies. But if I could play the devil's advocate for a moment, just because there are abuses in certain industries should we act to facilitate those abuses being spread across the field when there are naturally growing crops which, anecdotally at least, have been neglected when the owners of patents have given free seed in certain areas to allow the domination of the patented crops.

PROFESSOR MILLIS. I'm not too sure about how I shall answer this, but all I can say to you is that the principle this country has always adopted, as I've understood it, is that if you have developed a significant invention it doesn't matter whether this is the proverbial mousetrap you've put a lot of effort into producing this new creature which has a significant benefit to the user, you're entitled to protect that benefit for a period. I wonder whether there is something different about food from other commodities, whatever they may be. I think that's the argument that, for example, a drug producer might use or a vaccine producer or a motorcar or an inventor of software. I don't see it as being particularly different but some people do, I will concede that.

QUESTION: DR KUHN. Gabriel Kuhn. You have given us a very persuasive argument for regulation and I'd certainly be silly to - and so would anyone else - to oppose that because you'd squash that in about 30 seconds in the way that you've presented the work. At the same time, I think every time that we munch on a piece of fruit or eat vegetables just about all of them have been genetically modified in one way or another over the years or centuries. So I have two questions. One of them is why previous to this new technology has this never been an issue? To my knowledge, apart from fava beans, no one has ever said that fruit and vegetables of any kind are dangerous or a hazard. And question two is, up to the present time what evidence is there available of these genetically modified foods being a hazard? You've mentioned canola as a potential hazard but what actual data do we have on that?

PROFESSOR MILLIS. In the case of the first question which is do we know of any conventional plant which is hazardous, the

pharmacopeia is full of poisons which are in fact plants naturally occurring all the time. I mean poppies, for example, opium poppies, Belladonna - you could just go on and on and on and on. So there are plenty of poisonous things out there which God made for us without any help from anybody. We have that problem that there are hazardous things out there all the time.

I really don't believe that we have much evidence that this particular technology is likely to be hazardous if we take the view that I pointed out earlier: If your host has a long history of safe use and your donor has a long history of safe use and you take one gene out, you know exactly what it codes for, you grow it up in a bucket, you extract the product, you identify the product, you know the code of the DNA. You know more about what you've put in it than would ever be the case when you cross two parents. I don't really see that that's a very difficult decision to take.

What are the real advantages over existing technology? I've tried in the BT case to give you an example where we could never have produced a conventional cross between cotton, maize, corn, soya beans and a bacterium. That's not ever been accomplished that I know about. Now we can quite predictably take that gene and place it in any one of those host plants to the advantage of that host plan I concede that the advantage is probably to the grower and the owner of the gene. They are the people who gain most from that activity. The question that I ask the growers and producers is when are you going to produce a tomato that doesn't take like a red cricket ball? I mean it really does taste of tomato. Then I will buy it with pleasure and I will pay a premium for that.

In other words, I think that getting food accepted is convincing us that it's good, better, best and we will buy it. We do that with respect to factor 8 growth factor. We do not want AIDS or CJD along with our growth factor. So we choose to have insulin and the like made by genetic engineering and nobody worries. Why? Benefit to me. Whereas I think the food people have missed the boat in having the wrong target. They've targeted the farmer and the chemical-maker and I believe if we could really target something that we want, we'd buy it like a shot. That's my personal view.

QUESTION: MR HAREWOOD. Laurence Harewood. There have been already examples of gene transfer from genetically modified crops into the wild population and we know that genes have the enormous ability to spread between different organisms. Particular

bacteria swap their genes, they're very promiscuous, and presumably that goes right up the food chain. I'm very convinced by what you're saying but not totally convinced that the gene technology can be restricted to where we want it.

PROFESSOR MILLIS. I think the point that I was making with canola is well made with the very issue that you've just raised. I believe with canola there's probably more danger in canola crossing with neighbouring canola than crossing with weeds. I would see this as a potential danger - let's say we have a huge area here, a region, and each of us represents a farmer growing canola. If you've got Round-up resistant canola, I'm growing Basta resistant canola, you're growing Triazene resistant canola and we're all pretty close to each other. The bees move between these groups. We could finish up with pyramiding those genes in hybrids so that you would finish up with canola which had two or three herbicide resistant properties. Now that is an undesirable outcome because you can't then get rid of canola when you want to. It will come up as a volunteer in your wheat or whatever else. I do see this as a management problem, and that's what I was saying at the beginning. Farm management is the heart of this. It's exactly the problem that you guys have met with antibiotic resistance. You pyramid the genes and then what? Do you hit them on the head with a hammer? You haven't got anything left. I believe that if we fail to learn that message from the medical side we have failed hopelessly.

