AstraZeneca and its genetic research
Feeding the world or fuelling hunger?

ActionAid's food rights campaign

ActionAid has launched an international food rights campaign to safeguard poor people's right to food. The campaign aims to ensure that international agricultural trade benefits the poor and protects farmers' rights to seed and plant resources.

ActionAid is particularly concerned about the potential impact of genetic engineering, and patenting of genetic resources for food and farming.

ActionAid wants fair, international laws which support poor farmers' rights and crops.

AstraZeneca and its genetic research: feeding the world or fuelling public hunger?

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ISBN 1 872502 59 8 paperback
A catalogue record for this title is available from the British Library.

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Executive summary

The world's agricultural systems are undergoing enormous change. Major corporate mergers between seed and agrochemical companies along with international legislation giving corporations more power has led to a concentration of control of the agricultural and food sectors by a handful of multinational companies.

The combination of genetic engineering of crops and the manipulation of the legal system in some countries to allow the patenting of these plants offers an unprecedented potential for impact on the food rights and livelihood security of the world's poor.

The result of the increased corporate patenting, commercialisation and promotion of genetically modified (GM) crops in developing countries is likely to be that poor farmers will get poorer. The mere presence of genetically engineered and patented seeds need not stop the seed saving and seed development so important to many poor farmers. But, as with pesticide use and its growth across the developing world, there is likely to be enormous pressure on farmers in developing countries to buy GM seeds. Predictions are that their use will rise exponentially over the next few years.

Those who cannot afford patent royalties or the 'technology fees' in addition to the higher cost of GM seed may well be either squeezed out of business or into a spiral of borrowing and debt. Patents and GM technology could push up seed prices and leave fewer, cheaper alternatives for farmers.

While much of the public and media focus in the biotechnology debate has been on the more prominent American multinational, Monsanto, it is not the only company worth scrutinising.

This report examines the British-based and recently-merged AstraZeneca, one of the group of only five companies that now dominates and controls GM crops world-wide. Based on 1997 figures, AstraZeneca is the third largest agrochemical company and the fifth largest seed company world-wide, with a major investment in GM crops and seeds.

We look at AstraZeneca's GM crop research, through its patent applications, to consider the implications of this work, if it is marketed, for poor people in developing countries. In examining its patent applications, a picture emerges of the direction the company's research is taking. It may well prove to be a worrying picture for developing countries, where a farmer's right to save and re-use seed is seen by many as fundamental and, in many of the world's poorest places, essential for survival.

AstraZeneca has tripled its spending on biotechnology research in recent years, and it is clear from its patent applications that it has major interests in applying GM technologies to alter and control crop behaviour and character in fundamental ways.

In this way Britain's own multinational, AstraZeneca, could play a dominant role in how biotechnology affects food security in developing nations. ActionAid has examined the 52 patent applications relating to GM crops made by AstraZeneca since 1993. The company's main areas of research cover:

- systems which switch on and off with chemical use, so that a plant cannot flourish properly without an application of the chemical, most often one manufactured by AstraZeneca's chemicals division. This could tie farmers into purchasing expensive seed/chemical packages;

- preparation for the 'next generation' of insecticide-producing plants, using such devices as the venom genes from the deadly Australian funnelweb spider or fat-tailed scorpion, and toxin genes from wasps and cone snails. While this could reduce the use of some chemical insecticides in the short-term, it could also mean that insects develop a 'built-in' resistance to the toxins used. This could force poor farmers to go back to the company to supply a different package of new insect-resistant crops. Poor farmers are unlikely to be able to invest in such expensive technology and if they do, may face sudden losses, if insect resistance emerges;
- plants made resistant to multiple herbicides. Rather than reducing the use of herbicides, if commercialised, these crops could tie farmers into yet another form of complex chemical dependency. The risks of resistant 'super weeds' developing and the potential for environmental and human health problems, as a result of increased use of herbicides, would be enormous. In developing countries, crop/agricultural biodiversity is high. Crops are often grown close to related wild plants. The potential for gene flow is therefore very real. If herbicide-resistant genes are transferred into neighbouring wild plants, serious weed problems could emerge;
- altered product characteristics, such as delayed ripening and altered composition, which appear to be aimed more at the designer markets of the affluent North than feeding the developing South;
- technologies which could alter the oil and starch composition of a crop. If crops grown in the North are engineered to do this, they could replace oils such as coconut oil, currently a major export earner for countries like the Philippines.

AstraZeneca's patent applications cover at least 90 nations world-wide, including many developing countries and many staple foods such as rice, wheat, maize, sorghum, melons and bananas.

One area of AstraZeneca's research of great concern to ActionAid is the control of crop fertility, through 'Terminator' technology where a plant's seed is rendered sterile. Sterility genes are either built into a plant, or 'switched' on or off by 'killer' genes such as 'Verminator' which uses genes from brown rats. This could make seed saving impossible for farmers buying these seeds.

However, as ActionAid was investigating this report, AstraZeneca confirmed to us that the company will not develop either Terminator or Verminator to make seeds sterile. AstraZeneca holds one of only two Terminator patents.

AstraZeneca is beginning a new corporate life. Its staff and shareholders have a chance to look anew at its research portfolio in genetic engineering. AstraZeneca's confirmation to ActionAid that it will not commercially pursue systems resulting in seed sterility is an important step in the right direction.

ActionAid, however, is still extremely concerned about other aspects of AstraZeneca's genetic research in that, if developed, these technologies have the potential to steer farmers in developing countries out of seed saving and into greater dependence on chemicals and on multinational companies.

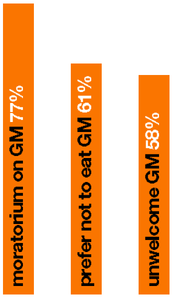
This report concludes with key recommendations for the company and for world governments on genetic engineering in food and farming.

Introduction

For thousands of years, farmers across the developing world have saved seeds from their harvest to plant the following year's crop [see box on opposite page]. But in the second half of this century, the globalisation of trade, cultures and tastes has made a significant impact and these are being reinforced by the technological advances in agriculture, the establishment of an international seed and chemical industry, the patenting of plants and now by genetic engineering of crops.

Genetic engineering has grown from a concept in the laboratory to crops in the field and goods on the supermarket shelf in ten years. But with the first germination of a GM seed came major concerns about safety and long-term effects. While in the North food safety issues are a driving public concern, to the developing world, genetic engineering in food and farming may pose a major threat to food security and the protection of people's livelihoods.

Figure 1
Public concern over GM foods and crops
Source: MORI



Feeding the world?

In the UK there has been considerable concern at the introduction of genetically modified (GM) crops and foods. For example, 77 per cent of the British public feel there should be a moratorium on growing GM foods in the UK, 61 per cent would prefer not to eat GM foods, and 58 per cent do not welcome the use of genetic modification in food [see Figure 1].[1]

One issue which appears important in determining how British people feel about the use of the technology, has been their view of whether developing countries will benefit from it.[2] The argument that genetic engineering could feed an increasingly large population has been used by industry and supporters of GM technologies in their effort to persuade a reluctant European public to accept GM food.

As one of the world's largest biotechnology companies, UK-based AstraZeneca, says:

> "Without higher yields, the world would undoubtedly lose the wild forests and grasslands that still cover more than a third of the Earth's surface, because lower yield agriculture would require vastly more land [to feed increased population]. The demand will therefore be for more intensive agriculture embracing genetically modified crops."[3]

In 1998, US biotechnology giant Monsanto ran advertisements in the UK arguing that food biotechnology would feed 'starving generations'.[4]

But ActionAid believes that the way the biotechnology industry is applying GM technology could threaten food security in developing countries and could well increase poverty and hunger. Even though the world's population is growing we know it produces enough food for all: food mountains are evidence of this. It is the inequitable distribution of food that keeps millions hungry.

This is also the view of many farmers and governments across the developing world. Last year, representatives of 20 African countries made a statement against genetic engineering in farming, entitled, *Let Nature's Harvest Continue*. They said:

> "We do not believe that such [agrochemical] companies or gene technologies will help our farmers to produce the food that is needed in the 21st century. On

1 MORI/GeneWatch opinion poll, June 1998.
2 Grove-White, R, Macnaghton, P, Mayer, S & Wynne, B, 1997: *Uncertain World. Genetically modified organisms, food and public attitudes in Britain*: Centre for the Study of Environmental Change, Lancaster University, Lancaster. 64pp.
3 Crowley , P, Fischer, H & Devonshire, A: *Feed the World, Chemistry in Britain*, July 1998, p25, cited in Dinham B, 1999, *Zeneca the impact of pesticides on food security. Hungry for Power*: UK Food Group, London, p73.
4 Eg Monsanto's advertisement in *The Observer*, 2 August 1998: *Worrying about starving future generations won't feed them. Food biotechnology will.*

the contrary, we think it will destroy the diversity, the local knowledge and the sustainable agricultural systems that our farmers have developed for millennia and that it will thus undermine our capacity to feed ourselves."[5]

Determining the likely impacts of agricultural genetic engineering on developing countries should be fundamental in deciding whether to allow the technology to go ahead. Indeed, if fears about the biotech revolution's socio-economic and environmental impact on the world's poorest people prove to be well-founded, these crops should not be promoted.

Seed saving

1.4 billion people are dependent on crops grown from saved seed by small farmers in the developing world. Up to 70 per cent of seed used by such farmers is saved on-farm.[6]

The system is well entrenched. Farmers save, store and replant their own seed. They also exchange seed with other farmers at local fairs and gene banks.[7] The practice means that only 10 per cent of seed is bought commercially.

India has 100 million farms, of which 80 per cent rely on saved seed.[8] Farmers, such as Aurogyam Balamma from Raikod in Andhra Pradesh, regard seed saving as a fundamental right.

"I have never purchased seed," says Mrs Balamma, who exchanges grain seed with her neighbours. "This way I am independent. If I had to buy seed it would cost 700 rupees, and the crops would need chemical inputs. That is very expensive for me," she told ActionAid campaigners in India in January 1999.

