GENETICALLY MODIFIED FOOD

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Part 1

Good morning everyone. As you can see we are going to be talking about genetically modified food this morning. And I notice a lot of you have already scribbled on your pieces of paper this definition, O.K. And obviously that's one of the reasons it's sitting there and this is a definition from Law in the European Union. The Novel Foods Regulation defines genetically modified food as a food which is, or which is made from, a genetically modified organism and which contains genetic material or protein, resulting from the modification.

Well I'm not going to assume today that any of you are biologists, but some of you may be. How many of you are biologists? Nobody – right well then I've got a more than usually uphill task. But let's not worry about that, O.K. What are we going to do? First of all I am going to talk to you a little bit about genetic modification and what that means – G.M. genetic modification. And then we are going to talk about the issue of G.M. food and the related issue of whether that food is safe, food safety, and then at the end we'll talk about some of the wider issues that are brought up by this business of G.M., and G.M food.

So first of all what is GM? Well, first of all you have to understand what a gene is, right, and I'm going to talk to you a bit about genes and DNA. DNA is a molecule, a chemical with the difficult name which I don't want you to try and remember but you can look it up, if you like… DNA stands for deoxyribonucleic acid, DNA is easier, right? O.K. – genes and DNA. A gene, what is a gene? A gene is an inherited character, O.K. An organism has characteristics which geneticists sometimes call 'traits' and some of those characteristics will be inherited from generation to generation. So you all know, right, from experience that certain of your characteristics have been inherited from your parents. Perhaps the colour of your eyes, perhaps the colour of your hair. But of course more broadly things like height are genetically determined but, but genetically determined in complicated ways. So these inherited characters are represented in the organism by these things called genes. Genes are as it were the invisible business which you have which leads to these inherited characters. But they are also, we now know, they are also molecules. Genes are molecules of this chemical we call DNA.

Now how is it that this molecule which we inherit from our parents, and it's part in the cell these molecules are contained in the cell nucleus, in the things we call chromosomes. We inherit those from our parents. How is it that these molecules, these genes give us the characteristics, and the answer comes that they do so by interaction with the environment. Now this is a diagram which shows you - and I use now a few genetic terms – the relationship between genes and characters. Now in genetics we call the collection of all the genes in an organism the genotype, so this means all the genes, and we call the collection of all the characteristics the phenotype.

Part 2

The genotype leads to the phenotype through an interaction with the environment. Now you need, at this point I think, just to step back and ask yourself what do I mean by the word 'environment'? Now, in normal, public language, environment these days denotes usually our global surroundings, yes? Flowers, trees, plants, rocks all that kind of thing. Well, this term 'environment' includes all those, but it also more importantly includes the environment within a cell – so these genes exist in cells those cells contain many proteins. Many other molecules and so that environment contains all the molecules in the cell and it also, of course, actually for any one gene includes all the other genes. So this is a rather bigger concept of environment than just whether it's nice and green outside. So we're saying that the genes do not map onto the characteristics exactly but they do so through a complex interaction with many other things. That means that, you cannot by knowing exactly what genes a person has, say what characteristics they *will* have, you can only say what characteristics they *might* have. Genes are talking about potential.

Now, that's the overall picture – now has does that picture reflect in terms of molecules, of chemicals? – and we have a parallel diagram. This diagram is often called the central dogma of molecular biology. That merely means that we believe it to be one of the most important principles in molecular biology. If you just look back at the other one, right, you'll see – I suppose I could animate this – you'll see that where genotype was stands for DNA for genes. We have already said those two things are identical. Where the phenotype was we've got proteins. Now in between those there's another molecule called RNA. This is a molecule which is related to DNA but is only temporarily made by the cell in order to interpret the DNA as proteins. So the DNA codes in some way for the proteins in the cell and this is an account of the mechanism by which that coding is brought to bear.

So if we go back to this slide – we've now looked at genes and the environment and how those two interact and we've shown that that is reflected in some chemicals. What we would say is that some DNA codes for and directs the synthesis of proteins. So most of our characteristics, those things we think of as belonging to ourselves are made up of proteins and their effects. So the fact that I have, well I have sort of browny-greenish eyes – that's caused by some proteins creating pigments, colours, which make my eyes look like that. The fact that I have this nondescript mousy hair is also because there are proteins in my hair follicles which secrete pigments into my hair which make it look like this. So the proteins control everything else that goes on although the visible signs can often be other molecules. Right, now having talked about genes and DNA the next things we are going to talk about it genetic modification technology. And genetic modification is essentially a technology. A set of processes which allow us to do certain things.

