

Colonizing the Seed

Genetic Engineering and
Techno-Industrial Agriculture

Gyorgy Scrinis

FRIENDS OF THE EARTH

Colonizing the Seed is published by

Friends of the Earth (Fitzroy)
Genetic Engineering Group
PO Box 222, Fitzroy 3065
Melbourne, Australia.

First Published 1995
Revised Reprint 1999

ISBN: 0 909313 37 7

Front Cover Image:
‘The Schwarzenegger Pepper’ by Peter Lyssiotis

Back Cover Image: ‘The Genetic Barcode’ by Mathilde Lochert

Cover Digital Layout by Sean Doyle

Acknowledgments

Many thanks to Clive Rosewarne, Richard Hindmarsh, Mathilde Lochert, Rosemary Robins, Sean Doyle, Peter Lyssiotis, Anthony O’Donnell, Paul James, Errol Beau Ellis and FOE Australia.

Contents

Introduction	4
1. Organic-Traditional Forms of Agriculture	6
2. Techno-Industrial Forms of Agriculture	9
3. Chemical-Industrial Agriculture: The Green Revolution	10
High-Yielding Varieties of Seed	10
Uniformity	10
Hybrid Seeds	11
Chemical Fertilisers and Pesticides	11
Irrigation	12
Soil Degradation	12
Agro-Chemical Poisoning	13
Squeezing-Out the Small Producer	13
4. Genetic-Industrial Agriculture: The Gene Revolution	16
Continuities and Discontinuities	16
A New Form of Plant Breeding	17
Some Specific Applications:	18
i) Herbicide-Tolerance	18
ii) Genetic Pesticides	18
iii) Virus Resistance	30
iv) Designer Crops	19
v) Crop Substitution	19
General Problems with Genetic-Industrial Agriculture	20
i) New Biological Imbalances	20
ii) Genetic Pollution	20
iii) Eroding Biodiversity and Creating Higher Levels of Uniformity	21
iv) Maintaining and Extending Unsustainable Practices	21
v) The Total Colonization and Commodification of the Seed	22
vi) The Centralization of Control and the Triumph of the Code	23
5. Opposing Genetic-Industrial Agriculture	24
Notes	26
Bibliography	28

Introduction

Genetic engineering will deliver ‘designer’ food crops capable of greatly improving contemporary agricultural systems or so the story goes. The biotechnology industry and its supporters are holding out the promise of plants that can be engineered to our precise specifications, creating a future of environmentally sustainable agriculture, more flexible crops, and an abundance of food with which to finally bring an end to world hunger. The reality, however, is that genetic engineering represents a continuation — indeed an intensification — of the techno-industrial approach to agricultural production, and the social inequalities, concentrations of power/wealth, and ecological problems it has produced. Genetic engineering also creates *new* avenues for the corporate domination of global agriculture, and poses new kinds of environmental threats, introducing an entirely new form of industrial pollution into our vocabulary and into the world: *genetic pollution*.

A scientific technique developed since the early 1970s, genetic engineering today makes possible the direct manipulation of the genetic structure of any life-form, including the ability to transfer genes across species boundaries from one living organism to another, and to switch particular genes ‘on’ or ‘off’. Genetic engineering reduces life to its genetic code, and this code becomes the means through which nature is not only controlled but also re-engineered into new forms. In the hands of genetic engineers and biotechnology corporations, all living things are encountered as genetic ‘raw material’ to be mined, and used to create new species that more closely conform to the requirements of corporate-industrial capitalism.

In agriculture, genetic engineering now makes possible the further *invasion into and control of the seed* at the level of the gene — or as Vandana Shiva refers to it, the total *colonization of the seed*.¹

Despite the ability to engineer and thereby control the genetic structure of plants via the seed, the new biotechnologies do not enable scientists to control and manipulate entire agricultural ecosystems and the dynamic interactions of plants, soils, climates, diseases and insects. Consequently, the narrow goals and benefits sought through techno-industrial forms of agriculture are inevitably accompanied by devastating environmental consequences, such as severely degraded soils, the evolution of super-pests, the creation of chemical and genetic forms of pollution, and the rapid erosion of local and global biodiversity.

Despite this inability to control entire agro-ecosystems, the ability to engineer the seed’s DNA does, nevertheless, enable seed/chemical/ biotech corporations to increase the sales of their products, and to extend their control over farmers and the entire industrial food chain. Many more small-scale farmers will be driven from the land, and in the Third World this will mean ever spiralling levels of landlessness, poverty and hunger. It is not only biological processes, but also social relations and structures of power that are being re-engineered through this new technology.

The list of ‘benefits’ that proponents of genetic engineering are now promising include: increased crop yields; the overcoming of pest problems; crops able to grow in a variety of environmental conditions; reducing the use of chemical fertilizers and pesticides; the introduction of new characteristics in food crops that are tailored to the needs of consumers, retailers, or the food processing industry; and ultimately, of course, solving the problem of world hunger. This is not the first time that some of these promises have been made: these were also characteristic of the aims of earlier techno-scientific plant-breeding programs. Higher-yields and designer plant varieties have already been achieved through earlier developments in plant breeding and with the help of chemical fertilizers and pesticides, but these very ‘successes’ are directly implicated in the devastating ecological and social consequences that have followed their introduction. I will refer to this earlier stage of industrial agriculture as *chemical-industrial agriculture*. The spread of chemical-industrial agriculture into the Third World is commonly known as the ‘Green Revolution’, and has in fact

directly contributed to the growth of poverty, hunger and environmental degradation in those countries.

The development and application of the new biotechnologies, such as genetic engineering, now transforms chemical-industrial agriculture into *genetic-industrial agriculture*. An understanding of the multi-dimensional failures of the Green Revolution, and of the trends in contemporary techno-industrial agriculture, is necessary in order to fully grasp the likely ecological and socio-economic impacts of genetic-industrial agriculture.

Genetic-industrial agriculture is characterised by both continuities and discontinuities with chemical-industrial agriculture. On the one hand, both of these forms of industrial agriculture are capital-intensive; they are dependent on the application of externally supplied inputs such as seeds, fertilizers and pesticides; they use purchased seeds that do not evolve to suit the conditions of the local agricultural ecosystem (ie. they are 'static'); and they involve the large-scale 'monoculture' cropping of uniform plant varieties. For these reasons, and others to be discussed later, genetic-industrial agriculture will necessarily continue and intensify the ecological and socio-economic tendencies of chemical-industrial agriculture. Genetic-industrial agriculture will therefore:

- i) further reduce biodiversity, by replacing indigenous plant varieties with highly uniform varieties developed and supplied by seed companies;
- ii) create the conditions in which 'super-pests' are able to evolve and acquire resistances to 'static' plant varieties, as well as to the chemical and biological pesticides used to control them;
- iii) allow for the continuation and even intensification of unsustainable industrial agricultural practices by creating plants that can tolerate degraded or marginal soils, or tolerate greater applications of chemical inputs; and
- iv) further reduce farmers' independence and self-sufficiency, by creating a greater dependence on external inputs and the corporations that supply them.

Genetic-industrial agriculture also marks a distinct break with the plant breeding methods and chemical products of the Green Revolution, as it involves engaging with nature *directly* at the level of the gene. As such, genetic engineering creates *new* types of biological and environmental problems, and the possibility of new forms of social control. These include:

- i) the spread and proliferation of a plant's new genetic traits to other domesticated and wild plants, and the release of other genetically engineered organisms, such as bacteria, into the environment (*genetic pollution*);
- ii) the creation of genetic uniformity *between* plant and other species, as well as a higher degree of uniformity within plant species;
- iii) enabling chemical/biotech corporations to design plants to only respond to their own brands of chemical inputs; and
- iv) making it possible for seed/biotech corporations to patent the genetic codes of plant varieties, and to more easily enforce the new patenting laws, thereby extending the corporate ownership of life to the genetic level.

It will be argued here that genetic-industrial agriculture can only exacerbate the environmental crises and social inequalities created by chemical-industrial agriculture, and therefore that its further development should be unambiguously opposed. It is not only the current corporate control of biotechnology and agricultural production that fosters such social and environmental problems, for genetic-industrial agriculture is inherently incompatible with the sustainability of agricultural ecosystems and the needs of small-scale farmers, particularly in the Third World. I will begin by outlining some of the characteristics of organic-traditional forms of agriculture, before discussing in more detail the chemical-industrial and genetic-industrial forms of agriculture.

1. Organic-Traditional Forms of Agriculture

Organic-traditional forms of agriculture have been practiced for thousands of years, and continue to be practiced today by millions of peasants in Third World countries, and to a greater or lesser degree by a small but growing number of organic farmers in First World countries. Organic-traditional farmers utilise a number of diverse and integrated strategies to achieve high yields, reduce insect and disease damage, maintain soil fertility, and minimize the need for commodified external inputs. These strategies include: the use of on-farm organic inputs; the breeding of indigenous plant varieties via the continuous replanting of seeds; and crop-rotation, complementary and 'polyculture' cropping methods. These ideally combine to ensure a high degree of self-sufficiency and independence for farmers, and permanently sustainable agro-ecosystems.

Agricultural ecosystems are constantly evolving, posing a challenge for the farmer to maintain an appropriate balance within the ecosystem. For this reason, food crops need to constantly co-evolve with, and adapt to, the local agro-ecosystem in order to develop and maintain their pest and disease resistance, and their general suitability to local environmental conditions such as soil quality, average and extreme temperatures, and water availability.² New plant varieties evolve through deliberate and accidental cross-breeding between different varieties of a crop species and through chance mutations within a plant. The seeds of the plants that survive well and produce the appropriate balance of desired characteristics are selected by farmers for replanting. Desirable characteristics include: high yields; taste; high resistance or tolerance to insects and diseases; multiple usages; and adaptation to local climatic conditions, such as low levels of rainfall (ie. periods of drought). Such inbred characteristics can only be created and maintained by the constant evolution of plant varieties in a particular region, and it is in this sense that organic-indigenous plant varieties can be said to be *dynamic*. In this way farmers maintain an optimal balance between high yields, inbred resistances and the plants' demands for nutrients and water.

Characteristics of Organic-Traditional Forms of Agriculture

Self-Sufficiency: Use of internal inputs that are drawn from on-the-farm, such as the use of compost and animal manure to renew soil fertility, and the replanting of seeds from previous crops. Subsistence farmers attempt to meet most of their own food and other needs. Many peasant communities as a whole also strive for self-sufficiency and independence through farmer co-operation and local forms of exchange.

Dynamic-Indigenous Seeds: The seeds of crops are selected and re-planted, and thus dynamically evolve with and adapt to local agro-ecosystems; in this sense these plants become indigenous to particular regions.

Indigenous Knowledge and Skills: Farmers develop knowledge and skills adapted to their local agro-ecosystems and indigenous seed varieties.

