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GREED OR NEED? Genetically modified crops

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Introduction

Bumper harvests and food for all, or monster tomatoes and biopirates? It is still too early to know what impact genetically modified (GM) crops are going to have. They are provoking opposition from experts and the general public in Europe and some developing countries. But many scientists argue that much of the criticism is ill-informed and sometimes "hysterical", fanned by an "irresponsible" media. It is true that many people tend to be suspicious of big companies and indeed scientists, and react strongly to scares about the safety of food. But the race is on to win the hearts and minds of people in developed and developing countries alike.

Supporters argue that the world desperately needs GM crops to ensure food security and sustainability. GM crops, they say, will produce higher yields of more nutritious food, with less use of chemical inputs. Opponents fear that the driving force behind GM crops is greed, not need.

Monsanto, the world’s largest GM seed company, foresees three waves of beneficial products: "The first consists of genetically modified crops which are resistant to insects and disease, or tolerant of herbicides. These will allow farmers to meet the growing demand for food... The second wave, due to begin in five years’ time, will see genetically induced ‘quality traits’ in food, such as high-fibre maize or high-starch potatoes, some of which will help doctors to fight disease. And in the third wave, plants will be used as environmentally friendly ‘factories’ to produce substances for human consumption."

But a growing coalition of dissenting specialists, farmers, citizens’ groups, scientists and ordinary consumers, North and South, is becoming vociferous in its warnings of possible dangers from GM crops and the need for caution -- at least -- in their introduction. The criticisms range from challenges to the scientific assumptions of the technologies, through questions about the motivations of the biotechnology industry, to arguments that such meddling with the genetic make-up of plants is immoral or sacrilegious.

Environmental campaigners in Europe are so concerned about the potential dangers of GM crops that they are prepared to break the law to disrupt testing, and the cautious attitude of the European regulatory authorities is symptomatic of public concerns about GM technology in food production. Opponents argue that increasing crop yields is not the solution to food insecurity, and warn that GM crops will bring dangers to the environment and human health, as well as negative impacts on farmers’ livelihoods, especially in poorer countries. Many are uneasy with the fact that the biotechnology industry, and an ever larger proportion of the whole agricultural supply and distribution system, is controlled by a small number of giant corporations.

Companies are racing to claim patents on genetic materials from all over the world on which they hope to reap large profits -- in order, they argue, to fund research and innovation. But the new technologies raise many new questions of science, law, ethics and economics, and patent and intellectual property laws have not kept up. The World Trade Organisation (WTO) will be under pressure in 1999 from the agricultural biotech industry side to globalise and strengthen patent protection -- while opponents will argue that plant varieties should be excluded and new mechanisms found for sharing the benefits of genetic material with communities and farmers who may have nurtured and used it for generations.

The debate over GM crops and their patents rages around the world, whether on farms or in law courts. Key to its resolution will be people’s access to accurate, understandable information, not public relations hype or scaremongering.

KEY FACTS

- More than 27 million hectares of genetically modified (GM) crops were sown in 1998, up from nearly 11 million in 1997 and about 2 million in 1996.
- At least 64 GM crop varieties have been approved in the USA and Canada, 20 in Japan and eight in Europe.
- The physical form and chemical composition of a typical crop plant is determined by up to 80,000 genes, or sections of DNA found in the nucleus of all cells. Genetic engineering enables scientists to insert new genes into an individual plant cell, which is then grown in tissue culture and can be used to regenerate full sized plants.
- The world market for agricultural seed is worth an estimated US$45 billion a year, of which one third is commercial proprietary seed (i.e. seed uniformly produced in bulk by commercial companies), one third is produced by governments or publicly funded institutions and one third is the value of seed saved by farmers for their own use in future crops.
- The commercial development of genetically modified crops is dominated by Monsanto and a few other major agrochemical companies, including: DuPont, Dow Elanco, Novartis, AgrEvo (jointly owned by Hoechst and Schering) and Zeneca.
- The efforts of these companies have so far been concentrated in high-volume crops which offer the most opportunity for sales large enough to recoup research costs and generate profits. The main targets have been soya beans, maize, cotton, oilseed rape (canola), potatoes and tomatoes.
- The US biotech industry and its allies are becoming increasingly frustrated with the reluctance of European countries to accept the technology. They have urged the US government to take their case to the World Trade Organisation if Europe introduces a compulsory labelling system for foods containing products of GM crops. The industry maintains that European Union governments are imposing non-tariff trade barriers which threaten to undermine the USA’s US$60 billion export trade in agricultural products.
- Companies are rushing to claim patents not only on newly invented processes but also on the (newly discovered) genes used in those processes and on the knowledge of their properties.

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1. THE BIRTH OF GENETIC ENGINEERING

Genetic experiments in agriculture are nothing new. For centuries, farmers around the world have selectively bred livestock and crop plants in order to produce strains with improved characteristics. But major changes have been occurring during the past decade, both in the methods being used and in the identity of those working to produce these novel strains.

To date, most varieties of crop plants have been developed either within farming communities or by publicly funded agricultural research institutions. Both farmers’ traditional selective breeding techniques and conventional institutional breeding programmes use the natural variation within plant species to develop improved strains. This method has now been augmented by molecular biology techniques, which allow the introduction into plants and animals of entirely new characteristics, including genes originally found in unrelated plants, animals or micro-organisms.

The physical form and chemical composition of a typical crop plant is determined by up to 80,000 genes, or sections of DNA found in the nucleus of all cells. Genetic engineering enables scientists to insert new genes into an individual plant cell, which is then grown in tissue culture and can be used to regenerate full sized plants.

Now public funding for agricultural research institutions is dwindling, and the private sector is taking the lead in research and development of new seeds using the new genetic engineering technology. The principal actors are transnational ‘life industry’ corporations, whose interests cover the food chain from seed distribution through the manufacture of herbicides and insecticides to food production.

Genetic engineering is moving fast and the stakes are high. It requires big investments, and it raises great hopes and fears. Its supporters expect it to bring great benefits to the environment, food producers and consumers worldwide, while its opponents fear dangers to the environment and human health and negative impacts on small farmers. It is too early to know whether either the benefits or the fears will materialise, but meanwhile the technology raises new questions of science, law, ethics and economics which should be thoroughly debated around the world.

Introduction of modified crops

More than 27 million hectares of genetically modified (GM) crops were sown in 1998 (not including China), up from 10.9 million hectares in 1997 and 1.7 million in 1996 [**1**]. The overwhelming majority of this land is in the USA, but GM soya beans are also grown in Argentina and Mexico. The first commercial GM crop in Europe was due in 1998: between 1,000 and 2,000 hectares of maize with resistance to the European corn borer is expected to be planted in France and 15,000 hectares in northern Spain. Meanwhile, non-commercial trials of GM crops are taking place in many countries throughout the world.