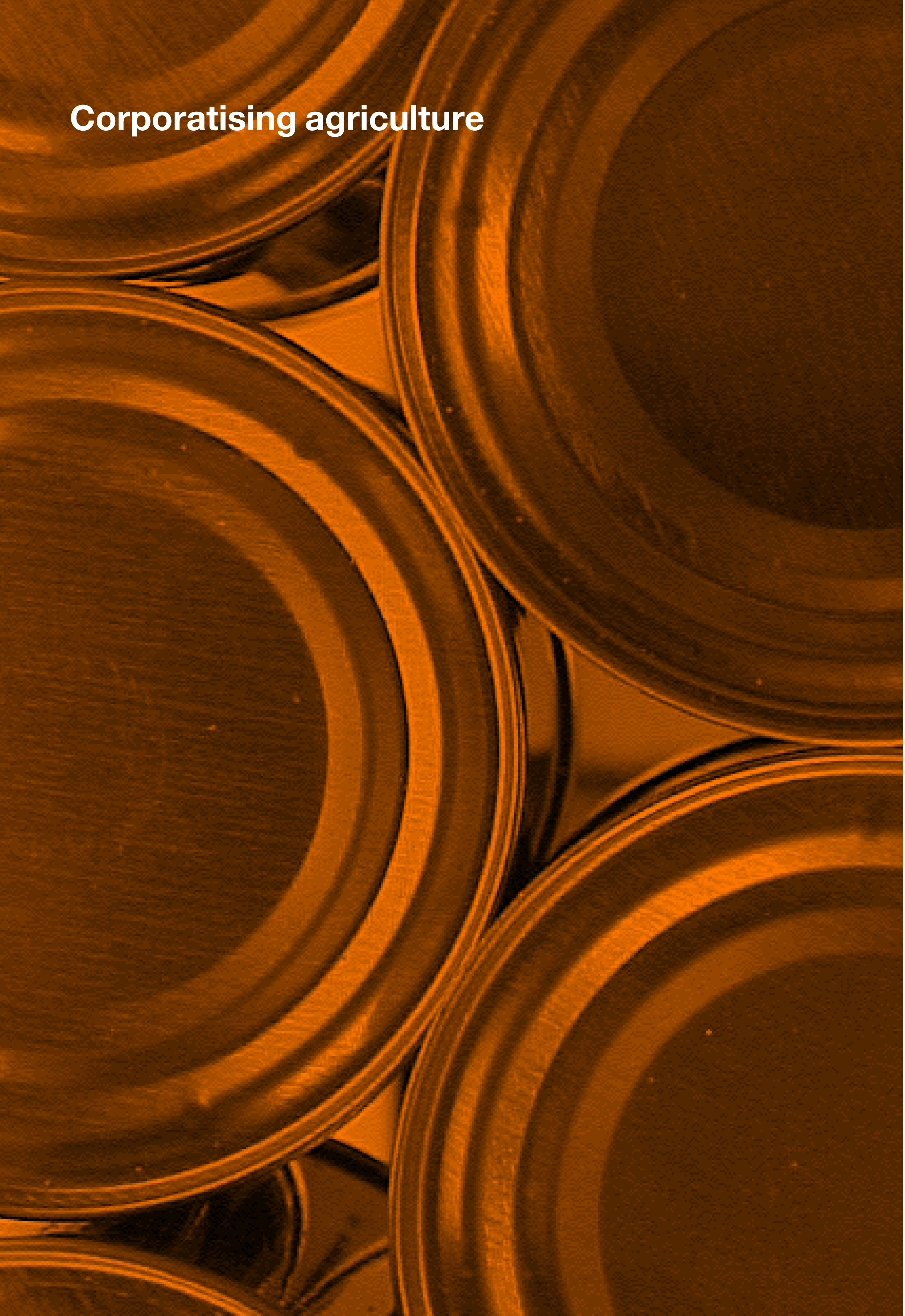
Seed saving also preserves genetic diversity. Multi-cropping means many local varieties continue to be grown. A study at Paucartambo in Peru showed farmers typically planted 27 local varieties of maize (representing 11 different races) which were distinguished for their boiling or parching qualities.[9]

In this report, we first set out a history of the corporate takeover of the global seed and biotechnology industry, through business deals and international institutions, and the funding of agricultural research.

We then focus specifically on the UK's biotechnology giant, AstraZeneca. A company's portfolio of patent applications and its research projects may give an indication of the company's strategic intentions. We examine AstraZeneca's patent portfolio from a developing country perspective, to see if the direction the company is taking is likely to 'Feed the World' or whether it could plunge the developing world further into poverty and hunger.

5 *Let nature's harvest continue*. African statement, FAO, June 1998.
6 Cromwell, E: *New Seed and Old Laws*, 1997, edited Tripp, R, Intermediate Technology Publications, p218.
7 Hiesey, P (ed), 1990 *Accelerating the transfer of wheat breeding grains to farmers. A study of the dynamics of varietal replacement in Pakistan.* CIMMYT, Mexico.
8 Vandana Shiva: *The Guardian*, 17 February 1999.
9 Tripp, R: *New Seed and Old Laws*, 1997, Intermediate Technology Publications, p15.

Corporatising agriculture



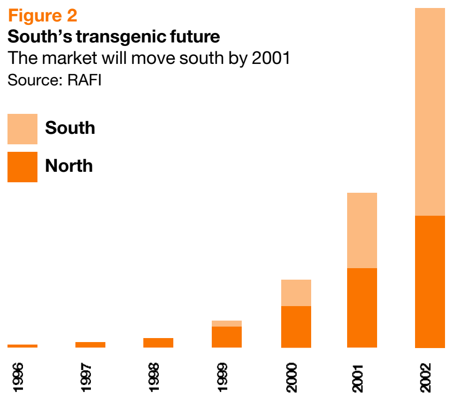
Genetic engineering in agriculture: seeds incorporated

The use of genetic engineering in agriculture is just beginning, but its growth is staggering. In 1995, the first commercial GM crops were planted. By 1998, GM crops accounted for 28 million hectares.[10] This area is predicted to grow to 180 million ha in 2000, 400 million ha in 2001 and 900 million ha in 2002.[11] While this growth began in the industrialised North, by 2001 almost half the world's GM crops will be in the South, and by 2002, 550 million ha of the 900 million predicted will be in the developing world [see Figure 2].

Since the first planting of a GM crop, the large agro-chemical companies consolidated and transformed themselves into biotechnology giants by buying plant breeding and seed companies, along with biotechnology research companies.

In 1998, five companies accounted for almost all GM crops: Monsanto, Novartis, AstraZeneca (formed by the recent merger between the Swedish company Astra and Britain's Zeneca), Aventis (created through the merger of Rhône Poulenc and Hoechst), and Du Pont. The majority of these GM crops are herbicide-tolerant, ie genetically engineered to be resistant to a specific herbicide, most often produced by the same company.

Figure 2
South's transgenic future
The market will move south by 2001
Source: RAFI



Sales of GM crop seeds were $1.35 billion in 1998, and are projected to rise to $6 billion by 2005 and $20 billion by 2010 [see Figure 3 overleaf]. By then, GM seeds are expected to form 80 per cent of the commercial seed market.[12] Given the record number of company takeovers in the past two years, we cannot predict which company names will appear on the products, but it is not likely to be more than the five current major ones in the industry.

This concentration of the seed market has worried observers.[13] Many see it as an unwelcome increase in control over the food chain and as a potential erosion of the public's ability to avoid GM seeds or food.

One seed industry analyst states:

> "The days of seed companies selling commodity seed products which will be sprayed with pesticides marketed by a separate industry are clearly numbered. Seed companies are now selling seed brands engineered to express pest resistance genes or to be tolerant to specific herbicides."[14]

As Monsanto's Chief Executive, Robert Shapiro, has explained: 'within the next 10 to 20 years, virtually all crops will be genetically engineered'.[15]

Another observer commented: "Unless there is greater legal control, nearly all the commercial seeds of all major crops could contain one or more bio-engineered traits by 2000."[16]

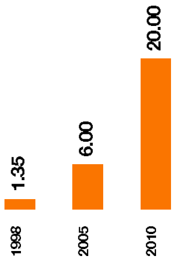
From farmers' rights to corporate patents: a history

This corporate takeover of the international seed market began about 50 years ago. At the same time, international agreements have steadily eroded farmers' rights to save, re-plant, exchange or sell their seeds.

Until the early 1920s, farmers in Europe and North America either saved

10 James, C (1998): *Global review of commercialised transgenic crops*, 1998: ISAAA Briefs No 8. ISAAA, Ithaca NY.
11 RAFI Communique, January/February 1999 *Traitor Technology: The Terminator's wider implications.* Rural Advancement Fund International, Canada, <http://www.rafi.org/communique/flxt/1991.html>
12 *Ibid.*
13 House of Lords Select Committee on European communities. *EC Regulation of Genetic Modification in Agriculture*. The Stationery Office: London. p26–27.
14 Beer, A: *Blurring the line between industries, 1998 Agrow Review of 1997*, P B J Publications: UK cited in Dinham B, 1999. *Zeneca: the impact of pesticides on food security. Hungry for Power*, UK Food Group: London, p73.
15 BBC, *Money Programme,* April 1999.
16 *Biotech crops flourish, Chemical Week*, 4–11 February 1998.

Figure 3
Expected increase in sales of GM crop seeds (in $bn)
Source: RAFI



their seed from the previous season's crop, or bought it from neighbours or a local merchant. Farmers across the world used hundreds of thousands of local crop varieties, which provided a basis for sustainable farming practices and the protection of biodiversity.

As the international seed companies took hold of the market from farmers, a key agreement was set up to begin the process of transferring seed rights from farmer to company.

In the 1960s, the international control of plant varieties was established via the Union for the Protection of New Varieties (UPOV) convention. This allocated, for the first time, specific rights to plant breeders over specific types of plants. In 1991, UPOV was revised. The new agreement actually turns the tradition of seed saving on its head and in practice farmers' rights to save seeds for use the next year are only protected in countries where special provisions for this are made.

Most of the signatories are industrialised countries, but to date 42 developing countries have ratified the agreement. Although many more have not signed the agreement, (partly because farmers fear that it would prevent saving seeds), there is strong pressure to do so.

Hybrids

The use of hybrids (seeds made from crossing two varieties of the same crop) has helped seed companies reduce seed saving by farmers because the seeds from hybrid crops are less productive than the parent.

Hybridisation techniques produce seeds with greater vigour but reduced fertility. Richer farmers have been encouraged to buy these seeds and, as a result, have become accustomed to the idea of buying seed annually, enabling further market expansion by the seed merchant. However, with some crops, such as wheat, rice, soybean, cotton, oilseed rape, oats and sorghum, hybrid production is difficult because they are self-pollinating.