Diversity: There are many types of diversity that are practiced, such as the diversity of crops — and varieties within each crop — that are grown together (polyculture cropping); the diversity of strategies simultaneously applied to problems such as maintaining soil fertility and keeping insects in check; and the diversity of human needs that are met by this type of agriculture.

Integrated approach: The various parts of the agro-ecosystem — soil, plants, water, animals, insects — and the various farming strategies are all integrated in ways that maintain an appropriate agro-ecological balance and a high degree of self-sufficiency for farmers.

The great diversity of varieties within each crop that exist to this day is the result of the continuous replanting and cross-breeding of plant varieties by the world's peasant farmers and indigenous peoples over thousands of years. It is this very biodiversity that plant scientists and biotech corporations now plunder as raw material, genetically modify, and then patent and acquire exclusive rights over.

Organic-traditional farmers also enhance plant growth, maintain soil quality, and reduce vulnerability to insects and diseases by planting complementary crops together, and by planting many varieties of the same crop within their fields (known as *polyculture cropping*). Insects and diseases which damage one variety of a crop species may leave other varieties untouched, thereby minimizing harvest loss. The principle of *diversity* informs many of the strategies of organic-traditional agricultural systems, and is one of their inherent strengths.³

Through crop rotation and the use of compost and animal manure, farmers return nutrients to the soil and maintain soil quality. The planting of legumes, for example, provides nitrogen for the main cereal crops through nitrogen fixation. Crop rotations also keep insects in check by 'breaking the cycles through which pests achieve destructive population levels.'⁴ To the organic-traditional farmer, all insects are not necessarily 'pests' nor are all non-food plants 'weeds' to be eradicated, as is the case with techno-industrial approaches to agriculture. Both beneficial and destructive insects exist for plants in any agro-ecosystem, with the beneficial insects feeding on and keeping in check other more destructive insects. Insects also play a role in plant pollination, and are a food source in themselves in many communities. In organic agriculture, the aim is not to eliminate all insects but to ensure an appropriate balance. Similarly, many crops have complementary wild plants which assist their growth and with which they continually cross-breed, and which can assist in controlling pests by providing a habitat for beneficial insects.⁵ Crop diversification and rotation, and other organic methods, also reduce the problem of weeds, although much manual weeding is required on organic farms. At any rate, so-called 'weeds' are an important food source for many people.

Not only is organic-traditional agriculture environmentally sustainable, but it also isn't dependent upon expensive external inputs. This keeps the costs down for small farmers, allowing them to remain largely self-sufficient, and is particularly important in the Third World. In this way, it is also a *socially* sustainable form of agriculture, because it ensures the sustainability of livelihoods and the empowerment of local communities, and thrives on co-operation between farmers.⁶ For example, seed exchanges between farmers promote the cross-breeding and sharing of plant varieties with desirable characteristics.

There are various levels of self-sufficiency maintained by many organic farmers: from self-sufficiency in the basic farm inputs (seeds, manure, compost, etc) to the higher levels of self-sufficiency achieved in many Third World peasant communities whereby they are able to provide for most of their own food and other needs, and maintain a minimal dependence on external markets. On the other hand, First World organic farmers are more likely to be dependent on the supply of external inputs and on energy-intensive production methods, and to be integrated into external-export markets.

Organic-traditional farmers not only value the edible part of the crop, but also use the rest of the plant as fuel, animal feed, organic fertilizer, building and weaving material, etc. This is another example of the integrated character of organic farming systems, and illustrates the symbiotic relationship maintained between soil, water, animals and plants. It also highlights the inappropriateness of attempting to 'economically' quantify the productivity of organic-traditional farming methods on a one-dimensional scale — such as measuring capital returns or crop yields — since there is not one, but *many* diverse needs being met in their systems of production, and in this sense they produce multi-dimensional outcomes.⁷

Women in particular play an important part in organic and subsistence agriculture, as they are directly responsible for the majority of food production in many parts of the world today, particularly in Third World peasant communities. Women have also been responsible for much of the development and handing-down of knowledge and techniques of seed selection and growth, the renewal of soil fertility, and of local agro-ecological conditions. Their knowledge and separate spheres of influence

and responsibility in food production can also form the basis of their decision-making power and autonomy.⁸

A large number of the world's people still engage in small-scale, subsistence, organic farming. Any attempts to 'improve' the livelihood of these people through technical means must be set within their own terms if they are to truly benefit them. Organic agriculture is not, and has never been, a static body of knowledge and techniques. There are a number of new movements in contemporary organic agriculture which draw and build upon traditional farming practices, and develop them into comprehensive ways of understanding and manipulating agro-ecosystems, such as 'permaculture' and 'biodynamics.'⁹

Despite the claims of Western agribusiness developers, poverty and hunger in the Third World have never been the result of any imagined inferiority of organic forms of agriculture. Indeed, neither is widespread hunger (as opposed to episodes of famine) the result of food shortages in any part of the world today. Rather, poverty, malnutrition and hunger are the result of an inequitable social order which denies people sufficient land to cultivate, a fair price for their produce, or an adequate wage with which to purchase food. The introduction of techno-industrial agriculture has in fact contributed directly to the exacerbation of these problems in the Third World, and has progressively driven ever-more farmers from the land in the First World.

2. Techno-Industrial Forms of Agriculture

In contrast with organic-traditional approaches to agricultural production, techno-industrial forms of agriculture are capital-intensive, highly dependent on non-renewable external-inputs, and are characterised by a one-dimensional, commodified, fragmented, static, uniform, and toxic approach to agricultural ecosystems. (These terms are briefly defined on the opposite page.)

The first stage of techno-industrial agriculture — referred to here as *chemical-industrial agriculture* — involved the development of high-yielding/hybrid seeds and petro-chemical inputs. The introduction and spread of this input and capital intensive form of agriculture into the Third World, beginning in the 1940s, is commonly referred to as the ‘Green Revolution’. The second stage of techno-industrial agriculture — which I will refer to as *genetic-industrial agriculture* — involves the genetic engineering of seeds and agricultural inputs made possible by developments in biotechnology since the early 1970s. In both of these stages, the colonization and commodification of the seed — and of other parts of the agricultural system — has been the key to the expansion of techno-industrial agriculture, and the rise to dominance of transnational seed/chemical/biotechnology corporations.

Characteristics of Techno-Industrial Forms of Agriculture

Static Seeds: Seed varieties are *static* in the sense that they are bred in laboratories and field stations and sold each year to farmers, rather than being constantly replanted and allowed to evolve within the dynamic environment of the farm. These seeds are often ‘sterile’, and therefore non-replantable.

One-Dimensional Approach: The approach is one-dimensional in the sense that plants are typically bred to maximise one aspect of plant growth — such as crop yields — at the expense of its all-round durability and of other uses of the plant.¹⁰

Uniformity: Highly uniform seed varieties are supplied to farmers, then planted as monocultures, thus replacing the diversity of crop varieties that have been traditionally bred and inter-cropped by farmers. Chemical fertilizers and pesticides and irrigation systems are used to create the one, basic, uniform environment that these uniform seeds require to grow.¹¹

Toxic Approach: Insects, weeds, and diseases are typically controlled by applications of toxic chemical or genetically-engineered pesticides in a (futile) attempt to totally eliminate all pests.

Fragmented Approach: The various parts of the farming system are separated off from each other (eg. animals are treated as separate from crops),¹² and each ‘problem’ that is associated with plant growth is treated separately, usually involving a single, narrowly-focused strategy, in contrast with the diverse and integrated strategies of organic agriculture.

Commodification: The inputs and outputs of the agricultural system are commodified, creating a dependence on external supplies and markets. Inputs that are autonomously reproduced by organic-traditional farmers take the form of non-renewable, external inputs that are purchased from suppliers (seeds, fertilizers, pesticides, fuel, etc).¹³ Outputs are commodified in the sense that farms are primarily designed to generate cash in external-export markets, rather than for directly meeting local food and other needs.

3. Chemical-Industrial Agriculture: The Green Revolution

It wasn't until the early decades of this century, following the rediscovery of Gregor Mendel's laws of heredity, that plant breeders were able to accelerate the development of new crop varieties designed for particular situations or to enhance particular characteristics, while still subject to the biological constraints of traditional cross-breeding. The characteristics that have typically been bred for include: high crop yields; suitability for mechanical harvesting and transportation; and long shelf-life. As Cary Fowler and Pat Mooney note:

By carefully selecting for the desired characteristics, breeders could "weed out" unwanted traits and arrive at a "pure line", a variety that was uniform and reproduced this uniformity.¹⁴

In breeding narrowly to optimize particular characteristics, the new plant varieties often lack the breadth or longevity of resistance to insects and diseases, or traits such as cold or drought tolerance, and their nutritional value may be reduced. There is always a trade-off.

High-Yielding Plant Varieties (HYVs)

To return the so-called 'miracle' of a higher yield than traditional varieties, the new 'High-Yielding Varieties' of plants (HYVs) essentially *require* the application of chemical fertilizers and pesticides and large amounts of irrigation water. Without the addition of these inputs, the HYVs would perform even worse than traditional varieties, and be highly susceptible to pests. So, HYVs are not in and of themselves 'high yielding'. For this reason, it has been suggested that the term High Responsive Varieties (HRVs) replace the term 'high-yielding varieties', as they only respond well when planted in suitable soils, given plenty of water, and treated with petro-chemical inputs.¹⁵

In adopting a one-dimensional strategy of increasing the quantity of edible crop produced, not only the plant's durability but also other potential uses of the plant are diminished. The increase in the edible (and therefore marketable) part of the plant reduces the volume of the rest of the plant which can be re-used on the farm as fodder for animals and organic fertilizer for soils. Vandana Shiva argues that there is no 'neutral' or objective measure of 'yield', and that the claims of high yields and increased productivity of the Green Revolution are based on one-dimensional and reductionist notions of productivity. If the massive use of energy and resources required by these seeds, the various types of pollution they create, and the reductions in other types of outputs are all taken into account, the unambiguous 'productivity increases' claimed by advocates of these seeds and agricultural systems appear highly questionable.¹⁶

Uniformity

There are two types of plant uniformity promoted by chemical-industrial agriculture: uniformity across crop varieties and crops, and uniformity within crop varieties. First, mixed-cropping systems — whereby a mixture of different crops are inter-cropped and rotated — are replaced by the growing of a single variety of a single crop on a large scale. This is referred to as *monoculture* cropping. Secondly, the particular crop variety planted on a large scale is *itself* bred to be highly uniform. A 'pure line' is created by repeated in-breeding within a crop variety, so that the resultant seeds consistently produce crops of uniform size, colour, and ripening times. This is in contrast to the genetic variation and the variety of characteristics found within traditional plant varieties.¹⁷

Uniformity of size and ripening times are necessary for mechanical harvesting, while uniform colour and size are required by the food processing industry and are often preferred by consumers. However, the two types of plant uniformity noted above also increase the vulnerability of plants to

insect and disease damage. Insects and diseases are able to more easily sweep through entire fields and entire regions when encountering such uniform crop varieties in the field.¹⁸ Thus chemical pesticides become all the more necessary in the face of monoculture cropping.

