

BIOPOLLUTION AND BIOSAFETY

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Biosafety refers to environmental safety in the context of genetic engineering. Genetic engineering risk a new form of pollution or ‘contamination’, called genetic pollution or biopollution. In certain cases, biopollution can have major health and environmental impacts and create biohazards – dangers threatening biodiversity at the genetic, species or ecosystem level. The introduction of new species into ecosystems is one form of biohazard – invasive species dominate ecosystems and displace native biodiversity. The introduction of exotic genes into organisms is another form of biohazard, since its ecological impacts are unpredictable.

Bioinvasions and Green Plagues

Ecological destabilization is leading to biological invasions of ecosystems by exotic species. Bioinvasions are now recognized as a major ecological problem, and are on the increase with globalization as viruses and seeds are moved across the world on planes and ships.

Zebra mussels, little shellfish the size of a kidney beans, were introduced to North America through the ballast waters of a supertanker around 1986. Zebra mussels clog up pipes and waterways, and multiply at an incredible rate – a single female may release more than five million eggs in the course of a year.

It has been estimated that the economic costs of this invasion could be \$5 billion by the year 2000. (Lyadyansky, et al., *Bio-Science*, September 1993).

When the Nile perch was introduced into Lake Victoria, 60 per cent of the native fish species disappeared. Indigenous fish accounted for the 76 per cent fish biomass in the lake in 1983, but for only 7 per cent in 1985, while the Nile perch increased from 16 per cent to 90 per cent. Unsurprisingly, the introduction of the exotic Nile perch is considered the main reason for the disappearance of fish diversity in Lake Victoria (Ogutu-Ohwaya, *Invasive Species*, 1999).

In 1956, 54 African queen bees were imported to Brazil from South Africa for breeding programmes. Twenty-six swarms of hybrid bees escaped from the laboratory, and became the 'African killer bees'. Their migration front reached Panama in 1982, Mexico in 1987, Texas in 1990, California in 1993. So far more than 1,000 people have died after being stung by the exotic hybrids. This is twice as many as the victims of the Ebola and Marburg virus infections put together (*Los Angeles Times*, 1 November 1994).

There are many examples of exotic plant species that were introduced into ecosystems where they became invasive. The kundzu plant was introduced into the USA from Japan as a cattlefeed. In the 1930s Civilian Conservation planted thousands of the plants to control soil erosion. The kundzu has overtaken the south-eastern states of the USA and can grow more than 75 feet (23 metres) in a single season.

Parthenium hysterophorus (wild carrot weed) is a noxious weed which has spread to many parts of India covering in total 5 million hectares (12 million acres). A native of tropical America, it is reported that its seeds came to India with grain shipments from the USA. It was first noticed in Poona in 1951. Since then it has spread like wildfire across the length and breadth of the country. It appeared in Karnataka in 1961, in Kashmir in 1963, in Madhya Pradesh in 1968, in the Western

Himalaya in 1970, and in Assam and Rajasthan in 1979. In addition to displacing local biodiversity, the weed causes dermatitis and other allergies. It also affects agricultural crops such as *maize*, *jowar* and *arhar*. A single plant produces more than 10,000 seed, which travel long distances and can propagate under all kinds of environmental conditions.

The *Lantana camera* was hybridized in Europe in the seventeenth century by using a complex of West Indian and South American species to make attractive flowering plants. Europeans introduced these hybrid Lantanas to their colonies in the tropics. Today these plants crowd out native species, invading pastures and forests. The plants are toxic to livestock but produces berries that birds eat and spread. 'Man unwittingly had created and then let loose on the world a green plague.' (Koopowitz and kaye, *Plant Extinction: A Global Crisis*, 1990.)

The erosion of biodiversity can also facilitate the spread of infectious disease –in fact, disease can be viewed as species invasions at fatal disease spread by monkeys into human populations in South India as the forest habitat was destroyed. The theory is often put forward that AIDS had similar beginnings. It is this disease and invasive species model that provides the most relevant lessons for anticipating and assessing the risks of genetic engineering.

Genetic Pollution

In a similar way, genetic engineering could be unleashing new 'green plagues', as genes for herbicide-resistance move into the wild relatives and create 'superweeds', and Bt. Crops create 'superpests' by killing predators and contributing to the emergence of pest-resistance.