With companies tending to sell a limited number of seed types, and farmers abandoning local varieties in favour of 'improved' seeds on offer from companies or governments, there has been a huge reduction in agricultural biodiversity.

For example, it is estimated that 50 years ago India grew around 30,000 indigenous or 'landrace' varieties of rice, but will grow fewer than 50 by 2010.[17]

Plant variety protection and patents

Next on the agenda of control is the patenting of plants. A patent gives monopoly rights to commercial exploitations of a product, and usually extends for 17–20 years. This means that if patents are awarded on crops farmers who use seed of this type for the following year's planting will either have to pay royalties to the seed company for re-use or go back to the company to buy new seed each year.

Patent rights on crops give even more control than Plant Variety Rights over plant breeding. As a scientist at Plant Breeding International, a former public research institute, now owned by Monsanto, recently explained:

> "The level of protection given by Plant Variety Rights and by patents differs in that with Rights the holder cannot prevent other plant breeders from using his protected variety as a parent in crosses aimed at the selection of further vari-

17 Mooney, P R: *The law of the seed*, 1993 Development Dialogue 1–2, p14. Cited in Shiva, V 1993, *Monocultures of the Mind:* Third World Network: Malaysia.

eties, but with patents he can. Thus, on the face of it, particularly if patents with broad claims are granted, the holders of patents are in a powerful position."[18]

Enter genetic engineering

Genetic engineering and the patenting of plants and biotechnological processes offer an unprecedented potential for corporate control over agriculture. Companies anxious to gain as much protection as possible for their GM crops can achieve this through patent protection. Again, farmers' rights and seed saving will be the worst affected.

A recent review in the UK showed that 13 companies held 80 per cent of GM patents. None of these companies is from the developing world.[19]

Patent policing

Companies police their plant patent protection carefully. Zeneca's policy on patenting is: "…to seek any available patent and trade mark protection for all product developments on a wide territorial basis and in all its major markets" and, "Zeneca monitors competitor activity carefully and will enforce or defend its intellectual property rights where appropriate."[20]

Monsanto has recently taken US and Canadian farmers to court for allegedly re-planting Roundup Ready soybeans. Monsanto argues this breaches the contracts drawn up between the company and the farmer on the patented seed.[21]

Monsanto has sent private investigators into farmers' fields to check if they are illegally replanting gene-altered seeds. Five full-time inspectors are employed to police 'seed pirates'. The company also sponsored a toll-free 'tip-line' to help farmers inform on neighbours.[22]

Next target: control over the South?

The result of increased corporate patenting, commercialisation and promotion of GM crops in developing countries is likely to be that poor farmers get poorer. Those who cannot afford patent royalties or 'technology fees' added to the cost of GM seed may either be squeezed out of business or into a spiral of borrowing and debt.

For farmers who operate on the margins of profit, debt or bankruptcy can have tragic consequences. Last year 400 cotton farmers committed suicide in Warangal in Andhra Pradesh, India, because of indebtedness linked, among other things, to new hybrid seeds and the expensive pesticides needed to grow them.

Indian farmers typically pay 15–100 rupees for a kilo of local cotton seed which requires no inputs. Hybrid cotton seed costs 600 rupees per kilo but also requires chemical fertiliser and up to 25 sprayings of pesticide at 100 rupees a go. Furthermore, Monsanto estimate that genetically modified *Bacillus thuringensis* (Bt) cotton will cost six times the price of hybrid seed when introduced into India in 2000.[23]

The mere presence of genetically engineered and patented seeds may not stop the centuries-old practice of seed saving. But, as with pesticide use and its growth across the developing world, there is likely to be enormous pressure on farmers in developing countries to buy GM seeds.

18 Sage, G C M: *The role of DNA technologies in plant breeding*. 1999 BCPC Symposium Proceedings No 72: *Gene Flow and Agriculture: Relevance for Transgenic Crops*: pp 23–31. British Crop Protection Council, Surrey.

19 *Evening Standard*, 24 Feb 1999: *13 companies own 80% of GM patents*. Derwent Information announced this data at a conference on patenting genetic material. It has not been formally published since but Derwent have confirmed that this information is correct.

20 Zeneca Annual Report and Accounts 1995.

21 *Progressive Farmer*, January 1998: *Roundup Ready Seed Saving*.

22 Weiss, R: Washington Post Service, 4 April 1999.

23 Interview Afar Jafri, Research Foundation of Science, Technology and Ecology, 13 April 1999.

The pressure is likely to include corporate advertising, sales pressure, recommendations by government extension services, the availability of credit facilities and land access. For a small and poor farmer with no alternative source of information or seed, GM crops may be impossible to resist.

If the seed industry continues its trend toward vertical integration, in the hands of a few companies intent on promoting the technology, farmers may have difficulties in finding alternative, cost-effective seed supplies.

If governments choose to support the development of GM seeds or, as will be the case in many poor countries, they are unable to offer continued financial support to their public-sector seed supplies, the impact will be felt at a local level.

The alternative exchange outlets which benefit small farmers, such as farmers' markets, seed exchanges etc, may be undermined as they receive less funding and other encouragement from governments. Again, this would make seed saving harder to sustain.

As seed saving becomes obsolete and seed is purchased from multinationals, both individual farmer and national debt burdens could increase. Small farmers will not be able to compete.

Biotechnology research goes private

The move from public to private control of seed markets in developing countries is another key factor in global control. It is already happening. In Thailand, private companies play more of a role in seed production, with the Government simply overseeing distribution.[24]

Even where governments do invest in GM crop research they may not be able to attract the best researchers or compete with private companies. For example, the Indian Government recently announced a research initiative to sequence the chick pea genome. But there are fears that scientists may prefer to work at Monsanto's genomic research centre in Bangalore which offers higher salaries and better conditions.[25]

A US company, Celera Genomics, will try to sequence the entire rice genome in just six weeks, upstaging more long-term publicly-funded efforts. One of the consequences is likely to be the patenting of economically important gene sequences found by Celera along the way.[26]

World-wide, company research priorities are also moving into previously public institutions. A number of publicly-funded research institutions have been bought by or have made research agreements with transnational companies, such as Zeneca's £50 million investment last year into a ten-year collaboration with the John Innes Research Institute in Norwich, UK.

What is the significance of these investments?

As research institutions accept funding from private companies, national public-sector, plant-breeding programmes relevant to poor farmers may be undermined. They may well be deemed as unnecessary and starved of investment.

Corporate consolidation in the seed sector may result in fewer seeds being available as the companies create a monopoly, thus narrowing the world's genetic base and creating greater uniformity of seed breeding.

24 *Bangkok Post*, 16 April 1999: *Seed output goes private – state will play regulatory role.*
25 *Nature Biotechnology* 17 March 1999, *India sequences chickpea*. Volume 17, p211.
26 *New Scientist*, 23 April 1999. *Rice Race*, p 5.

This, in turn, could increase the likelihood of crop disasters as pesticide resistance builds up. It would also further limit the agricultural biodiversity on which farmers depend to withstand environmental changes.

Globalisation: the World Trade Organisation

The increasing control over GM crops and the food chain by a few large companies takes place within a broader context of global liberalisation.

International rules set by the World Trade Organisation (WTO) enable private companies such as AstraZeneca to assert their control over the world's resources.[27] AstraZeneca is operating within this framework set by governments, but in the process, the people to lose out are those in the developing countries with declining food security as well as those in industrialised countries, such as the UK, through risky food and threats to the environment. This tendency for governments to give precedence to corporate interests, rather than people's rights, represents a challenge to democracy on a global scale.

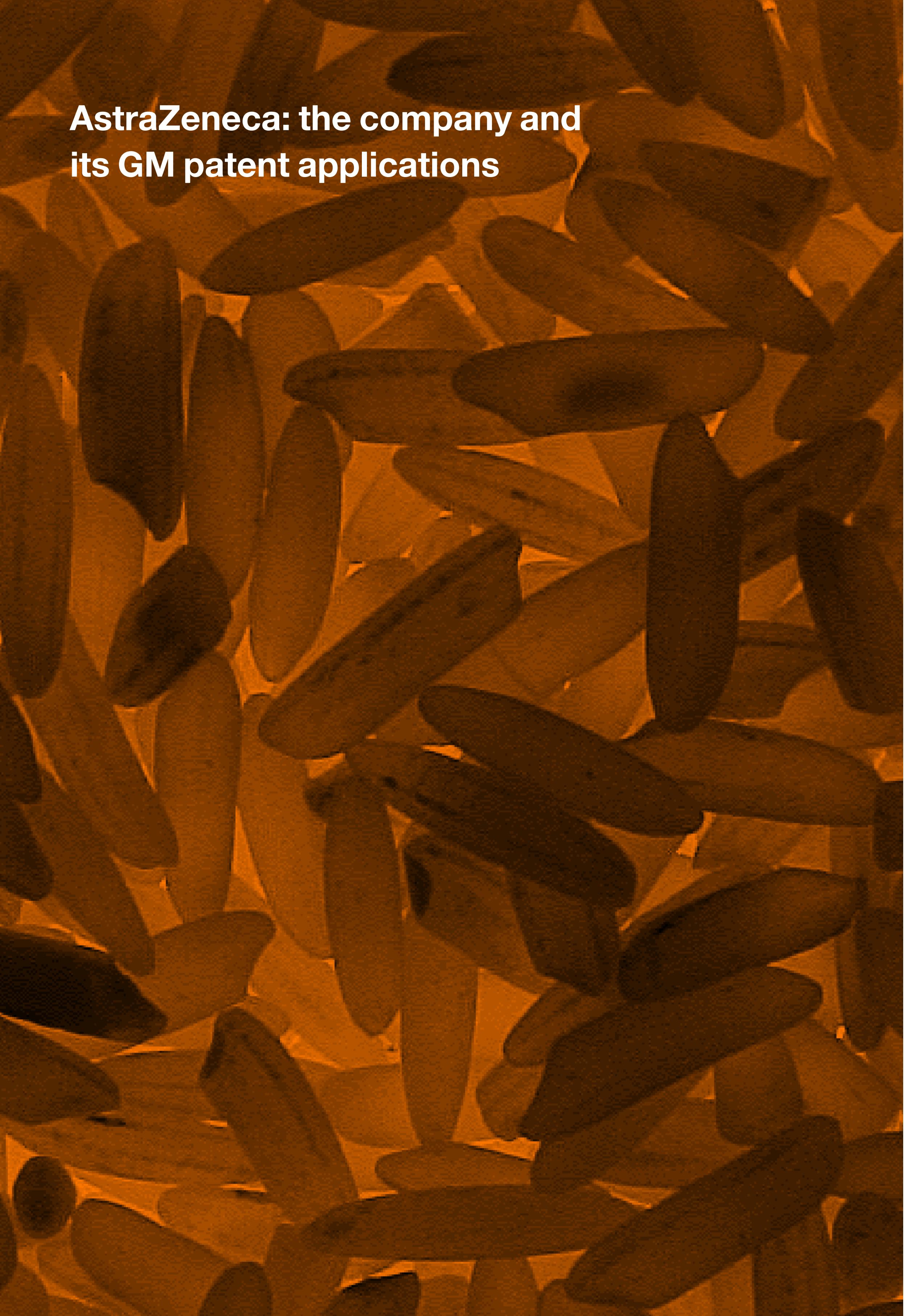
Countries still have a choice as to whether they accept patents on GM plants. The WTO is reviewing the plant related aspects of its Trade Related Intellectual Property Rights Agreement (TRIPs) this year. At the moment the TRIPs agreement allows countries to make their own legislation to protect plant varieties and to exclude plants, animals and biological processes from being patented, although it remains unclear whether genetically modified organisms (GMOs) can be excluded. Countries such as the US would like to increase patenting on plants and animals, and may lobby to include GMOs.