At least 64 GM crop varieties have been approved in the USA and Canada, 20 in Japan and eight in Europe (with applications pending on a further 13 products). However, the European authorities have only given conditional approval to the new technology. Only one of the authorisations so far allows large scale commercial production. The licence for Monsanto’s Roundup Ready soya only allows the beans to be imported and processed within the EU, while two member states, Austria and Luxembourg, have banned the growing of a GM maize.

The attitude of the European regulatory authorities reflects widespread public concern about the use of GM crops in food production. The strength of feeling varies between different countries, but even among many people who accept the value of genetic manipulation for producing new medical treatments there is uneasiness about the ’unnatural’ character of GM food.

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2. GENETICALLY MODIFIED CROPS: THE INDUSTRY CASE

The proponents of biotechnology claim that it will transform agriculture, giving us the ability to ‘design’ crop plants to produce increased yields, even in difficult conditions, with far less reliance on chemical inputs. Their vision is of GM crops as a clean and sustainable solution to the problem of food security for the world’s growing population in the 21st century. Monsanto, one of the world’s largest GM seed companies, foresees three waves of beneficial products: "The first consists of genetically modified crops which are resistant to insects and disease, or tolerant of herbicides. These will allow farmers to meet the growing demand for food from a population set to double in size over the next 50 years. The second wave, due to begin in five years’ time, will see genetically induced ‘quality traits’ in food, such as high-fibre maize, or high-starch potatoes, some of which will help doctors to fight disease. And in the third wave, plants will be used as environmentally friendly ‘factories’ to produce substances for human consumption" [**2**].

These are some of the environmental benefits the industry expects:

- **Increased crop yields**

  Monsanto has found that through better control of weeds and pests, yields from its GM crops of maize, cotton and soybeans in the US have increased by between 5 and 8 percent (compared with increases of 1 -- 2 percent expected from other new varieties). They quote former US President Jimmy Carter: "Making available cropland as productive as possible is key to reducing hunger and environmental destruction, by sparing other areas for forests and other uses" [**3**].

- **Reduced use of herbicides**

  Among the first wave of GM crops have been several varieties of seeds resistant to a herbicide, glyphosate. The industry maintains that the new seeds will help farmers increase yields by improving weed control while reducing the total number of sprays needed to control weeds: the resistant crop would be the only plant still standing after the herbicide is applied. So far the most widely grown GM crop is a variety of soya bean produced by Monsanto which is resistant to the company's own glyphosate-based herbicide,Roundup. 'Roundup Ready' soya beans have been grown in the USA, Canada and Argentina.

- **Reduced use of insecticides**

  A major target for development has been varieties of genetically modified plants which contain their own insecticide to destroy common agricultural pests. Several companies have developed strains of maize, cotton and potatoes containing a gene from the naturally occurring soil bacterium *Bacillus thuringiensis*. This produces a protein called the Bt protoxin which causes insects feeding on the plant to starve to death. (Bt can also be used directly as an insecticide spray and has been highly effective for over 40 years).

  Strains of potatoes have been launched commercially in the USA which repel attacks by two of the major causes of losses, the Colorado potato beetle and aphids which transmit leaf roll virus disease. Monsanto says that replacing chemical sprays with genetic resistance will produce considerable environmental benefits. Spraying is expensive and inefficient since most of the active ingredient never reaches the target pest and simply adds to the amount of potentially harmful chemicals circulating in the environment. Moreover, tractors or aircraft are used to distribute the spray. Monsanto calculates that if half of all US potato acreage was planted with their NewLeaf insect-resistant variety, which has been found to require 40 percent less insecticide, this would save 680,000 litres of fuel a year [**4**].

- **Reduced soil erosion**

  Monsanto also says that GM crops will help counter land degradation through the loss of topsoil -- a global problem, with an estimated 25 billion tons lost annually. Monsanto is already promoting farming techniques using their Roundup herbicide, in which the soil is only ploughed very little, or not at all; instead the residue from the previous crop is left on the field and the new crop is sown by dropping the seed into holes made by a seed drill. "Because the soil is not disturbed or exposed through ploughing, it is much less susceptible to erosion from both water and wind. No-till has been shown to decrease erosion rates by 90 percent and nutrient and pesticide run-off by 70 percent over conventional tillage." With the introduction of herbicide-resistant GM crops, such as Roundup Ready soya, Monsanto expects the no-till and conservation-tillage systems to be more widely adopted. The area under erosion-control farming had already grown from 45 million hectares globally in 1990 to 115 million hectares by 1996[**5**].

- **Drought tolerance**

  Water shortage and the increasing salinity of large areas of arable land are major constraints on agricultural productivity in many developing countries. If scientists can genetically modify plants for increased tolerance to these factors, GM crops could have significant beneficial effects on global food production. Scientists in Spain and the UK have reported success in producing modified strains of crops including rice, melons, tomatoes and barley, using genes extracted from yeast which improve the plants' ability to deal with excess sodium salts.

- **What Monsanto says**

  "The key contributions of biotechnology will be several-fold:

  - producing more food on the same area of land, thereby reducing pressure to expand into wilderness, rainforest or marginal lands which support biodiversity and vital ecosystem services;
  - reducing post-harvest loss of food (caused by disease, pests and decay) and improving the quality of fresh and processed foods, thus boosting the 'realised nutritional yield' per acre;
  - displacing resource- and energy-intensive inputs, such as fuel, fertilisers or pesticides, thus reducing unintended impacts on the environment and freeing those resources to be used for other purposes or to be conserved for the future;
  - encouraging reduction of environmentally damaging agricultural practices and adopting of more sustainable practices such as conservation tillage, precision agriculture and integrated crop management;
  - stimulation of a new kind of economic growth: more benefit with less throughput and harm."

  Robert Horsch, director of technology for Monsanto [**6**]

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3. GM CROPS: THE CRITICS' CASE

A growing coalition of dissenting specialists, farmers, citizens' groups, scientists and ordinary consumers, North and South, is becoming vociferous in its warnings of possible dangers from GM crops and the need for caution -- at least -- in their introduction. The criticisms range from challenges to the scientific assumptions of the technologies, through questions about the motivations of the biotechnology industry, to arguments that such meddling with the genetic make up of plants is immoral or sacrilegious. Environmental campaigners in Europe are so concerned about the potential dangers of GM crops that they are prepared to break the law to disrupt the field trials of them. There were many instances during 1998 of experimental crops being destroyed by activists in various countries including Germany, the Netherlands, the UK and Ireland.

- **Bad science**

  Some critics believe that genetic engineers will not be able to deliver on their promises because the genetic structure of plants is so complicated that scientists cannot yet fully understand and modify it. For example, these critics doubt whether it will be possible to modify crops reliably for salt tolerance. Salt metabolism is dependent on an interaction between several different genes. The more genes involved in a GM plant, the more unpredictable the results. Sometimes the genes simply do not work, or they may produce unexpected results. Some researchers themselves are cautious about the prospects of useful changes made to cells in the laboratory surviving when the plants are grown outside in the field [**7**].