Genetic engineering has raised concerns for biosafety since the tools for gene-splicing were first developed. There have been two phases in the discussions of risks associated with it. The first was during the time when the techniques for recombinant DNA were emerging. This phase was experimental and work was based

on the use of crippled organisms which were not meant to survive in the environment. The main practitioners were university scientists, and, through the Asilomar Declaration in 1972, they themselves called for a moratorium on recombinant DNA research. The second was the 'Wall Street' phase, when scientists who had developed genetic engineering left universities to start biotechnology firms. Concerns for safety were sacrificed to the promise of biotech miracles. This phase is now itself undergoing changes. Genetically engineered organisms are being released for production and consumption on global markets, and the small start-up firms are being bought up by giant chemical corporations. Production is undertaken using ecologically robust organisms. The issues of biosafety are now very different from the days of the Asilomar Declaration.

Laboratory strains of genetically engineered organisms are not designed to survive in an open environment. Therefore we cannot justify extrapolation from laboratory data to ecosystems. Further, existing field tests for safety and risk assessment are not designed to collect environmental data, and test conditions do not approximate production conditions that include commercial scale, varying environments and time scale.

Unlike machines, living organisms have the capacity to organize themselves. Introduced genes can function differently than predicted, and they can move unpredictably into other organisms. Engineering is in fact an inappropriate word for genetic manipulation. Basically, a plant's genome (all of its genes taken together) is a black box. Genetic engineering takes a gene from one black box and forces it into a second black box, hoping that the new gene will take. Most of the time the experiment fails. Once in a thousand times the foreign gene embeds itself in the recipient plant's genome, and the newly modified plant gains the desired trait. But that is all the technicians know. They have no idea where in the receiving plant's genome the new gene has found a home. This fundamental ignorance, combined with the speed and scale at which modified organisms are being

released into the global ecosystem, raises a host of questions for the future on the safety of agriculture, of the environment and of human health ('Against the Grain', *Rachel's Weekly*, 18 February 1999).

Transgenes are based on species pollution by definition, since they are formed by crossing species boundaries, mixing genes of species that do not breed and changing the integrity and uniqueness of a species. Ecosystem pollution can occur because genetically engineered crops can change interactions between species, leading to the domination of certain species, and the displacement of others.

Since genes do not exist in isolation but interaction, the genome is described as fluid, suggesting that the gene has no well-defined continuity or boundaries, the expression of each gene being ultimately dependent on, and entangled with every other gene in the genome. Since the genome is fluid, genes also jumps – they can excise and reinsert themselves in different locations in the genomes –jumping genes or transposons were first discovered by geneticist Barbara McClintock more than forty years ago.

Genes can also move from one organism to another, and between species that do not interbreed, 'horizontal gene-transfer'. Horizontal, or lateral, gene-transfer is defined as the non sexual transfer of genetic information between organisms. Ordinarily gene-transfer takes place vertically from parent to offspring. Horizontal gene-transfer has been identified as the reason for the emergence of antibiotic resistance. The first definitive evidence for this came from DNA sequence analysis of the genes for neomycin-kanamycin resistance to *Staphylococcus aureus*, Streptococci and *Campylobacter*. Antibiotic-resistant gene, especially those carried on plasmids and transposons, can, in principle, cross species as well as genera and even kingdoms. Horizontal gene-transfer is also identified as the process behind the emergence of new and old virulent strains of pathogens since the 1980s. A severe infection by *streptococcus pyogenes* was

traced to toxin encoded by a gene belonging to a bacterial genome.

Genetic engineering can increase the risks of horizontal gene-transfer. Firstly, the vectors used for transferring genes from one organism to another can themselves become mechanisms. These vectors are aggressive hybrids made by joining together bits of natural gene-transfer vectors – viruses, plasmids and transposons. They are designed to be promiscuous, so that they can effectively smuggle genes into cells that would otherwise exclude them. The most common vector used is *Agrobacterium tumefaciens*, which causes cancerous tumours, known as crown galls, in plants. In order to put new genes into plants, such as the ‘Roundup Ready’ gene in Monsanto soya beans, the gene is first introduced into the DNA of *Agrobacterium* plasmids and the bacteria are then imported into the plants. Monsanto describes this aggressive bacterium as: ‘A naturally occurring soil bacterium used to genetically improve plants.’ The potential for the *Agrobacterium* plasmid horizontal gene-transfer is unlimited. Yet monitoring such risks is not required under current regulations.

How Biosafety was Sacrificed for Commerce

The international platform for preventing biopollution and ensuring biosafety is the Convention on Biological Diversity signed at the Earth Summit in Rio in 1992. The Biosafety Protocol which was negotiated under Article 19.3 of the Convention is the legally binding instrument that should address issues related to the impact of GMOs on the environment and public health.