But much of the developing world perspective is different. The Organisation of African Unity suggests a legal recognition of community property rights as an alternative to patenting plant varieties and Intellectual Property Rights for food and agriculture. The majority of developing country governments are concerned that patenting of plant and animal genetic resources may be to their disadvantage. But they lack the financing to ensure they have adequate diplomatic and scientific representation at the WTO to demand a review of the legislative option.

The other major global agreement is the Convention on Biological Diversity (CBD) and its controversial Biosafety Protocol which governs the international movement of GMOs. Negotiations on the Protocol broke down early this year as the US and a few other nations opposed any rules which could restrict the unlimited spread of GM in agriculture.[28]

27 Dinham, B, 1999: *Zeneca: the impact of pesticides on food security. Hungry for Power*, U K Food Group, London. p56.
28 *Washington kills global pact to govern GM trade: The Guardian*, 23 February 1999.

AstraZeneca: the company and its GM patent applications



AstraZeneca: company profile

AstraZeneca was formed in 1999 in a merger between the Swedish pharmaceuticals company, Astra, and the British 'life sciences' company, Zeneca. With a market capitalisation of £53 billion,[29] it is one of the world's largest companies. According to sales figures, AstraZeneca is the third largest agrochemical company world-wide (behind Novartis and Monsanto). Currently ranked the fifth largest international seed company,[30] its aim is to be the largest.[31]

AstraZeneca's GM plant interest comes from Zeneca, the pharmaceuticals, agrochemicals and speciality products division, which split from the chemical giant ICI in 1993. Zeneca's research and development is undertaken by its Agrochemicals division. Zeneca predicts that GM crops will provide a market opportunity of $75 billion by 2020.[32]

In 1997, Zeneca spent £163 million on agrochemical research. By 1998 the company had trebled its investment in biotechnology research spending, from $20 million in 1997 to $60 million in 1998.[33]

Zeneca recently described itself as:

> "One of the leading companies in agricultural biotechnology. Key to the research strategy is the increasing integration of bioscience activities across agrochemicals and seeds. This integrated approach enables Zeneca to offer farmers improved crop quality and yield with better crop protection solutions."[34]

To achieve this integration, Zeneca began acquiring seed companies. In 1996 it entered into a joint partnership with Royal VanderHave, a Dutch company, to join VanderHave, Garst, ICI Seeds, Interstate Payco, Olds Seeds, Michigan State Seeds, Advanta Seed West, Shamrock Seed, Zenco, Mogen and Sharpes International under the group name, Advanta.[31]

Zeneca's GM focus is on maize, wheat, rice, banana, tomato, sunflower, oilseed rape and sugar beet.[35] Zeneca (in the form of Zeneca Research, Zeneca Mogen and Advanta) also has over 50 collaborations world-wide which include links with universities in Europe and North America and research institutes such as the John Innes Centre in the UK, and other companies such as Incyte and ExSeed.[36]

AstraZeneca's large and long-term interest in the markets of developing countries is built on its sales of agrochemicals. Zeneca's pesticides include the notorious paraquat (Gamoxone), the world's second largest agricultural product after glyphosate. Some countries, such as Germany, have introduced severe restrictions on its use.[31]

Other chemicals include diquat and glyphosate trimesium (Touchdown). Zeneca has pesticide manufacturing plants located in China, India, Indonesia, Thailand, Argentina, Brazil, Guatemala and Mexico, giving the company a global infrastructure on which to build its GM crop market.

AstraZeneca is developing alliances in GM crops in South East Asia and is expected to establish a joint venture with Japan Tobacco to develop GM rice, wheat, beans and maize at the end of 1999.[37]

Zeneca introduced the first GM food onto British supermarket shelves: paste made from 'Flavr Savr' tomatoes, genetically modified to soften more slowly and sold as 'own brand' by Safeway's and Sainsbury's, although Sainsbury's has now discontinued the line in its recent commitment to go GM-free.[38] AstraZeneca also hope to have delayed-ripening bananas available for the UK market by 2003.[39]

29 *AstraZeneca link gets strong investor backing: Financial Times* 7 April 1999.
30 Agrow No 311, 28 August 1998: RAFI Communique, July/August 1998.
31 Dinham, B, 1999: *Zeneca: the impact on food security. Hungry for Power*: U K Food Group, London.
32 Zeneca Agrochemicals presentation, 2–3 March 1999, London.
33 Reuters, 3 March 1999.
34 Zeneca Annual Report and Accounts 1995.
35 Zeneca Annual Report and Accounts 1998.
36 Zeneca Agrochemicals presentation, 2–3 March 1999, London.
37 *COMLINE Daily News Chemicals and Materials*: 5 April 1999: *Zeneca to link for newer variety of rice operations.*
38 *The Scotsman*, 18 March 1999: *Sainsbury's to join M&S in effort to supply GM free food.*
39 *Financial Times*, 18 Feb 1999: *Drug companies find food fears hard to swallow.*

AstraZeneca's patent portfolio

Now one of Britain's top multinational companies, AstraZeneca is also in the group of the 'top five' companies competing in the world's biotechnology race for food and farming. It has a significant share of the seed market, as well as a stake in the agricultural chemical market. It has trebled its biotechnology research budget.

Where does the company now go with its biotechnology? The developing world is the largest potential future market for the seed and agrochemical industry.

The company's patent applications give insights into its research interests in GM crops and foods.

In researching Zeneca's patent application portfolio, ActionAid undertook a patent search against 'Zeneca' under the category of 'Transgenic Plants' through the Derwent Biotechnology Abstracts service, which covers 42 countries. The timeline started in January 1993, when Zeneca split from ICI and continued to December 1998, before Zeneca's merger with Astra.

We searched World Patents and European Patents, using the European Patent Office's database. We found 52 Zeneca patent applications relating to GM crops, and this was the list of patents which ActionAid has used to evaluate AstraZeneca's research interests.

A list of the patent titles and numbers are given in the Appendix.

Table 1 outlines the type of processes for which AstraZeneca has patent applications. Various processes stand out: the use of chemical 'switches' to alter traits such as disease resistance and time of flowering, delayed ripening and altered composition. Also important are altered agricultural input traits such as herbicide, insect and disease resistance.

What is clear is that all of AstraZeneca's GM patent applications have potentially huge implications for the developing world.

Table 1

Summary of the patent applications made by Zeneca between 1993 and 1998 inclusive

Application	Number
Altered product characteristics	
i) modified composition	13
ii) delayed ripening	11
Plant characteristic control	
(Terminator and other applications)	7
Herbicide resistance	3
Insect resistance	4
Disease resistance	9
Gene sequences (promoters etc)	5
Total	**52**

Has Terminator been terminated?

To a seed company, farmer-saved seed means loss of potential profits. Finding new ways to ensure that farmers return to the company each year is a highly prized goal. One way of achieving this is through sterile seeds.

Enter the 'Terminator', which has been genetically engineered to make a plant's seed sterile. Sterility genes are either built into a plant, or 'switched' on or off by 'killer' genes such as 'Verminator' which uses genes from brown rats. Its use would make it impossible for farmers to save some of the harvested seed and use it for planting the next year.

All five companies developing GM crops and dominating the global seed market have applied for patents on their own Terminator technologies.[40] If these are approved and used, farmers may find they have little choice other than to buy Terminator seeds.

The Rural Advancement Foundation International (RAFI) has estimated that if Terminator technology is adopted, by 2010 (or sooner) it could form 80 per cent of the entire global commercial seed market, and be included in all GM crops,[41] with a sales value of $20 billion.

However, the potential threat to developing countries from Terminator technology has caused protests across the developing world. In India, farmers pulled up GM test crops. The crops were not Terminator test crops, but the farmers feared that the door to Terminator was opening: "These trials are paving the way for the entry of the Terminator gene, which would make it impossible to generate seeds for subsequent crops and would force growers to depend on patented Western technology every sowing season," said Mahanta Devaru Nanjundaswamy, a Bangalore-based farmer who turned to teaching law and is now a full-time proponent of farmers' rights.[42] The protests went to the heart of the Indian Government. Indian Agriculture Minister, Som Pal was forced to reassure the Upper House that "the interests of Indian farmers would be fully protected and it is our final view that it [Terminator seeds] would not be allowed in the country".[43]

Recognising the threat to seed saving and the frightening implications for food security, the Consultative Group on International Agricultural Research (CGIAR), the world's largest network of publicly-funded agricultural research centres, agreed in November 1998 that none of its 16 centres would develop "any genetic system designed to prevent germination".[44]

Zeneca backs off Terminator

The protests against Terminator technologies have jolted the corporate world.

Monsanto, through its recent acquisition, Delta Pine & Land, jointly owns one of only two patents granted on Terminator with the US Department of Agriculture. In April 1999, in response to the public outcry in many developing countries about the effects of Terminator, Monsanto announced:

> "Until a thorough, independent examination of gene protection systems has been conducted and all points of view considered, we will not attempt to commercialise these technologies."

