ENVIRONMENT AGENCY

the NATURAL STEP

A Framework for Sustainability

2020 Vision Series No. 1

Genetic Modification and Sustainability

Dr Mark Everard, Director of Science, The Natural Step UK

Diana Ray, Facilitator, The Natural Step UK

About This Document

2020 Vision is a process initiated by the Environment Agency to help create a vision of the kind of environment and sustainable future to which society aspires. The 2020 Vision series of seminars undertaken by The Natural Step[1], in conjunction with the Environment Agency, tackles various contentious issues critical to achieving a sustainable future.

This report on Genetically-Modified Organisms (GMOs) is the first 2020 Vision report in the series. It is based on consensus achieved within a group of invited experts from the UK, representing various aspects of the debate. (See the section *Who Was Involved in the 2020 Vision Seminar?* for further details of participants.) This brief report seeks to convey, in simple terms, some of these key areas of consensus. Consensus is a process that brings in opposing views and seeks points of agreement, including majority views about issues and questions yet to be addressed, to take forward debates that might otherwise become "stuck".

The Public Debate about GMOs

The public profile and media interest in GMO issues have steadily increased in recent years. The issue is contentious, and The Natural Step framework offers a helpful way of thinking through contentious issues in a more sustainable future.

In the current climate of debate, it is timely for the Environment Agency to be determining the issues and implications of GMOs in a measured and balanced way. The Environment Agency is not itself a regulator of the technology. However, the Agency has a role as an arbiter and source of sound advice on behalf of the environment and the public interest. It also has a core duty (Section 4 of the Environment Act 1995) to contribute to the achievement of sustainable development, and supports The Natural Step as a contribution to this objective.

For Further Information

The Environment Agency is collaborating with The Natural Step in this work. Further information and contact points for each of these organisations can be found in the back cover of this report. A description of the 2020 Vision process also appears on the inside back cover.

This document is a brief summary of the 2020 Vision seminar on GMOs held in April 1999. This summary report is available at The Natural Step's web site: *http:\\www.naturalstep.org.uk.* A detailed report of this workshop is also available from The Natural Step, priced £15 to cover production and handling costs, using the contact details at the end of this document.

[1] More information about The Natural Step, and how it helps thinking about sustainability, is provided at the end of this document.

What Are GMOs?

Genetically Modified Organisms may be plants, animals or microorganisms that have had DNA (the genetic material - deoxyribonucleic acid) inserted into their cells from another organism. In some cases, this organism may be from another individual of the same species, although it is more commonly from another species with which they would not normally cross-breed. This inserted DNA thus becomes part of the genetic material in every cell of the recipient organism, and is passed from generation to generation.

Is Biotechnology New?

You may have heard in the press or on the television that genetic modification is not new, and that biotechnology has been with us for centuries. The terms *genetic modification* and *biotechnology* are often used interchangeably, but have different meanings about which we should be clear.

Biotechnology is literally technology that exploits living organisms. We've been doing that for the whole of recorded history. Today, for example, we use microorganisms in the development of drugs, in bread-making and in brewing, and we use plants, animals and microorganisms in many ways to support agriculture, industry and other activities.

We have also been influencing the genetic make-up of these plants, animals and microorganisms for centuries through selective breeding, cross-breeding, and various other techniques. Historically, these techniques have relied upon the natural processes of sexual reproduction and selection of features that are part of the variability inherent in nature. In recent decades, various novel laboratory techniques have been developed to accelerate the selection of features from this natural variability within nature. Examples of these techniques include irradiation of seeds, embryo rescue, mutations induced by toxic substances, and wide crosses in tissue culture.

GMOs are a New Technology

However, it is only in the last couple of decades that we have learned how to manipulate directly the DNA of organisms. The direct in vitro (under laboratory conditions; literally "in glass") transfer of DNA between or within species is a new branch of biotechnology, which we refer to as *genetic modification*. Given that the DNA within organisms is the product of about four-and-a-half billion years of evolution, and is immensely complex, many would argue that we can not at this early stage fully understand the implications of this technology. The same point also relates to some novel types of wide cross-breeding (such as those now possible in tissue culture and embryo rescue) that must also be subject to the same concerns, though do not currently fall within the scope of biosafety regulations.