The USA has undermined the Biosafety Protocol since 1991 when article 19.3 was being negotiated. It mobilized the Miami Group –consisting of Canada, Australia, Chile, Argentina and Uruguay –to prevent the Protocol from being finalized at Cartagena, Columbia in February 1999. The attempt to prevent an environmental agreement from coming into force was

repeated in Vienna in August 1999. However, in February 2000 the negotiations for a Protocol were completed in Montreal. This has, at least for the time being, countered the attempt to move the discussions on biosafety from where they belong — the Biosafety Protocol — to where they do not belong — the WTO, which has neither the mandate nor the capacity for environmental regulation to prevent and prohibit activity causing pollution. Its mandate is to promote-trade and remove trade restrictions for products that generate pollution. In the case of GMO's, the pollution generated is biological pollution.

The objective for moving biosafety issues from a multilateral environment agreement, the CBD, to a free-trade agreement, the WTO, was evident in the US proposal of 4 August 1999. It was also reflected in the Ministerial Text of 19 October 1999 for the Seattle WTO conference. The proposal calls for: 'Disciplines to ensure that trade in products of agricultural biotechnology is based on transparent, predictable and timely processes.' Transparency, predictability and timely processes, however, mean different things to different people. It is ironic that the country calling for transparency has actively prevented transparency in the trade of GMOs by refusing the segregation and labelling of GM products. Decisions on trade in GMOs have been opaque from the perspective of citizens and consumers. For citizens, transparency implies transparency of corporation action.

For corporations, transparency implies their easy access to government decisions. The USA is clearly referring to the latter, while the anti-GM movements refer to the former.

The USA has repeatedly used WTO rules and disputes as a threat to European countries who refuse GM/biotech foods. On 18 June 1997, the biotech and agriculture industry wrote to President Clinton suggesting that it was critical that the EU understand at the highest level that the USA would consider any such trade barrier unacceptable and subject to challenge in WTO. In June 1997, the US Trade Representative warned the

EU Agriculture Commission not to continue with proposals to require the labelling of genetically modified organisms (GMOs) or their segregation from regular products. The Trade Representative told the Senate Agriculture Committee that the USA cannot tolerate a step which would cause a major disruption in US exports to the EU. In a letter to the US Secretary on 12 June 1997, American agribusiness corporations stated that the segregation of crops for labelling is both scientifically unjustified and commercially unfeasible. However, after a number of leading food processors, such as Nestle, Unilever, Gerber, Heinz, and Kirin announced they would not use GM ingredients in their foods, and major European supermarkets announced their intention to ban GM foods, leading grain companies such as Archer Daniels Midland and Consolidated Grain and Barge told farmers and grain merchants to segregate crops from new GM crops.

According to US industry, labelling of foods violates the GATT agreement on free trade. The Sanitary and Phyto-Sanitary Measures in GATT are thus viewed by industry as Protecting their interests. The consumers' democratic rights to information cannot be decided by arbitrary technocratic and corporate decision-making on what is 'sound science' and what is not.

Sound Science or Unsound Science?

'Sound science' has become a mantra for protecting the biotechnology industry by banishing safety regulations from the commercialization of genetic engineering. This was the phrase used by the industry in the letter to President Clinton at the G7 Summit in Denver 18 June 1997. It is the language of a *Wall Street Journal* editorial of 6 November 1997 that accuses Europe of practising 'junk science' in banning the import of hormone-fed beef, and referring to the WTO decision. The US Agricultural Secretary, Dan Glickman, stated categorically that the United States will stand behind its genetically engineered

food and will oppose any European labelling requirements as a trade violation. According to Glickman: 'We've got to make sure that sound science prevails, not what I call historic culture, which is not based on sound science. Europe has a much greater sensitivity to the culture of food as opposed to the science of food. But in the modern worlds, we just have to keep to pressure on the science. Good science must prevail in these decisions.'

The safety debate has been suppressed again and again by bad science parading as 'sound science'. One of the unscientific strategies used to extinguish the safety discussion is to define a novel organism or novel food created through genetic engineering as 'substantially equivalent' to conventional organisms and foods. However, a GMO is different because it has genes from unrelated organisms – it cannot, therefore, be treated as equivalent to a non-genetically engineered organism. In fact, the biotechnology industry itself gives up the claim of 'substantial equivalence' when it claims patents on GMOs on grounds of novelty.