The supplying of a small variety of uniform seeds by seed companies to farmers around the world inevitably replaces the diversity of countless varieties of each crop that had previously been bred in particular regions. A large percentage of traditional crop varieties have been lost in this way. The creation of uniformity and the destruction of diversity are one and the same process.¹⁹ Ironically for these industrial seed companies, the wiping out of the diversity of plant varieties reduces access to plant resources that are continually needed to breed new varieties, particularly as insects and diseases become resistant to the old varieties.

Chemical inputs and irrigation systems are used to create the one, basic, uniform environment that these uniform seeds require — an abstract environment that can be created almost anywhere, but is not adapted to any particular local environment. Indeed, it is intended to over-ride local agro-ecological conditions. However, unlike the diverse, stable, and sustainable environments of organic agriculture, these uniform environments are polluted and polluting, more vulnerable to pests, destructive to soils, and are input and capital-intensive.

Hybrid Seeds

Many of the Green Revolution's HYVs are hybrid seeds. 'Hybridization' does not simply refer to the cross-breeding of two different varieties of a crop (such crosses are also characteristic of traditional cross-breeding methods). Rather, it refers to the crossing of two different varieties which have each first been inbred to the point of being genetically uniform.²⁰ When these two different 'pure line' varieties are then crossed, the resultant seeds produce a significantly higher crop yield the first time they are planted. This is known as 'hybrid vigour'. However, when the seeds collected from the first generation of hybrid plants are re-planted, they produce significantly lower yields.²¹ The lower yields of the second generation thus render hybrid seeds biologically or 'economically' sterile and unviable for replanting, and therefore transform seeds from *renewable* into *non-renewable* resources.

This has two negative consequences for the farmer who uses hybrid seeds. First, the farmer must continually re-purchase new seeds for the following year's crop. This increases the capital costs of farming, and creates a strong dependence on the seed companies that supply these seeds and other necessary inputs. Secondly, as the seeds cannot be re-planted year after year, they are not able to co-evolve with, and adapt to, the dynamic conditions of local agro-ecosystems. They are therefore not likely to be suited to local soil and other climatic conditions, and will be more susceptible to new varieties of insects and diseases that evolve and which are able to overcome any in-built resistances the plants may have had. This then increases the need for ever greater quantities and new types of chemical inputs. Thus, these non-replantable seeds are *static* in the face of a dynamic ecosystem.

Here it should be pointed out that instead of breeding 'sterile' hybrid seeds, research institutes could breed 'open-pollinating' varieties with new characteristics. Farmers would still have to initially purchase these open-pollinating seeds, but they would then be able to replant the seeds year after year and thus allow them to adapt to the local agro-ecosystem. For obvious financial and proprietary reasons, seed-chemical corporations and complicit government research institutes have pursued hybrid seed development.

Chemical Fertilizers and Pesticides

Chemical fertilisers provide for the increased energy demands of the high-yielding and hybrid seeds. Most of the growth in crop yields is attributed to the use of massive amounts of chemical fertilizers, rather than being just due to some neutral 'superiority' of the new seeds. Chemical fertilisers substitute for organic methods of returning nutrients to the soil such as crop-rotation, compost and animal manure, and they have created lifeless and dusty soils that are much more prone to soil erosion.

Chemical-industrial agriculture uses chemical pesticides to control insects, weeds and diseases, thus replacing the integrated-organic approach to pest management with a fragmented, one-dimensional *toxic* approach. The new plant varieties require large doses of insecticide to survive in part because they lack the in-built insect-resistance of traditional varieties nurtured by continual replanting of the seeds, and also because they are planted as monocultures. Insecticides not only kill ‘harmful’ insects, but also kill the ‘beneficial’ insects (ie. their predators), and poison other animals in the agro-ecosystem. After the insecticides have wiped out most of the insects in the local area, the numbers of harmful insects increase due to a lack of predators, and so the prior balance is disrupted. These pests continue to evolve, and through the process of natural selection build up resistances to chemical pesticides. As a result, yesterday’s pests are becoming today’s *super-pests* that can withstand large doses of pesticides, are sometimes cross-resistant to five or more pesticides, and are less likely to be troubled by predators. New types of pesticides must therefore be constantly developed to replace the old ones in order to stay one step ahead of the insects. It can take only a few years for insects to evolve an inbred resistance to a particular pesticide. The end result of all this is an even more serious pest problem than before, and farmers are then caught in a chemical treadmill from which it is difficult to escape.

Like insects, diseases (in the form of fungi, bacteria, or viruses) are also constantly evolving. Once again, when the plant is not evolving within the dynamic environment of an agro-ecosystem and is planted as a monoculture, it is more susceptible to new strains of diseases that evolve. As in the case of insects, diseases also become resistant to the pesticides used to control them, thus again creating the need for greater quantities and new types of chemical inputs. The new ‘pure line’ and hybridized seeds also tend to be more susceptible to diseases because of their weakened resistance.

Whereas traditional crop varieties grow with companion or complementary plants, the new ‘pure lines’ and hybrids are unable to co-exist with other plants in this way. Thus all surrounding plants are re-defined as weeds to be eradicated through the use of herbicides. Furthermore, the chemical fertilisers used to accelerate crop growth also promote weed growth, thereby creating a further need for herbicides. As the weeds themselves evolve a resistance to these herbicides through natural selection, greater doses of the herbicides are constantly required to keep them in check, and eventually new types need to be developed. The use of herbicides such as 2,4-D may render crops more susceptible to insect infestation and disease.²² Herbicides also kill off the ‘weeds’ and wild plants in farmers’ fields that are an important source of food and medicinal herbs for many of the world’s people.

Irrigation

Hybrid and HYV seeds also require large amounts of water to take up large doses of fertilizers and to produce high yields. This necessitates the construction of irrigation systems and dams. The Third World experience has been that large dams and irrigation projects mainly service a minority of rich farmers and regions, and disrupt the natural watersheds which service poor farmers. To build these dams, fertile soils in river valleys may be flooded and lost for future use, dislocating millions of people from their land and therefore creating social and environmental problems elsewhere. These water systems also intensify pest problems, as insects breed in irrigation waters and dams. Excessive irrigation contributes to the problem of salinization, whereby the ground water rises and brings salt to the soil’s surface. Conversely, growing demand for water can lead to the drying up of ground water, which is another way in which land is rendered marginal or unusable.

Soil Degradation

The impact of chemical-industrial agriculture on the land has been devastating, particularly in the form of soil nutrient depletion and soil erosion. The combination of artificial fertilizers, chemical pesticides, and monoculture cropping systems has undermined the natural fertility of the soils, and killed what were once living soil ecosystems. The soil’s structure is broken down and is increasingly vulnerable to

soil erosion. The use of heavy machinery has created the problem of soil compaction, which reduces the soil's ability to absorb water. The water runs off the soil and thus contributes to soil erosion. Compacted soils also reduce crop yields.²³

Soil erosion has become a major global problem, with some 24 billion tonnes of soil eroded from the world's agricultural lands each year, thus destroying about eight million hectares of farmland. It has now been estimated that the world has lost nearly one third of its arable land over the past 40 years due to chemical-industrial crop production, the over-grazing of cattle and sheep, and deforestation and vegetation clearance.²⁴

Agro-Chemical Poisoning

The health and other environmental consequences of chemical-intensive agriculture are now well recognised. Not only are local ecosystems degraded, but the soils and waterways upon which people depend for their livelihood are being poisoned. This has serious consequences for the entire food chain.

Chemical residues in food have been linked to the increased incidence of many types of cancer. Such health problems are particularly acute amongst farm workers, who are more directly exposed to the agro-chemicals. Over 40,000 Third World farm workers are killed each year, and up to one million made ill or permanently injured, due to overexposure or mishandling of agro-chemicals.²⁵ The farmers often have little understanding of the lethal nature of these chemicals either because they are not educated about their use, or they are not labelled in their own language, or else because they may not have access to or be able to afford the appropriate safety equipment. Further, chemicals banned in First World countries are commonly dumped on markets in Third World countries where there are less stringent regulations.

Squeezing-Out the Small Producer

Chemical-industrial agriculture undermines the independence and relative self-sufficiency of small farmers and communities. The need to purchase seeds, chemical inputs, irrigation systems, machinery and fuel, greatly increases the costs involved in running a farm, and creates a technological and economic dependence upon the companies that supply them.

While the capital costs continue to escalate, the prices paid for primary produce have been declining due to over-supply and the monopoly control of markets by transnational corporations. These trends combine to wipe-out profit margins, and favour only large scale farms that rely on massive economies of scale and a dependence on labour-saving chemical inputs and machinery, or else farms that pay next-to-nothing wages to their labourers. As the authors of *Whose Common Future?* put it:

With the control of markets firmly in their hands, multinational corporations and state-controlled enterprises have driven down farm prices while driving up the cost of the inputs on which farmers are increasingly dependent. The result is a cost-price squeeze that sends many farmers spiralling into debt, and eventually into bankruptcy.²⁶

The dumping of huge food surpluses on world markets by large, government-subsidised, First World farms makes it difficult for small-scale Third World farmers to demand a reasonable price for their produce.

In the First World, such policies continually squeeze many farmers from the land. The cost-price squeeze these farmers face, and the debts they have invariably accumulated, means that even those farmers that manage to survive have little breathing space or time in which to experiment with shifting to organic or less environmentally destructive farming practices. The onset of drought or some natural calamity can then be enough to send these farmers into bankruptcy. The concentration of land ownership continues to increase as the mega-farms buy out the bankrupt farmers. Large farms also take the great bulk of government subsidies offered to farmers.

Another way in which farmers are losing their independence is through the increasingly common practice of 'contract farming', whereby they are contracted to sell their produce exclusively to one retailing company. The corporations that hold the contracts are able to specify in advance precisely how and when their produce will be grown, including the brands of seeds and chemicals that must be used. Farmers thus become just another cog in the agro-industrial machine.

It is in the Third World, however, that the impact of chemical-industrial agriculture — in the form of the 'Green Revolution' — has been most devastating. Peasant farmers encouraged to take out loans to purchase the seeds, inputs, and irrigation systems, are drawn further into the cash economy. They are often coerced into using the new hybrid seed varieties by making their use a pre-condition for loans or government assistance programs. Third World farmers are less able to afford all the parts of the techno-industrial agricultural system, such as irrigation technology, and this further increases their vulnerability. Just one crop failure, or even just a low yield, can mean that farmers may be unable to meet their loan repayments and will have their land taken from them, which is most likely their primary or only source of food, income, shelter and security. The increased ecological vulnerability of the new crop varieties makes such crop failures all the more likely. A sudden drop in market prices for their produce can have a similar impact on their livelihoods. Even if peasants manage to retain ownership of their land, the need to repay debts can mean that they are forced to sell the food they produce whilst their families go without adequate nourishment. Apart from its impact on individual households and communities, the Green Revolution has also left many Third World nations with massive foreign debts, and heavily dependent on the import of expensive chemical inputs and machinery. In these ways, the Green Revolution has directly contributed to the spiralling problems of landlessness, malnutrition, unemployment and poverty in the Third World.