So I agree with you, that's a bad outcome and it's already happened in Canada. They have reported three resistance genes in a single plant which has come from that type of gene exchange. But as you can readily understand, the crossing between canola and canola is much easier than the crossing between canola and a weed. The fertility is very low, often you can't get hybrids at all, and you've got to use enormously complicated methods to demonstrate that possibility. But canola crossed with canola, there's no difficulty at all. I concede that is a problem and I don't walk away from that at all.

QUESTION: MR CURTAIN. Professor, we hear about Dolly and the animals that are modified all the time. Are you satisfied that the legislation in place in Australia will adequately protect the future of the modification of agricultural crops or do you believe that goodwill still has a great part to play in the people who own the patents?

PROFESSOR MILLIS. It always requires goodwill. I mean we all have speeding laws but whether you keep them or not relies on the goodwill of the public, doesn't it, really? You can't have policemen

in every car. So goodwill is everything. Clearly, however, people have to be satisfied that the law is sensible and that there is a system which assists in keeping the law. You're asking me about Dolly. Dolly doesn't come under our jurisdiction.

MR CURTAIN. Until she's crossed with a cauliflower.

PROFESSOR MILLIS. Well, indeed, you never know what might come from that. Though, indeed, we do have in many of our constructs, cauliflower mosaic virus promotors. We do have DNA from different organisms in our constructs but they're not complete genomes, obviously. But in the case of Dolly, we're not talking about recombination; we're talking about whole genomes moving from one host to another. So it is a totally different technology, but it is wrapped up in the minds of many folk with genetic engineering. But it is a very different technology. Many people would put IVF in line with animal cloning. The whole area is seen by many as one continuum but I would hope that people in this group would not have such a view.

QUESTION: MR CURTAIN. But isn't that one of the issues that people used to think when they went to the butcher and bought a lamb chop that was slaughtered locally? Now in Europe it's likely to have been grown in France, killed in Belgium, its parts taken out in Germany and shipped partly to Turkey and partly to England. There's a cultural resistance to accepting the technology that is overtaking the community. Isn't part of the issue here the resistance to the fact that people don't think that scientists should be manipulating their food in a way that in fact they have been for generations?

PROFESSOR MILLIS. I think what you're talking about there is something rather different from the technology of moving single genes about. You're talking about the whole business of agriculture and big business getting mixed together and I am not the person who's competent to discuss that issue. But I do see a very big difference between the sort of things that we try to address which are very directly concerned with the safety of particular genetic constructs and we do our best to ensure that we do this in the safest way we can. I accept that what you're talking about is the fact that commodities are moving very much more broadly than they once did and technology, refrigeration and freeze drying and all those things have assisted in that process. We're on a treadmill that we're unlikely to get off and I accept that too.

In the case of the Europeans, the Brussels group at the EU are making regulations which do apply across the 17 European countries and they relate to such things as the amount of novel material a food

may contain as a contaminant, and still be regarded as GM-free or conventional. That's being argued at the moment. That issue arose when the Canadians exported to UK canola seed which was sown in UK and contained up to (roughly) 1 per cent of GM seed in what was thought to be conventional canola and that put the proverbial cat amongst the pigeons.

QUESTION: In terms of your comments relating to goodwill, I was a little concerned by your subsequent comments in regard to the experience of the situation in Canada where, for example, the canola has been contaminated and an example of, say, three adjacent farms with different types of canola each of which are resistant in a particular way. It would seem to me that even if we do rely on goodwill, in the long term, as this particular technology progresses, we're going to have to regulate the farming of products far more carefully so as to avoid that example that you mentioned earlier. I'm wondering to what extent we can actually do that effectively, when after all most of our lessons are learned after something goes wrong.

PROFESSOR MILLIS. I can only respond to this by saying that they are addressing this problem by attempting to set a minimum amount of genetically modified material which may be present in a food or in a crop above which the crop must be labelled as GM. The question then arises, what should this minimum figure be? The Canadians have set a figure where if up to 1 per cent of the seed contains a GM gene it is regarded as conventional. If it's greater than 1 per cent then it must be so labelled.

The Canadians simply regarded the exported canola seed as conventional and sold it accordingly. In Europe the European Union at the moment is saying that they would like to have a zero figure. Now, scientifically, you can't measure zero, it is a non-event. So that you must have some minimum figure with which you can set a standard that says, "If it has more than this figure you must label it." In the food regulations of this country we have accepted 1 per cent of novel genetic material as being the maximum amount that you may have in a food without its attracting a label. If you know your food to contain GM you must label it. That's the rule we have here. Anybody with any sense knows that if you say zero you've got to determine how you will decide what is zero. You have to have a method of measuring, and if your method cannot measure below 0 .1 and you have 0.1, what do you call it? If it's less than 0 .1, it's 0.001, it still contains something but you can't measure it, so zero is a meaningless phrase. It would seem

sensible to come to a minimum figure, and the Wisdom of Solomon is needed to say what that figure should be, but I contend that a zero figure is unacceptable.