  GM crops, just like conventionally developed new varieties, will undergo field trials before they can be commercially released, which should reveal unexpected behaviours. But in 1996, in the first commercial growing season of Monsanto's Bollgard cotton, the pesticide effect of the engineered Bt was not sufficient to kill off all pests throughout the season, as the company had promised. Dr Mae-Wan Ho, of the UK's Open University, attributes this failure to unpredicted changes in the behaviour of the Bt gene [**8**]. In 1997, 20 percent of the first commercial crop of Roundup Ready cotton suffered deformed bolls and bolls dropping off early. "Unrelated multiple side-effects of introduced genes cannot be predicted in advance and are not always visible or easily detected," notes Dr Ricarda Steinbrecher of the Women's Environmental Network.

Ecosystem dangers

Besides having doubts about genetic engineers' capacity to achieve reliable results, many critics hold that the GM technologists are too focused on the specific crops they are developing, and do not pay sufficient attention to the wider environmental context in which the crops will be grown. Even organisations which generally welcome the new technologies have demanded caution about moving too fast. In its evidence to a UK Parliamentary investigation, the British National Farmers' Union recommended compulsory monitoring for up to 10 years after commercialisation for all genetically engineered crops to ensure that there are no unexpected ecological impacts [**9**].

There are concerns, for instance, about the long-term effect of crops with built-in pesticide properties. One possible effect is the appearance of Bt-resistant insect pests. It is feared that insects that are constantly exposed to the Bt protoxin will eventually become resistant to its effects, in the same way that bacteria mutate to develop immunity to the effects of medical antibiotics. The US government takes the threat seriously and insists that GM crops should be grown alongside conventional crops to minimise the risk. Some observers believe that resistance has already developed. According to reports from the non-governmental organisation Genetic Resources Action International (GRAIN), studies carried out in the USA are demonstrating that resistance to Bt is likely to develop far faster than Monsanto's scientists have claimed and that insects resistant to Bt are already present in the USA and elsewhere in the world.

Another fear is that the Bt gene may be an imprecise weapon which affects beneficial insects as well as pests. The US Institute for Agriculture and Trade Policy reports that: "In Thai field tests of Bt cotton, 30 percent of the bees around the test fields died. The bees are necessary for the pollination of flowering plants and the production of honey [**10**]."

There is some evidence that introduced genes may "jump" into other organisms, with unpredictable and probably uncontrollable results. Interbreeding already occurs occasionally between conventional crops and their wild relatives, but it has been assumed that the resulting cross-breeds would quickly die out. With genetic modification comes the possibility that engineered genes -- such as genes for resistance to weedkillers -- could transfer from crops to wild plants, giving them competitive advantage and turning them into 'superweeds' which could pose a threat to wild and cultivated plant populations. Dr Beatrix Tappeser of the Institute for Applied Ecology, Freiburg, Germany points to several scientific studies which show that this is possible. According to Topsy Jewell of the Pesticides Trust, "This could be particularly significant in countries where crops have weedy relatives. In the USA, where many of the transgenic crops are being forged, there are no weedy relatives of soya beans, maize, wheat or cotton. Weedy relatives of these crops, however, exist in other regions where the genetically modified crops are targeted, including Central America, Asia and the Middle East."

Another concern is that plants modified to contain genes from crop disease viruses might exchange these genes with other viruses, generating entirely new viral strains with unpredictable properties. Scientists from Agriculture Canada have demonstrated this possibility. They developed a strain of cucumber mosaic virus lacking the gene for a specific protein needed to infect new plant cells. They then took an equivalent gene from another virus and inserted it into the host plant's DNA. In plants artificially infected with the disabled virus, new and fully infective viruses appeared within 10 days. "This appears to be the first time anyone has shown recombination between two different kinds of viruses within a plant," warns *New Scientist* magazine. "The risks may be much higher than biotechnology companies want to admit [**11**]."

- ## Greater reliance on chemicals

Many environmentalists also have doubts about the benefits of genetically engineered herbicide resistance. Will it reduce the use of chemicals, as the industry claims, in the longer term? An analysis by the Pesticides Trust on behalf of the environmental campaigning organisation Greenpeace argues that the introduction of herbicide-resistant varieties will alter the pattern of herbicide use but will not significantly change the overall amounts used. If it leads to greater use of glyphosate, says the report, this will damage other crops and have adverse effects on wildlife, including beneficial insects such as ladybirds. Glyphosate and glufosinate are said to be less toxic than the earlier generation of weedkillers, but the compounds can still remain active in the soil for long periods, and can contaminate water. The report points out that the compound is highly toxic for fish, which form an important part of the protein available to the population of countries such as Bangladesh. "In the end, the introduction of herbicide-resistant soya has more to do with competition for market share of agrochemical products than sustainable agriculture," it concludes [**12**].

Planting of a GM herbicide-resistant crop may lead to over-reliance on a single herbicide. According to Dr Steinbrecher of the Women's Environmental Network, "If spraying occurs regularly, there is every reason to believe that weeds in or near fields of genetically engineered crops would develop resistance to the herbicide -- as weeds become resistant, higher and higher doses of herbicide would need to be used, leaving larger and larger amounts of chemical residue on the crops [**13**]." In spite of earlier claims by scientists that it would be virtually impossible for weeds to develop resistance to glyphosate, resistance to the herbicide has appeared in ryegrass in Australia. It now seems that multiple uses of glyphosate in a single season provide the ideal conditions for weed resistance to evolve [**14**].

- ## Loss of biodiversity

Another area of concern is the likely increased loss of biodiversity as a result of the introduction of GM crops. At present, many small farmers in developing countries maintain a rich diversity of plant varieties. In India alone, 50,000 varieties of plants are grown, and one survey found 70 different varieties in a single village in the north-east of the country. These plants all show different characteristics and can survive under different conditions, so the genes they contain provide insurance against drought or disease -- both for the local farmers and, ultimately, on a global scale. Replacing this richness of local varieties with vast 'monocultures' of a single variety leaves the crop vulnerable to attack by pests or disease. Monoculture of conventionally bred crops has already demonstrated these dangers. For instance, the US maize crop was devastated by a fungal disease called corn blight in the 1970s, and in 1975 Indonesian farmers lost half a million acres of rice to damage caused by the rice hopper insect. The promotion of GM crops is likely to increase the tendency to monocropping with a limited range of genetically uniform commercial varieties. If the local varieties around the world are lost as a result of the spread of commercial varieties, the range of genes available to feed the world is drastically reduced.

- ## Health risks

Opponents also fear that GM crops may pose risks to human health. Fears focus on two main issues: the risk of transplanted genes producing proteins in the plants which may cause allergic reactions in people eating the food, and the use of genes which could produce resistance to antibiotics. These have been used as marker genes during genetic modification, attached to the target gene to identify cells containing the new gene element: when exposed to the antibiotic the normal cells die but those with the marker gene survive. The antibiotic-resistant genes could be picked up by harmful bacteria, which would clearly reduce the range of drugs which can be used to treat disease [**15**]. (In fact, genetic engineers have recognised this danger and the use of antibiotic resistance markers may be phased out) [**16**].