The new high-yielding seeds and their complementary chemical inputs initially increased the total output of food production around the world on a yield per acre basis. However, these techno-industrial agricultural methods have degraded and depleted the soils and created more ecologically vulnerable crops. Such high yields are therefore not sustainable in the long term, and overall global food output can be expected to decline as more land is rendered unusable by these destructive agro-industrial practices.

The increase in agricultural output has contributed to lower prices paid to farmers for primary produce. The lower cost of produce may be beneficial to many consumers, but only those with money to buy that produce. Third World peasants who have lost their land have little money to spend on food. Instead, one third of the world's grain is now purchased by meat producers to feed grain-fed cattle and other livestock, and which ends up on the dinner plates of the already over-fed, but is way out of the reach of the poor. This represents a gross wastage of food, as it takes something like 16 kilograms of grain to produce one kilogram of beef, and this 16kg of grain provides about 20 times more calories and 8 times more protein than the one kilogram of meat if it is eaten directly.²⁷ At the same time, forests are continually being cleared, and millions of peasants in Third World countries are being forced from their lands, in order to provide grazing lands for the First World's ever growing demand for meat. According to Jeremy Rifkin, 'a quarter of the earth's landmass is used as pasture for cattle and other livestock.'²⁸ Two-thirds of the agriculturally productive land in Central America is devoted to livestock production, yet most of this meat is exported to the U.S.A., and to a lesser extent consumed by the wealthy classes in Central America.

There is an associated problem in the fact that a large proportion of arable land in Third World countries is now being used to grow cash-crops. Cash-crops are crops that produce commodities to be sold on the market, such as coffee, sugar, cotton or rubber, and are usually exported to First World countries. Cash-crop production displaces the production of food for the local population. Africa, for example, needs to import food to feed its people in part because such a large proportion of its arable land is used to grow cash-crops that are exported to the First World.²⁹ Cash-crops are commonly grown to generate income to pay off household and national debts, but these commodities are grossly under-priced and their market-value continues to decline. As Vandana Shiva notes: 'not only do cash

crops produce no food [for the local population], they do not even produce much cash either over time.³⁰

The export-market orientation of the Green Revolution has also shifted production of food crops towards higher yielding and more globally marketable crops such as wheat and rice. This is at the expense of other crops such as legumes, which are an important source of protein for Third World people.³¹

Chemical inputs and machinery — both dependent on fossil fuel energy — increasingly substitute for human energy. The number of people working on farms in First World countries has declined dramatically since the Second World War. The consequences of industrial agriculture on employment are more severely felt in the Third World, where machinery and chemical inputs have created serious unemployment and pushed down wage levels, and where there are few other employment opportunities for out of work farm labourers and dispossessed peasants.

The shift from organic and subsistence agriculture to capital and chemical intensive, market and cash-crop oriented agriculture has also undermined women's traditional roles in food production in many Third World countries. Women's knowledge of and skills in seed selection and growth and maintaining soil fertility are undermined and devalued by the introduction of the new chemical inputs and hybrid seeds. As men are forced to take on wage labour outside of the home to supplement the declining farm income and to pay for the external inputs that have been purchased, an even greater burden of household and agricultural chores is taken on by women. Cash crop production tends to fall under male control, and men are more likely to have access to credit. As men come to assume control of the finances of the household, women's domains and spheres of influence and autonomy are encroached upon, devalued and restricted.³² For many women, this kind of 'development' and 'modernisation' can lead to forms of domination and exploitation that are 'more intense, extreme and absolute than any form of patriarchy before.'³³

The uniform seeds and environments of techno-industrial agriculture not only create biological uniformity, but also cultural uniformity — human monocultures — in that they involve the application of standard products supplied by global corporations, and the integration of farmers and communities into the world market and techno-industrial grid, thereby undermining local knowledge, skills and independence, and eroding the differences between farming communities.

Techno-industrial agriculture favours the expansion of large-scale, mechanized, monocultural, chemical and capital-intensive farms, and the transnational corporations that supply the seed-chemical packages. It therefore undermines the viability of small-scale, organic, mixed-cropping, labour intensive, and environmentally sustainable farming systems. The Green Revolution has allowed transnational agricultural corporations to extend and further centralize their control of the entire industrial food chain — from the supply of seed-chemical packages and the purchase of cheap primary produce, to adding value to the food in processing, and its retailing in supermarket chains. This is ultimately the driving force behind the spread of monocultural-chemical-industrial agriculture. As Vandana Shiva observes:

Monocultures spread not because they produce more, but because they control more. The expansion of monocultures has more to do with politics and power than with enriching and enhancing systems of biological production. This is as true of the Green Revolution as it is of the gene revolution or the new biotechnologies.³⁴

4. Genetic-Industrial Agriculture: The Gene Revolution

Proponents of genetic engineering are now acknowledging some of the ecological problems associated with chemical-industrial agriculture, but only for the purposes of attributing the causes of these problems to the supposed inadequacy and under-developed nature of the scientific techniques that had been available up until the 1970s. Genetic engineering is now to be celebrated as a *more precise* way of controlling and manipulating living organisms and ecosystems. It has the potential, proponents argue, to rectify these earlier problems with its improved techniques, and indeed to offer an 'improved' version of nature itself — a version that will in fact more readily fit the needs of biotechnology and agribusiness corporations, large-scale industrial farms, and the food-processing industry.

There is apparently no end to the number of desirable characteristics that biotechnologists will be able to engineer a plant to possess: insect and disease resistance, higher yields, accelerated plant growth, adaptability of a plant to a variety of growing conditions, longer shelf-life, etc, etc. This list of possible applications that are consistently advertised to the public make it a seemingly irresistible techno-scientific intervention into the micro-structures of living organisms. A general public that is unaware of the social and ecological consequences of the Green Revolution, the dynamics of contemporary industrial agriculture, and the social forces that are shaping the development and application of the new agricultural biotechnologies, may find it difficult, however, to see beyond the seductive arguments of the biotechnology industry and its supporters.

Continuities and Discontinuities

As noted earlier, genetic-industrial agriculture is characterised by both *continuities* and *discontinuities* with the chemical-industrial approach of Green Revolution agriculture. It is continuous with it to the extent that they both share the static, one-dimensional, commodified, fragmented, uniform, toxic, and capital and input-intensive approach to agriculture discussed earlier. Genetic-industrial agriculture will continue, and indeed extend, the techno-industrialization of agricultural production, including the practice of monoculture cropping, the replacement of diverse plant varieties with static laboratory-bred varieties, and the use of toxic inputs. Genetic engineering will also enable the destructive practices of techno-industrial agriculture to continue where they may otherwise have reached their limits by creating plants that can tolerate greater quantities of chemical inputs or that are adapted to the soils degraded by techno-industrial agricultural practices. For these reasons, the new genetically engineered seeds and inputs will perpetuate and intensify the environmental problems and concentrations of power and wealth produced by chemical-industrial agriculture. Indeed it is the very same corporations that have developed and continue to sell chemical products and hybrid seeds that are now developing and commercializing the products of genetic engineering.

Despite these continuities, the new biotechnologies differ significantly in the *mode* in which they take a hold of nature and reconstitute it in new forms, since they now engage with organisms at the level of the cell or sub-cell. In being able to tamper *directly* with the genetic structure of organisms, and to transfer genes *across* species boundaries, genetic engineering creates new kinds of environmental dangers as well as the possibility of new forms of social control.

It is important to note here that in introducing the term 'genetic-industrial agriculture', I do not mean to imply that this new stage in industrial agriculture involves the complete replacement of

chemical inputs with genetically engineered inputs. On the contrary, genetic-industrial agriculture incorporates both chemical and genetically engineered products, and will most likely involve an *increase* in the volume of toxic chemicals already in use.

A New Form of Plant Breeding

The new biotechnologies consist of genetic engineering techniques derived from recent developments in molecular biology, biochemistry and genetics, but also include new cellular procedures based on the older technologies of tissue culture, fermentation and mass propagation.³⁵

Genetic engineering now enables scientists to *directly* tamper with a plant's genetic structure by attempting to code particular gene sequences to be active or inactive (ie. switching them 'on' or 'off'), or by transferring genetic material directly from one organism to another, thus bypassing sexual reproduction as a necessary aspect of plant breeding.³⁶ The new biotechnologies potentially allow *any* gene or gene sequence from *any* organism to be moved to another organism, to create a new 'transgenic' organism. This means that not only can species boundaries between plant varieties now be crossed, but also the crossing of boundaries between plants and other living organisms is possible — that is, even genes from pigs, fish, insects, bacteria or humans can be inserted into a plant's genetic structure, and vice versa. For example, scientists have inserted genes from a flounder into tomatoes in an attempt to increase their resistance to cold weather.

This is entirely different from all previous breeding methods. Both traditional cross-breeding methods and the accelerated cross-breeding programs of the Green Revolution are bound by the *constraint* of only being able to cross-breed closely related varieties of crops. Conventional plant breeding operates at the level of the whole organism, and relies upon sexual reproduction for breeding. This means that, until now, plant scientists would gradually breed towards the genetic characteristics they required, but without direct control over other genetic characteristics that are also altered during cross-breeding. By transcending these ecological constraints, the new biotechnologies now make possible both the further acceleration of earlier techno-scientific plant breeding programs, as well as completely new kinds of plant breeding.

The new kinds of environmental risks that are posed by genetic engineering are discussed by Jane Rissler and Margaret Mellon of the Union of Concerned Scientists in *Perils Amidst the Promise*:

First, since genetic engineering can draw on an enormous pool of genes, it can add more genes with harmful potential than can traditional breeding. Ecological risk depends on complex and difficult-to-predict interactions between new genes, crops and their environment. In general, the greater the variety of genes that can be added, the greater the likelihood of something going awry.

Second, we have some reason to believe that organisms containing these new gene combinations may be less predictable in their traits and behaviors than those produced by traditional breeding. Traditional breeding tends to replace one version of a gene for another, resulting in the modulation of existing traits that have coexisted for long periods of time. Genetic engineering, by contrast, often adds a completely new gene. These new genes may not be subject to the same mutual constraints as the genes that have evolved as a group. Without the same constraints, the new genes may enable a wider variety of behaviors and characteristics in the resultant plants.

Third, many of the transgenes that are being moved into crops control traits that are ecologically advantageous to plants. Traits such as resistance to disease, cold, or herbicides would enable plants to overcome obvious limits on population growth. Moreover, because, for the present, the new traits are determined by one or two genes, they can be readily transmitted to wild populations.