Biotechnology may be nothing new, but GMOs certainly are. As a matter of common sense, we should be cautious about the rapid application of any technology for which our understanding is still only partial. This applies equally to genetic modification and to other novel forms of cross-breeding noted above.

Transgenic Organisms

We use the term *transgenic* to describe new strains of organisms in which the DNA has been modified by the in vitro insertion of genetic material from a "foreign" organism (an organism of another, or more rarely the same, species).

What Transgenic Strains are Available Today?

Many new transgenic strains of organisms have been developed over the past decade, for example:

- Tomatoes containing a tomato-derived gene that prevents fruit softening and hence wastage;
- Maize and potatoes into which have been inserted genes from bacteria which cause the production of an insecticide (this insecticide is known as *Bt*);
- Tomatoes in which some genes have been inserted from arctic fish to make the tomatoes more resistant to cold; or
- Oilseed rape which is resistant to a weedkiller. (Note: weedkiller-resistant strains of oilseed rape have also been produced by conventional breeding techniques).

Aren't These Natural Features?

If we are simply putting natural features of one organism into another, can there be risks for human health or to the environment? There is considerable disagreement about the associated risks. For example, the bacterial insecticide in the potatoes and maize is produced by every cell in the plant, including the parts which we eat and the residues that break down in soil. Extensive food safety testing has been carried out in the USA on the *Bt* insecticide in the human diet. Further research on any wider implications upon the ecosystem is still required. We also know that the pollen produced by maize plants containing the same bacterial insecticide gene can kill the larvae of butterflies in laboratory conditions. The implications for wildlife may be potentially significant and can not be ignored, although there is at present no evidence that this is happening in nature. It appears that more research is required, some of which is now being undertaken, to determine how this new technology affects the food we eat, any wider impacts upon the environment, and if there are any grounds for concern about potential health hazards.

Random Effects

Furthermore, when DNA is inserted into an organism, its position in the genome (the new host's DNA) is random. We do not yet have a complete understanding about the genomes of any organisms, though we know that the position of genes within the genome can be important for the function of that gene. We are also unclear about the impacts of "promoters" - the DNA from viruses and other organisms used to activate the new gene in its host - on transgenic organisms.

The random positioning of genes, and the inclusion of "foreign" DNA other than the intended genes, require a precautionary approach whilst supporting further research. Again, this concern may also relate to new strains produced by non-GM techniques.

Impacts on Nature

Will the Genes Stay Where They are Put?

We do know that genes can be transferred from transgenic organisms by a number of routes, including viral transfer and pollen drift. Hybridisation between GM crop plants and their wild relatives is known to occur and to have resulted in herbicide-resistant weed species. (The same argument of course also applies to herbicide resistance bred into plants by more traditional methods, and we should bear this in mind when evaluating the discrete issue of herbicide genes inserted into crops by GM technology.) The pollen of plants is not easy to contain in open fields. Pollen of some crops can travel many kilometres by wind and insect transmission. The full implications of this gene transfer from GM crops are not yet known.

Many would argue that we cannot afford to release genes into the wild as, once the "genie is out of the bottle", the genes are capable of spreading and self-replicating throughout nature. The effects of transgenic species, including their hybrids, on their competitors, grazers, decomposers and other wildlife, remain poorly understood. It is clear that there is, at present, no widespread consensus about the most sensible way forward, nor the magnitude of these risks. However, there are obvious and sensible experiments that can be done to test various issues.

Are GMOs Better for Nature?