- ## The profit motive

Finally, critics are alarmed that genetic engineering is being developed and promoted primarily by private corporations, and that with recent consolidations in the 'life industry' sector, a few giant corporations have control over a large proportion of the germplasm, agricultural processes and distribution systems needed to feed the world. Food is a basic right, these critics argue, for the poor as well as the rich, and it should not be in the hands of companies whose prime motivation is profit rather than the good of humanity.

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4. A QUESTION OF TRUST?

Many scientists argue that much of the criticism of genetic engineering is ill-informed and sometimes "hysterical", fanned by an "irresponsible" media. In Europe, it is true that the general public have tended recently to be suspicious of scientists, and react strongly to scares about the safety of food. A heated debate over genetically modified crops has been raging over recent months in the press in several countries. Professor Richard Dawkins, a leading authority on evolutionary genetics, sums up the views of many within the biotechnology industry and many scientists when he argues that biotechnology is in fact not essentially different from older types of breeding: "All plants, and all animals including humans, are genetically modified. That is what evolution means. They are genetically modified by natural selection of random mutations and recombinations. Some, such as maize, wheat, cabbages and roses, are additionally modified by domestic breeding. And some are modified by engineered mutation or recombination. Any of these three kinds of genetic modification can have desirable or undesirable consequences [**17**]." He gives the example of tobacco, a non-engineered plant whose harmful properties are well known.

Others agree that the ecological risks must be kept in perspective. Dr Phil Dale of the John Innes Centre, a UK agricultural research institute, carries out experimental work on GM plants. He acknowledges that cross-pollination between GM plants and wild relatives is a possibility. But "there is no scientific justification for assuming this to be either undesirable or harmful in principle -- each case needs consideration on its own merits[**18**]." He points out that crop plants do not usually thrive in natural habitats. He agrees with many in the industry and in the regulatory bodies who believe that environmental risks can be predicted, assessed and managed; the way to do this is through large-scale experimental field plantings under carefully controlled conditions.

The industry also argues that the potentially damaging health effects have been exaggerated and any problems will be identified in tests long before the crops are sold commercially. Hendrik Verfaillie, president of Monsanto, says GM crops could help to solve existing health problems. An example is rape seed (canola) modified to contain high levels of a compound called beta carotene which is converted in the body to form vitamin A. "In Asia there is a lot of night blindness caused, basically, by a lack of sufficient levels of vitamin A. With this canola oil, if you make it into margarine or if you spread it on your salad, then people would receive enough beta carotene to avoid night blindness" [**19**].

But campaigners reject Professor Dawkins’s claim that public fears and suspicions are irrational. Though many would join him in dismissing some of the more exaggerated and ill-informed fears, they hold that there is an entirely justifiable concern that the big biotechnology companies, in their push for profits, are deliberately over-promoting the benefits of genetic modification and underestimating the possible negative effects -- particularly on the environment and on food security. These technologies, they argue, are being developed and deployed too fast and too widely without adequate regulation, public debate or scrutiny.

Key events in the development of GM crops:

1953

- Crick and Watson (Cambridge, UK) unravel the structure of DNA, the compound which encodes the genetic information of all plants and animals.

1975

- Genetic engineering was made possible by the development of enzymes (restriction endonucleases) that enable scientists to cut DNA at precise points. In effect the enzymes are like ’molecular scissors’, tools which allow DNA to be cut and spliced between different cells.

1976

- First attempts at producing genetically modified plants

1982

- First precise engineering of genetically modified plants

1988

- European Union begins attempts to introduce a directive covering patents on genetically modified organisms.

1992

- In the USA, Agracetus, a biotechnology firm owned by the US chemicals manufacturer W R Grace, receives a broad-ranging patent covering all genetically modified cotton.
- Calgene in the USA obtains a patent for FlavrSavr, a tomato modified to delay ripening and maintain its freshness.

1994

- US Patent Office changes its mind and revokes the patent granted to Agracetus for genetically modified cotton. The case continues...
- Products containing FlavrSavr tomatoes go on sale for the first time in US supermarkets.

1996

- First large-scale commercial planting of GM crops. Attempts by the US to export genetically modified soya cause protests from European environmentalists and consumer groups.

1998

- European Parliament accepts a redrafted directive on patenting.
- Delta & Pine Land Co receives a US patent on a method for producing plants with seeds which are sterile when replanted -- the ’Terminator technology’.

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5. FOOD SECURITY: THE CONTRIBUTION OF GENETICALLY MODIFIED CROPS

Positive.....

A major argument from the industry for continuing the rapid development and use of GM crops is that they will be the best means of providing food security for the world in the 21st century.

Food security -- the state in which all people at all times have access to enough safe and nutritious food to maintain a healthy and active life -- is still a distant goal. The past two decades have seen an increase of 15 percent in the amount of food available for the world’s population of nearly six billion, but according to the

UN’s Food and Agriculture Organisation (FAO) one in seven of the world’s population are still chronically malnourished, including one in three children [**20**]. At the World Food Summit in 1996, governments committed themselves to halving the number of hungry people by the year 2015. Moreover, global food demand is expected to go up by as much as 50 percent in the next 15 to 25 years as a result of population growth and rising incomes.

The majority of analysts agree that the world needs to produce larger quantities of food (though most agree that the distribution of food is also a fundamental factor) without in the process exhausting and polluting our limited resources of land and water. Proponents believe that genetic engineering will make a major contribution to this goal. The Green Revolution of the 1960s and 1970s led to huge improvements in crop yields for rice and wheat, but its new varieties required substantial inputs of fertiliser, pesticides and water. It is now widely recognised that further progress along that road is unlikely to be sustainable.

Agrochemical companies maintain that GM crops will play a big role in sustainable agriculture by increasing yields, reducing the need to expand the area of cultivated land, and at the same time reducing the need for herbicides and pesticides. They are supported by many independent scientists including the Nobel Prize-winning agriculturalist Professor Norman Borlaug, a leading figure in the Green Revolution in the 1960s. He sees GM crops as a logical extension of the developments during the Green Revolution.

He accuses environmentalists of wanting to turn back the clock by insisting on technologies which were only adequate for supporting a much smaller world population than exists today. "I am particularly alarmed by those who seek to deny small-scale farmers of the Third World -- and especially those in sub-Saharan Africa -- access to the improved seeds, fertilisers and crop protection chemicals that have allowed the affluent nations the luxury of plentiful and inexpensive foodstuffs... While the affluent nations can certainly afford to pay more for food produced by the so called organic methods, the one billion chronically undernourished people of the low-income, food-deficit nations cannot [**21**]."

....or doubtful?