Official of the Food and Drug Administration had repeatedly cautioned that foods produced through biotechnology entail different risks from their conventionally produced counterparts. In spite of scientific warnings, President Bush and the US government issued a 'no labelling' and 'no safety testing' policy on gene-altered foods in 1992. The false assumption of 'substantial equivalence' was introduced by President Bush in US policy immediately after Rio to blunt the call for biosafety regulation. It was later formalized and introduced in 1993 by OECD (UN Organization for Economic Co-operation and Development, and subsequently endorsed by FAO (UN Food and Agriculture Organization) and WHO (World Health Organization). The OECD document states:

For foods and food components from organisms developed by the application of modern biotechnology, the most practical approach to the determination is to consider whether they are substantially equivalent to analogous food

products if such exist. The concept of substantial equivalence embodies the idea that existing organisms used as foods, or as a source of food, can be used as the basis for comparison when assessing the safety of human consumption of food or food component that has been modified or is new.

Apart from being vague, this definition is unsound. Foods with Bt. toxin genes are not the same as foods without. Herbicide-resistant crops are different from existing varieties because they have new genes for resistance to herbicide. An article by Marc Lappé and other in the *Journal of Medicinal Food* (1999) has established that Monsanto Roundup Ready soya beans change the levels of phytoestrogens by 12 to 14 per cent. To treat these differences as insignificant when it is a question of safety, and as significant when it is a question of patentability, is totally unscientific. As Millstone, Brunner and Mayer have stated in 'Beyond Substantial Equivalence.' (*Nature*, 7 October 1999):

Substantial equivalence is a pseudo-scientific concept because it is a commercial and political judgement masquerading as if it were scientific. It is, moreover, inherently anti-scientific because it was created primarily to provide an excuse for not requiring biochemical or toxicological tests. It, therefore, serves to discourage and inhibit potentially informative scientific research.

Politics and profits parading as science has been institutionalized into the WTO trade systems. Through the Sanitary or Phyto-Sanitary (SPS) agreement, and the Technical Barriers to Trade (TBT), WTO has made one body, the Codex Alimentarius Commission, the ultimate decision-making body in disputes related to food safety. The participants are mainly Northern countries and industries, with the South and citizens heavily under-represented. The biotech industry and rich countries therefore determine Codex decisions. The WTO rules state that disputes will be arbitrated on grounds of 'sound science'. However, as the assumption of substantial equivalence shows,

what is 'sound science' can be very unscientific and unsound.

The biotech industry can use WTO to prevent people from exercising their basic right to safe food. Article 2.2 of the SPS Agreement states that all sanitary and phyto-sanitary measures will be based on scientific principles and will not be maintained without sufficient scientific evidence. This goes totally against the Precautionary Principle embodied in Principle 15 of the 1992 Rio Declaration on Environment and Development: 'When there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.'

Biotechnology exemplifies the clash between profits and safety, between commerce and conservation, between greed and need between trade treaties like GATT/WTO and environmental treaties such as CBD. The outcome of this conflict will determine the future of our health and environment. It will also determine whether global corporations will rule our lives, protected by WTO and governments, or will be governed by rules of justice and sustainability, and accountable.

Biopollution

As the Green Revolution miracle fades into ecological disaster, the biotechnology revolution is being heralded as an ecological miracle for agriculture. But genetic engineering is unleashing biological and genetic pollution, while in addition spreading agrichemicals in agro-ecosystems where they have not been used before. Chemically intensive farming in the last forty years has led to severe environmental threats to plant, animal and human life. In the popular mind 'chemical' has come to be associated with 'ecologically hazardous'. The ecologically safe alternatives have been commonly labelled as 'biological'. Biotechnology has benefited from falling into the 'biological' category. Biotech industry has described its agricultural innovations as 'Ecology Plus'.

It is, however, more fruitful to contrast the ecological with the engineering paradigm, and to locate biotechnology in the latter. The engineering paradigm offers technological fixes for complex problems, and by ignoring the complexity, generates new ecological problems that are later defined away as 'unanticipated side-effects' and 'negative externalities'. Within the engineering ethos it is impossible to anticipate the ecological breakdown that an engineering intervention can cause. Biotechnology cannot provide the frame work for an assessment of its ecological impact on agriculture.

Unlike toxic hazards, biohazards multiply and have no recall. As Elaine Ingham, Professor of Soil Ecology at Oregon State University, has stated:

Any engineered organism to be released into the real world, free from the controlled laboratory situation, must be treated as the potential hazard that it is. The biotechnology industry needs to step back and make certain that the biological potential of the organisms being altered, both before and after alternations, is recognized an understood. After all, organisms are capable of reproduction, of increasing in number and spreading. Human-produced chemicals may have posed problems to the environment but at least chemicals, whether organic or inorganic, did not reproduce. One molecule of a problem chemical remained one molecule and did not replicate and become a million problems.

