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GENETIC ENGINEERING: A Review of Developments in 1998

GeneWatch

Briefing Number 5
January 1999

1998 has been a year of conflict over genetically engineered (GE) crops and foods in Europe and especially the UK. There has been mounting public opposition to the use of GE ingredients in food which has been met with mixed responses from food producers and retailers, the biotechnology industry and politicians.

In the broader field of gene technology and its use in medicine, debates have included the ethical implications of cloning, the use of animals to provide organs for transplantation, and to what extent human behaviour is determined by our genes.

This briefing reviews the major developments in the science, regulations and politics of gene technology during 1998 and considers their implications.

Genetically Engineered Organisms Authorised For Marketing In Europe

During 1998, six GE products have been given authorisation for marketing in the European Union (see Table 1), bringing the total since 1992 to eighteen (see Table 2). Only the GE carnations have received the unanimous approval of Member States. All other marketing applications have been disputed, and almost all of the food crop approvals are subject to bans under Article 16 of the Deliberate Release Directive in some Member States or are subject to legal challenge.

Table 1: GE Products Approved for European Marketing under the Deliberate Release Directive 90/220/EEC during 1998 (in chronological order)

Product	Purpose/Target	Company	Approval Restrictions	Approval Date
Oilseed rape	Herbicide resistance	AgrEvo	Importation	22.04.98
	Banned by France and Greece			
Maize	Herbicide resistance	AgrEvo	Growing	22.04.98
	Subject to legal challenge in France			
Maize	Insect resistance	Monsanto	Importation for animal feed and human food uses	22.04.98
	Subject to legal challenge in France			
Maize	Herbicide and insect resistance	Novartis (formerly Northrup King)	Importation for animal feed and human food uses	22.04.98
Carnation	Improved vase life	Florigene	Cut flowers and plants	20.10.98
Carnation	Modified flower colour	Florigene	Cut flowers and plants	20.10.98

Table 2: GE Products Approved for European Marketing under the Deliberate Release Directive 90/220/EEC to 31st December 1997 (in chronological order)

Product	Purpose/Target	Company	Approval Restrictions	Approval Date
Vaccine against Aujeszky's disease	Pigs	Vernie Veterinõr Chemie GmbH	According to veterinary product licences	18.12.92
Vaccine against rabies	Foxes	Rhone-Murieux	Hand or aerial dropping twice annually	19.10.93
Tobacco	Herbicide tolerance	SEITA	Growing and use by tobacco industry	08.06.94
	Reported not to be in use			
Vaccine against Aujeszky's disease	Pigs	Vernie Veterinõr Chemie GmbH	According to veterinary product licences	18.07.94
Oilseed rape	Herbicide tolerance and hybrid production	Plant Genetic Systems	Seed production only	06.02.96
	Banned in France			
Soybeans	Herbicide tolerance	Monsanto	Importation for food and feed	03.04.96
	Mixed with conventional soybean and derivatives found in large number of processed foods and animal feed			
Male sterile chicory	Herbicide tolerance	Bejo-Zaden BV	Growing for breeding purposes only	20.05.96
	Reported not to be in commercial use yet			
Maize	Herbicide tolerance and insect resistance	Ciba Geigy (now Novartis)	Growing, animal feed and food use	23.01.97
	Grown commercially in France, Spain and Germany in 1998. Banned by Austria and Luxembourg. Authorisation now provisionally withdrawn in France following legal challenge and questions asked of European Court of Justice			
Oilseed rape (2 varieties)	Herbicide tolerance and hybrid production	Plant Genetic Systems	Growing	06.06.97
	Still awaiting final authorisation by France			
Test kit to detect antibiotic residues in milk	Milk quality testing	Valio Oy	Use in test kit only	14.07.97
Carnation	Modified flower colour	Florigene	Cut flowers and plants	01.12.97

Monsanto's PR Campaign Fiasco

June 1998: Monsanto launches £1 million, 3 month advertising campaign to "*encourage a positive understanding of food biotechnology*"[47].

June 1998: GeneWatch makes formal complaint to Advertising Standards Authority (ASA) that the first two advertisements in the series are "*dishonest and untruthful*"[48]. By the end of the series of advertisements, the ASA had received nearly 100 complaints. The ASA has not yet published its draft report which is taking longer than usual "*due to problems finding a consultant with the necessary knowledge and independence*".[49]

July 1998: Ann Foster of Monsanto said that since the launch of the adverts, their hotline had taken over 2,700 calls. Despite opinion poll evidence that the majority of people in the UK do not welcome GE foods, she added that "*we were not prepared for the hostility, some calls were pure vitriol*"[50].