However, it is now widely accepted that food insecurity does not result from an absolute world shortage of food, but has economic roots. Some analysts believe that the world already produces adequate food and can continue to do so with traditional techniques, but that the food is unevenly distributed. The single most important cause of hunger is poverty. The FAO, while emphasising that "low productivity in agriculture" is one of the principal causes of under-nutrition and food insecurity, identifies poverty and policy constraints as more important causes of low productivity than inadequate technology. "The causes and consequences of food insecurity and poverty are inextricably linked [**22**]."

In this view of food security, expensive new technologies like GM will not address the real problem; indeed they might even make it worse. NGOs, farmers and researchers around the world are developing different new models for sustainable agricultural development which do not depend on expensive imported technology and which use the skills of local people. They believe that overcoming hunger and poverty calls for a wide range of measures, from debt relief to land redistribution, and that technical improvements must be geared to environmental sustainability and protection of livelihoods, not just to increasing yields. For example, organic and permaculture methods are successfully achieving yield increases where they are being tried around the world. "The FAO itself is calling for a new Green Revolution," observed an earlier Panos report. This "will focus more on small, resource-poor farmers, embrace equity issues and sees farmer participation as essential for blending new technologies with traditional knowledge and for setting research agendas for the future [**23**]."

Professor Swaminathan, one of the developing world’s most respected agronomists and father of India’s Green Revolution, believes firmly that genetic engineering will have an important role, as long as it is developed and introduced as part of a holistic vision of environmental and socio-economic sustainability. "Since there is no option in population-rich and land-hungry countries but to produce more per units of land, water and labour, there is need for technologies which can promote and sustain an ever-green revolution rooted in the principles of ecology, economics and social and gender equity. It is obvious that the challenge can be met only by integrating recent advances in molecular genetics and genetic engineering, information and space technologies, renewable energy technologies and management science with traditional technologies and ecological wisdom, resulting in appropriate ecotechnologies. There should be no relaxation of yield-enhancing research, since there is no other way of meeting global food needs [**24**]."

But some doubt that genetic engineering is being introduced in the way Swaminathan would wish to see. They fear that the scientists and corporations who are making the running are focusing narrowly on the ‘technical fix’ aspect of GM crops, to the exclusion of socio-economic and environmental aspects.

Critics are concerned that GM crops might repeat some of the characteristics of the Green Revolution, in which higher yields were achieved at such a cost in inputs that smaller farmers’ prosperity was not increased and indeed many were forced into debt and off their land. For one thing, the seeds of new GM strains will probably be hybrids or modified to have low fertility. Farmers would therefore be unable to keep seed, the traditional practice of most Southern farmers, but would be reliant on fresh seeds bought from commercial suppliers each season.

Another concern is that none of the GM crop varieties available so far is likely to be used to feed local people in Third World countries. Environmental campaigner George Monbiot points out that GM maize was developed primarily as animal feed. If it is grown in Africa it will be for production of meat to be eaten by local elites or exported to supply the developed world’s appetite for animal protein. He believes that GM crops will escalate an existing trend in which land used by peasant farmers is swallowed up by large-scale commercial agriculture. Producing animal feed "is one of the engines of African famine, as land previously devoted to meeting local people’s necessities has been expropriated to supply the rich world’s luxuries [**25**]." Most of the patent applications relating to genetically modified maize (one quarter of the total of GM patent applications) are for modifications increasing the starch content so that it can be used for industrial applications [**26**]. Analysis of the portfolio of commercial GM research shows that the focus is on crops and crop characteristics which will bring the quickest profits: increased sales of herbicides, for example, or easier food marketing [**27**]. A report to the World Bank in 1997 found that there were only four "coherent, coordinated" GM research programmes on developing country crops [**28**].

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6. THE ROLE OF CORPORATIONS IN THE WORLD’S FOOD SUPPLY

The worldmarket for agricultural seed is worth an estimated US$45 billion a year, of which one third is commercial proprietary seed (i.e. seed uniformly produced in bulk by commercial companies), one third is produced by governments or publicly funded institutions and one third is the value of seed saved by farmers for their own use in future crops [**29**].

The commercial seed market is increasingly dominated by a few large corporations, after a number of mergers and buy-ups among major companies. Many of the top companies have interests in the development of GM varieties. In 1998 it was estimated that the top 10 seed companies control 30 or 40 percent of worldwide sales [**30**].

The commercial development of genetically modified crops is dominated by Monsanto and a few other major agrochemical companies, including: DuPont, Dow Elanco, Novartis, AgrEvo (jointly owned by Hoechst and Schering) and Zeneca. The efforts of these companies have so far been concentrated in high-volume crops which offer the most opportunity for sales large enough to recoup research costs and generate profits. The main targets have been soya beans, maize, cotton, oilseed rape (canola), potatoes and tomatoes.

The major players have invested heavily in the development and promotion of GM crops. For instance, after its recent series of buy-ups and mergers, some observers say that the future of Monsanto may depend on the success of GM crops. The US biotech industry and its allies are becoming increasingly frustrated with the reluctance of European countries to accept the technology. They have urged the US Government to take their case to the World Trade Organisation if Europe introduces a compulsory labelling system for foods containing products of GM crops. The industry maintains that European Union governments are imposing non-tariff trade barriers which threaten to undermine the USA’s US$60 billion export trade in agricultural products [**31**].

So far US exports of GM technology to developing countries have been concentrated in countries such as

Argentina and Brazil. These already have significant big farm sectors run by wealthy landowners able to afford the premium prices paid for GM seed and the accompanying inputs of fertilisers and pesticides. However, recent developments such as Monsanto's acquisition of the Terminator technology and its abortive deal with the Bangladeshi Grameen Bank demonstrate that the industry sees potential markets throughout the developing world.

However, even if no GM crops are actually grown in developing countries the technology could still have a significant adverse effect on their national economies, if it enables developed countries to grow for themselves crops which they have until now had to import from developing countries. In 1996 the Canada-based NGO Rural Advancement Foundation International (RAFI) drew attention to a patent awarded to researchers at Colorado State University for quinoa, a high-protein grain traditionally grown in the High Andes of South America. The researchers were working on methods to improve the yield, but quinoa grown in the USA would displace Bolivia's US$1 million export market and damage the livelihoods of the mainly small-scale farmers who supply the trade [**32**]. (The patent was later withdrawn, after protests by local people and North American NGOs.)

In 1995 US farmers harvested the first commercial crop of a rapeseed plant modified to contain lauric acid, an important material in the soap and cosmetics industries. The compound is a natural ingredient of palm and coconut oil, for which 80 percent of the world market is supplied by the Philippines and Indonesia. If the market for one of their main export crops disappears, the livelihood of up to 30 percent of the Philippine population would be hit. Calgene, the company which produced the modified rapeseed plants, maintains that the variety is not intended to replace palm oil but to be grown as a buffer in years when the tropical oil is in short supply. Others are less sure: "The biotechnology industry says it will feed hungry people and increase productivity in the Third World. The truth is it may have devastating impacts on the poor people of the Third World," says Hope Shand, research director of RAFI [**33**].