Some biotechnology companies, together with donor agencies and a number of scientists, promote the view that GMO crops are less harmful to the environment than traditional crop varieties. However, there is far from general agreement on this point. The transfer of genes to wild species and the potential for pollen to affect wild insects have already been highlighted above. Both are potentially cause for serious concern. There are differing views in the media and in the scientific literature about the ways in which GM crops influence insect biodiversity in comparison to normal agricultural practices. This needs careful evaluation, as any benefit to biodiversity must be welcomed.

Equally, reductions in agricultural resource intensity must be welcomed. Some claim, with support from preliminary survey data on farmers growing GM crops, that GM technology is delivering reductions in pesticide and herbicide usage, and in inputs of energy and fertilisers. Other reports suggest that the build-up of resistance by pests and weeds can result in similar or even increasing inputs. It is clear that more testing is required and that generalisations cannot be applied between different crop types. As will be discussed later, GMOs should be considered as one potential element within the wider context of sustainable farming.

Understanding Complexity

Biological organisms are exceedingly complex, and the interpretation of gene sequences and the interactions between genes are far from fully understood. Moreover, processes of natural hybridisation and mutation are continually creating new variants. Every transgenic organism, as indeed every new hybrid, is a unique biological construct that has never existed in quite that form before. This inherent complexity is one of the many factors, which make the assessment of these novel organisms a formidable task.

Ethical Considerations

Providing Food for a Developing World

Claims that GMO technology will "feed the world" are not validated by the crops that have been commercially developed to date. There is a strong body of opinion that food shortages throughout the world are largely related to distribution and not production. This may be true, although it is equally the case that people's livelihoods are best strengthened by self-reliance - for example growing their own food - than by dependence on welfare or other political solutions to effect redistribution. A creative blend of ethics and technology may therefore present a path towards sustainable food production in the developing world. It is also true that developing world populations are rising; today's population stands at six billion, but this may rise to nine billion by the middle of the next century. Topsoil is also being lost at alarming rates. A food crisis may therefore lie ahead. GM technology may have a role in decreasing food shortages, although it is only one element of the wider debate on sustainable agriculture. Further exploration is also required of the implications of GMOs as a development technology, particularly in the context of overcoming poverty, although political and ethical solutions must also be considered alongside technological solutions.

Who Benefits?

There is a perception that the concerns of the general public (for example, relating to allergies and other aspects of health, impacts on nature, "playing God", etc) are not being addressed in the current debate, and that the public bear a disproportionate risk whilst the larger biotechnology companies share all the financial benefits. There was also consensus that insufficient public funding in the technology was contributing to narrow thinking about the technology, in which wider implications were not adequately being addressed in the rapid progression to market. Current investment in this new technology is largely by business, and the desire to realise a return on this substantial investment is understandable. Many felt the pace of commercial development and application to be incautious. This is perceived to result in profit to agri-business and the shedding of risks - largely unquantified as yet - to society. Indeed, the application of the technology to consolidate profit into multinationals, and away from rural communities in both developed and developing nations, was an issue of widespread concern.

There is a pervasive concern that GM technology has the potential to disenfranchise farmers through patenting of naturally-occurring genes, and licence controls on seed that would normally be retained and sown the following year. The concept of "patenting of life" has proved particularly emotive in the media, highlighting subliminal concerns about commercial controls on shared natural resources. If the real target for GM technology was subsistence and small-scale farmers, and the aim to promote mixed farming rather than increasingly intensive monocultures, it is possible that real "sustainable rural livelihood" benefits could be achieved. At present, over 90% of farmers grow their own crops from seed they have saved from the previous harvest. Farmers will need to decide for themselves whether the cost of licenses for GM seed is worth the investment, or whether they will continue with farm-saved seed of non-GM varieties. At present, in the absence of quantified benefits to poor people in the developing world, there are question marks over the wider sustainability benefits of the commercialisation of this technology.

Impacts on Resource Flows

Implications for Input-intensity in Farming

All efficiency increases in agriculture are to be welcomed, provided that they are not outweighed by adverse impacts such as loss of soil structure and fertility, gene flux from transgenic crops to weeds, other impacts on biodiversity and ecosystem structure. Proponents of GM technology believe that GMOs may make a significant contribution to sustainable development by reducing the amounts of natural and other resources used to meet society's needs. Those opposed to the technology tend to claim the converse. To date, and as noted previously, there is no consistent agreement from field trials and agricultural returns (particularly in the USA) with this conclusion.