September 1998: Monsanto claim they have always supported labelling and segregation of GE foods and crops[51]. GeneWatch research reveals that in 1996 Monsanto argued that segregation of GE soybeans was impractical and unnecessary[52] and that there was no need for special labelling[53]. This was at the time the precedent for mixing GE and conventional crops was established.

September 1998: Monsanto have to issue apology to Ben Gill, President of the National Farmers' Union, for using an out-of-context quote in their advertising campaign without permission. Ben Gill is quoted as saying "*I had no prior knowledge that they were going to use statements in such a bald way without first checking with me*"[54].

October 1998: One senior industry figure accuses Monsanto of "*arrogant stupidity*". Another said, "*We're as fed up as some others with the Yankee-Doodle language that comes to our consumers*".[55]

November 1998: Leaked Monsanto public opinion research shows "*an on-going collapse of public support for biotechnology and GM foods*" and that "*The Monsanto advertising campaign ….. was, for the most part, overwhelmed by the society-wide collapse of support for genetic engineering in foods.*"[56]

December 1998: UK Government announces it is to prosecute Monsanto for failing to observe safety conditions during experimental trials with GE oilseed rape.

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technique that was used to produce Dolly but shops short of the creation of an individual. It could be developed to grow new tissues or organs.

December 1998: Roslin BioMed began negotiations with the Roslin Institute to use the Dolly cloning technology with human cells[45].

December 1998: Iceland Government passed a bill which allows a private company, deCode Genetics, to have access to the medical database of the Icelandic people for use in genetic studies.

The world's food production is rapidly coming under the control of a handful of ever-expanding multinationals.

December 1998: Korean scientists claimed to have cloned the first human embryo although it is disputed by scientists in the UK[46].

Conclusions

1998 has seen further concentration of the genetic engineering industry into ever fewer hands. Monsanto has continued to acquire seed and other companies, although the failure of its merger with American Home Products has slowed down its buying spree. However, other companies have maintained their impetus in the race for control. Hoechst and Rhone Poulenc announced the merger of their "life sciences" interests into a new company, Aventis, and - in the largest ever European merger - Zeneca merged with the Swedish company Astra Pharmaceuticals. The world's food production is rapidly coming under the control of a handful of ever-expanding multinationals with disturbing implications for future food security.

Developments in genetic engineering and other genetic technologies during 1998 continue to raise many questions and concerns over the potential impacts on the environment, human and animal health, and agricultural practices. They have also raised serious ethical issues, not least in the area of cloning. Despite considerable public opposition, there has still been a seemingly inexorable progression towards designer foods and crops and cloned animals. This in itself casts grave doubts over the adequacy of our systems of governance in Europe, and disputes over safety and patenting suggest that an overhaul of regulatory mechanisms is urgently needed.

An overhaul of regulatory mechanisms is urgently needed.

Research in 1998 has demonstrated that many questions remain over the risks associated with GE crops and foods. Whether such risks can be justified is particularly doubtful in the more trivial cases of non-floppy lettuces, non-fattening potatoes and perfect Christmas trees. But even apparently beneficial developments such as disease resistance in crops may bring hidden problems - problems which would be much less likely to occur if safer, alternative methods could be developed to achieve the same goal. There has been little support for investigating such alternatives, however, and the European Union and other governments have been far more inclined towards uncritical acceptance of the GE industry's spurious claims for job creation and competitiveness. This does not reflect public opinion and therefore represents a subversion of the democratic process. The debate must be widened to take account of public opinion before it is too late.

Positions Of European Countries

During 1998, there has been considerable dispute between Member States in Europe about the safety of GE crops and foods. Products approved as 'safe' have subsequently been banned in some countries and others have taken steps to try and slow the introduction of the technology. Box 1 outlines what actions have been taken by various EU countries.

Products approved as 'safe' have subsequently been banned in some countries.

BOX 1: European Governments' Responses to Concerns about GE Crops and Foods

Austria – banned (using Article 16 of the Deliberate Release Directive) the commercial growing or other uses of Novartis's insect and herbicide resistant maize because of concerns about the presence of an antibiotic resistance gene, the potential for resistant strains of insect to emerge, and the potential for harmful effects arising from the use of herbicide resistant crops.