Monsanto -- a major player in the biotechnology industry

Founded in St Louis, Missouri, USA, in 1901, Monsanto has through its history produced a range of chemicals, including saccharin for Coca-Cola, aspirin, plastics, textiles, Agent Orange, and recently Roundup glyphosate herbicide. Its campaign to become a leader in 'life sciences' -- food ingredients, medicines and agricultural products -- began in the mid-1980s, and since 1996 the company has spent over US$8 billion acquiring seed and agricultural biotechnology companies. After its 1998 merger with American Home Products, Monsanto became the world's largest agrochemical firm, the second largest seed company, fourth largest in pharmaceuticals, and among the top five in veterinary medicines [**34**].

By 1997 the company was providing commercial seed for herbicide-resistant cotton, soya and rapeseed, insect-resistant cotton, maize and potatoes and a variety of lauric oil-yielding rape. Steps in its recent growth include:

1995

- Buys major share in Calgene, developer of the GM FlavrSavr tomato
- Buys controlling interest in Gargiulo LP, the largest US tomato grower

1996

- *April:* Buys Agracetus, an agricultural biotech company, for US$150 million
- *November:* Buys Asgrow Agronomics, a leading international supplier of soya seed, for US$240 million

1997

- *January:* Buys Holdens Foundation Seeds, seed supplier for over a quarter of the US hybrid maize crop
- *April:* Takes over the remaining shares in Calgene

- *October:* Agreement with the gene analysis company Millennium Pharmaceuticals on a five-year deal to assist the search for new and patentable crop genes

- Acquires Sementes Agroceres, a Brazilian supplier of maize seed with around 30 percent market share in Brazil

1998

- *May:* Forms joint venture with US seed company Cargill and later takes over Cargill's international seeds business, thus acquiring seed multiplication and distribution operations in 51 countries in Central and Latin American, Europe, Asia and Africa

- Acquires seed companies DeKalb, second largest maize seed supplier in the USA, and Delta & Pine Land, which supplies 73 percent of the US cotton seed market and holds the patent on the 'Terminator technology'. The two companies are valued at US$4.2 billion. Forms 50:50 joint venture with the leading Indian seed supply company, Mahyco

- *June.* Merger with pharmaceuticals company American Home Products; the new company will have a combined annual research budget of an estimated US$3 billion

- *July:* Buys Plant Breeding International (Cambridge, UK) from Unilever for US$320 million. Monsanto is particularly interested in PBI's expertise in breeding wheat, the world's most widely cultivated crop.

When Monsanto introduced its Roundup Ready soya beans in 1996 it charged farmers US$5 per 50lb (23 kg) bag as a "technology fee". It also tied customers to using the company's own brand herbicide -- enforced by inspection of fields for up to three years and damages payments from violators. Farmers are also prevented from saving, reusing or selling the patented seed, even for breeding research. The strict terms of the contract proved unpopular with farmers, and the company agreed to change the contracts in later years. Nonetheless, according to RAFI, Monsanto is in the process of suing more than 100 US soya bean farmers for breaking the licence agreement, and has hired private investigators to identify farmers re-using seed [**35**].

The first shipments of GM soya beans reached Europe in late 1996, mixed with conventional beans. A campaign of opposition began: opponents feel that consumers have a right to chose whether or not they eat GM food. They are demanding that GM beans should be kept separate from conventionally grown beans, and food containing the GM beans should be clearly labelled.

In June 1998 Monsanto launched a US$1.8 million advertising campaign to persuade European consumers of the benefits of GM foods. One advertisement was planned to include endorsements from some leading African academics and politicians, promoting the role of biotechnology in increasing the food supply and protecting the environment in Africa, Asia, Latin America and Central Europe under the banner "Let the Harvest Begin" [**36**]. However, this plan attracted hostile comment in the European press and a rebuke from delegates of African countries at the FAO Commission on Genetic Resources meeting in Rome: "We ... strongly object that the image of the poor and hungry from our countries are being used by giant multinational corporations to push a technology that is neither safe, environmentally friendly, nor economically beneficial to us" [**37**].

In June 1998 Monsanto announced sponsorship of US$150,000 for the Grameen Bank (Bangladesh's pioneering microcredit organisation) launching the Grameen Monsanto Center for Environmentally-Friendly Technologies. The centre was to provide access for the poor to new sustainable technologies including seed varieties, and to evaluate their usefulness for the people of Bangladesh. However, critics both at home and abroad condemned the project and in July the Grameen Bank announced its withdrawal from the deal.

7. THE RACE FOR PATENTS -- LEGAL REGIMES AND REGULATIONS

Patents are a central issue in the development of genetically modified crops. To develop a genetically modified variety needs considerable investment in research and testing; to recoup this investment, and profit from it, the researcher (usually a company) wants the right to the sole commercial use of the new discovery -- a patent on it -- for a certain period before the technology enters the public domain. High profits are expected from biotechnology, so corporations are racing to claim patents on the new processes, the genetic knowledge and the products, at the same time pushing for the patent protection system to be extended worldwide. Suddenly the once dry and specialised subject of Intellectual Property has become controversial.

Industrial patents and plant breeders' rights

The patent system was introduced by governments in the 19th century to encourage innovation in industry by giving the patent holder legal protection for a fixed period -- in Europe this is generally 20 years from registering the patent, in the USA 17 years from the time it is granted. In the words of 19th century US President Abraham Lincoln, "The patent system added the fuel of interest to the fire of genius." Patents traditionally apply to inventions -- of new products or processes -- and not to discovery of things that already exist in nature. Patent holders have the power to take legal action and claim damages from any individual or organisation making unauthorised use of their 'intellectual property'. The patent holder can license out the invention for commercialisation by another party and claim royalties, a share of profits from the products sold. Every country has responsibility for its own patent law and the granting of patents within the country, overseen by the World Intellectual Property Organisation.

Under most countries' patent law it has been impossible to patent plant or animal varieties derived from conventional breeding programmes. To protect the interests of plant breeders many countries introduced separate plant variety legislation, harmonised internationally under the 1961 Union for the Protection of New Varieties of Plants (UPOV) Convention, with 38 member states, mainly in the North. The UPOV Convention gives breeders rights very similar to regular patent legislation: the 1991 revision restricts farmers' rights to save proprietary varieties of seed for their own replanting or breeding.

New developments

Researchers and corporations are rushing to claim patents not only on newly invented biotechnological processes but also on the (newly discovered) genes used in those processes and on the knowledge of their properties. Computerised screening methods make it possible to screen large amounts of material to identify potentially useful genes -- and some companies are claiming broad patents before they know exactly how or for what their 'discoveries' will be used: they race to appropriate the material first. So far the greatest rush, and the largest profits, are in the area of pharmaceuticals, but many patents are also being sought on food crops.

