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crease biodiversity at the very time when governments around the world are calling for conservation.

In this and other respects GM crops and GM food could make the world a more 'ordered' and more controlled place with everyone from the producer to the consumer locked into a 'scientifically-correct' but 'politically unpopular' system of food production and consumption — some awful hybrid between Huxley's *Brave New World* and Orwell's *1984*. At the end of the day you must ask yourself not 'do we want it' but 'do we really need it' and the answer to the latter, irrespective your view on the former, must be no.

Contents

Origin' for most of the world's staple crops are elsewhere — wheat in Western and Central Asia, maize in Central America and soya bean in Asia, South Pacific and Australia. It is in the centres of origin where all the wild types and closely related 'weeds' will be found. Once these 'alien' genes get into wild types and weeds nobody knows how they will react. If they become dominant we could end up with whole races of 'super weeds' resistant to commonly used herbicides or containing other genetic traits that enable them to colonise whole areas and in doing so reduce biodiversity.

GM crops like Bt cotton which produce toxins to kill insect pests may not be able to differentiate between insects pests and beneficial insects and, therefore, kill anything that alights on them. In addition to bees this may include ladybird beetles and other useful insects which actually control insect pests naturally by feeding on them. There is already evidence that the growing of Bt cotton is accelerating the occurrence of bollworm populations which are resistant to the Bt toxin. In addition to sidelining Bt cotton this would remove the sprayable formulations of Bt as a useful and harmless biological control of dozens of caterpillar pests which damage all sorts of crops. The Bt gene has additionally been put into potato and maize to control the very same caterpillars — corn earworm and potato/tomato leafworm which attack the cotton bolls. The use of GM crops tolerant to particular herbicides is likely to increase rather than decrease the use of herbicides. The big fear is of miles and miles of 'green concrete' — crop monocultures all sprayed with the same herbicide and not a weed in sight. Being completely weed free is in nobody's interest because all sorts of animals including insects and birds rely on weeds for their existence. Indeed the removal of seed-bearing weeds from modern agriculture has been a major factor in the rapid decline of many erstwhile common seed-eating birds such as the linnet, goldfinch and yellowhammer. GM cropping could well de-

Consumers in the developing world, and especially those countries where there are regular shortages of staple foods, may be thought to have a different viewpoint and priority especially following recent propaganda to persuade the population that GM crops and GM food is the only way to 'feed the world'. In fact this subtle piece of 'blackmail' was really aimed at the 'consciences' of the developed world, the reasoning being that if consumers in London accept GM foods those in Lusaka will have to fall into line. However, GM cropping should not be compared with 'The Green Revolution' of the 1960s which was founded on a lot more than new, higher yielding varieties — fertilisers, irrigation and mechanisation. Anyway these crops have not been genetically modified for higher potential yield and famine has more to do with climate, weather patterns, poverty, war and corruption rather than deficiencies in existing agricultural technology.

The environment

Potential threats to the environment are many. There are hundreds of crop plant species and thousands of weed species but less than a hundred plant families. The big fear is that the 'alien' genes introduced into specific GM crops will escape and find their way into wild plants — there are already claims from France that a gene introduced into oilseed rape has been identified in wild radish — oilseed rape, cabbage, cauliflower, kale, sugar beet, swede, marigold, turnip, radish and many others are all members of a huge plant family called the Cruciferae. The *Collins Guide to British Wild Flowers* lists some 75 wild Cruciferae including some very close relatives of oilseed rape. Oilseed rape itself is thought to have originated from a cross between cabbage and mustard.

And this problem is likely to get worse as GM cropping moves out of its North American base because the 'Centres of

Lecture to South Place Ethical Society, London

Genetic change in living organisms is desirable and without it evolution would not exist. Until the end of The Second World War virtually all genetic change could be accounted for by naturally occurring mutations (changes) in genes and the exchange of genetic material during natural sexual reproduction and conventional plant breeding. With first atomic explosion over Japan in 1945, followed by a whole succession of nuclear tests from then until now, radiation released into the environment has undoubtedly increased the rate of mutation in plants, although it has not been quantified. Indeed scientists have, over the last fifty years, used radiation as a mutagenic agent in an effort to secure mutations in crop plants that could be usefully used in conventional plant breeding programmes.

Twenty years ago genetic change entered a new era with the advent of a new technology called gene transfer, by which genes were transferred from one living organism to an often totally unrelated living organism. The very first experiments were conducted with micro-organisms and then scientists moved on to crop plants. These were initially called 'transgenic' crops but more recently and probably because it doesn't sound quite as threatening to the general public, they have been labelled 'genetically modified' crops.