One example of the risks of genetic pollution was the case of a genetically engineered soil organism, *Klepsiella Planticola*, which had been designed to digest biomass and produce ethanol as a way of getting rid of farm wastes and producing alternative sources of energy. The German biotech company applied to the USA for field tests, and Oregon State University took up the trials. Elaine Ingham and Michael Holmes compared the result of applying the genetically engineered *Klepsiella* and the naturally occurring *Klepsiella* to soils and crops. Every plant grown with the GE *Klepsiella* died. If released, it could have killed all plant life and destroyed agriculture and food

production. What prevented this was the independent research by independent scientists who assessed the impact in living soil and not sterile soils, as is usually the case. As Elaine Ingham admits, 'If we hadn't done this research, the *Klebsiella* would have passed the approval process for commercial release.' (Holmes, et al., *Applied Soil Ecology*, Vol. 326, 1998.)

The Oregon experiment was among the very few ecological assessments of the impact of GMOs on the environment. Promoters of genetic engineering often cite that thousands of GM trials have taken place and they have established safety. However, safety assessments have not been carried for any of the crops that cover millions of acres. The false assumption of 'substantial equivalence' of GMOs and non-engineered organisms establishes a strategy of deliberate ignorance. Ignorance of risks is then treated as proof of safety. 'Don't look – don't see' leads to total lack of information about the ecological impacts of genetic engineering.

It is often claimed that there have been no adverse consequences from over 500 field releases in the US. However, the term 'releases' is completely misleading. Those tests were largely not scientific tests of realistic ecological concerns, yet 'this sort of non-data on non-releases has been cited in policy circles as though 500 true releases have now informed scientists that there are no legitimate scientific concerns'. (Rissler and Mellon, *The Ecological Risks of Engineered Crops*, 1996).

Recently, for the first time, the data from the US Department of Agriculture field trials were evaluated to see whether they support the safety claims. The Union of Concerned Scientists (UCS) who conducted the evaluation found that the data collected by the USDA on small-scale tests had little value for commercial risk-assessment. Many reports fail to even mention – much less measure – environmental risks. Of those reports that allude to environmental risk, most have only visually scanned field plots looking for stray plants or isolated test crops from relatives. The UCS concluded that the observations that

‘nothing happened’ in those hundreds of tests do not say much. In many cases, adverse impacts are subtle and would never be registered by scanning a field. In other cases, failure to observe evidence of the risk is due to the contained conditions to the tests. Many test crops are routinely isolated from wild relatives, a situation that guarantees no outcrossing. The UCS cautioned that ‘care should be taken in citing the field test record as strong evidence for the safety of genetically engineered crops’.

It is also frequently argued that millions of acres planted under genetically modified crops is evidence of testing and safety and proof of consumers acceptance. However, in the absence of labelling, American consumers were unaware that they were consuming GM foods. And GM crops spread because of absence of testing. For example, Bt. Toxin is treated as a pesticide by EPA (US Environment Protection Agency), but it is not treated as a food additive or pesticide by FDA (US Food and Drug Administration). Neither EPA nor FDA test Bt. crops for safety (Michael Pollan, *New York Times*, 25 October 1998).

Genetically engineered transgenic crops can contribute to genetic pollution or biological pollution in many ways:

- In herbicide-resistant varieties, transgenes can spread to wild and weedy relative, creating superweeds.
- Contamination or pollution of biodiversity can destroy the unique characteristics of diverse species.
- Transgenic crops engineered to produce pesticides can lead to evolution of resistance in major insect pests, creating superpests.
- Toxins from the genetically engineered crop can kill beneficial species.

GMOs can also spread disease. Breeding plants resistant to viral infections by inserting virus genes in the plant genome can create new super viruses which have new hosts and new properties (Green and Allison, ‘Viruses and Transgenic Crops’. *Science*, 1994).

Genetic pollution or biopollution can also occur through horizontal gene-transfer. Horizontal gene-transfer is the non-sexual transfer of genetic information between organisms. One such case is the sudden 'jumping' of genetic parasite belonging to yeast, a favourite subject for genetic engineers, into many unrelated species of higher plants.

Our knowledge at the genetic level is too immature to assess the probability or consequences of such horizontal gene-transfer, and the genetic pollution resulting from it. Little has been done to understand the ecology of genes, though much effort has gone into the engineering of genes without any knowledge of the impact of genetically engineered organisms on other organisms and the environment. The lack of knowledge has been taken as proof of safety when it is, in fact, ignorance of biohazards.

Creating Superweeds and Superpests

Two applications of genetic engineering in agriculture account for most plantings and trials –the first is to make crops resistant to herbicides, and the second is to build pesticide-producing properties into plants. Both 'herbicide-resistant' and 'pest-resistant' strategies pose major threats to biodiversity and the environment.