Moving significantly further, AstraZeneca has now told ActionAid that the company will not commercialise its Terminator or Verminator technologies and "will not develop or commercialise technology which results in the sterility of …second generation seed, or as it is sometimes called, farmer-saved seed."[45]

40 RAFI Communique, January/February 1999 *Traitor Technology: The Terminator's wider implications.* Rural Advancement Fund International, Canada, <http://www.rafi.org/communique/flxt/1991.html>

41 Vandana Shiva: *The Guardian*, 17 February 1999.

42 *South China Morning Post*: 8 December, 1998, p13.

43 *Asia Pulse*: 3 December 1998.

44 *New Scientist*: 7 November 1998, *Fertile victory*, p5.

45 Personal communication from M P Pragnell, Chief Executive Officer of Zeneca, 5 May 1999.

Chemical control: playing God with plants?

Judging from its patent portfolio, one of AstraZeneca's major research interests has been in applying GM technologies to control plant behaviour and growth.

Seven of its patent applications involve the development of a system which uses a chemical to 'switch' on and off plant characteristics – using technology built upon Terminator.[46]

While AstraZeneca have committed not to commercialise these technologies to create sterility, the approach described in patent applications could still be used in plants to 'switch' on and off a multitude of other significant effects and facilitate hybrid seed production through male (pollen) sterility.

These effects include such characteristics as making a plant disease-resistant or changing its flowering time. The company has said, for example, that it proposes using the chemical technology to stop potatoes [see Figure 4] from sprouting,[47] to reduce storage space loss when they sprout in-store.

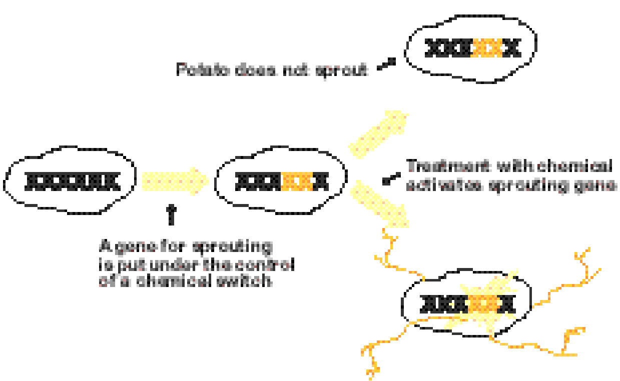
The essential feature of this system is that plants containing it have a gene-switch that is chemically controlled. The most common way in which AstraZeneca's patent applications describe the use of this switch is in a 'gene cascade'. When a chemical is applied to the seed or plant, this turns on a switch, resulting in another gene becoming either functional (eg making it disease-resistant) or non-functional (eg stopping the production of a toxin which inhibits pollen formation).

Increasing chemical use

In relying on the use of chemicals to be effective, some GM seeds must be soaked in chemicals before planting or sprayed on fields to trigger the desired characteristic (such as early flowering, disease or cold resistance, etc).

Most of the chemicals listed in AstraZeneca's patent applications are chlorinated or fluorinated which increases their environmental toxicity.[48] Not only would farmers using this system be tied into an expensive chemical dependence, they would also be exposed to more potentially harmful chemicals.

Figure 4
AstraZeneca's chemical gene switch process
Example: Potato sprouting
Source: Zeneca, Agrochemicals Presentation 2–3 March 1999



AstraZeneca has proposed using 20 chemical 'safeners' such as dichlormid in these systems. The company manufactures dichlormid[49] itself, so it would be able to tie together use of its seed with its own chemical.

AstraZeneca refers to the use of tetracycline as a 'trigger' in its systems. Tetracycline is an extremely important antibiotic in everyday use by doctors and veterinary surgeons to treat infection. There is already widespread antibiotic resistance in humans and animals. Using it in crops across the world could increase this resistance. Exposing soil to high antibiotic concentrations could also damage micro-organisms.

46 WO93/12239; WO94/03619; WO97/35983; US5,808,034; WO93/24639; WO94/11519; WO93/21334.
47 Zeneca Agrochemicals presentation, 2–3 March 1999, London.
48 RAFI Communique, January/February 1999 *Traitor Technology: The Terminator's wider implications.* Reference on chlorine and environmental impact. Rural Advancement Fund International, Canada, <http://www. rafi.org/communique/flxt/1991.html>.
49 Dichlormid (also known as dichloramid) works as a herbicide 'safener' by switching on the glutathione-S-transferase enzyme gene and increasing its output. This thereby increases the metabolism of herbicides such as thiocarbamate and other compounds which are detoxified by glutathione-S-transferase. *The Pesticides Manual*, 11th Edition 1997. British Crop Protection Council, Surrey.

Ecological impacts: damage to insects, loss of biodiversity

Another of AstraZeneca's patent applications is to link the chemical switch system to change a crop's flowering time[50] so that it produces seed or fruit earlier in the season. This could also alter the geographical range of crops.

While this may seem attractive to farmers who want to improve productivity and possibly achieve more than one season per year, it raises serious ecological and practical agricultural questions.

Insects depend on crop flowering as a source of food (nectar). Therefore, their habitat and breeding period is closely linked to flowering. Insects are also crucial to crop species for pollination. Altering a crop's flowering time could damage entire insect populations, and have knock-on effects throughout the food web. A crop could fail without an adequate supply of pollinating insects.

How will this technology affect developing countries?

AstraZeneca acknowledges that chemical switches are an important part of the company's future approach to GM crops.[51] An AstraZeneca representative has claimed that linking the benefits to a chemical switch "allows genes to lie dormant until needed [which] places less strain on crop plants".[52]

But where a chemical triggers a 'beneficial' effect, such as early flowering or disease resistance, whoever buys the seed will also have to buy the chemical to go with it.

This new technology affords unprecedented levels of control over seed behaviour and productivity to the manufacturer rather than the farmer. It also consolidates the widespread use of chemicals in conjunction with GM seeds.

This will increase costs for small farmers. The poorest are unlikely to be able to afford a functioning 'seed/chemical package'. Millions of small-scale farmers across the developing world would lose any potential benefits of GM crops.

Designer crops: foods for the affluent North?

AstraZeneca's patent application portfolio places great emphasis on modifying the composition and ripening of crops.[53] The target market for these alterations is not the developing world farmer, but appears rather to be the food processing industries of the developed world.

In this part of the portfolio, several applications could be amalgamated by the company so that a nutritional benefit such as increased vitamins could be combined with a process resulting in a fruit with prolonged shelf-life.

While some of these applications could open up new markets for farmers in the South, there is also a possible downside, depending on the demand from northern food importers. For example, they may insist that farmers in developing countries grow new 'long-life' varieties, thus pushing non-patented, local varieties out of the international market.

More dangerously, some developing countries may lose their entire northern export markets as the technologies lead to a product, such as coconut oil, being genetically engineered into a European or North American crop instead of being derived from its natural, southern source.

50 WO 93/1421.
51 Zeneca Agrochemicals presentation, 2–3 March 1999, London.
52 *Farmers Weekly*, 26 March 1999: *Beware! It's the terminator*.
53 Ripening: WO 93/07275; WO93/13212; WO 93/23551;WO94/21794; WO94/21803; WO 95/04152; WO95/10622; WO95/23227; WO97/21816; WO 98/11228. Altered composition: WO93/1421; WO93/05159; WO94/04693; WO94/09144; WO94/23027; WO95/29246; WO95/35026; WO96/02652; WO96/02650; WO97/07222; WO97/ 20936; WO98/11228; EP0654531.

Delayed ripening

AstraZeneca's patent applications include applying a technology to delay ripening in fruit.

Being able to store fruit and vegetables for longer, allowing them to be transported further, to look fresh longer, have a more attractive colour or be easier to make into pastes or purees, are commonly stated goals in AstraZeneca's patent applications in this area.

The company explains that increasing solid contents of tomatoes will be useful in making processed food products such as tomato paste or tomato soup.[54] Another application is to delay ripening in bananas, primarily to improve storage, transport and packaging.[55]

While slower ripening may be advantageous for developing country producers in terms of transport time, it will be the poorest farmers who cannot pay for expensive seeds or plants and who may lose their access to the international market. As slow-ripening crops become the norm, the international food industry may require these specific varieties in their contracts. Again, poor farmers are likely to lose out.

The European and North American food trade is already demanding that developing country farmers grow non-traditional crops, and there are numerous examples of farmers in developing countries doing just that.

World prices for non-traditional crops are higher than for traditional ones. Indeed, one of the fastest growth sectors has been horticulture products where northern demand has risen sharply.

Kenya, for example, in 1995, produced almost £10 million worth of fresh and chilled green beans for the UK market.[56] However, if farmers move into producing crops for the export market, there may be less food available for local people, thereby undermining their self-sufficiency.

Altered composition

Another of AstraZeneca's patent applications for 'designer' crops include changing the oil composition of crops, such as oilseed rape, or modifying the starch content of maize.[57]

The fatty acids in oilseed crops affect how the oil can be used in products such as soap and margarine. Soap manufacturers currently mix several different oils to get the desired composition. Having a crop genetically engineered to produce an oil with the right balance of fatty acids would ease production processes and lower costs.

But the oils which the GM crop may replace, such as palm and coconut oil, are enormously important to developing countries which produce and export them. For example, in 1987, developing countries' palm oil exports generated $1,789 million and coconut oil $534 million.[58]

The Philippines is currently the largest exporter of coconut oil. The crop provides direct or indirect employment for 21 million people, about 30 per cent of the country's population.[59] In Kerala, India, 10 million people depend on the coconut industry.[58]

This type of crop substitution is not a new problem for developing countries. The development of high fructose corn syrup as a sugar substitute in soft drinks such as Coke and Pepsi devastated Philippine sugar exports to the USA.

54 WO93/14212.
55 WO98/11228.
56 Madden, P & Orton, L , 1996, *The global supermarket*: Christian Aid, London, p9.
57 Eg WO96/02652 and WO95/29246
58 Shiva, V, 1998: *Betting on Biodiversity: Research Foundations for Science, Technology and Ecology*: New Delhi, p38–56.
59 Nottingham, S, 1998: *Eat Your Genes*: Zed Books, London.

The corn syrup is extracted from maize and is a third cheaper and 1.7 times sweeter than sugar. As a result, between 1980–87, Philippine sugar export earnings fell from $600 million to $50 million.[60] However the potential for rapid crop substitution through the use of biotechnology is unprecedented.