Denmark – has followed the UK's approach of slowing down the introduction of the technology.

France – introduced a two year moratorium on the commercial cultivation of GE oilseed rape and sugar beet. They are holding up final European approval of two of Plant Genetic Systems' herbicide resistant oilseed rape varieties and have banned the two other varieties of GE oilseed rape which had already been given approval for importation and seed production. Following a legal case brought by Greenpeace and others, the French Supreme Court has provisionally withdrawn approval for Novartis's insect resistant maize and is consulting the European Court of Justice. Cases are pending on other maize varieties given European approval for marketing.

Greece – banned the import of an AgrEvo herbicide resistant oilseed rape.

Italy – joined the Netherlands in opposing the European Patenting Directive.

Luxembourg – like Austria, has banned the commercial use of Novartis's insect resistant maize.

The Netherlands – is opposing the European Directive on patenting biotechnological inventions (98/44/EEC) at the European Court of Justice.

UK – announced a 'managed' and monitored introduction of herbicide resistant oilseed rape which is expected to involve farm scale trials on approximately 50 farms. Industry announced a voluntary ban on the introduction of insect resistant crops for three years.

Research On The Effects Of Genetic Engineering

In 1998, there has been some significant research published which suggests we should be cautious with GE organisms, especially with regard to the potential for environmental impacts. There have also been controversial claims about the impact of GE foods on human health and concerns about the effects of using organs from GE animals for transplantation to humans:

Research suggests we should be especially cautious with regard to the environmental impacts of GE organisms.

March 1998: UK research showed that when viral genes are used in a GE crop to control other genes (such as those coding for functions like herbicide resistance), if the crop is infected by the virus the function of the genes can be switched off[1]. The result could be unexpected crop failure if such situations arise in the field.

April 1998: Professor Robin Weiss of the Institute of Cancer Research warned that at least two pig viruses can replicate in human tissue. This raises concerns about the possible transfer of disease if a humanised, genetically engineered pig is used as an organ donor. *"We cannot say it is impossible and the outcome could be devastating*" he is reported as saying[2].

April 1998: Swiss research indicated that the toxin in insect resistant crops can have harmful effects on beneficial species that feed on pests which have ingested

the toxin[3]. Lacewing larvae fed on insects which had eaten the Bt toxin had reduced fertility and increased mortality.

August 1998: In a *World in Action* programme, Professor Putzai of the Rowett Research Institute claimed that GE potatoes containing a lectin gene from the snowdrop damaged the immune system of rats. A few days after the programme was broadcast, Professor Putzai was sacked because he was alleged to have presented the wrong data. An independent review of the research later concluded (with typical British optimism in cases of scientific uncertainty) that there was so much variability in the results that it was not possible to say that the GE potatoes had harmful effects on the immune system and so could not be said to be unsafe.

August 1998: Newspaper articles claimed that research at the Institute of Arable Crops near Cambridge showed that Monsanto's GE herbicide resistant oilseed rape is good for wildlife because more weeds can be left for insects to survive on. Follow-up investigation by GeneWatch determined that the data had not been analysed and the studies had not been designed to measure insect diversity in a scientific manner[4].

77% want a ban on the growing of GE crops until their impacts have been more fully assessed.

September 1998: A report increased concerns over the potential for genetic pollution of native plants if they are fertilised by GE oilseed rape. Scientists from Ohio State University reported that hybrid plants formed from crosses between GE herbicide resistant oilseed rape and related wild plants can be fertile and reproduce normally[5].

September 1998: Research published in the magazine *Nature* showed that genetic engineering could cause unexpected and unpredicted effects in the host plant. When comparing an experimental GE herbicide tolerant plant (*Arabidopsis thaliana)* with one derived by conventional breeding, the GE plant had an outcrossing rate about 20 times higher than the non-GE plant[6].

October 1998: British ecologists warned that GE virus resistant crops may have a down side. New viruses could be formed if the introduced genes in the crop recombine with those of infecting viruses. Additionally, if virus resistance genes are transferred to crop relatives, they may be able to spread and become problem weeds or alter natural communities[7].