Part 3

And GM technology is essentially about taking DNA molecules, DNA, this molecule, this substance, and treating it a bit as if it were a piece of recording tape. Because DNA is in fact a very long molecule, , and the sequence of certain units in it, is what gives us what codes for proteins, it's very much like recording tape, ok?, it's linear code, right?, which can be interpreted in various ways. So, we talk about it as if it were recording tape. We talk about cutting and pasting it, right? So, GM technology is about taking cells, isolating this chemical from them. So, isolation of DNA, and I say DNA sequences, because as I said it's the order of various things in the DNA, the sequence of things, which contain the information. The isolation of DNA sequences, and their transfer and their cutting and pasting into little bits and their pasting - sorry their cutting into little bits and their pasting into new organisms, ok? And I will take it from one cell, and I put it into another cell, ok? That's genetic modification. You can, I mean, imagine it very simply. Imagine that this is a piece of DNA, all right? And this is the DNA of a cell, ok? What in fact we do is we cut it, ok? We take the new piece and we paste it in like that, ok? And that's actually a very good illustration of exactly how it works, because DNA has two strands, ok? And we cut them a little offset, so that they stick to each other, just as these things I've got here stick to each other, right?

So, cutting and pasting is very much like what you might do if you are cutting a piece of tape, ok, a piece of tape you might use, some sticky substance to glue the two pieces of tape together. In fact, the molecule does it for you. That's GM technology, it's simply taking these DNA sequences which are responsible for proteins, ok? And transferring them from one organism to another, and then what we get - we hope - at the end are what we call genetically modified organisms or GMOs, genetically modified organisms. And the technology is not very precise, so when you do that sort of experiment although I showed it to you looking very elegant, what you do is you take a mixture of these which you haven't analysed terribly well, and you allow it to join to a number of these, ok? And you get lots of organisms. Some of which will be useful and some of which won't. So, it's very important to know that there is always selection step at the end of this, yeah? Because the process itself is not terrible efficient - ok, that's largely of course because we as scientist don't know enough to make it efficient and specific yet, we may, one day.

Ok, so that's GM technology. Now of course what we're doing in taking a gene from one organism and moving it to another, is in some way very much like the process, the normal process of breeding, ok? Let's say I have a cow, yeah? On my farm which is very good at giving milk ok? And my friend down the road has a herd of cows who are not very good at giving milk. What you would normally do, yes, you would take the cow which is good at giving milk, right? And you would cross it with the bull who had sired cows which are good at giving milk, ok? And you would hope that their offspring would give good milk. So, you would select but you do the selection first, year? Ok? You would hope to get good genetic material, and you would cross it, ok? The difference in breeding is that you don't know what's going on among the genes at all, ok? You're guessing that, you are only looking at the characteristics, you are saying if I take a cow with these characteristics and I cross it with the bull with these characteristics I hope to get of offspring which are better. But I don't know what's going on at gene level at all.

Part 4

What we are doing in GM technology is thinking we know what's going on at gene level and moving the genes across and creating new organisms. When I say transfer to another organism, this can be an organism of the same species of course although GM technology does give us the chance to move genes from one species to another. Something which is new, well relatively new. There are certain species which we can breed with each other, horses and donkeys for instance. We can breed together, different species, ok. Tigers and lions you can breed together, just about. But there is only a very limited number of species that you can breed together. This extends that, so let's just look at the comparison between genetic modification and breeding.

So in genetic modification we are doing a directed change. I think I know what the DNA is that is influencing this trait, I will move it. Whereas in breeding we don't know anything about the genes what we're doing is a random assortment. In GM very often anything about genes – what we are doing is random assortment - we are just choosing one gene, one piece of DNA and moving it. In breeding you are taking all the genes in one organism and mixing it with all the genes in another – you've got many genes involved. And if we think of that diagram I had, genes going through the environment to phenotypes in, this case of course since all the genes in an organism are part of the environment, we are moving the environment as well.