Finally, the combinations of genes from biologically unrelated sources is genuinely new on earth. Such combinations are not found in either nature or in traditionally bred organisms, which may contain new genes but only from related organisms. We simply have no experience with the use and behavior of organisms with the novel genetic makeups of transgenics.³⁷

This description of the novel character of genetic engineering techniques runs counter to those who argue that it involves simply a continuation of traditional plant breeding methods. The kinds of environmental threats discussed above are attributable to any and all releases of genetically engineered products, regardless of the specific application. The corporate control of genetic engineering further

heightens these concerns due to the kinds of research that are being pursued for the purposes of increasing the profits and the power of these corporations.

Some Specific Applications

What follows are some specific applications of genetic engineering in agriculture currently being researched, and which highlight both the current biases in research and development as well as some of the inherent dangers and consequences of genetic-industrial agriculture.

i) Herbicide-Tolerance

The most common area of research and field-testing is in the development of *herbicide-tolerant crops*, which are aimed at better adapting crops to chemical forms of weed management. Herbicide-tolerant crops are engineered to tolerate contact with types of herbicides or dosages of herbicides that would previously have damaged the crop itself. Crops can now be engineered to enable a wider range of herbicides to be applied in higher dosages, on a wider range of crops, and in a wider range of situations (for example, both before and after the plants emerge from the ground).

In particular situations, herbicide-tolerant crops could, proponents claim, initially reduce the number of herbicide applications already being applied by making possible different weed management strategies, and they may enable the switch to supposedly less environmentally harmful, 'broad spectrum' herbicides. But on the whole, they will most likely further entrench and possibly expand the use and dependence upon chemical herbicides. Herbicide-tolerant crops will enable the more indiscriminate use of herbicides in a wider range of situations, including an expansion of aerial spraying practices.

As weeds continue to evolve resistance to herbicides, herbicide-tolerant crops become necessary to achieve effective weed-kills by allowing increases in the quantity and frequency of applications, or the switch to other types of herbicides. Crops need to be made tolerant to herbicides not only for direct spraying to control weeds, but also to protect them from spray-drift from neighbouring fields or from herbicide residues in the soil from previous crops. For example, the CSIRO is field trialling cotton which tolerates high doses of the herbicide 2,4-D to protect it from the spray-drift from 2,4-D applied to wheat crops.

Seed-chemical companies can also genetically engineer crops to tolerate their own particular brand of herbicides, and to thereby require farmers to purchase these companies' seed-herbicide packages. A prime example here is Monsanto's 'Roundup Ready' soybeans, which have been engineered to tolerate contact with their own herbicide Roundup, whereas non-modified soybeans cannot. When Monsanto's patent on Roundup runs out in the year 2000 — thus allowing other companies to sell similar glyphosate-based herbicides — Monsanto will maintain their market dominance by requiring farmers to sign contracts stipulating that only Roundup can be applied to their own herbicide-tolerant seeds. The contracts also prohibit farmers from saving seeds for replanting the following season. These herbicide-tolerant (and therefore herbicide-drenched) soybeans are the first genetically engineered wholefood to be sold in Australia, which is significant given that soybeans are used as additives in around 60% of all processed food products.³⁸

ii) Bio-Pesticides

Another common area of research is in the genetic engineering of crops that produce their own insecticides, which I will refer to as 'genetic pesticides'. The naturally occurring *Bt* (*Bacillus thuringiensis*) group of microorganisms found in soils produce crystals that are highly toxic to some types of insects. Sprays and dried mixtures of fermented live *Bt* formulations have been used by farmers, particularly organic farmers, as a relatively environmentally benign insecticide for several decades. Now, however, genes from *Bt* microorganisms are being inserted directly into crops so that they will express these *Bt* toxins continuously through the leaves and stems of the plant. These *Bt*

crops — or genetic pesticide crop — are intended to replace the use of some chemical pesticides in particular situations. Yet these genetic pesticides can be understood as further entrenching the toxic approach to pest control by engineering this approach directly into the plant's genetic structure, such that they produce their own insecticides from within. Like synthetic chemical pesticides, genetic pesticide crops will exert strong selection pressure on insects to evolve resistance to these toxins within a few years, particularly given the massive increase in *Bt* toxins being released into agroecosystems. When this occurs, chemical-industrial farmers will simply increase their use of chemical pesticides as before, whereas organic farmers will have lost the use of their *Bt* sprays.

Another concern is that the ecological and health consequences of the massive expansion and proliferation of live *Bt* toxins in the environment are unknown. The *Bt* toxins expressed by *Bt* crops have also had their toxicity and mode of operation altered, which may result in them remaining toxic for longer in the soil and in harming a wider range of insects and soil organisms, including beneficial insects that may feed on the target pests.

Bt crops will simply be used to add another toxic weapon to the tool-kit of the chemical-industrial farmer, rather than posing any challenge or offering a genuine alternative to this mode of farming. The toxic approach to pest control — which involves attempting to kill all insects with insecticides — is necessary in the context of large-scale, monoculture farming, since such crop uniformity creates ideal conditions for crop pests to multiply. This is in contrast to organic approaches, which utilise mixed or polyculture cropping methods to create the conditions in which a balance is maintained between the destructive pests and the benign insects which feed on them, and which prevent the build-up of destructive pests.³⁹

iii) Virus Resistance

Scientists are also working on genetically engineering plants to be resistant to pathogens such as fungi, bacteria and viruses, with the main area of research and the greatest progress so far being in the development of virus resistant crops. Conventional farmers currently use chemical pesticides to kill the insects, worms or fungi which act as the vectors through which viruses infect a crop. The development of virus resistant transgenic crops potentially allows for a reduction in pesticides used to control the spread of viruses.

The primary technique being used to develop virus resistance is by inserting genes from the virus into the plant, which through some unknown mechanism confers protection against viral infection.⁴⁰ There is growing evidence and concern, however, that these virus genes in the plants could lead to the creation of new and more serious diseases, or the possibility of increased disease severity in crops. Some scientists have shown that these viral fragments can recombine with naturally-occurring viruses, and in some cases this could lead to new viruses that infect a wider range of hosts or to strains that more systematically infect the plant.⁴¹ Such recombinations could also turn previously mild viruses into more severe strains.⁴²

iv) Designer Crops

While the above examples — and most research and commercialisation of genetically engineered crops — are aimed at modifying plant growth and methods of crop production, some research is also aimed at altering the end-product characteristics of some food crops. The primary thrust of this area of research is to better adapt crops to the demands of longer-distance transportation and a longer shelf-life, in order to meet the particular needs of food processors, and to create some designer products for niche consumer markets.⁴³

Food products being engineered for longer distance transportation and a longer shelf-life include tomatoes, pineapples and bananas.⁴⁴ The aim is to delay the ripening and rotting of fruit and vegetables, thereby improving its appearance, and allowing it to be transported over longer distances to food processing plants or to sit on supermarket shelves for longer, whilst still appearing new and fresh.⁴⁵ In doing so, such transgenic food products over-come some of the existing limits to the further

industrialisation and globalisation of food distribution and processing. Crops being engineered for processing traits include Monsanto's high-solid tomatoes, which are designed to contain less water to aid in the industrial production of tomato paste and sauces.⁴⁶ Monsanto is also developing a high-solid potato that would absorb less oil and reduce cooking time, and thus lower costs to food processors. Similarly, potatoes that do not turn brown after being cut are also being developed to meet the needs of the potato chip industry. The company DNA Plant Technology has added genes to strawberries in an attempt to control their texture when frozen.⁴⁷

v) Crop Substitution

The use of the new techniques of cell and tissue culture may in the near future enable food substances such as starch, proteins, and fats to be 'grown' in fermentation tanks in factory-like conditions. This would replace the need for some agricultural crops — such as vanilla, sugar, or oil-seeds — to be grown at current production levels. Amongst other concerns, this substitution of traditional food crops with factory-produced 'foods', or with other genetically modified crops that better suit the requirements of the food processing industry, would be disastrous for Third World farmers and nations dependent on income from these cash-crops.⁴⁸

General Problems with Genetic-Industrial Agriculture

Overall, there are a number of problems with any application of genetic engineering to agriculture, particularly given the corporate control of contemporary agriculture and the interests which the new biotechnologies will be used to serve.

i) New Biological Imbalances

Genes and gene sequences often perform a number of functions other than those which genetic engineers are currently aware of and seek to utilise. Given the far from comprehensive knowledge of plant genetics at present, there is a great level of uncertainty as to what other aspects of plant growth may be affected when the genetic structure of a plant is manipulated directly. If the plant's in-built ability to perform other functions is undermined, such as its resistance to pests, the need will arise for further chemical or genetic inputs to compensate for new biological or ecological imbalances. The lesson from the Green Revolution is that you do not get something for nothing, and despite the promise of miracles, it will be no different for genetically engineered plants. The pressure to quickly commercialise new genetically engineered organisms also heightens the inherent risks associated with this form of plant breeding.

Altering the genetic structure of food crops may also pose dangers to human health: a big question-mark hangs over what the consequences of ingesting these novel foods might be. These may include: undermining the health-giving qualities of foods by reducing their nutritional value or their disease fighting properties; the possibility of acquiring the food's genetically engineered attributes, such as antibiotic resistance; or other more directly and immediately harmful reactions.⁴⁹

ii) Genetic Pollution

The new traits of genetically engineered plants may give them such an environmental advantage that these plants could themselves become 'weeds' in agricultural ecosystems. At the same time, the modified genes of genetically engineered plants can, and will inevitably, be transferred to surrounding wild and domesticated plants, thus conferring to them this environmental advantage. Similarly, the release of other genetic engineered living organisms, such as bacteria, will have an unpredictable impact on ecosystems that goes beyond just the specific locations in which they are introduced. In spreading their new genetic traits into the environment, genetically engineered organisms thus introduce a new form of industrial pollution into the world: *genetic pollution*.

Jeremy Rifkin, an activist in the U.S.A., notes that one of the main differences between petrochemical products and genetically engineered products is that the latter are *alive*, and this creates a new type of environmental threat:

Because they are alive, genetically engineered products are inherently more unpredictable than petrochemicals in the way they interact with other living things in the environment. Consequently, it is much more difficult to assess all of the potential impacts that a biotechnical product might have on the earth's ecosystems. Genetically engineered products also reproduce. They grow and they migrate. Unlike petrochemical products, it is impossible to constrain them within a given geographical locale. Finally, once released, it is virtually impossible to recall living products back to the laboratory, especially those products that are microscopic in nature. For all these reasons, genetically engineered products pose far greater long-term potential risks to the environment than petro-chemical substances.⁵⁰

We cannot know the full extent of ecological disruption and genetic pollution that releases of genetically engineered organisms will create, but this in itself is more than enough reason to oppose their release.

iii) Eroding Biodiversity and Creating Higher Levels of Uniformity

As with the seeds of the Green Revolution, genetic-industrial seeds will reduce the already diminished diversity of plant varieties that still exist. A small number of laboratory-designed varieties of plants will continue to replace the many indigenous varieties continuously evolving in particular regions. A reduction in such biodiversity not only increases the vulnerability of farmers' crops to complete devastation, but also increases the farmer's dependence on patented seeds owned by seed/biotech corporations.