1998 Opinion Poll Results in the UK

June 1998: GeneWatch/MORI poll[8]

- 77% want a ban on the growing of GE crops until their impacts have been more fully assessed.
- 73% are concerned that GE crops could interbreed with natural, wild plants and cause genetic pollution.
- 61% do not want to eat GE foods (an 8% increase since a similar MORI poll was conducted in December 1996).
- 58% oppose the use of genetic engineering in the development of food (a 7% increase on 1996).

June 1998: Guardian/ICM poll[9]

- 50% not very/not at all happy about the introduction of GE food.
- 85% think GE crops should be kept separate.
- 96% think that GE foods should be clearly labelled.
- 95% think ingredients derived from GE foods should be labelled

October 1998: Friends of the Earth/NOP poll[10]

- 58% of supermarket customers believe supermarkets should stop selling GE foods.

May 1998: The world's largest charity, The Wellcome Trust, announced a £110 million investment in research to unravel the human genetic code partly because it was "*concerned that commercial entities might file opportunistic patents on DNA sequences*"[30].

June 1998: The UK Government gave a grant of £600,000 to PPL Therapeutics to develop its cloning techniques[31]. It was also revealed that the DTI is spending almost £3 million a year on cloning work, mainly at the Roslin Institute[32].

The DTI is spending almost £3 million a year on cloning work.

July 1998: Scientists in Hawaii and Japan cloned cows and mice from adult cells. Several generations of mice were produced from a single adult female.

July 1998: Patent battle loomed between the Roslin Instiute and the University of Hawaii over who will have the lucrative patent rights to cloning technology[33].

August 1998: PPL Therapeutics announced their intention to clone a flock of 4,000 sheep in New Zealand to produce human pharmaceuticals in their milk[34].

August 1998: An American citizen paid a laboratory $5 million to develop a method of cloning his dog 'Missy' within two years[35].

September 1998: Roslin Institute applied for Dolly the cloned sheep to be a trademark[36].

October 1998: American scientist, French Anderson, said he wanted to conduct gene therapy experiments on aborted foetuses. Critics fear this would open the way to 'designer babies'[37].

November 1998: Japanese studies showed an unexplained elevated death rate among cloned calves. Eight of fifteen cloned calves died within three days of birth[38].

November 1998: A scientist in the USA announced a breakthrough which could allow replacement organs to be grown in the laboratory from embryo cells[39]. Dr Austin Smith, a scientist from Edinburgh University, proposed the development of a national bank of cloned embryos – one for every person – to supply replacement tissues during life[40].

November 1998: Having had their own ovaries replaced with ovarian tissue from an elephant, mice produced elephant eggs to increase the numbers of an endangered species[41].

November 1998: 'Hairy' mice were developed through genetic engineering with the intention of finding a 'cure' for baldness in men[42].

Research shows there is widespread public concern about cloning and no support for its use in humans.

December 1998: Japanese Scientists at Nara Institute of Science announced a more efficient cloning method – eight calves from one cow, but four died at or soon after birth.

December 1998: The Wellcome Trust published the result of research showing there is widespread public concern about cloning and no support for its use in humans[43].

December 1998: UK Government advisors said that cloning of complete humans should be banned. However, they left the door ajar by recommending that experiments using 'cell nucleus replacement' with human cells up to the 14 day embryo stage should be allowed for medical research and could start within a year of the appropriate legislation being passed[44]. Cell nucleus replacement is the same

engineering to Christmas trees to produce the perfect tree - greener, bushier and slower to shed its needles.

Commercial Cultivation of Genetically Engineered Crops Worldwide

Since 1996, when 2 million hectares of GE crops were grown commercially worldwide, there has been a massive increase, particularly in North and South America (see table below). Of the 28 million hectares of GE crops planted worldwide in 1998, 71% (19.8 million) were herbicide resistant and 27% (7.7 million)[26] were insect resistant.

The estimated area of land sown commercially with GE crops worldwide (excluding China) in millions of hectares:

COUNTRY	1997	1998
USA	8.1	20.5
Canada	1.3	2.8
Argentina	1.4	4.3
Australia	0.1	0.1
Mexico	<0.1	0.1
Spain	0	0.015
France	0	0.001
South Africa	0	<0.1
TOTALS	**12**	**28**

Commercial interest in cloned animals, spare parts and gene therapy is growing and the fight for control is well under way.

Cloning And Related Developments In Gene Technology

The pace of developments in both animal and human genetic technologies increased rapidly in 1998. Because the profit potential is enormous, commercial interest in cloned animals, spare parts and gene therapy is growing and the fight for control is well under way. Despite public concern over cloning, the UK Government continues to invest heavily in the technology and its advisors propose leaving the door open for cloning in the future.