GM – this joining up I showed you, that looked so elegant, in fact occurs at random we cannot put a gene in a particular part of a chromosome. Whereas in breeding the cellular events which are involved in reproduction mean that the genes mix in an ordered way. Here we're doing it randomly, here we're doing it ordered. Note that that is the opposite to the selection of the genes. So with GM we are being deliberate in our selection of genes, but we can only insert them randomly. In breeding we are being random in our selection of genes, but we can only insert them. But they are being inserted for us in an ordered way. Breeding as I said normally occurs within a species, it's intra specific whereas GM – we can be inter specific, we can move genes from one species to another. I'm sorry for those of you at the back, are you having difficulty seeing the bottom of the screen? You've not got long enough necks. I can't put the screen up any higher and I don't think we can make the image any higher either. Looks like the projector is on its maximum reach, sorry.

So in GM technology we're making genetically modified organisms. We're moving single genes from one organism to another. You will find if you look up information on the web about genetically modified organisms – you'll find that people are worried about them, and we'll look a bit more at these worries in a minute. First of all, the initial worry when people first made genetically modified organisms was because the original experiments were done on bacteria, and these bacteria were potentially disease-causing, the worry was that if we moved the genes not knowing how we were doing it we would create new organisms which would be more pathogenic. We have been doing this now for 30 years and as far as we know no new pathogens have been accidentally made. So worries about health are probably not justified. However we have been very careful not to

allow genetically modified organisms like bacteria to escape from laboratories so we keep them in the laboratory

Part 5

Secondly, of course, what we can't keep in the laboratory is if we make genetically modified large organisms. So if I make a genetically modified plant or a genetically modified animal, I've got to take it out of the laboratory eventually. Particularly if it's the size of a cow. Or if it's a genetically modified field crop I'll want to plant it in a field one day and see what it does. And people have been worried that if we do let them out of laboratories and, of course, they have been let out of laboratories, that they will have detrimental effects on the environment. They point to what has happened many times in the course of history' that is people have taken species from one place to another and have accidentally destroyed an environment. Ok, so, there are many islands, for instance, in, both in the Indian Ocean and the Pacific Ocean where travelling seamen brought rats to those islands. Rats were living on the ships, they escaped to those islands and they hcompletely changed the environment because they have out-competed various native species. The collection of species on those islands has changed.

But I mean you can think of much more close to home examples. So before the year 1066, Britain as an island contained no rabbits. Rabbits – you know rabbits those long eared things that live around the campus, you've no doubt seen them scampering around. There were no rabbits native to England they were brought from France by the Normans in 1066. To hunt. They have, as you see, in the subsequent millennium they have occupied this island very happily.

Those of you who come from South East Asia will perhaps have noticed that there's a plant that grows wild in these grounds, particularly over in the Wilderness, which is the rhododendron, which is native to South East Asia. Not native to England; it was brought here in the 18th c to make gardens look beautiful. But it's escaped and you will see it running wild down the sides of roads in England, very pretty during the month of May when it flowers, but a nuisance actually in general. So we know that putting strange species into different environments changes those environments. So people have been worried about that.

People have ethical issues. People say it is not a good thing to move genes from one organism to another. It is somehow not natural and not being natural is perhaps wrong. Now you can have a good philosophical discussion about whether 'not natural' is the same as wrong and I don't think we necessarily want to have it here, but that's perhaps something you would like to talk about in your class.
I am now going to talk about GM foods, and GM food safety. First of all I want to say something about the nature of food. Yes, I know we all know what food is, it's the stuff we eat, but what are we talking about. I then want to talk about the history, briefly, of genetically modified food in this country. Then I want to talk about some of the wider issues with respect to GM food.

GM food as we saw at the beginning is what you get if you process GM organisms into food. We're mainly talking about genetically modified crop plants. Now the

genetically modified crop plant has been genetically modified probably not to make it a better food but to make it easier to grow. Many GM crop plants are changed so that they grow better in the presence of weed killers. So that they are resistant to the weed killers that are used to kill the other plants that are in the field. And it may be to make them resistant to certain types of insect attack.

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It's unlikely to make them better foods although there is one example of that which I will tell you about. So what's the nature of food? Well of course we can divide food into two sorts, there is the unprocessed food which basically we are just taking out of the environment and eating, right – fruit, vegetables, meat, fish. Now these may have been growing wild or they may have been farmed. It doesn't really matter which, we are talking about the same sort of foods. We can think about processed foods, that is what we do when we take these ingredients and we do something to them. Usually what we do when we are processing a food is we take, somehow, purified ingredients and mix them together to make something nicer. So one of the essences of processed food is that we've got some things like flour, sugar, butter, these are all things which are taken from unprocessed foods and produced by a processing mechanism. Let's say we're mixing them together to make pastry. Then we are putting some meat in the pastry and we've got a pie which you buy in the Student's Union for lunch. So that's processed, and what we are looking at there – the purified ingredients, are the purified ingredients that you find in cells. They are sugars, proteins and fats, and we all know something about having a balanced mixture of these things in our diet and that being relatively good for us.