Nutritional quality

Using GM to improve the nutritional quality of foods is one area which might offer potential benefits to people with poor diets. In one patent application, a biochemical pathway of the melon is altered because this will be "particularly useful for modifying fruit and vegetable colour…".[61]

The invention also allows the levels of Vitamin A and other compounds to be increased or decreased which the application says may 'have a protective effect against certain diseases' (p 11). This is an example of a 'functional food' which gives a health benefit over and above that of eating the food itself. These are thought to be attractive to developers of GM crops who wish to target the health conscious markets of the affluent nations.[62]

It is conceivable that such products could improve the diets of people in developing countries. However, questions remain over whether a large, profit-driven company would make the financial effort to ensure these products are cheap and distributed well enough to reach the world's poor and hungry. The affluent niche markets of the North seem to be the more likely target.

Scorpion, wasp, spider and snail toxins: new generation insecticides?

Many current GM crops have been engineered to make plants resistant to insects by producing an insecticide. The biotechnology industry has promoted this technique as a significant way to reduce the use of chemical insecticides. But one concern, now widely accepted by industry, is that resistance to the insecticide plant could build up quickly in insects.[63]

There is considerable concern about the knock-on effects of using crops containing Bt toxin. Scientists have found lower survival and reproduction rates in some beneficial insects feeding on pests which have eaten the toxin from such a plant.[65] The same is true when ladybirds eat aphids fed on GM potatoes containing another insecticidal protein, a lectin from the snow drop.[66] The Bt toxins used were originally thought to harm only a narrow range of pest species.

There are already GM crops commercially available in both the US and Europe which contain an insecticide to protect a crop against insect attack. These contain a toxin from a bacterium, *Bacillus thuringensis* (Bt). AstraZeneca does not market any of these crops but its patent applications show it has a research interest in developing 'novel' insecticidal compounds to include in genetically modified crops and viruses.

These include patent applications for processes to engineer a toxin from a wasp, or the cone snail, from the venom of a deadly scorpion or the Australian funnel web spider into plants.[64] This would render the GM crop toxic and, therefore, infect and kill any insect which fed on it, or the virus.

The use of insect toxins in GM crops by AstraZeneca could also have knock-on effects on beneficial insects, threatening the food web. If a GM crop was

60 Hobbelink, H, 1991: *Biotechnology and the future of world agriculture*, p76.
61 WO96/02650.
62 Brower, V, 1998: *Nutraceuticals: poised for a healthy slice of the healthcare market? Nature Biotechnology* 16: p728–731.
63 Rissler, J & Melon, M, 1998: *Now or Never. Serious plans to save a natural pest control*: Union of Concerned Scientists, Cambridge, MA.
64 WO 96/16171;WO 95/11305; WO 94/23047; US 5,763,568
65 Hilbeck, A, Baumgartner, M, Fried, P M & Bigler, F, 1998: *Effects of transgenic* Bacillus thuringensis *corn-fed prey on mortality and development of immature Chrysoperla carnea* (Neuraptera: Chrysopidae)*: Environmental Entomology* 27: p480–487.
66 Birch, A N E, Geoghegan, I E, Majerus, M E N, Hackett, C & Allen, J, 1997: *Interactions between plant resistance genes, pest aphid populations and beneficial aphid populations*: Scottish Crop Research Institute Annual Report 1996–97, p68–71, SCRI, Dundee.

grown in an area where there were wild plants related to the GM crop, the toxin gene could be transferred. As a result, in the longer-term beneficial insects could be further harmed.

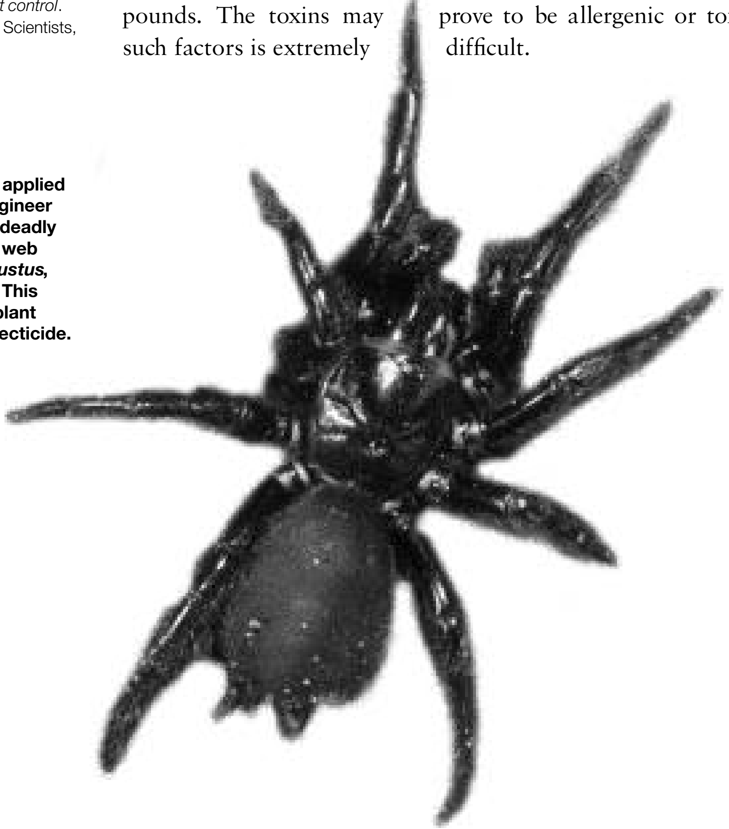
Clearly this has serious implications for the use of biological control systems, commonly used in developing countries as part of integrated pest management programmes.

The other concern of great importance to all farmers is the build up of insect resistance to toxins in GM crops.[67] If the emergence of resistance is rapid, farmers in developing countries could face crop failures and become dependent on companies producing GM crops – to help them stay one step ahead of the insects, by having a GM crop with the latest new insect-toxin plant.

AstraZeneca's patent applications, covering a variety of different toxins, suggest it has just such a series under research. There are major questions over whether this is ecologically, socially or economically sustainable.

Of course, the presence of scorpion, wasp, spider and snail toxins also raises doubts about the human safety of eating foods containing them. Although the toxins which have been selected in AstraZeneca's patents are not thought to be toxic to mammals, as with other GM crops, there may be unexpected effects, as we have no experience of eating such compounds. The toxins may prove to be allergenic or toxic. Testing for such factors is extremely difficult.

67 Mellon, M & Risler, J (eds), 1998: *Now or Never. Serious plans to save a natural pest control*. Union of Concerned Scientists, Cambridge, MA.



AstraZeneca has applied for a patent to engineer the venom of the deadly Australian funnel web spider (*Atrax robustus*, right) into plants. This would make the plant operate as an insecticide.

Multiple herbicide resistance: maintaining chemical sales?

One alarming patent application in AstraZeneca's portfolio[68] concerns multiple herbicide-resistant crops. Making crops resistant to one herbicide has already been heavily criticised.[69] The majority of the commercial GM crop grown today is herbicide resistant.

Whilst companies often claim these crops will reduce herbicide use, the reality is not that simple. Chemical companies have already commercialised GM crops which resist their own chemical herbicides, so these must be used with the crops in order to work. Companies can then sell a package of seed and chemical to maximise profits.

Two companies, Monsanto and AgrEvo, are already increasing production facilities of their glyphosate (Roundup) and glufosinate (Liberty) herbicides as their use increases, and they predict this to continue.[70] Whilst the companies claim these are safer than other herbicides, there are still considerable concerns about environmental and human safety.[71]

Two herbicides for one plant

Recently, AstraZeneca has negotiated an agreement with Monsanto to use its own version of glyphosate (Touchdown) with Monsanto's glyphosate-resistant (Roundup Ready) crops. AstraZeneca's patent application also suggests the company is working on the second generation of herbicide-resistant crops,[68] which are resistant to both herbicides. These include an array of different herbicides: the company's own brands such as paraquat (Gramoxone) and others. The patent applications describe how one herbicide could be used before the crop germinates, and the second after the crop emerges.

The patent application describes how the method can be applied to a crop already tolerant to one herbicide to make it tolerant to *three* different chemicals.

Company benefits?

As Monsanto has done with AstraZeneca over Touchdown and Roundup Ready crops, the development of these multiple herbicide-resistant crops will allow AstraZeneca to negotiate agreements with other chemical companies to license the technology.[72]

The development of GM crops resistant to more than one herbicide intensifies the problems of crops resistant to a single one. Weeds could acquire resistance to two herbicides at once; there would be even more pressure on biodiversity; and any seed lost at harvest could produce weeds with multiple herbicide-resistance. The UK Pesticides Trust considers this approach 'irresponsible and downright criminal'.[73]

AstraZeneca may also benefit from the work of other companies. Monsanto, which has Roundup Ready crops already commercialised, is working in developing countries, such as Thailand, with governments, extension workers and NGOs to encourage farmers to use their herbicide-tolerant crops and herbicide as part of no-tillage systems.[74] AstraZeneca's recent agreement with Monsanto over Touchdown means that once a developing country, such as Thailand, starts growing the Monsanto Roundup Ready crop, AstraZeneca's Touchdown market could also grow.

68 WO98/20144 (multiple herbicide resistance); WO93/11243 & WO93/24673 (single herbicide resistance).
69 See eg: *Why are environmental groups concerned about release of genetically modified organisms to the environment?*: A Green Alliance Briefing Document, Green Alliance, London, October 1994.
70 Monsanto Annual Report 1997: Agrow November 28 1997, p4–5, *Biotech success exceeds AgrEvo's hopes.*
71 Pesticides Trust, 1997: *Crops resistant to glutamine synthetase inhibitors*: Pesticides Trust, London.
72 COMLINE *Daily News Chemicals and Materials*, March 29, 1999: Zeneca–Monsanto agree on agchem business.
73 Personal Communication, Peter Beaumont, Director of the Pesticides Trust, London, UK.
74 Rissler, J & Mellon, M, 1993: *Perils amidst the promise. Ecological Risks of transgenic crops in a global market*. Union of Concerned Scientists: Cambridge MA.