Some of the major developments in these areas are listed below:

February 1997: Spurred on by the desire to produce genetically engineered sheep more quickly - and thus more economically - scientists at the Roslin Institute in Scotland produced Dolly the sheep, the first animal cloned from an adult cell.

January 1998: Charlie and George born – calves cloned from foetal cells by Advanced Cell Technology in the USA. Closely followed in February by Mr Jefferson, a cloned calf born to PPL Therapeutics, a company close to the Roslin Institute that produced Dolly[27].

January 1998: Human veins grown in the laboratory[28].

April 1998: Competition in the organ transplant market intensified. The Roslin Institute formed a new company, Roslin BioMed, to commercialise cloning and develop organ transplant potential. PPL Therapeutics had hoped to license the cloning technique for use on pigs to supply 'humanised' organs for transplant (human genes are transferred into the pigs so that pig organs would be less likely to be rejected by the human immune system) and corner the market but now face new competition[29].

May 1998: Molly and Polly were born at the Roslin Institute – cloned lambs containing a human blood-clotting gene.

Choice And GE Foods

During 1998, it has become almost impossible to avoid eating food which contains ingredients from GE crops - mainly imported soybean and maize - as derivatives of these commodity crops are used in a wide range of processed foods. Labelling regulations agreed during 1998 take no account of the *method* of food production and specify that labelling is only required when there is foreign DNA or protein in the *end product*. This means that foods containing GE soybean oil or lecithin (an emulsifier used in chocolate and other products) will not be labelled as the protein and DNA are removed during the production process.

During 1998, it has become almost impossible to avoid eating food which contains ingredients from GE crops.

Because of such anomalies in the labelling regulations, consumers are deprived of the right to make informed choices about what they eat. Apart from avoiding processed foods altogether (no GE fresh fruit, vegetables or meat are commercially available in Europe as yet, although animals may have been fed on GE feed), one of the few ways to avoid GE products is therefore to buy only organic foods, which are guaranteed to be GE free.

Some food producers and retailers have responded more favourably than others to public opposition. The following gives a brief summary:

Wholefood stores: Many wholefood shops have removed products containing GE ingredients from their shelves but it is important to check with individual stores to ensure they are complying[11].

Iceland Frozen Foods: Has the most progressive policy of the major supermarket chains. In March 1998, it announced that its own-brand products would no longer contain *any* GE ingredients, including derivatives such as oil and lecithin.

Asda: Announced in November that they were to ban GE ingredients from any new own-brand products and were asking suppliers to find alternatives to GE soya and maize.

Sainsbury's: Has eliminated GE soybean protein from the majority of its own-brand products. This policy does *not* extend to soybean derivatives such as oil or lecithin, and products containing these ingredients will not be labelled. Sainsbury's own-brand tomato paste is made from Zeneca's delayed softening GE tomatoes and is labelled accordingly.

Safeway: Now label all own-brand products which contain any ingredient from a GE source. This includes foods containing GE additives and refined ingredients such as oils and lecithin. Non-GE soy and other ingredients are used "*where practicable*". Safeway's own-brand tomato paste is made from Zeneca's delayed softening GE tomatoes and is labelled, "*produced from genetically modified tomatoes*". Interestingly, their non-GE, more expensive tomato paste outsells the GE version in many stores.

Consumers continue to be deprived of the right to make informed choices about what they eat.

Waitrose: Are extending labelling beyond legal requirements to include additives and ingredients derived from GE plants even though the end product does not contain GE material. They use non-GE soya and maize in own-brand products or have changed their recipes. Only "*a handful of products*" now contain ingredients from GE sources.

Tesco: Announced in September that they will label all own-brand products which contain soybean derivatives, including oil and lecithin. This goes further

than the regulations demand since only items which contain foreign DNA or protein *have* to be labelled.

Co-operative Retail Stores, Marks and Spencer, Somerfield Stores and Wm Morrisons: Merely comply with labelling regulations, so products containing soybean derivatives such as oil and lecithin will not be labelled. No effort to exclude GE ingredients.