But we also know that processed foods often have additives to stop them going stale in the shop and artificial colourings and flavouring to make them look nicer and taste nicer to us because we know that the industry does these things in order to sell food. So some people think processed food, perhaps, is less natural - will it is less natural - than unprocessed food but perhaps it's worse in some way. Because perhaps some of these things we add to it are not too good for us.

This slide is just there to remind you that, of course, unprocessed food can be bad for you too. So every time you eat unprocessed food, even if you wash it quite carefully, if it's been grown in the soil you will almost certainly be eating some bacteria. There's no way that you could wash them all off, they're sort of, you know they bury themselves. But if you are not too careful about washing it you may be eating a few insects as well, you can't help that because they are too small to see, insects can be very small. So there are always some contaminating organisms but mostly if we treat food sensibly those organisms are not pathogenic and we don't get any harm from them. But there also can be, the result, there can be toxins in fresh food which are bad for you. It's a really interesting fact, for instance, you probably don't know – potatoes and tomatoes they come from related plant species in South America and yes, in the potato plant everything except those tubers is poisonous. In the tomato plant everything except that fruit is poisonous. We have just taken the two bits and in one it happens to be the roots and in the other it happens to be the fruit, that is not poisonous. Well, no doubt there were some trials early on when some humans unfortunately ate the wrong bit, and they soon learned not to eat the tubers of a

tomato plant or not to eat the fruits of a potato plant. They do have them, you just don't eat them. There are very many parts of food that we eat that we can't eat because they are toxic and we throw them away.

So foods can be processed or unprocessed, there can be contaminating things in all of them which are dangerous to us. So what about GM food? I want to tell you just briefly about 3 GM foods and what happened to them, in the U.K., in the United Kingdom.

Part 7

Now cheese, this pack of cheese from the supermarket. Today about 90% of the hard cheese that you buy in a supermarket in the U.K. is made using an enzyme called *kymosin,* also called rennin. This enzyme is made by genetically modified microbes. The natural kymosin is only found in the stomach of young calves, and once upon a time what farmers used to do was they killed the young calves, they washed out their stomachs to produce the enzyme and they used that to clot milk, that's the old farmhouse based technology.

Killing off a lot of young calves and collecting the enzyme turned out to be very expensive and when GM technology was introduced someone introduced the gene for this protein into a microbe, and you can make it in big vats very cheaply. It has the additional advantage that for people who are vegetarians this enzyme has now been made by a microbe and not by an animal. So some vegetarians wouldn't eat cheese because it contained some protein from a calf; they thought this was cruel. The fact that this stuff is made from milk from a cow seemed to be a secondary consideration but that just shows how mixed up an idea vegetarianism is in the U.K. Notice this cheese is not made using the organism, but it is made the product of the organism, that is an enzyme or a protein. You remember back to our initial definition that makes it a GM food. You will still find this stuff on sale in the supermarket. People haven't noticed it's a GM food.

The second example I want to give you is tomato paste from GM tomatoes. This is the one example of GM crops where things were changed to make the food better. People changed tomatoes so that they contained an extra enzyme which meant that they ripened more slowly. This makes it easier for people processing things because the tomatoes after you have picked them don't damage so easily when you are moving them to the factory, but also it means that because they are less ripe when you process them they contain less water, and therefore you have to use less energy to drive that water off to make something like tomato paste.

In 1996 two supermarkets, Safeways and Sainsburys put this on their shelves. They put it on their shelves alongside almost identical tins which didn't have this label 'made with genetically modified tomatoes' because they weren't made from genetically modified tomatoes. So there they were, the two cans, one modified, one not, next to each other on supermarket shelves. I think I could taste the difference, I may be fooling myself. I thought this tasted nicer, more tomatoey and that was perhaps because it had been heated less and therefore the tomatoey flavours had not gone away. In a report in 1997 Safeway said they had sold three quarters of a million tins of this stuff and the average sales per store of the genetically modified one exceeded its normal equivalent. There was a slight price

advantage, they both had the same price but the genetically modified tin was slightly larger, so it was slightly cheaper.