The new biotechnologies also make possible tissue culture techniques whereby millions of identical copies of a particular seed variety may be reproduced, thus taking the relatively 'imperfect' copies of earlier seed multiplication techniques onto a higher level of uniformity.⁵¹

While the hybrid seeds of the Green Revolution reduced the diversity of varieties *within* particular species of plants, genetic engineering now also reduces the diversity *between* species with the transfer of genes across all species boundaries. This can only take the environmental and social problems created by the earlier type of uniformity onto a new and more dangerous level.⁵² It also means that, in practice, we will no longer recognise or respect distinctions between species; that is, we will no longer encounter any living species as distinct and as given. Every living thing, and the parts which make it up, become interchangeable with every other. That which is seen to be common to all life-forms — DNA — becomes the mechanism through which all differences between life-forms are erased.

One consequence of this erosion of species boundaries will be that we will hardly know any more what it is that we're eating. What looks, feels, smells, and even tastes like an apple may also contain genes from a capsicum or a pig or a human, or all of the above. But what if all you really wanted to eat was an apple?

iv) Maintaining and Extending Unsustainable Practices

Genetic engineering will be used to temporarily overcome some of the limitations of — and problems created by — chemical-industrial agriculture, whilst at the same time allowing such destructive practices to continue, and indeed to be extended. While the geographical areas in which the high-yielding and hybrid seeds of the Green Revolution could be planted were to some extent limited to the best available land and soils, the new biotechnologies will make possible the development of seeds able to grow on poorer land as well.⁵³ Plants could be engineered to tolerate the degraded and salinized soils resulting from chemical-intensive, monoculture farming, thus allowing the continuation of these industrial practices. More generally, any genetically engineered acceleration in the rate of plant growth will only accelerate the current rate of soil degradation and erosion. The range of crops which could be bred for high-yields or hybridized will also be greatly expanded. The development of herbicide-

tolerant plants discussed earlier is an example of attempts to create plants that can cope with greater levels of toxic chemicals. Genetic engineering also allows for the accelerated development of new varieties of chemical and biological pesticides that are needed to keep one step ahead of the insects and diseases that evolve resistances to them. All of these developments will allow agribusiness corporations to increase the volume of sales of their products, and to extend their control over farmers. Farmers who are caught in the industrial treadmill will be forced to adopt any new product or technique that increases their crop yields — regardless of the environmental consequences or of their deepening enslavement to agribusiness corporations — or else face the prospect of being priced out of the market and into bankruptcy.

v) The Total Colonization and Commodification of the Seed

Farmers will not be able to *replant* these new genetically engineered seeds for two reasons: the first biological, the second legal. First, these new seeds may have a diminished biological ability to reproduce themselves like the hybrids of the Green Revolution. Genetic engineering now makes possible the hybridization of common food crops that had proven too difficult or too costly to hybridize using the earlier techno-scientific plant breeding methods.⁵⁴ It will also allow for the deliberate engineering of biological sterility into the seed, regardless of whether or not they are hybrids. A new seed sterilisation technique, known as the ‘Terminator’, has now been patented by the U.S. Department of Agriculture and an American cotton seed company, and they have indicated that the primary targets for the Terminator technology are crops such as rice, wheat, sorghum and soybeans — all significant crops in Third World countries.⁵⁵ With genetic engineering, the logic of ‘planned obsolescence’ will now be able to be engineered directly into the seed’s DNA.

Secondly, even if the seeds *were* able to reproduce themselves, farmers will be *legally prohibited* from replanting patented seeds, or will have to pay a royalty to do so, thanks to the new Plant Breeders’ Rights regulations coming into force worldwide. Many seeds have already been patented, as will all new genetically modified varieties. Meanwhile, seed/biotech corporations have been buying out or taking control of the world’s seed banks in order to reduce the availability of unpatented seeds or non-hybrid varieties. Not only plant varieties, but now also the genetic codes of whole plants or of particular genetic characteristics can now be patented and ‘owned’ by corporations. The Plant Breeders’ Rights regulations prevent farmers from re-planting seeds that have been patented, and will ensure that the farmers re-purchase their seeds every year. To enforce these regulations, new DNA ‘finger-printing’ techniques can be used to identify the variety of crops growing in any farmer’s fields.

The double-standards implicit in Plant Breeders’ Rights and intellectual property rights regulations are glaringly obvious. Biotech corporations will be permitted to continue to freely appropriate and utilise the countless unpatented seeds that have been developed by the world’s indigenous farmers, and without any form of compensation. By then modifying even one gene of these plant varieties, they are able to patent the seed and its genetic structure, thus preventing others from freely using the new seeds. These new patenting laws are clearly designed to transfer the ownership and control of the world’s diversity of genetic resources — most of which has been developed and maintained by farmers in the Third World — into the hands of First World corporations.

Under these scenarios, farmers will become forever dependent on seed corporations, and will have to purchase the complementary inputs that each particular seed is engineered to require. Farmers will therefore be less able to breed plants to adapt to and co-evolve with their local agro-ecosystem. As with Green Revolution seeds, the seeds of genetic-industrial agriculture will be ‘static’ in the face of dynamic ecosystems. As insects and diseases evolve resistances to these non-renewable seeds (as well as to the pesticides used to control them), new plant varieties (and pesticides) will need to be continually developed. This will become more and more difficult as the diversity of indigenous varieties — which provide the sources of new genetic characteristics — is rapidly diminished.

The age-old cycle of the *production* and *reproduction* of the seed will be further broken. Vandana Shiva argues that ‘seed that reproduces itself stays free, a common resource and under the farmers’

control.⁵⁶ But the biotechnological *invasion into and control of the seed* — or *colonization of the seed* — transforms a *self-generative* resource into a mere *input*, and transforms a common and shared resource into a commodity. Shiva suggests that the commodified seed is crippled in two ways:

- (i) It cannot *reproduce* itself, as it is rendered impotent to do so; and
- (ii) It cannot *produce* itself, as it requires the application of manufactured inputs in order to survive and grow.

The combination of the manipulative power of genetic engineering and the new patenting laws thus represents the *total colonization and commodification of the seed*. Techno-industrial agriculture *colonizes* the seed in the sense that it penetrates into, and takes control of, the functioning of the seed, and imposes its own logic upon it — the logic of accelerated productivity, in-built obsolescence, and corporate monopoly ownership. It *commodifies* the seed in two senses: first, in the sense that farmers must pay for a product that they formerly attained from the plant at no cost; and secondly, in the sense that farmers are no longer involved in the reproduction of the seed, and therefore are not able to shape the character of it, and are instead delivered a ready-made, pre-packaged product.

For small-scale farmers, this will translate into higher levels of debt and enslaved dependency on these corporations, and in the Third World this means ever spiralling levels of land dispossession, unemployment and hunger.

vi) The Centralization of Control and the Triumph of the Code

Enabled by the total colonization of the seed, control of the global food industry will be further centralized into the hands of transnational corporations. This is ultimately the aim and the driving force behind the development of the new biotechnologies and the new patenting laws.

This fusion of the agribusiness corporation and techno-science now culminates in the triumph of the logic of the code; in particular, the *genetic-code* of biotechnology, and the *bar-code* of consumer-industrial capitalism. The genetic-code and the bar-code are the means through which ever more aspects of contemporary life are being colonized, commodified and controlled. In this context, perhaps the fusion of these two codes may even lead to the imprinting of bar-codes directly onto the DNA of genetically engineered organisms. Scientists at the Novagene corporation have apparently already ‘devoted enormous time and money to write the company logo into a cell, the world’s first living trademark.’⁵⁷

6. Opposing Genetic-Industrial Agriculture

Genetic engineering will not alleviate any of the social and environmental disasters of Green Revolution and techno-industrial forms of agriculture, but has instead emerged to further entrench and expand the dominance of these agricultural forms. Genetic engineering research is not being directed to meet the requirements of chemical-free, organic, small-scale, self-sufficient agriculture, and neither do genetically engineered organisms have any necessary role to play in supporting these forms of agriculture. At present, the international organics movement has rejected genetic engineering as being compatible with organic agriculture.⁵⁸

The argument that we are going to *need* the new biotechnologies in order to feed a growing and already malnourished global population is naive in a number of respects. First, it wrongly assumes that world hunger is at present the result of food shortages, and therefore due to the technical inadequacy of contemporary and traditional agriculture. On the contrary, it has been argued here that there is already enough food produced to feed everyone, and that hunger and poverty are the result of landlessness, unemployment, low market prices for primary produce, the wastage of grain and land for cattle production, etc. World hunger is simply not a technical problem. Secondly, it ignores the ways in which techno-industrial agriculture has itself been a primary *cause* of hunger and poverty and of environmental degradation, and that genetic engineering will be used to further the exploitation and impoverishment of both small-scale farms and of agro-ecosystems. Techno-industrial forms of agriculture are not sustainable in the long or even the short term, and continued faith in their technical solutions to our present and future social and ecological problems seems tragically misplaced.

In general, the unambiguous opposition to the application of genetic engineering to agriculture can be argued for in two ways. First, genetic engineering is an *inherently* dangerous approach to manipulating ecosystems, and threatens to intensify our present environmental and social crises *regardless* of the particular aims of those who develop it. That is, it is not only a question of the misuse or abuse of this technology that we should consider at this stage, since it presents unacceptable dangers in any application, whatever the benign intentions of its engineers and patrons. Above all, it is a completely unnecessary form of intervention given the proven success and sustainability of organic forms of agriculture.

Secondly, genetic engineering should be unambiguously opposed because of the current corporate control of genetic-industrial research and applications. Genetic engineering research is being conducted by large agricultural corporations, and by government research laboratories that support their aims. It is being used, and it will inevitably lead, to the extension of the control these corporations have over the entire industrial food chain — from the seed to the supermarket — and the further entrenchment of large-scale, monocultural, chemical and input intensive forms of agriculture. It promises a bleaker future for small-scale farms globally, and further ecological degradation.

Some critics of genetic engineering simplistically call for more public controls in its development, or for more testing of genetically engineered plants before they are released. Such critics assume there are potentially safe and beneficial uses of this technology and are essentially concerned about its misuse or premature commercialization. However, given the environmental and political lessons of the Green Revolution and the power relations and present trends in contemporary industrial agriculture, the notion of an environmentally sustainable and a socially equitable application of genetic engineering in the current global context is naive and flawed.

The only solutions worth considering that would regenerate the soils, create permanently sustainable agricultural systems in both environmental and social terms, and tackle the problems of global poverty and malnutrition, are those which combine traditional-organic farming methods with a number of socio-political reforms. These reforms would include the equitable redistribution of land, the

strengthening of local autonomy and self-sufficiency, and the reform of global trading relations and of the market prices for agricultural produce.