There is a general consensus - although experts on either side of the debate express widely divergent opinions - that knowledge about the resource implications of GMO crops is substantially lacking at present. Therefore, further careful and well-designed experimentation is necessary so that conclusions appropriate to a variety of environments can be achieved. Care should be taken to prevent the incautious extrapolation of conclusions from one crop or set of environmental conditions to all other situations.

The market mechanisms through which this new technology is made available must take account of a wide range of human and social needs. Resource efficiency in this case can not be judged on a short-term basis, nor on direct investment returns alone. This is as much a matter of public policy as it is about business development.

Comparison with Current Agriculture

Current intensive farming is the benchmark against which the possible impacts of GMOs and other new agricultural technologies are generally measured. However, it would be mistaken to believe that modern high-input agriculture is benign to nature, supports adequately rural economies here or overseas, or is sustainable.

Equally, significant advances are occurring in non-transgenic crop development, despite their low profile in the press and in public debate. As an example, the application of gene mapping as a method for improving traditional forms of cross-breeding is advancing very rapidly.

Considerable efforts are being expended in seeking more sustainable forms of agriculture. The potential place of GM technology in agriculture has therefore to be taken in the context of the wider debate about sustainable agriculture, and of sustainable development in general, and not just relative to today's substantially less-than-sustainable norm.

The Regulation of GM Technology

There is a broad consensus that no adequate framework currently exists to regulate the development of GM technology internationally. Too much, it is felt, is left to industry. We hope that the recent announcement by the UK Government of the setting up of an *Agriculture and Environment Biotechnology Commission* will help fill this gap.

Taking Account of Public Concern

However, it is clear that the concerns of the public are not well represented in the present debate, and in the regulatory process, and this has already been touched upon in this document. Whilst it is true that there is a need to increase public understanding of the science behind the GMO debate, the establishment of a two-way flow of understanding between scientists and the public is also required. Science needs to listen.

A Multi-Disciplinary, Consensus-based Approach

Leaving the regulatory debate just to "the experts" was felt to promote the perception in the public eye of poor accountability. There is a strong consensus about the need for a multi-disciplinary approach, including the public, to shape the direction of GM technology. This will entail a more consensus-based approach than the present, largely inadequate, regulatory mechanism. In order effectively to broaden the base of discussion, involving more sectors of society than just "the experts", there is also a need to develop tools for public communication and, perhaps more importantly, promoting the public understanding of this and related issues. This communication is not just one-way, nor indeed two-way, but should encourage dialogue between all participants.

Factors such as the economic and political issues involved with the fair distribution of food, or the macro-economic implications entailed in patenting genes, suggest that GMOs have to be assessed within the far bigger context of more sustainable agriculture and development. It is not merely a matter of assessing the technology in isolation from its application and exploitation. There should also be a deliberate attempt at involving other stakeholders, such that all sectors of society have representation in decision-making about GM technology in order that it can be fully brought into the context of sustainability.

There was also consensus that an independent body should take the lead in stimulating further debate. This is perhaps a role that could be adopted by the new *Agriculture and Environment Biotechnology Commission.*

Dissemination of Knowledge

There was a clear consensus that insights from the "2020 Vision" seminar should be disseminated in an easy-to-understand form; this is the primary role of this document.

Who Was Involved in the 2020 Vision Seminar?

The following twenty-seven people took part in 2020 Vision Seminar on which this report is based.