However, public attitudes changed in 1999 and they changed because of American policy. The Americans decided that certain genetically modified crops would not be segregated from their normal crops. This was particularly the case for maize and for soya beans and they said 'if you buy maize and soya beans from us you will not be able to tell whether it is genetically modified or not. The reaction of the English people was to say first of all 'I don't like that I am not being given a choice' and therefore I won't eat things containing this and I'm quite suspicious of genetic modification. They were so suspicious of genetic modification at that point that the supermarkets decided that the best policy was to say that there was no genetically modified food in their stores and so they withdrew this product because the public started not to want to buy it.

Part 8

However you will still find genetically modified food in this country. As I said the cheese is still there, funnily enough. And although we don't import GM maize and soya into this country we do import processed food from America and if it contains corn or soya, most often as a …soya is used in many products because the fat from soya, soya lecithin is an excellent emulsifying agent. That means it enables you to mix oils and waters together. So if you have a soya product coming from America then it will almost certainly contain products from GM soya. Similarly like corn syrup. Now I would argue that neither like corn syrup nor soya lecithin contains any DNA, it's a purified product so it's not genetically modified in any real sense. It's the same lecithin you would get from an unmodified plant, the same corn syrup you would get from an unmodified plant. But that's a somewhat, well that's the position that I hold but not everybody holds that.

So these GMO's that we were talking about contained different genes. So the GM yeast had a cow kymosin gene which was what we made the cheese from. The GM tomato had an altered polygalacta-uronase gene, don't worry about that, it gave different sorts of cell walls to the tomatoes. The GM maize has a toxin gene from a bacterium which kills off insects. The GM soya is resistant to the weedkiller glyphosate. It has an enzyme in it which means it can degrade glyphosate and therefore glyphosate is harmless to it.

All these different organisms they have different genes, they have been modified in different ways. But people lump them all together, is that fair I wonder? So what are the health concerns of eating GM food? As I say there's only one that you could be eating, and that's the cheese if you don't buy American products. Well peoples concern was that GM foods would contain poisonous things or things which gave you allergies, toxins or allergens. No-one has ever shown that this takes place but this is a fear. In other words the toxin or the allergen might be the result of adding the gene, it might be the direct result of adding the gene.

Also adding the gene may disrupt the complicated interaction between genes and the environment inside the plant, so that by accident the plant produces a new toxin or an allergen. Again, never been shown to take place but … and again

because some of these manipulations involve genes for anti-biotic resistance there is a fear that those antibiotic resistant genes will escape from your plant and move into the micro-organisms in your gut and that you will then have potentially organisms in your gut which you cannot kill with an antibiotic – if they are pathogenic. Those are the health concerns. And as I say there is no firm scientific evidence that any of these have taken place but they are all possibilities.

So, how do people treat the safety of GM food? We can say that the English attitude has been to take up a precautionary principle that is to say we don't know whether these will be bad or not, but at this point we are not prepared to eat them. Ok? We will not the precaution of not eating them. Essentially supermarkets don't put them on the shelves, so we can't buy them. In America, that is not the position that is taken. You can buy genetically modified food on every supermarket shelf. You could look at this and say the American are doing a wonderful experiment for the rest of us. They are eating this stuff. In 20 years, we find they are all going to die of some horrible disease, right? Then, they have done the experiment, we are right, they are wrong - of course if they are still alive and happy in 20 years, they are right and we are wrong. But we've have taken the precautionary attitude.

Part 9

The American attitude is based on a principle which they have, which is called substantial equivalents. That is they take some genetically modified food and they take its equivalent ungenetically modified, and they analyse it by chemical analysis. And if they find that the genetically modified food is 99.9% equivalent to the normal food that is, it contains no more than .1% difference, whatever that difference may be, then we will count it as equivalent and we say it's normal.

What people argue is that .1%, if it's something particularly toxic, of course can kill you. But we don't investigate the .1%, we don't worry about what it is at all. This is done, then, on the basis of reviewing specific information given to the regulatory authorities by the companies that produce the food.

Now of course, as I said, the only real test is the long term health surveillance of a population that's eating it and as I said the Americans are very kindly doing the experiment for us. It may well be that they are right and there is nothing different as far as its effect on human beings is concerned, of genetically modified food.