Herbicide-resistant crops can create superweeds by the transfer of resistant traits to wild and weedy relatives through

Global Area of Transgenic Crops (million hectares)

Trait	1997	%	1998	%
Herbicide-resistant	6.9	63	19.8	71
Insect-resistant	4.0	36	7.7	28
Others	<0.1	<1	<0.1	1
Global Total	11.0	100	28.8	100

Source: Clive James, Global Review of Commercialized Transgenic Crops, *International Society for Acquisition of Agbiotech Applications (ISAAA)*, 1998

hybridization and cross-pollination. Research in Denmark has shown that oilseed rape can hybridize up to 93 per cent with wild relatives (*American Journal of Botany*, 1994). Wild beets have become a major problem in European sugar beet production since the 1970s. Genetically engineering sugar beet to be herbicide-resistant can only be a temporary solution to the weed problem since gene exchange can occur between transgenic sugar beets and weed beets. This would broaden the niche for weeds and create superweeds resistant to herbicides. The efficacy of herbicide-resistant crops would therefore be totally undermined (Bondry, et al. *Theoretical Applied Genetics*, 1993).

Scientists at the National Institute of Agricultural Botany in the UK discovered the first GM superweeds, following the spread of pollen from a GM trial crop to wild turnip plants. As Marie Woolf of the London *Independent* reports (18 April 1999), 'Some of the "Frankenstein" plants, which had inherited their GM parents' herbicide-resistant genes, were able to breed.'

When introduced to regions such as China, Taiwan, Japan, Korea and the former USSR, where wild relatives of soya are found, Monsanto's Roundup Ready soya bean would transfer the herbicide-resistant genes to wild relatives leading to new weed problems. The hazards of gene-transfer to wild relatives are higher in the Third World, because these regions are home to much of the world's biodiversity. As the US Academy of Science' 1989 guide 'Field Testing Genetically Modified Organisms' States:

Temperate North America, especially the United States, includes the home ranges for very few crops, as US agriculture is based largely on crops of foreign origin. This paucity of crops derived from North American sources means there will be relatively few opportunities for hybridization between crops and wild relatives in the United States. The incidence of hybridization between genetically modified crops and wild relatives can be expected to be lower here than in Asia Minor, South-east Asia, the Indian subcontinents, and South America, and greater care may be needed in the

introduction of genetically modified crops in those regions. The native biodiversity richness of the Third World thus increases the environmental risks of genetic pollution from introduced genetically modified species.

University of Chicago scientists have shown that transgenic crops have a higher tendency to outcross and transfer genes to related crops. Genetically engineered (GE) plants were 20 times more likely to cross with related species compared to conventionally bred plants, in spite of both having the same gene for herbicide-resistance (*Gene Exchange*, Fall/winter 1998). Research in Germany has shown that genes from GE crops can be transferred to crops in fields 200 meters away, about 660 feet (*Gene Watch Briefing*, May 1998).

Research is also showing that pollen from GE crops remains fertile over longer distances than expected. A study found that even at sites 400 metres (1300 feet) from the GE plots, as many as 7 per cent of the seeds were herbicide-resistant. At 100 metres (330 feet), between 8 and 28 per cent were resistant (*New Scientist*, 17 April 1999).

Plants with the introduced transgene are not fragile. They are robust and produce as many seeds as unmodified counterparts (*Gene Exchange*, Fall / Winter 1998). The threat of genetic and biological pollution are therefore real and serious. While genetic engineering has nothing to show in terms of its proclaimed objectives of increasing yields and decreasing chemical use, the risks that were denied are becoming more and more evident through independent scientific research. This is why there is a global call for a five-year freeze on genetically engineered organisms.

Just as herbicide-resistant can create super weeds. Pest-resistance in GE plants can create superpests. Toxin-producing genes from the naturally occurring organism *Bacillus thuringiensis* are being added to a wide range of crops to enable the plants to produce their own insecticide. Monsanto sells its Bt. potato as 'Nature Mark' in Canada. Hendrik Verfaillie, Monsanto's

president, speaking at the national Academy of Science in Washington, D.C., on 30 October 1997, describes it as a plant using 'sunshine, air and soil nutrients to make biodegradable, protein that effects just one insect pest, and only those individual insects that actually the a bite of the plants'.

- The Bt. plant does not merely use 'sunshine, air and soil nutrients'. It has a gene from *Bacillus thuringiensis* which produces the Bt. toxin.
- The so called 'biodegradable protein' is actually a toxin which the gene continuously produces in the plant.
- Insect pests like the cotton bollworm that destroy cotton can actually evolve resistance because of continuous release of the toxin and hence become 'superpests'.
- The Bt. crop does not affect 'just on specific insect pest'. Beneficial insects like bees and ladybirds can be seriously affected.