The Terminator gene

Shortly before its purchase by Monsanto, Delta and Pine Land Inc was awarded a patent on a gene modification which prevents saved seed from germinating. The technology, popularly known as the 'Terminator Technology', has so far only been shown to work in cotton and tobacco, but the patent covers all cultivated seeds. The company has applied for patents in 78 countries and intends to make the technology available for licensing by other seed breeding companies. The first commercially available seeds are likely to be on the market some time after 2000.

Modern hybrids already don't reproduce reliably, so that farmers who use them have to buy new seed regularly. But this technology would introduce sterility to non-hybrid crops (such as wheat). It would prevent farmers saving some of their best seed as they have done since the beginning of agriculture. Currently 80 percent of crops in the developing world are sown using farmer-saved seed. Though of course farmers will not be forced to buy new modified types of seed, critics fear that there may be increasing pressures on them to do so, catching them in a spiral of costly inputs, debt and dependence on the seed-marketing companies. The companies feel this will be a good thing for Southern farmers: "This development will broaden access to continuing agricultural improvements. The centuries-old practice of farmer-saved seed is really a gross disadvantage to Third World farmers who inadvertently become locked into obsolete (i.e. old-fashioned, low-yielding) varieties because of their taking the easy roads and not planting newer, more productive varieties [**38**]."

There is also a fear that concentration of research on GM crops will widen the technology -- and wealth -- gap between small poor farmers and big producers. The new technology is designed to protect US industry from unauthorised use of its products and to increase sales of commercial seed. It could "increase the value of proprietary seed owned by US seed companies and open up new markets in Second and Third World countries", according to Willard Phelps, of the US Department of Agriculture, co-owners of the "terminator" patent [**39**]. Its inventors also claim it will encourage investment in biotechnology for developing countries, and thus provide farmers with more choice.

The idea of patenting living things and parts of living things is new, complex and controversial. ‘Patenting of life’ began in 1980 when the US Supreme Court decided for the first time that a patent could be granted on a living organism. After a nine-year legal wrangle, judges ruled by a narrow margin that the important criterion for patentability was not the distinction between living and inanimate objects but whether the organism could be regarded as a man-made invention, and they granted a patent on a bacterium engineered to contain an enzyme capable of breaking down oil. The decision delighted the biotechnology industry but dismayed its critics. Patents on plant and animal strains produced by genetic engineering soon followed. "By a margin of one vote, the US Supreme Court handed over the genetic commons of the Earth to private ownership," said Andrew Kimbrell of the International Center for Technology Assessment [**40**].

Existing patent law is not clear on many of the new issues being raised by biotechnology patent claims, such as what can be claimed as an invention (rather than a discovery), what can be claimed as new, what can be claimed as private intellectual property, who ‘owns’ substances that are found in nature, perhaps in many different countries, or what should be the scope of ownership.

Companies, and Northern governments, particularly the USA and recently the European Union, are pushing for clear extension of patent law, or some similar sort of legal protection of intellectual property, to living things and their genetic material, and for globalisation of intellectual property law through such bodies as the World Trade Organisation (WTO).

The patenting debate

For industry, the issue is quite straightforward: innovation is essential to satisfy the world’s growing needs for food and medicines to be produced from an increasingly constrained environment; innovation needs costly research and testing, which will only happen if it can be paid for -- and it can be paid for most effectively through the profits generated by intellectual property protection. This should operate worldwide, because markets are increasingly worldwide.

Many people oppose the trend towards granting private ownership of plant and animal materials, on the grounds that it is immoral to allow monopoly control over living materials, or that living things are the product of natural processes and cannot be claimed as human inventions. Others demand transparent worldwide discussion and agreement on principles, scope and regulatory/patent-granting mechanisms before the race for patents has gone much further.

There are several different objections to patents, including:

- Some dispute the biotechnology industry’s claim that patent protection encourages research. They point to the amount of research that has been carried out without the benefit of a strong worldwide intellectual property regime, and say that patents in fact hinder research by preventing the free exchange of knowledge among researchers.

- Some critics, including many farmers themselves, fear that patents on agricultural plant and animal materials will harm the interests of farmers, by establishing monopolies and forcing farmers to pay more for inputs.

- Patents strengthen the ability of Northern industries to extract profit from Southern raw materials. Most of the globe’s genetic wealth is found in the south, and researchers are scouring the biodiversity-rich forests, seas and wetlands of the south to find potentially useful plant, animal and microbe species and claim patents on them. This is called "Bioprospecting" -- or "Biopiracy" by those who regard the appropriation of the genetic resources of a developing country by a foreign company as theft. It is claimed that companies are improperly claiming ownership, thus depriving local people of the possibility of benefiting themselves from the commercial exploitation of the substance or knowledge, and perhaps forcing the original users themselves to pay. Many farmers fear having to pay to reuse seed based on genes they themselves have cultivated. The US government claimed during the Uruguay Round of GATT negotiations that lack of patent protection allowed Southern companies to trade in pirated versions of products registered by US companies, losing US$202 million a year in royalties on agricultural chemicals and a similar amount in royalties on pharmaceutical products. Dr Vandana Shiva noted that in fact the USA is a substantial net beneficiary of the trade in genetic resources with the South. By her reckoning, US industry could be said to owe US$2.7 billion in royalties on agrochemical and pharmaceutical products originally developed from sources in the Third World.

- There are also objections to patenting on practical grounds of sustainability. It is argued that if we want people all over the world to act positively to conserve the biodiversity found in their traditional crop varieties or local habitats, then we must ensure that they benefit from conserving them, rather than see all the profit from them vanish to Northern companies.

As well as these general objections, specific patent claims by biotech companies are being challenged, sometimes successfully, on the grounds that they are for substances, or the genes and properties of these substances, that have already been known and used in the South for generations -- though perhaps in a different, less ‘scientific’ form. There is often ambiguity about whether a company is claiming a patent for a very specific genetic manipulation using the genes, or the genes and knowledge and use of them. There are questions about who can actually claim ownership of a gene sequence that occurs widely in nature or in farmers’ fields or which has been known and used by traditional farmers or healers, or of a crop plant variety which has been developed by local farmers.

Biopiracy -- some examples

In September 1997, the Texan company RiceTec was granted a patent by the US Patent Office on a variety of rice produced by crossing a strain of Indian basmati rice with an American ’semi-dwarf’ variety. Under the patent, the company claims ownership of basmati-like rice grown anywhere in the Western Hemisphere and future rights on any new varieties produced by crossing this new variety with traditional Asian strains.

The approval of this patent claim caused outrage across the Indian subcontinent. In India farmers took to the streets in protest against a foreign company laying claim to what they saw as a national resource. Basmati has a worldwide reputation as a high-quality rice grown only in India, Pakistan and Nepal; they argued that a US rice producer should not be allowed to use the name. (In fact, says the WTO, their fears were based on a misunderstanding, as the patent did not concern the use of the name.) But there was more than national pride at stake. Basmati rice is a valuable export crop earning India alone around US$800 million a year. The USA takes less than 10 percent of the annual exports of 480,000 tonnes. But the Indian government may fight the patent claim, fearing it might destroy the North American market and the more important European export trade [**41**].