To oppose the development of genetic-industrial agriculture, two types of political activity can be pursued. First, in terms of ‘oppositional’ forms of political activity — which take place within the constraints of existing political and economic structures and attempt to reform these institutions through public pressure and lobbying — the aims would include:

(i) Creating strong coalitions to raise public awareness of the consequences of genetic-industrial agriculture, and to lobby governments and international bodies to halt research and development of genetic engineering. With surveys showing a considerable level of public mistrust and rejection of genetically engineered foods, the demand that any foods released that contain genetically engineered organisms be *labelled* is a way of giving consumers the right to an informed choice, of raising awareness of the issue, and of possibly slowing down the commercialization of these foods.

(ii) Campaigning for policies that support organic and small-scale forms of agriculture, and lobbying for the reform of global trading relations. This would include opposing new policies that undermine local self-sufficiency and independence, such as the recent ‘free trade’ World Trade Organisation (which has superseded G.A.T.T.) agreements, and patenting and intellectual property rights regulations.

Given the dynamics of contemporary industrial agriculture, the growing dominance of transnational corporations, and the complicity of governments with the corporate quest for profits and control, such far-reaching changes are certainly not going to be easy to achieve. It is therefore also necessary to engage in a second kind of political activity — one which undermines the power of these mainstream institutions. This can be referred to as a ‘reconstructive’ politics, or a *politics of creating alternatives*, whereby mainstream structures are by-passed and — wherever possible — activists directly create alternative structures, organizations, lifestyles, and modes of production and exchange, which allow individuals and communities to exercise greater and direct control over all aspects of their lives. There are two stages in this process of creating alternative forms of food production and distribution:

(i) Unplugging:

Each time we shop at the supermarket, or buy techno-industrially grown, processed and packaged foods, we are financially supporting the growth of the transnational corporations that own and control a large part of the industrial food chain, including the biotechnology industry. More generally we are contributing to the growth of corporate-industrial capitalism, and its expansion into and colonization of ever more aspects of our lives and ever more parts of the world. Leading high consumption and resource-dependent lifestyles similarly contributes to the extension of corporate power and to ecological degradation. As a first step we need to unplug ourselves from the practices and organizations that support the growth of this megamachine, and we do that by:

(ii) Creating and Supporting Alternatives:

* Through our consumer practices, buying produce that is grown organically and minimally processed and packaged, and comes from small, local producers, and by shopping at small retail outlets;

* Forming more direct links with the producers and communities that have created and are maintaining the types of agriculture that we support;

* Growing and preparing our own food wherever possible, and setting-up and supporting food co-operatives, seed banks, and other alternative organizations and modes of production and exchange, which allow communities to exercise greater and direct control over all aspects of the agricultural food chain and over other spheres of everyday life.

Notes

1. See Vandana Shiva, *The Violence of the Green Revolution*, Zed Books, 1991; & 'The Seed and the Earth: Biotechnology and the Colonisation of Regeneration', *Development Dialogue*, 1/2, 1992. This book will be concerned primarily with food crop production, thus leaving aside the area of animal production. For a discussion on the genetic engineering of animals, see for example Nicanor Perlas, *Overcoming Illusions About Biotechnology*, Third World Network, 1994.
2. See Fowler, C. & Mooney, P., *Shattering: Food, Politics, and the Loss of Genetic Diversity*, University of Arizona Press, 1990.
3. See Miguel Altieri, 'Traditional Farming in Latin America', *The Ecologist*, Vol.21, No.2, March/April, 1991.
4. Jane Rissler & Margaret Mellon, *Perils Amidst the Promise: Ecological Risks of Transgenic Crops in a Global Market*, Union of Concerned Scientists, 1993, p.100.
5. Altieri, 'Traditional Farming in Latin America', p.94.
6. Vandana Shiva, *Monocultures of the Mind: Biodiversity, Biotechnology, and the Third World*, Third World Network, 1993, p.136, 141.
7. *ibid*, p.137-8.
8. See Vandana Shiva, *Staying Alive: Women, Ecology and Development*, Zed Books, 1989; Shiva & Dankelman, 'Women and Biological Diversity: Lessons from the Indian Himalaya', in *Growing Diversity: Genetic Resources and Local Food Security*, (eds) D.Cooper *et al*, IT Publications, 1992; Shiva & Mies, *Ecofeminism*, Spinifex, 1993.
9. See Tracey Clunies-Ross and Nicholas Hildyard, *The Politics of Industrial Agriculture*, Earthscan, 1992; Peter Goering *et al*, *From the Ground Up: Rethinking Industrial Agriculture*, Zed Books/ISEC, 1993.
10. Shiva, *Monocultures of the Mind*, p.137.
11. Fowler & Mooney, *Shattering*, p.60.
12. Shiva, *Staying Alive*, p.45.
13. See Jack Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology 1492-2000*, Cambridge University Press, 1988, p.10.
14. Fowler & Mooney, *Shattering*, p.46.
15. See Shiva, *Monocultures of the Mind*, p.42.
16. *ibid*, p.39. See also Henk Hobbelink, *Biotechnology and the Future of World Agriculture*, Zed Books, 1991, Ch.9.
17. See Shiva, *Monocultures of the Mind*, p.48; Kloppenburg, *First the Seed*, p.121.
18. A well-known disaster of this kind was the Irish 'potato famine' of the 1830s, when most of the potatoes grown in Ireland were derived from a very narrow genetic base and were wiped out by an imported disease. Another is the U.S. corn blight of the early 1970s. See Fowler & Mooney, *Shattering*, p.43-47.
19. Shiva, *Monocultures of the Mind*, p.48.
20. Kloppenburg, *First the Seed*, p.68.
21. See Jeroen van Wijk, 'Hybrids, Bred for Superior Yields or for Control?', *Biotechnology and Development Monitor*, no.19, June 1994.
22. Richard Hindmarsh, 'The Flawed "Sustainable" Promise of Genetic Engineering', *The Ecologist*, Vol.21, 5, 1991, p. 197.
23. Clunies-Ross & Hildyard, *The Politics of Industrial Agriculture*, p.22.
24. Steve Connor, 'Soil erosion claims third of world's arable land', *The Age Newspaper*, Melbourne, February 25, 1995.
25. 'Pesticides kill 40,000 a year: UN', *The Age newspaper*, Melbourne, 17 May, 1994.
26. *Ecologist*, *Whose Common Future?: Reclaiming the Commons*, Earthscan, 1993, p.46.
27. Frances Moore Lappe, *Diet for a Small Planet*, Ballantine Books, 1982, p.69.
28. Jeremy Rifkin, *Beyond Beef*, Penguin, 1992, p.153.
29. *ibid*, p.138.
30. Shiva, *Staying Alive*, p.137.
31. *ibid*, p.128.
32. *ibid*, p.113. See also *Ecologist*, *Whose Common Future?*, p.65.
33. *Ecologist*, *Whose Common Future?*, p.38.
34. Shiva, *Monocultures of the Mind*, p.7.
35. *ibid*, p.95.
36. Kloppenburg, *First the Seed*, p.2.
37. Rissler & Mellon, *Perils Amidst the Promise*, p.12.
38. On herbicide-tolerant crops, see Hindmarsh, 'The Flawed "Sustainable" Promise'; Hobbelink, *Biotechnology and the Future of World Agriculture*; and Krimsky & Wrubel, *Agricultural Biotechnology and the Environment*.
39. On *Bt* pesticides, see Steinbrecher, 'From Green Revolution to Gene Revolution'; Krimsky & Wrubel, *Agricultural Biotechnology and the Environment*; Rissler & Mellon, *Perils Amidst the Promise*.
40. Rissler & Mellon, p.60.
41. Rissler & Mellon, p.63; Steinbrecher, p.277.
42. Rissler & Mellon, p.68.
43. See Steinbrecher, p.280; Rissler & Mellon, p.xi., p.17-22.
44. Rissler & Mellon, p.17.
45. Steinbrecher, p.280.
46. Rissler & Mellon, p.17.
47. Rissler & Mellon, p.17.
48. Hobbelink, *Biotechnology*, Ch.6.
49. See for example Shiva, *Monocultures of the Mind*, p.96; 'Scientists plan to take the pout out of sprout', *The Age*, April 3, 1995, and my response 'Genetic tinkering sprouts problems', *The Age*, letters page, April 12, 1995. Such health concerns are particularly being expressed over the human consumption of animal products from animals treated with genetically engineered growth hormones

50. Jeremy Rifkin, *Declaration of a Heretic*, Routledge & Kegan Paul, 1985, p.47, quoted in Nicanor Perlas, *Overcoming Illusions About Biotechnology*, p.47.
51. Kloppenburg, *First the Seed*, p.244; & Hobbelink, *Biotechnology*, Ch.3.
52. Kloppenburg, *First the Seed*, p.244; & Shiva, *Monocultures*, p114.
53. Frederick Buttel et al, 'From Green Revolution to Biorevolution', *Economic Development and Cultural Change*, 34:1, October, 1985, p.39.
54. Kloppenburg, *First the Seed*, p.242.
55. Jude Fanton and Michel Fanton, 'Seed Saving', *Permaculture International Journal*, 67, June-Aug, 1998, p.39.
56. Shiva, *Monocultures of the Mind*, p.144.
57. Cary Fowler et al 'The Laws of Life', *Development Dialogue*, 1/2, 1988, p.55.
58. Richard Hindmarsh, 'DNA Inc. - The Organic Rip-Off', *Permaculture International Journal*, No.55, 1995, p.14.