Work began in the early 1980s and produced strains of bacteria that were able to 'seed' ice crystals on the surfaces of leaves — the usefulness being to stop internal freezing damage in frost susceptible fruit trees like peaches, apricots and citrus. This particular example sticks in my mind because I attended a conference at one of the Cambridge Colleges where this and a whole host of other projects, then loosely called biotechnology, were presented. The only press representatives were myself and several specialists from research based publications in biochemistry and related fields. I distinctly remember saying to myself, as the true extent of what was happening became evident, 'I hope the relevant authorities are going to keep the public in-

formed for they will die of fright if presented later with a *fait accompli*'.

Now some fifteen years later the true extent is being unveiled. Genetically modified maize, soyabean, oilseed rape, potato and tomato to name just a few and the general public are frightened.

Potato and tomato

Potato and tomato, both members of the plant family *Solanaceae*, were two of the first crops to be 'played with'. Potato has been genetically modified for the farmer to resist specific insect pests by transferring a gene from the 'snowdrop'. This produces an insecticidal protein' called lectin which occurs naturally in snowdrop bulbs. This is the GM crop which is at the centre of controversial research at The Rowett Research Institute in Scotland involving effects on the immune systems of rats.

Genetically modified tomato was developed with the processing industry's requirements in focus. You will notice from supermarket shelves that genetically modified tomatoes are not sold as fresh fruit but as ingredients in processed products such as paste and puree. This is because the genetically modified tomato has its 'softening gene' blocked by treatment with a so-called 'anti-sense RNA' mechanism which is common in bacteria. This blocks the gene which controls a specific enzyme responsible for dissolving a sticky chemical called pectin. Pectin holds the tomato cells together and keeps the fruit firm. These gene blocking mechanisms could be inserted into any existing well-known varieties (including the garden favourites 'Moneymaker' and 'Alicante') which in all other respects will be identical to the original variety.

With this enzyme blocked GM tomato ripens on the vine full of flavour, while staying firm, thus providing the proces-

Consumers

Consumers in the developed world are raising objections but the whole business of GM crops and GM manufactured foods is so all-pervading that it is probably already too late to avoid GM food particularly if your diet is mainstream — supermarket shopping with a large proportion of processed and fast foods.

The ingredients of soya and maize in particular are widely used in processed foods. Soya protein, soya oil, soya flour, corn flour, corn oil and maize protein are all used in processed food of which some 60% contains soya. Soon to be released is a GM wheat to make springy dough which is designed for bread making, although the gene for this at least has been sourced from a variety of wheat itself. Furthermore the big exporters of soya and maize such as the United States are the very places where GM crops are well established commercially and growing fast.

Millions of hectares of GM crops are being produced in the USA and there are already over 300 test sites in the United Kingdom. At this rate of acceleration if hundreds of millions of consumers suddenly refused to purchase GM foods there would probably be insufficient 'natural' food to satisfy the demand. On top of this it is virtually impossible to separate GM and 'natural' crops by looking at them. CWS (The Cooperative Society) has recently said that it will label all processed foods with soya as containing GM soya because it is impossible to say with certainty that they do not.

The only way of ensuring that certain foods do not contain GM soya is to separate GM soya from non GM-soya at the farm gate and maintain this by strict inspection, enforcement and legislation through the whole marketing chain, the processor and right up to the supermarket shelf — a nightmare of administration and red tape which will cost a small fortune. It is a cruel irony that soya should be one of the first crops to go 'GM' in a big way when an increasing proportion of the population are moving towards soya milk at the expense of cows milk.

achieved by introducing a so-called 'terminator gene' which stops the GM crop producing viable seed thus forcing the farmer to buy new stocks of seed each year. Clear enough but what happens if the gene escapes into neighbouring non-GM crops being legitimately grown for seed?

The situation for the organic farmer is dire. Pollen can travel thousands of miles in air currents in the upper atmosphere, let alone to the neighbouring farm. Indeed pollen, whether carried by wind or insects is adapted for efficient movement and dispersal to other plants of the same species. For a few crops like potato which are sown, harvested and consumed in the vegetative state — i.e. the potato tuber with no sexual reproduction and genetic exchange involved — there should be no problem. However, for the majority like wheat, barley, maize, soyabean, sunflower etc., where the harvested part is a seed or fruit then if an organically grown crop has been pollinated and fertilised by GM pollen it is no longer an organic crop. The futility of trying to stop the escape of pollen from one field into another, even by the use of barrier crops, is clear and is at the root of the problem suffered by Monsanto in a recent court case in Lincolnshire.