So finally what are the wider issues that are involved in this? Why is it for instance that most people in the U.K. would prefer not to eat genetically modified food? There are some ethical questions as I indicated before. Those are based on – we might call them intrinsic objections, that is objections to genetic modification itself. And they can be based on feelings about how the world is, expressed in religious language, often as talking about Creation. The Creation of the world as being the work of God and that what we have – and you can put this under many religious headings, I am obviously talking from a Christian viewpoint because that's the way I am, but you can think of it in relationship to your religious background. That the world is as it is, and that is proper. Right? And that to – if you fiddle around with how it is, that is to move genes from one organism to

another is somehow changing things in a way which is not right. So rightness is in Creation as it is given to us *right and wrongness* is in other kinds of things.

The other sort of intrinsic objection basically comes down to 'well, you scientists might tell me that it's harmless but I am not really inclined to believe you. There is in Great Britain and in a number of other European countries - what I might call, 'healthy distrust' of the scientist. In other words, prove to me that what you say is true and if you can only say to me well these three things might happen, but I don't have any evidence that they do or they don't, as in for instance these things. I say these might happen, but I don't know that they do or they don't. So people will say – well if that's all you're going to say, unless you have gone away and done some experiments and find out that it definitely doesn't happen I'm going to say – well, just for now I won't trust you. I'll take my own advice and I'll leave it alone thank you.

So the intrinsic objections, people don't really believe that genetic modification is not harmless because it seems somehow strange, odd. Scientists say it's O.K. but, you know, are they really trustworthy?

There are other extrinsic objections, in other words there are people who don't object to genetic modification *per se* but would object to these particular genetic modifications, the crops themselves because they endanger the environment potentially if they escape – then what will happen? Or consumers are deprived of choice, it's a particularly big thing about the American decision not to segregate genetically modified from non-genetically modified products. Because I am deprived of choice, choice is what I rely on for my freedom. You are depriving me of choice, I don't want that I won't choose you. So those are the ethical questions – it's good or bad for those reasons.

Part 10

Problems with the crops themselves, we've discussed some of these. Ecological disturbance because the crops might escape and change the local flora and fauna. We've done a very big experiment, deliberate farm-scale experiment in this country with a number of genetically modified crops comparing genetically modified crops treated in the way that they have to be treated with normal crops treated in the way that they have to be treated. One of the three crops – there were found differences in flora and fauna. In other words the flowers and the insects and the birds that grew and flourished around the genetically modified fields were different from the others. But interestingly the reason that they were different was because of the pesticides that were used. Because on the genetically modified crops which were pesticide resistant they used different levels of a different pesticide from the other crops it was all down to the pesticide. It wasn't actually down to the crop at all, it was the way it was grown.

So changing local flora and fauna in the fields that we're actually growing them in or escape. The problems that people have there – is O.K. could these genes escape from the plant to a relative? Could they contaminate organic crops? As you know in this country organic crops have to be free of genetic modification, could they contaminate organic crops? This is affected by two scientific considerations really, is the pollen from the GM crops spread by wind or by

insects? That will determine how far it goes in general wind spread goes less far than insect spread. Insects can fly further than pollen can move on wind. Of course are there any relatives of these particular plants actually growing, what we would call as weeds, so weedy relatives? Of course as far as maize is concerned – this is a crop from the new world, there are no relatives of maize growing in this country.

Finally, and perhaps this weighs heaviest with some people, there are the global issues. Who is it who is selling us genetically modified food? And the answer is large monopoly multinational corporate companies. So the growth of multinational monopolies and their power is perhaps something which people disagree with, and perhaps fear. It is in the interest of those multinational monopolies to encourage industrialised agriculture as it is practised here in Europe and in the United States, and there are people who say that industrialized agriculture is not appropriate for other countries. So there are big arguments about whether small scale subsistence farming in communities as practised traditionally in Africa and many countries in South East Asia isn't actually better for those communities than the industrialized agriculture that we have in this country. Then there is an ethical point, because these things are grown, they're grown to make foods, and the foods are made to make profit. This is the whole spread of global materialism which is what the protests over the G8 Summit next week are going to be all about, aren't they.? They are going to be about the spread of globalisation and the export of economic rules from the developed to the undeveloped world and whether those being transferred to the developed world, to the developing world are the right thing for those countries. Is it right for them to get into debt? Wouldn't it be much better if we gave them money or gave them resources or actually went and worked with them rather than just throwing money at the problem.

So there is this wider matter – it's all caught up with the ethics of global materialism. Now, there is plenty of room there for you to talk about things which have nothing to do with biology at all and I hope when reflecting on this subject that you won't get too worried about the biology but you'll think about the wider aspects, because I think they are very important – but there we'll finish for today, but thank you very much for listening.