Bibliography

- Altieri, Miguel, 'Traditional Farming in Latin America', *The Ecologist*, Vol.21, No.2, March/April, 1991.
- Buttel, Frederick, Martin Kenney & Jack Kloppenburg, 'From Green Revolution to Biorevolution: Some Observations on the Changing Technological Bases of Economic Transformation in the Third World', *Economic Development and Cultural Change*, 34:1, October, 1985.
- Clunies-Ross, Tracey & Nicholas Hildyard, *The Politics of Industrial Agriculture*, Earthscan, 1992.
- Ecologist, *Whose Common Future?: Reclaiming the Commons*, Earthscan, 1993.
- Fanton, Jude and Michel Fanton, 'Seed Saving', *Permaculture International Journal*, 67, June-Aug, 1998, p.39.
- Fowler, C. & Mooney, P., *Shattering: Food, Politics, and the Loss of Genetic Diversity*, University of Arizona Press, 1990.
- Fowler, C., Eva Lachkovics, Pat Mooney and Hope Shand, 'The Laws of Life: Another Development and the New Biotechnologies', *Development Dialogue*, 1/2, 1988.
- Goering, Peter, Helena Norberg-Hodge, John Page, *From the Ground Up: Rethinking Industrial Agriculture*, Zed Books/ISEC, London, 1993.
- Goldburg, Rebecca *et al*, *Biotechnology's Bitter Harvest: Herbicide-Tolerant Crops and the Threat to Sustainable Agriculture*, Biotechnology Working Group, New York, 1990.
- Hindmarsh, Richard, 'DNA Inc. - The Organic Rip-Off', *Permaculture International Journal*, No.55, 1995.
- Hindmarsh, Richard, 'The Flawed "Sustainable" Promise of Genetic Engineering', *The Ecologist*, Vol.21, 5, 1991.
- Hindmarsh, Richard, David Burch, Kees Hulsman, 'Agrobiotechnology in Australia: Issues of Control, Collaboration and Sustainability', *Prometheus*, Vol.9, No.2, December, 1991.
- Hobbelink, Henk, *Biotechnology and the Future of World Agriculture*, Zed Books, London, 1991.
- International Movement for Ecological Agriculture, 'From Global Crisis Towards Ecological Agriculture', *The Ecologist*, Vol.21, No.2, March/April, 1990.
- Kloppenburg, Jack, *First the Seed: The Political Economy of Plant Biotechnology 1492-2000*, Cambridge University Press, 1988.
- Krimsky, Sheldon and Roger Wrubel, *Agricultural Biotechnology and the Environment: Science, Policy and Social Issues*, Urbana, University of Illinois Press, 1996.
- New Internationalist*, Issue on Biotechnology, March, 1991.
- Perlas, Nicanor, *Overcoming Illusions About Biotechnology*, Third World Network, 1994.
- Phelps, Bob, 'Genetic Engineering: Miracle or Menace?', *Chain Reaction*, 62, 1990.
- Pimental, David, 'Biopesticides and the Environment', *Biotechnology and Sustainable Agriculture: Policy Alternatives*, (ed) J.F.Macdonald, NABC, 1989.
- Rissler, Jane & Margaret Mellon, *Perils Amidst the Promise: Ecological Risks of Transgenic Crops in a Global Market*, Union of Concerned Scientists, 1993.
- Rifkin, Jeremy, *Declaration of a Heretic*, Routledge & Kegan Paul, 1985.
- Science as Culture*, Issue on Biotechnology and Agriculture, Vol.2, 4, No.13, 1991.
- Scrinis, Gyorgy, 'Colonising the Seed', *Arena Magazine*, 36, 1998, pp. 41-44.
- Shiva, Vandana, *Monocultures of the Mind: Biodiversity, Biotechnology, and the Third World*, Third World Network, Penang, 1993.
- Shiva, Vandana, 'The Seed and the Earth: Biotechnology and the Colonisation of Regeneration', *Development Dialogue*, 1/2, 1992.
- Shiva, Vandana, 'The Seed and the Earth: Women, Ecology, and Biotechnology', *The Ecologist*, Vol.22, 1, Jan/Feb, 1992.
- Shiva, Vandana, *The Violence of the Green Revolution*, Zed Books & Third World Network, London, 1991.
- Shiva, Vandana, *Staying Alive: Women, Ecology and Development*, Zed Books, London, 1989.
- Shiva, Vandana & Maria Mies, *Ecofeminism*, Spinifex, London, 1993.
- Shiva, Vandana & Irene Dankelman, 'Women and Biological Diversity: Lessons from the Indian Himalaya', in *Growing Diversity: Genetic Resources and Local Food Security*, (eds) D.Cooper *et al*, IT Publications, 1992.
- Shiva, Vandana *et al*, *Biodiversity: Social and Ecological Perspectives*, Zed & World Rainforest Movement, 1991.
- Skelly, Susan, 'Attack of the Killer Tomatoes?', *HQ*, March/April, 1995.
- Steinbrecher, Ricarda, 'From Green Revolution to Gene Revolution: The Environmental Risks of Engineered Crops', *The Ecologist*, 26, 6, 1996.

van Wijk, Jeroen, 'Hybrids, Bred for Superior Yields or for Control?', *Biotechnology and Development Monitor*, no.19, June, 1994.

¹ See Vandana Shiva, *The Violence of the Green Revolution*, Zed Books, 1991; & 'The Seed and the Earth: Biotechnology and the Colonisation of Regeneration', *Development Dialogue*, 1/2, 1992. This book will be concerned primarily with food crop production, thus leaving aside the area of animal production. For a discussion on the genetic engineering of animals, see for example Nicanor Perlas, *Overcoming Illusions About Biotechnology*, Third World Network, 1994.

² See Fowler, C. & Mooney, P., *Shattering: Food, Politics, and the Loss of Genetic Diversity*, University of Arizona Press, 1990.

³ See Miguel Altieri, 'Traditional Farming in Latin America', *The Ecologist*, Vol.21, No.2, March/April, 1991.

⁴ Jane Rissler & Margaret Mellon, *Perils Amidst the Promise: Ecological Risks of Transgenic Crops in a Global Market*, Union of Concerned Scientists, 1993, p.100.

⁵ Altieri, 'Traditional Farming in Latin America', p.94.

⁶ Vandana Shiva, *Monocultures of the Mind: Biodiversity, Biotechnology, and the Third World*, Third World Network, 1993, p.136, 141.

⁷ *ibid*, p.137-8.

⁸ See Vandana Shiva, *Staying Alive: Women, Ecology and Development*, Zed Books, 1989; Shiva & Dankelman, 'Women and Biological Diversity: Lessons from the Indian Himalaya', in *Growing Diversity: Genetic Resources and Local Food Security*, (eds) D.Cooper *et al*, IT Publications, 1992; Shiva & Mies, *Ecofeminism*, Spinifex, 1993.

⁹ See Tracey Clunies-Ross and Nicholas Hildyard, *The Politics of Industrial Agriculture*, Earthscan, 1992; Peter Goering *et al*, *From the Ground Up: Rethinking Industrial Agriculture*, Zed Books/ISEC, 1993.

¹⁰ Shiva, *Monocultures of the Mind*, p.137.

¹¹ Fowler & Mooney, *Shattering*, p.60.

¹² Shiva, *Staying Alive*, p.45.

¹³ See Jack Kloppenburg, *First the Seed: The Political Economy of Plant Biotechnology 1492-2000*, Cambridge University Press, 1988, p.10.

¹⁴ Fowler & Mooney, *Shattering*, p.46.

¹⁵ See Shiva, *Monocultures of the Mind*, p.42.

¹⁶ *ibid*, p.39. See also Henk Hobbelink, *Biotechnology and the Future of World Agriculture*, Zed Books, 1991, Ch.9.

¹⁷ See Shiva, *Monocultures of the Mind*, p.48; Kloppenburg, *First the Seed*, p.121.

¹⁸ A well-known disaster of this kind was the Irish 'potato famine' of the 1830s, when most of the potatoes grown in Ireland were derived from a very narrow genetic base and were wiped out by an imported disease. Another is the U.S. corn blight of the early 1970s. See Fowler & Mooney, *Shattering*, p.43-47.

¹⁹ Shiva, *Monocultures of the Mind*, p.48.

²⁰ Kloppenburg, *First the Seed*, p.68.

²¹ See Jeroen van Wijk, 'Hybrids, Bred for Superior Yields or for Control?', *Biotechnology and Development Monitor*, no.19, June 1994.

²² Richard Hindmarsh, 'The Flawed "Sustainable" Promise of Genetic Engineering', *The Ecologist*, Vol.21, 5, 1991, p. 197.

²³ Clunies-Ross & Hildyard, *The Politics of Industrial Agriculture*, p.22.

²⁴ Steve Connor, 'Soil erosion claims third of world's arable land', *The Age Newspaper*, Melbourne, February 25, 1995.

²⁵ 'Pesticides kill 40,000 a year: UN', *The Age newspaper*, 17 May, 1994.

²⁶ *Ecologist*, *Whose Common Future?: Reclaiming the Commons*, Earthscan, 1993, p.46.

²⁷ Frances Moore Lappe, *Diet for a Small Planet*, Ballantine Books, 1982, p.69.

²⁸ Jeremy Rifkin, *Beyond Beef*, Penguin, 1992, p.153.

²⁹ *ibid*, p.138.

³⁰ Shiva, *Staying Alive*, p.137.

³¹ *ibid*, p.128.

³² *ibid*, p.113. See also *Ecologist*, *Whose Common Future?*, p.65.

³³ *Ecologist*, *Whose Common Future?*, p.38.

³⁴ Shiva, *Monocultures of the Mind*, p.7.

³⁵ *ibid*, p.95.

³⁶ Kloppenburg, *First the Seed*, p.2.

³⁷ Rissler & Mellon, *Perils Amidst the Promise*, p.12.

³⁸ On herbicide-tolerant crops, see Hindmarsh, 'The Flawed "Sustainable" Promise'; Hobbelink, *Biotechnology and the Future of World Agriculture*; and Krimsky & Wrubel, *Agricultural Biotechnology and the Environment*.

³⁹ On *Bt* pesticides, see Steinbrecher, 'From Green Revolution to Gene Revolution'; Krimsky & Wrubel, *Agricultural Biotechnology and the Environment*; Rissler & Mellon, *Perils Amidst the Promise*.

⁴⁰ Rissler & Mellon, p.60.

⁴¹ Rissler & Mellon, p.63; Steinbrecher, p.277.

⁴² Rissler & Mellon, p.68.

⁴³ See Steinbrecher, p.280 box; Rissler & Mellon, p.xi., p.17-22.

⁴⁴ Rissler & Mellon, p.17.

⁴⁵ Steinbrecher, p.280.

⁴⁶ Rissler & Mellon, p.17.

⁴⁷ Rissler & Mellon, p.17.

⁴⁸ Hobbelink, *Biotechnology*, Ch.6.

⁴⁹ See the Flavr-Savr tomato example above; Shiva, *Monocultures of the Mind*, p.96; 'Scientists plan to take the pout out of sprout', *The Age*, April 3, 1995, and my response 'Genetic tinkering sprouts problems', *The Age*, letters page, April 12, 1995. Such dangers are particularly being expressed over the human consumption of animal products from animals treated with genetically engineered growth hormones, such as milk from cattle treated with the bovine growth hormone BST.

⁵⁰ Jeremy Rifkin, *Declaration of a Heretic*, Routledge & Kegan Paul, 1985, p.47, quoted in Nicanor Perlas, *Overcoming Illusions About Biotechnology*, p.47.

⁵¹ Kloppenburg, *First the Seed*, p.244; & Hobbelink, *Biotechnology*, Ch.3.

⁵² Kloppenburg, *First the Seed*, p.244; & Shiva, *Monocultures*, p114.

⁵³ Frederick Buttel et al, 'From Green Revolution to Biorevolution', *Economic Development and Cultural Change*, 34:1, October, 1985, p.39.

⁵⁴ Kloppenburg, *First the Seed*, p.242.

⁵⁵ Jude Fanton and Michel Fanton, 'Seed Saving', *Permaculture International Journal*, 67, June-Aug, 1998, p.39.

⁵⁶ Shiva, *Monocultures of the Mind*, p.144.

⁵⁷ Cary Fowler et al 'The Laws of Life', *Development Dialogue*, 1/2, 1988, p.55.

⁵⁸ Richard Hindmarsh, 'DNA Inc. - The Organic Rip-Off', *Permaculture International Journal*, No.55, 1995, p.14.