New Crops And Foods In The Pipeline

The crops and foods which are being developed in the laboratory show us what the self-styled 'life sciences' corporations have planned for our consumption in the future. The current 'first wave' of GE crops have mainly been developed to be herbicide or insect resistant and are purportedly designed to make life easier for farmers. Monsanto has explained that their strategy in the second wave is to introduce so-called 'quality' traits (i.e. intended to benefit the consumer) into crops designed for animal and human consumption. The third wave will consist of plants which are intended to replace factories as production facilities for drugs or other compounds[12].

The second and third waves are part of the life sciences companies' interest in what they have called 'nutraceuticals', which can de divided into three main classes (see Box 2). Of these, functional foods are thought to be particularly attractive to the developers because, although they are supposedly intended to give a health advantage (important in the health conscious markets of the affluent nations), there is no requirement to demonstrate clinical efficacy and therefore no need for expensive clinical trials[13]. Consequently, producers can make claims that functional foods are good for us without the burden of having to prove it. Those which are currently under development include Monsanto's Laurical (a GE oilseed rape with increased laurate content and claimed to lower blood cholesterol), and DuPont's GE soybean and oilseed rape (which are claimed to reduce the risk of heart disease by excluding trans fatty acids)[13].

Producers of GE 'functional foods' can make claims that they are good for us without the burden of having to prove it.

BOX 2: What is a Nutraceutical? (Adapted from Reference 13)

A nutraceutical is a food or food supplement that is supposed to bring a medical or health benefit. There are three main classes:

Nutraceutical	Description	Example	Regulatory requirements
Dietary supplement	Chemical(s)	Vitamin supplement	No requirement to demonstrate clinical efficacy
Functional foods	Food engineered or supplemented to give improved nutritional value	GE oilseed rape with altered fatty acid content claimed to lower heart disease risk - no restriction on sales anticipated.	No requirement to demonstrate clinical efficacy
Medical foods	Foods with medicinal properties	Potato or banana with vaccine - only from a doctor.	Have to demonstrate clinical efficacy

By promoting the 'health-giving' properties of nutraceuticals, companies hope to attract consumers to the GE foods they have so far rejected[14]. There are no anticipated restrictions on the sale of such altered foods.

Other developments during 1998 have included work on GE peas, carrots, cotton and even Christmas trees. Some of these are listed below:

January 1998: Australian scientists announced that they had almost completed a gene map of the prawn and were therefore a step nearer to producing a 'super-prawn'[15].

By promoting the 'health-giving' properties of nutraceuticals, companies hope to attract consumers to the GE foods they have so far rejected.

January 1998: Oxford scientists reduced the water content and increased the starch of potatoes by manipulating an enzyme involved in energy production. The outcome will be potatoes which absorb less fat during frying – an attractive proposition for sales of chips and crisps. Zeneca are now investing in further trials[16].

May 1998: UK scientists developed plants with genes from a Pacific jellyfish so that they can produce fluorescent pigments. They hope to link them to signals in the plant which indicate when it is short of water, nutrients or is diseased. The plant would fluoresce a certain colour so a gardener or farmer would know there was a problem[17].

May 1998: Monsanto scientists developed blue cotton by transferring a gene from a blue flower (which one is commercially confidential). Other colours are being developed[18].

May 1998: Plants were genetically engineered to produce a viral protein which stimulates immunity to a virus which causes diseases in some animals. Trials indicated that the isolated protein protects animals from the disease. The rights to the technology, developed by the John Innes Institute in Norwich and Purdue University in the USA, are now owned by the UK company Axis Genetics[19].

June 1998: Australian scientists developed peas which resist weevils by producing a protein toxin which stops the weevils' development[20].

August 1998: Oxford scientists announced they were perfecting GE sprouts to absorb nickel, copper and cadmium from contaminated soil[21]. It is not clear what will happen to the toxic sprouts.

October 1998: York scientists transferred a carrot antifreeze gene into tobacco plants to make them more resistant to frost[22].

October 1998: To clean up polluted land, American scientists engineered poplar trees to take up mercury. Unfortunately, the mercury is then released into the atmosphere[23].

November 1998: Dutch scientists transferred a gene from the Jerusalem artichoke into sugar beet so that it produces sweet-tasting fructans which are not digested[24]. The resulting low-calorie sugar will have an enormous impact on the lucrative slimming market but comes at a cost - as consumers of Jerusalem artichokes will testify, fructans cause flatulence!

November 1998: Scientists at Nottingham University announced a breakthrough in the genetic engineering of lettuce to delay the onset of droop[25].

December 1998: American scientists announced the application of genetic