The widespread concern expressed about the development of herbicide-resistant crops and their use in both the developed and developing world includes:[75]

- The possibility that the foreign herbicide tolerance gene may be transferred to related plants and thereby lead to the emergence of 'super weeds'.
- That the herbicide-resistant crop itself may become a troublesome weed if seeds are spread at harvest or in transport and emerge in the next season's crop.
- That neighbouring farmers' crops may be pollinated by the herbicide-resistant crop leading to genetic contamination and herbicide-resistant weed problems.
- The destruction of biodiversity through the increased use of broad-spectrum herbicides – all weeds will be killed, with knock-on effects for the food chain, including birds, as their food supplies are lost.
- Reduced productivity if herbicide-tolerant crops were to replace traditional varieties.[76]

Gene flow is of particular concern for developing countries because they are centres of biodiversity. Weedy relatives are often found in close proximity to crops. For example, there are 22 species of wild rice in Asia, Africa, Australia, Oceania and Latin America, many of which are important weeds and some of which have become more troublesome because of gene flow from cultivated rice.[77]

Moreover, the majority of today's crop species grown world-wide originated in the South. Given that it is these species which are being engineered, gene transfers to weedy relatives are more likely to occur in the developing world – than in Europe or North America.[78]

Implications for poor farmers

There are also implications for rural poverty and unemployment that a shift to increased herbicide use can bring. For example, using herbicides could lead to a decline in labour-intensive agricultural work, such as weeding, which is estimated to contribute 30 per cent by volume in developing country agriculture and assures a reliable income, mainly for women.[79]

Small farmers may be unable to afford the equipment needed to use herbicides. Rubber gloves, a face mask, rubber boots and plastic coverings can cost up to $250 – six months' disposable income for most Asian farmers.[80] In Africa it is mainly women who apply pesticides to fields but they are less informed about the hazards. Safety labels go unread and old containers are reused, sometimes leading to poisoning and death.[81]

Disease resistance: meeting farmers' needs in developing countries?

Disease resistance is one area of GM crop development that possibly offers the greatest benefits for farmers in developing countries. AstraZeneca has nine patent applications for disease resistance, focusing on fungal resistance.[82]

In this area, AstraZeneca's strategy is to develop GM fungal control systems in banana by 2003, potato and rice by 2005, wheat by 2008 and maize by 2010.[83]

However, as with alterations to the nutritional quality of foods, ensuring

75 *Genetically engineered herbicide resistant oilseed rape: Agricultural saviour or new form of pollution*: GeneWatch, Tideswell, Derbyshire. 1998.
76 Shiva, V, 1998: *Betting on Biodiversity*: Research Foundations for Science, Technology and Ecology, New Delhi. p38.
77 Rissler, J & Mellon, M, 1993: *Perils amidst the promise. Ecological Risks of transgenic crops in a global market*. Union of Concerned Scientists: Cambridge MA.
78 Cohen, M B, Jackson, M T, Lu B R, Morin, S R, Mortimer, A M, Pham, J L & Wade, L J, 1999. *Predicting the environmental impact of transgene outcrossing to wild and weedy rice in Asia*, 1999, BCPC Symposium Proceedings No 72: *Gene Flow and Agriculture: Relevance for Transgenic Crops*, p151–157, British Crop Protection Council, Surrey.
79 Seiler, A, 1995: *Biotechnology and third world countries: economic interests, technical options and socio-economic impact*: 45th Pugwash Conference on Science and World Affairs, Hiroshima, Japan, 23–29 July 1995.
80 *Focus on Food:* Supplement to *Pesticides News* No 33, p10, September 1996.
81 Sow, M, 1996: *African women and pesticides, growing food security*: Pesticides Trust, London, p53–54.
82 WO93/05153; WO93/04586; WP94/16076; WO94/11511; WO95/24486; WO95/18229; WO96/32488; WO97/21814; W97/21815.
83 Zeneca Agrochemicals Presentation 2–3 March 1999. London.

that the benefits reach the poorest people and provide a sustainable approach is the important question. The questions that need to be addressed include:

1 Whether gene transfer could lead to weeds with disease resistance, which then makes them more of a problem. For example, small differences in susceptibility to fungal disease strongly influence the distribution of skeleton weed, a serious weed in Australia.[84]
2 Whether resistance will emerge in the disease organisms. The anti-fungal approach described in AstraZeneca's patent applications is a method of using genes which produce a chemical already found in many plant species. In the same way that resistance emerges in chemical fungicides, resistance to the GM plant versions could arise.
3 Whether poor farmers will be able to afford such seed or gain the potential advantages if they are linked to chemical switches.

If GM crop disease resistance proved to be transitory, poor farmers could face sudden crop losses and, as with insect- and herbicide-resistant crops, may need to buy a new package from the company.

Is the GM crop the best and most sustainable solution for poor farmers? This type of assessment must be carried out before these technologies are adopted.

Gathering global control over staple food crops

The majority of AstraZeneca's patent applications which are published by the World Intellectual Property Organisation (WIPO) under the Patent Co-operation Treaty (PCT) seek monopoly rights in all, or almost all, of the 90 states which are party to the PCT [see Figure 5 overleaf]. Whilst the company may claim that it will not apply for patents in each particular country, the geographical scope of these claims indicates that AstraZeneca wishes to see its inventions protected world-wide.

AstraZeneca's patent applications portfolio suggests it aims to protect all food crops to which their technologies are applied world-wide, including in 30 developing countries. Significantly for poor farmers in these countries, its patent applications include GM versions of many staple foods they depend on. Rice, wheat, maize, sorghum, melons and bananas are some of the crops AstraZeneca is trying to patent.

For example, one of AstraZeneca's patent applications[85] covers all plants to which it is applied, regardless of species. It describes in the patent how the technology could be applied to "maize, wheat, and other small grain cereals, sunflower, oil seed rape, soybeans, tomato and other vegetables, sugar beet and ornamental foliage and flowering plants".

Another of AstraZeneca's patent applications[86] covers a large number of crop species, many of which are important in developing countries: "…field crops, cereals, fruit and vegetables such as: canola, sunflower, tobacco, sugarbeet, cotton, soya, maize, wheat, barley, rice, sorghum, tomatoes, mangoes, peaches, apples, pears, strawberries, bananas, melons, potatoes, carrots, lettuces, cabbages, onions".

If AstraZeneca takes up and develops these patents in the wide range of countries it has listed as possibilities, the company could determine who has access to which genes and which crops and at what cost.

The livelihoods of millions of small farmers world-wide could be threatened as they are exposed to increased corporate control, where profit, not food security, is the primary goal.

84 Burdon et al (1981) cited in Rissler, J & Mellon, M, 1993: *Perils amidst the promise. Ecological Risks of transgenic crops in a global market.* Union of Concerned Scientists, Cambridge MA.
85 WO94/03619.
86 WO93/21334.

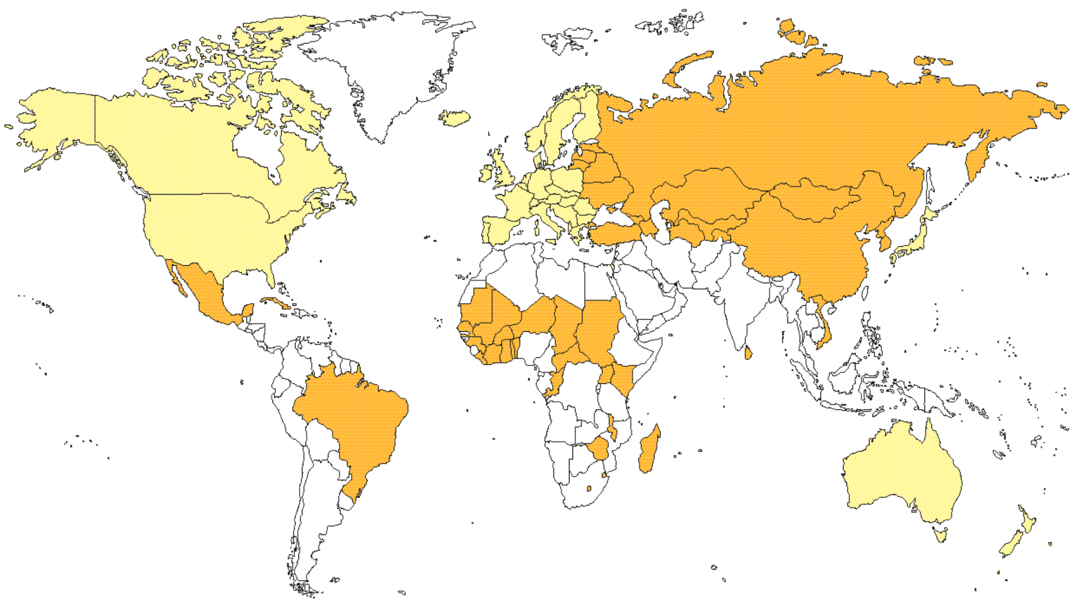
Figure 5

Countries AstraZeneca has listed in its patent applications for some or all of its GM crops

Albania	Armenia	Austria	Australia
Azerbaijan	Bosnia and Herzegovina	Barbados	Belgium
Burkina Faso	Bulgaria	Benin	Brazil
Belarus	Canada	Central African Republic	Congo
Switzerland	Côte D'Ivoire	Cameroon	China
Cuba	Czech Republic	Germany	Denmark
Estonia	Spain	Finland	France
Gabon	United Kingdom	Georgia	Ghana
Guinea	Greece	Hungary	Ireland
Israel	Iceland	Italy	Japan
Kenya	Kyrgyzstan	Democratic Peoples Republic of Korea	Republic of Korea
Kazakhstan	Saint Lucia	Liechtenstein	Sri Lanka
Liberia	Lesotho	Lithuania	Luxembourg
Latvia	Monaco	Republic of Moldova	Madagascar
The Former Yugoslav Republic of Macedonia	Mali	Malawi	Mexico
Mongolia	Mauritania	Niger	Netherlands
Norway	New Zealand	Singapore	Slovenia
Slovakia	Senegal	Swaziland	Chad
Togo	Tajikistan	Turkmenistan	Turkey
Trinidad and Tobago	Ukraine	Yugoslavia	Zimbabwe

Developing and least developed countries

Developed countries



Conclusions

The use and patenting of GM food and farming technologies in developing countries could have extremely serious economic implications. This is especially likely given the increasing concentration of international control within the genetic engineering, agrochemical and seeds industry.

The farmers who can afford to buy expensive GM seeds may then be tied into a cycle of chemical and financial dependence on large companies. The industry itself admits that GM seeds will be more expensive than hybrids.

They may no longer be able to save seeds or exchange them with their neighbours and may suffer from the impact of cross-pollination or other environmental effects which come with increased chemical use.

The worst-off are likely to be the poorest farmers, who may find themselves excluded from the technology because of its high costs, and so further marginalised from seed buying and the national and international markets. Erosion of seed saving and development by richer farmers and by the public sector may make affordable access to seeds more difficult. This may ultimately lead to the very poorest leaving farming altogether, exacerbating the shift to cities and increasing urban poverty.