Well publicised instances of GM food contaminating non-GM food products such as GM corn in 'organic' tortilla chips from the USA, which had to be destroyed, could well be due to contamination of the growing crop. Beekeepers are in a similar position because they have no control over which flowers their bees visit while livestock farmers, especially those catering for the organic market, will have to be very sure from where their feed — rich in maize, soya, sunflower, cotton seed, wheat and barley — is sourced.

sor with tasty, firm fruit still full of pectin. Advantages for the processor are that 'he' does not have to add pectin and there is less water in the fruit to boil off. Advantages for the consumer are identified as 'fullness of flavour' but since many processed tomato products are adulterated with all sorts of spices including garlic this tomato as a 'saver of flavour' could turn out to be a 'red herring'.

Soyabean, maize and oilseed rape

The main beneficiaries of GM soyabean, GM maize and GM oilseed rape, very much in the news over the last twelve months, are the pesticide manufacturing companies. The clue to this association has been evident over the last fifteen years as the big players in pesticide chemistry bought up dozens of plant breeding and seed producing companies. Not the household names of the UK garden market, which are essentially 'small fry', but the huge North American seed companies developing and selling seed to Mid West and prairie farmers growing soyabean, wheat, and maize. In Europe substantial seed companies in France, Germany and the UK offering oilseed rape, sunflower, sugar beet and cereals have been snapped up. You may still be asking what is the connection. The connection is that the pesticide companies want to sell more of their agrochemicals and especially herbicides.

Herbicides are chemicals designed to kill weeds. A weed is simply a green plant growing in the wrong place at the wrong time. For example Sorghum, a cereal and member of the grass family (Graminae), is classed as a weed in many parts of North America while in the drier parts of Africa it is the main staple food crop. Because herbicides kill living green plant tissue they must be used very selectively and carefully in the crop situation. There are some which only kill certain species, e.g. the hormonal weedkillers (MCPA and 2,4 D commonly used

in lawn herbicides) kill broad leaved weeds like daisy and dandelion but leave members of the grass family unharmed. For this reason they can be used in cereal crops to kill broad-leaf weeds without harming the wheat or barley. But most others are not selective and therefore must be carefully timed to hit the weeds before the crop seeds germinate in the soil. This obviously restricts their use. GM soya, GM maize and GM oilseed rape have been produced by inserting genes which make them specifically tolerant to particular herbicides. Thus Monsanto's GM soyabean is tolerant to glyphosate, one of Monsanto's leading herbicides. This means that farmers growing GM Soyabean ('Roundup Ready Soyabeans' — 'Roundup' is Monsanto's trade name for glyphosate) can use glyphosate to kill weeds growing in their crop at any time without fear of damaging the crop.

Cotton

Cotton presents a particularly interesting example because scientists have taken a gene from a naturally occurring bacterium, which infects and kills the bollworm (a caterpillar of a moth and the world's worst insect pest of this fibre crop) to produce GM cotton. In fact commercial formulations of this bacterium called *Bacillus thuringiensis* (Bt) have been available for more than ten years for spraying on to the cotton crop. The bacterium infects the bollworm and makes a toxin (poison) which kills it. The gene responsible for making this toxin has now been put into cotton plants (Bt cotton) which can produce this bacterial toxin. When the bollworm hatches from the egg and starts to feed on the leaves and cotton bolls it is poisoned and dies.

Simple and effective enough and, you may say, nothing to do with the human food chain. But in addition to being grown for its fibre (lint cotton) the crop also produces a huge tonnage of seeds rich in oil which is used to make margarine and other

edible fats, the residue after crushing called cotton seed cake being widely used in animal feed. Furthermore cotton in full flower is one of the most attractive crops to bees.

Winners and losers

Whether you are a winner or a loser depends very much on who you are and your viewpoint.

Here there is no straight answer. On the surface and in the short term the large scale arable farmer in North America and Europe may stand to gain but if things go wrong he could find himself in a nightmare situation. For instance if whole swathes of farmers start to grow GM crops, say soyabean, tolerant of a particular herbicide, they will only be using that particular herbicide, with its own chemistry, to control weeds.

This will place incredible and intolerable selection pressure on weed populations. In turn it will speed up the evolution of herbicide-resistant weeds (already a huge problem even before the advent of GM crops) rendering useless not only that herbicide but all others with a similar chemistry. If farmers have become locked into the GM crop phenomenon they may well find that there are no alternatives if things go wrong. Farmers can grow what they want but will only secure a profit beyond the farm gate. If the public does not want to buy there is little they can do — the BSE crisis in the beef industry has shown that.

The situation for farmers in the developing world is even more threatening because lacking their own strong representation and through the economic weakness of their country's finances they are likely to be railroaded into growing GM crops. These farmers traditionally save their own seed because many do not have the financial security to buy new seed each year. The owners of GM Crops will want to make sure that farmers are growing 'pure' GM crops each year. This can only be