The primary justification for the genetic engineering of Bt. into crops is that this will reduce the use of insecticides. A Monsanto brochure with a picture of a few worms stated, 'You will see these in your cotton and that's OK. Don't spray.' However, in Texas Monsanto faces a lawsuit filed by twenty-five farmers over Bt. cotton planted on 18,000 acres which suffered cotton bollworm damage and on which farmers had to use pesticides. In 1996, 2 million acres in the USA were planted with Monsanto's Bt. transgenic cotton called Bollgard, but cotton bollworms were found to have infested thousand of acres of it in Texas.

The question is not whether superpests will be created by the Bt. crops, but when they will become dominant. The fact that the US Environment Protection Agency (EPA) requires refugia of non-engineered crops to be planted near the GE crops reflects the real dangers of creating resistant strains of insects. The widespread use of crops containing Bt. could accelerate the

development of insect resistance to Bt. used for organic pest control. Already eight species of insects have developed resistance to Bt. toxins, either in the field or laboratory, including diamond back moth, Indian meal moth, tobacco budworm, colorado potato beetle and two species of mosquitoes. The GE Bt. crops express the toxin throughout the growing season. Long-term exposure to Bt. toxin could lead to selection for resistance in all stages of the insect pest on all parts of the plant for the entire season. Owing to this risk, EPA offers only conditional and temporary registration of varieties producing Bt., and requires up to 40 per cent *refugia* with Bt. cotton, i.e. 40 per cent of the cotton planted is to be conventional and does not express the Bt. toxin. It therefore acts as a refuge for insects to survive and breed, and keeps the overall level of resistance in the population low. Even with *refugia*, insect resistance will evolve in as little as three to four years.

While the Monsanto literature states that farmers will not have to use pesticides, the reality is that the management of resistance requires continued use of non Bt. cotton and pesticide sprays. This leads to rapid development of superpests and the destruction of their natural predators. In Andhra Pradesh in India the 1998 cotton crop failed, five hundred farmers committed suicide, and Bandi Kalavathi of Venkatapur village was one of them. She was in dept for over \$ 1,000 from buying pesticides for her four acres (1.6 hectares). The cotton catastrophe in Andhra Pradesh will no doubt be used to promote Bt. cotton as a miracle cure for pest problems. But in laboratory tests it has been found that the two pest species that destroyed the Andhra Pradesh cotton crop can evolve resistance to Bt. toxins engineered into Bt. cotton. This shows how vulnerable our agriculture has become – ecological problems need ecological solutions, not magic-bullet technologies.

A study at Cornell University, published in *Nature* 20 May 1999, has shown that Bt. corn killed the larvae of Monarch butterflies, dubbed by the media the ‘bambi of the insect world’.

A recent study in Switzerland found that lacewings, which prey on corn pest, suffered mal-development and increased mortality when fed corn-borers raised on Bt. maize (Hilbech, et al., in *Environmental Ecology*, 4 August 1998). Bees and other pollinators are also affected. When given sugar solution with protease inhibitors, which are used to create resistance to insects in transgenic oilseed rape, bees were found to have difficulties learning to distinguish the different smells of flowers (Tudge, *The Engineer in the Garden*, 1993). The Scottish Crop Research Institute at Dundee found that ladybirds fed on aphids that had been feeding on transgenic potatoes laid fewer eggs and lived half as long as those on a normal diet (Brich, et al., *Annual Report*, 1996-97). At New York University researcher found that Bt. toxin from transgenic crops does not disappear when added to soils. Unlike natural Bt., it is not degraded by microbes, nor does it lose the capacity to kill insects. Soil organisms in the soil that degrade organic matters could be harmed by this toxin. The accumulation of transgenic Bt. in the soil poses a major threat to soil ecology (*Gene Exchange*, Fall/Winter 1998).

The pollution from transgenic crops is spreading through cross-pollination and hybridization, as well as through vertical gene-flow through the food chain. There are no biosafety regulations to stop this genetic pollution. In India, the buffer zone in GE trials is a mere 5 metres (about 16 ½ feet). In the UK it is 200 metre (about 660 feet). But the canola seed from Canada introduced into Europe had been contaminated in spite of a 800 metre (2,600 feet) buffer zone. The UK Minister for the Environment, Michael Meacher had to admit that bees, which may fly up to 9 kilometres (6 miles) in search of nectar, cannot be expected to observe a 'no-fly zone' (Greenpeace and the Soil Association, *The True Cost of Food*, 1999). A study by the National Pollen Research Unit in 1999 shows that wind can carry viable maize pollen hundreds of kilometres in 24 hours. Transgenic pollen was found 4.5 km (nearly 3 miles) from a field of GM oilseed rape in the Oxfordshire. This was at least

20 times over the limit set by the regulatory agencies (*Reuters*, 30 September 1999).