In 1995 two researchers at the University of Mississippi Medical Centre were granted a US patent on some pharmaceutical applications of turmeric. Turmeric has been used in Indian medicine to treat wounds for thousands of years. The US authorities later withdrew the patent, accepting the objection by the Indian Council for Scientific and Industrial Research that the proposed ’new’ use of turmeric lacked novelty, an essential requirement for a patent.

In January 1998 two Australian research institutes dropped an attempt to claim monopoly rights on varieties of chickpeas acquired from the International Crops Research Institute for the Semi-Arid Tropics, in Hyderabad, Pakistan. The UN Food and Agriculture Organisation and the Consultative Group on International Agricultural Research acted to end any further attempts to claim ownership of varieties of plant held in trust by international institutions.

Other patents which have caused protest are on Neem, a tree with agricultural and medicinal uses cultivated widely in Asia and particularly India. Monsanto has taken out patents on neem products, claiming broad fungicidal and insecticidal uses [**42**]. The Indian government challenged patents granted to US company WR Grace for extraction and storage processes for neem, but withdrew its complaint on realising that in these cases the processes were in fact new inventions, rather than traditional knowledge.

The battle over patent legislation: TRIPs and the CBD

The question of whether plant and animal (and human) genetic materials can and should be patented, or regulated by some other type of intellectual property regime, will be hotly debated over the next few years, in fields and forests, law courts, boardrooms, academic and intergovernmental fora. Clear and internationally agreed principles and definitions should be established, in the light of current technological possibilities, globalisation, pressures from corporations, and global welfare and conservation goals.

It will not be easy to achieve international agreement on issues of such importance, in which several different international organisations are involved. Much current debate focuses on the roles of two of these, the Convention on Biological Diversity (CBD) and the World Trade Organisation’s International Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPs). Many analysts believe these two agreements contradict each other.

The CBD, which came into force in 1993, states some basic principles. Genetic material found within a country is owned by that country (as opposed to the previous position, that natural substances are a global common heritage, owned by nobody). Benefits from genetic materials and biotechnology should be shared -- with the communities where the substances are found or who know and use their properties, or with farmers who have developed valuable crop plant varieties. Intellectual property regimes should be devised that do not conflict with the CBD’s over-riding goals, the conservation and sustainable use of biodiversity.

There are many issues to be worked out before these general principles can be turned into effective laws, regulations and monitoring systems. For instance, how to define a ‘community’ that ‘owns’ a plant which may grow in several different areas and different countries? Or, what are the criteria for ‘equitable sharing’ of the benefits of commercial exploitation? Many research and academic bodies, NGOs and inter-governmental expert institutions are working on these problems.

The TRIPs agreement is part of the WTO, established in 1994. TRIPs article 27.3(b) requires all member countries to introduce legislation allowing patenting of microorganisms, biotechnological processes and products, and patents or some other type of protection (*sui generis*, or unique) for plant varieties. Developing countries have until 2000 to enact this legislation, least developed countries until 2005. There is some ambiguity and differing interpretations of these requirements. For instance, what sort of *sui generis* legislation will be acceptable to the WTO? Article 27.3(b) is due to be reviewed in 1999, in advance of a review of the whole of TRIPs in 2000. It is not clear what the scope of the reviews will be, and governments, NGOs and industry worldwide are preparing to promote their -- widely differing -- views during the negotiations.

Some critics of patenting are calling for Article 27.3(b) to be amended; they say the push for private ownership of biological resources is unethical, inequitable and contrary to the goals of the CBD. Others suggest that TRIPs as it stands already allows countries to exclude biological materials from patentability. The Canadian development organisation RAFI points out that under international patent law, governments can refuse to allow patents on any inventions which they believe are morally unjustifiable, using the *Ordre public* (Public Order) clause. This covers inventions which it is felt would be harmful to human, animal or plant life or health, or could cause serious prejudice to the environment. RAFI argues that patents contrary to national morality include any claims "usurping national or indigenous knowledge", i.e. biopiracy. Meanwhile, patents on GM crop plants could be rejected on the grounds of being damaging to the environment and threatening national food security.

One of the fora struggling to debate the issues and formulate more detailed rules, definitions and mechanisms is the Commission on Genetic Resources for Food and Agriculture of the Food and Agriculture Organisation (FAO). Its current revision of the International Understanding on Plant Genetic Resources has already reached its fourth draft without agreement. On the whole the Understanding emphasises the need for national-level and farmer-based development of varieties (by conventional methods as well as biotechnology, though the Understanding does not articulate this). It proposes global monitoring of the acquisition and development of genetic materials. Areas of disagreement include a proposal to promote s*ui generis* plant variety protection systems rather than patent law; and the whole chapter on farmers' rights (their right to benefit from their own breeds, and to save seed from year to year).

Representatives of the Organisation of African Unity (OAU) meeting in Addis Ababa, Ethiopia in March 1998 were determined that national Intellectual Property rules should support the CBD. They drew up draft legislation for OAU member states which seeks to regulate access by outside interests (such as foreign companies) to the biological resources of the community and ensures that any benefits resulting from the commercial exploitation are equitably shared [**43**].

On the other side, many northern governments, especially the US, under pressure from the agricultural and pharmaceutical industries, are pushing for a tightening up of the TRIPs agreement. The US would prefer a uniform patents system and has been criticised for using heavy handed tactics to persuade other nations to enact laws favourable to its own commercial interests. There are reports of several instances of American diplomats using threats of trade penalties or cancelled cooperation agreements against countries including Thailand, Ethiopia, Panama, Paraguay, India and even one Northern country ally, Denmark. In other situations the persuasion is more gentle, but according to a report by the Gaia Foundation and GRAIN [**44**], "Developing countries are being told that patents and other forms of IPR are the key to attracting investment in biotechnology which will uplift their economies and improve food security. These claims are utterly false. The only motivation behind the global IPR campaign is to increase profits for transnational corporations housed in the North."

The European Union moved closer to the US position in 1998 when it adopted a new Directive on the Patenting of Biotechnological Inventions, despite opposition from many organisations and individuals, including the Green Party group within the Parliament and many NGOs, consumer and patient groups within Europe. Much of the debate focused on the ethics of allowing human DNA to be patented by companies working on new medical treatments for inherited diseases, but there were other important concerns, including the effects of the proposed system on farmers. In its final form the Directive, which aims to harmonise national patent law systems across Europe, aims to bring the scope of patents in the EU more or less into line with US practice, beyond what is required by the TRIPs agreement. The debate continues, with the Netherlands government challenging the Directive at the European Court of Justice, partly on the grounds that it conflicts with the existing European Patent Convention.

Underlying the technicalities of law and patent claims is a fundamental question: whether private ownership of materials for genetic engineering is necessary to drive innovation and feed the world, as the industry claims; or whether human welfare would be better served by keeping control over such basic issues as agricultural sustainability and food security in the public domain.

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