Another casualty is likely to be agricultural and plant biodiversity as the millions of farmers in developing countries increasingly use fewer and fewer types of seeds, as multinational corporations continue the gradual takeover of southern agricultural systems.

AstraZeneca

It is clear from AstraZeneca's patent applications that they are designed to establish monopoly rights to a wide variety of genes, cells and plants for potential use across the world.

The company claims rights to patent its applications on almost any species of crop, including the staple crops of developing countries.

With the notable and welcome exception of its recent announcement on seed sterility or Terminator systems, it therefore has to be assumed that AstraZeneca is keeping its options open with an intention to apply, market, and control its GM technologies globally, including the 30 developing countries listed in its applications.

In a world of globalisation, the corporate sector, especially in a strategically sensitive and vital sector such as food and agriculture, has a responsibility to society to ensure it operates in a transparent and ethical manner.

AstraZeneca, as the new British gene giant, has the potential to take a more enlightened approach to the future development of biotechnology in agriculture than either its peers or its research portfolio suggest to date. Confirming that it will not commercialise Terminator technology is an important step, but there is a long way to go.

There is little in the company's research portfolio to suggest that its GM crop research is focused on helping to increase world food supplies in ways which will help the poor access more food.

Recommendation 1

AstraZeneca is beginning a new corporate life. Its staff and shareholders have a chance to look anew at its research portfolio in genetic engineering for food and

farming. AstraZeneca must adopt global food security as a dimension of its international business ethic and practice.

Terminator technology is not the only threat to seed saving. The whole cycle of chemical dependence and patented GM seeds work against the culture of seed saving. Before it develops these and future patent applications any further, AstraZeneca should undertake a socio-economic and environmental assessment of the impact of the agricultural use of its GM technologies on poor people.

There may be many as yet undiscovered problems associated with GM crops. Given the speed of the technology advance today, and the lack of long-term testing before a GM crop is exposed to the environment, damage is a distinct possibility. AstraZeneca must be prepared to pay the full cost of any damage caused by a GM plant system.

By doing this and by supporting the intergovernmental and governmental processes necessary to ensure a precautionary legal framework for GM food and crops, AstraZeneca may be able to go some way towards alleviating the growing problem of public and regulatory acceptance of GM world-wide.

Governments and international institutions

Research has shown there is a very low public confidence in the regulatory process on genetic engineering in the UK. Governments in all countries have a critical role to play in this key policy area – creating a stringent regulatory framework, which is precautionary, based on independent and publicly-funded science and open to public debate and scrutiny.

Aspects of that framework must be international in scope and should be capable of exerting some control over the behaviour of transnational companies, especially when there is legitimate concern over excess consolidation of power by a small number of large companies.

A biosafety protocol to the convention on biological diversity

While AstraZeneca's patent applications indicate a potential for the use of the technology in countries listed, international rules to govern the actual shipments of these and other GM plants and seeds are not yet in place. The lack of agreement on a Biosafety Protocol to the Convention on Biodiversity was partly because developing countries were extremely concerned by the threat GM technologies may pose to the livelihoods of their farmers and so were unwilling to agree to a weak protocol.

Recommendation 2

Governments must agree, with urgency, a Biosafety Protocol to the Convention on Biological Diversity to regulate international movements of GMOs. The Protocol must cover, at minimum, the GM crops currently in the ground, along with all future crops. It must allow for government authorities to be able to make informed decisions on the entry of GMOs into their country and to refuse them on the basis of environmental, health or socio-economic concerns. It must also include full provisions for liability in case of damage caused by the release of GMOs to the environment.

The World Trade Organisation

This year sees the important review of the WTO's TRIPs provisions. There is a grave danger that developing countries will not have the scientific nor diplomatic capacity to properly negotiate an equitable review. Pitted against the might of the industrialised countries, they stand to lose the most.

This important review, coupled with the Biosafety Protocol and national legislation, could hold the key to whether a developing country has the right to promote sustainable agricultural systems and livelihoods. The economic effects of strong Intellectual Property Rights such as patents are far from simple, clear or well understood.

Recommendation 3

The review of the clauses in the WTO's TRIPs provisions which deal with the patenting of life, should enable countries to prioritise the sustainable development of their biodiversity resources for food and farming and protect and promote farmers' rights and equitable sharing of benefits.

The 1999 review of article 27.3(b) of the TRIPs agreement at the WTO should offer developing countries the option to widen exclusions from intellectual property protection to all biodiversity-related products and processes that affect food and farming.

Capacity building for developing countries

If biotechnology is to continue its expansion, then developing country governments must be supported in planning for and adapting to the potentially massive change that it would bring to their agriculture systems.

In particular, they need the capacity to carry out detailed socio-economic studies to decide whether a GMO release into their agricultural systems will have unacceptable socio-economic or environmental impacts.

It is fundamental that these countries have the ability to ensure that their poor are not marginalised further by the use of biotechnology.

Implementation of national plant variety protection legislation to protect farmers' rights to save seed is also of particular importance in protecting the efforts of the poor to feed themselves and conserve their resources.

Finally, one of the most important ways in which poor people can be supported in their efforts to conserve their resources and feed themselves is through the strengthening of public-sector control over national plant breeding and seed provision. This should build on successful community seed breeding and exchange programmes and focus on the need to benefit the small-scale farmer operating in many different soil situations.

Recommendation 4

With the advent of genetic engineering in farming, international financial institutions and northern governments must be prepared to increase aid to the developing world in order to:

- **help fund adequate risk assessment for the use of GMOs**
- **help fund and build institutional expertise to develop appropriate regulatory frameworks**
- **carry out socio-economic and environmental risk assessments for GMOs use in agriculture**

- **help develop sustainable local seed supply systems that build on successful community seed breeding and exchange programmes**
- **help meet the needs of small-scale farmers in a range of ecological conditions essential to support food security in developing countries**
- **increase priority of funding research into sustainable tried and tested agriculture techniques to help feed the hungry.**

Governments and institutional donors should therefore promote a policy framework that promotes public-sector interests in national plant breeding and seed provision, including appropriate seed legislation and specific policy-making bodies, such as national and regional seed boards, embodying the precautionary approach to the use of novel technologies.

Pause for thought

Clearly many of these governmental and intergovernmental measures will require significant resources and will take considerable time to put in place.

Recommendation 5

ActionAid calls for a five-year suspension of commercial releases and international shipments of GM food and crops and of patents and patent applications related to genetic resources for food and farming. ActionAid calls on AstraZeneca to take an industry lead in supporting this approach.

This period of time would give both the governments and public in developing countries and elsewhere the opportunity needed to make well-informed decisions about the potential role of genetic engineering in food and farming.

Appendix

Biotechnology Patents held by AstraZeneca
AstraZeneca Ltd
15 Stanhope Gate
London W1Y 6LN

US 5,808,034 Plant gene construct comprising male flower specific promotors.
WO 94/03619 Improved Plant Germplasm.
WO 98/39454 Methods for modulating the biomass of plants .
WO 98/20144 Herbicide resistant plants.
WO 98/11228 Modulation of ripening or tissue senescence in bananas.
WO 97/38106 Gene Promoter sequence from bananas.
WO 97/21815 Antifungal proteins.
WO 97/21814 Antifungal proteins.
WO 97/21816 Strawberry fruit-ripening DNA.
WO 97/20936 Modification of starch synthesis in plants.
WO 97/07222 Plant gene encoding acetyl coenzyme A carboxylase carrier protein.
WO 97/35983 Cysteine protease promoter from oilseed rape and a method for the containment of plant germplasm.
WO 96/32488 S-adenosyl-L-homocystein hydrolyse promoter.
WO 96/02652 Beta-ketoacyl ACP reductase genes from Brassica napus.
WO 96/16171 Toxins from the wasp *Bracon hebetor.*
WO 96/02650 New isolated DNA encoding melon phytoene-synthase.
WO 95/29246 Plant gene specifying acetyl coenzyme A carboxylase and transformed plants containing same.
WO 95/24486 Antimicrobial proteins from *aralia* and *impatiens*.
WO 95/23227 DNA encoding a pectin esterase, cells and plants derived therefrom.
WO 95/18229 Antimicrobial proteins.
WO 95/11305 Insecticidal proteins.
WO 95/10622 Modified fruit containing galactanase transgene.
WO 95/04152 Tomato ripening TOM41 compositions and methods of use.
WO 95/35026 Novel plants and processes for obtaining them.
WO 94/28180 Fruit with modified NADP-linked malic enzyme activity.
WO 94/23047 Cone snail toxins inserted as insecticide in transgenic plants.
WO 94/23027 Plant gene specifying acetyl coenzyme A carboxylase and transformed plants containing same.
WO 94/21803 Fruit ripening-related tomato DNA, DNA constructs, cells and plants derived therefrom.
WO 94/21794 DNA, DNA constructs, cells and plants derived therefrom.
WO 94/11519 Production of polyhydroxyal-kanote in plants.
WO 94/11511 Biocidal chitin binding proteins.
WO 94/09144 Novel plants and processes for obtaining them.
WO 94/04693 Novel plants and processes for obtaining them.
WO 94/16076 Antimicrobial-protein-producing endosymbiotic microorganism
WO 93/11243 Maize acetyl CoA carboxylase encoding DNA clones.
WO 93/12239 Alteration of plant and plant cell characteristics.
WO 93/24639 Expression of genes in transgenic plants.
WO 93/24638 Expression of genes in transgenic plants.
WO 93/24637 Herbicide resistant plants.
WO 93/23551 Co-ordinated inhibition of plant gene expression.
WO 93/21334 DNA constructs and plants incorporating them.
WO 93/1421 Transgenic plants with increased solids content.
WO 93/13212 DNA, DNA constructs, cells and plants derived therefrom.
WO 93/07275 DNA, DNA constructs, cells and plants derived therefrom.
WO 93/05159 Modification of lignin synthesis in plants.
WO 93/05153 Biocidal proteins.
WO 93/04586 Biocidal proteins.
WO 93/02194 Production of polyalkanoate.
US 5,763,568 Insecticidal toxins derived from funnel web (*Atrax* or *hadronyche*) spiders.
EP 0820517 S-adenosyl-l-homocystein hydrolyse promoter.
EP 0804586 Beta-ketoacyl reductase genes from *Brassica napus.*
EP 0654531 ADP glucose-pyrophosphorylase.

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