Biological pollution implies that the possibility of producing uncontaminated organic food is destroyed. In 1999, 87,000 pack of organic Tortilla chips worth over \$100,000 were recalled and destroyed because they were found to be contaminated with DNA from transgenic maize. In a radio programme on 31 January 1999, Nick Brown, UK Minister of Agriculture, asserted that, 'The government is absolutely committed to making sure that those who do not want to eat crops that have been cross-contaminated, are to have their rights in this protected as well.' However, as long as ecological research is hampered by lack of funding for science in the public interest, and as long as laws to prevent genetic pollution are not put in place, people's right to be free of biopollutions will be denied.

The building-up of pest-resistance undermines the use of natural Bt. in organic agriculture. This is the reason that legal action against the EPA was filed in Washington in September 1999 by Greenpeace International, the International Federation of Organic Agriculture Movements (world organization of organic farmers, certifiers, producers, retailers, with 650 members in over 100 countries), the Sierra Club, the National Family Farm Coalition, California Certified Organic Farmer, the Rural Advancement Foundation International (RAFI), the Institute for Agriculture and Trade Policy and over twenty organic farmers' organizations. The central demands of the petition are that the EPA cancels registration of all genetically engineered plants that contain the Bt. pesticide, and stops taking new registrations. Further, that it issues an impact statement analysing the registering of GE plants that express Bt.

In India, the Research Foundation for Science, Technology and Ecology (RFSTE) has legally challenged the Bt. cotton trials of Mansanto-Mahyco (Maharashtra Hybrid Company, set up by Monsanto as a joint venture). These trials were illegal since they bypassed the rules of the Environment Protection Act. Since

India is home to cotton biodiversity, GE cotton posed higher risks of genetic pollution to agriculture and biodiversity.

Biopolluters should Pay

Some of the risks of biopollution and genetic pollution created by the release of genetically modified organisms are now well known and well established empirically. Movements against genetic engineering have grown and spread across the world. They are based on the unpredictability of the impact of GMOs on the environment and public health, and they have made the trade in GMOs unpredictable. Consumer rejection has forced retailers and processors to become GE-free, which in turn has forced traders to segregate and offer premiums for GE-free crops. The unpredictability of trade in GMOs is a fallout of the environmentally irresponsible manner in which GM crop-planting was spread to cover millions of acres, and GM foods were introduced into global market with any biosafety regulation.

The challenge at Seattle in November 1999 was to stop the further deregulation of GM trade, already characterized by political and environmental unaccountability, and to stop the trend of transforming environmental problems needing environmental solutions into trade problems with further trade deregulation presented as the solution. An important principle of environmental protection is the Polluter-Pays Principle. Genetic engineering creates the potential for biopollution. This requires that we put in place regulatory systems that prevent biopollution, and make the polluter pay when it does occur. However, while the commercial application of genetic engineering is growing exponentially, the knowledge of its ecological impact is still in its infancy. This has come about for many reasons. Firstly, most biologists are now financed through corporate grants as public financing of research dwindles. An independent publicly financed research community is therefore fast disappearing. Biosafety requires a large body of independent

research. This expertise is different from the expertise of constructing transgenic organisms. Refrigerator manufacturers are not experts in ozone depletion, automobile makers are not experts in climate change and genetic engineers are not experts in biopollution.

While biosafety cannot be left in the hands of the biotech industry, the industry should bear the costs of independent research by putting a major share of its investments in a publicly held 'Biosafety Fund'. Meantime, since we do not have complete knowledge of impacts, we should err on the side of caution and act according to the Precautionary Principle. This is why scientists and citizens across the world are calling for a five-year freeze on commercialization of GMOs. This will give time for our research and regulatory systems to catch up with the challenge of biosafety and become scientifically and politically equipped to prevent biopollution.

Since biopollution occurs when GMOs are not 'contained' in a closed environment, it is the field trials and planting of GM crops that environmentalists seek to 'freeze', not the production of medicines under contained conditions. The 'freeze' is to accelerate and expand research so that molecular biology is contextualized as gene ecology and our knowledge grows beyond reductionist prisons. The tools offered by the new sciences, such as DNA fingerprinting and genetic identification, are also useful for deepening our understanding of the ecology of genes. Commerce should be guided by knowledge, not the other way around.