From the Natural Step

Dr Mark Everard (Chair), Director of Science
Diana Ray, TNS Facilitator
David Cook, Chief Executive
Professor Stephen Martin, Director of Learning

From the Environment Agency

Nigel Haigh, Board Member
Professor Jacqui McGlade, Board Member
Professor Donald Ritchie, Board Member
Tony Rodgers, Board Member
Stefan Carlyle, Head of SATIS
Liz Greenland, Science and Data Exploitation Manager
Emma Hayes, National Centre for Environmental Data and Surveillance
Dave Bird, Research and Development
Richard Howell, Biodiversity Manager
Rob Robinson, Rural Land Use
Beatrice Rose, Sustainable Development Unit (Forum for the Future Scholar)
Clare Twigger-Ross, Social Issues Office

Other Invited Guests

Paul Burrows, Department of Environment, Transport and the Regions
Mark Griffiths, Natural Law Party
Robin Grove-White, Centre for Study of Environmental Change, Lancaster Univeristy
Suzy Hodgson, Centre for Environmental Strategy, University of Surrey
Anna Hope, English Nature
Professor Roger Hull, Associate, John Innes Centre
Dr Marie Janson, CEST Programme Ltd
Dr Brian Johnson, English Nature
Sue Mayer, Genewatch
Andy Swash, Farming and Rural Conservation Agency
Dr John R Witcombe, CAZS, University of Wales at Bangor

About the 2020 Series

The **2020 Vision Series** of publications aims to provide information about a range of contentious issues, many of which have featured in the media. The Natural Step, together with SATIS (the Scientific and Technical Information Service of the Environment Agency), runs a series of **2020 Vision Seminars**. These seminars involve invited participants in the sharing of information and debate about the place of specific contentious issues in a future more sustainable world. This publication reports on the outcomes of the first **2020 Vision Seminar** on GMOs. It outlines the key points of agreement and the ways ahead identified by participants, and highlights gaps in our present knowledge and the sensible next steps. This summary report is available at The Natural Step's web site: http:\\www.naturalstep.org.uk. A detailed report of this workshop is also available from The Natural Step, priced £15 to cover production and handling costs, using the contact details at the end of this document.

About the Environment Agency

The Environment Agency has wide-ranging powers and duties relating to water management, environmental protection and pollution control across England and Wales. Its principal aim is to exercise them so as to contribute to sustainable development. The Agency therefore has strong interests in the application of science to decision-making - both its own and that of other sectors of society - as an important part of its contribution towards the achievement of sustainable development. The 2020 Vision process started internally within the Agency as a mechanism to envisage the kind of environment that the Agency wished to work towards. The 2020 Vision series of seminars and publications has stemmed from this aspiration, and provides an expert analysis of the place that a range of contentious issues occupy in a future sustainable world.

About The Natural Step

The Natural Step (TNS) is a science-based learning and decision-making programme aimed at helping organisations to understand and apply the concept of sustainable development. It was developed in Sweden in the late 1980s. The Natural Step has been operating in the UK as a charity, led by the well-known environmentalist Jonathon Porritt, since the beginning of 1997. It has already been successful in helping a range of large companies address sustainable development as a strategic issue. The science-based model of a sustainable world, which lies at the heart of TNS, can also be used as an "intellectual round table" around which to address the various social, environmental and economic aspects of contentious issues. Together with a range of other specialist tools, TNS therefore provides a framework for the building of consensus about the place of these issues in a future more sustainable world. The Natural Step, which is supported by the Environment Agency, is a partner of the Agency in the 2020 Vision series of seminars and publications.

ENVIRONMENT AGENCY

A Framework for Sustainability

Scientific and Technical Information Service
The Environment Agency
Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol BS32 4UD

Tel: 01454-624400
Fax: 01454-624409

E-mail: stefan.carlyle@environment-agency.gov.uk

Environment Agency Web Site:

http:\\www.environment-agency.gov.uk

The Natural Step UK
9 Imperial Square
Cheltenham
Gloucestershire GL50 1QB

Tel: 01242-262744
Fax: 01242-524445

E-mail: info@tnsuk.demon.co.uk

The Natural Step is a Forum for the Future activity.
Charity Number 1040519

The Natural Step's Web Site:

http:\\www.naturalstep.org.uk