# Seeds of opportunity: Towards a sustainable, consultative and ethically justified use of genetically modified plants

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**Statement of Originality**

The work presented in the thesis is, to the best of my knowledge and belief, original and my own, except as acknowledged in the text, and the material has not been submitted, either in whole or in part, for a degree at this or any other university.

Lucy Carter

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**Publications by the Candidate Relevant to the Thesis and Forming Part of it**

Carter, L. (2007) "A case for a duty to feed the hungry: GM plants and the third world". Science and Engineering Ethics, **13**(1): 69-82.

**Additional Publications by the Candidate Relevant to the Thesis but not Forming Part of it**

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**Conference presentations by the Candidate Relevant to the Thesis**

Edible plant vaccines: The case for a duty to rescue the third world using GM crops
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Can indigenous worldviews advance the current impasse intrinsic to naturalistic objections to novel gene technologies: A preliminary discussion
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**Abstract**

Public debate about the ethical acceptability of genetically modified (GM) plants in general and GM food in particular, is highly polarized. Proponents of GM products passionately argue that novel gene technologies have the potential to contribute to more efficient agricultural processes, promote environmental sustainability, and curb malnutrition in the developing world. Opponents of novel plant biotechnologies, counter with equal vehemence, that GM products are unnatural, potentially harmful to humans, and capable of catastrophic environmental injury. As more uses for GM products are realised, and investment in plant biotechnologies continues to grow, both groups have stepped up advocacy of their respective views in academic and public forums. Both sides continue to be at loggerheads with one another, in trying to force the public to choose between their two opposing views.

This research discusses in detail the most prominent arguments put forward in favour of, and in opposition to, the development and use of novel plant biotechnologies. It covers developing and industrialized contexts and describes the most likely applications of GM products within these contexts. The principal approach used in this analysis is one that embraces a spirit of pragmatism in its commitment to moving forward through the traditional impasse in which ethical and policy debates often finds themselves. This project sets out to clarify the issues, explore the most salient of these, and make suggestions about the best ways to move the debate forward.

Early on in this work it is established that within specified constraints, novel plant technologies have the capacity to make a substantial contribution to agricultural practices, the environment, and the wider community. These assumptions are carried throughout the project and serve as points of departure in discussions about the ethical concerns raised by the application of novel genetic technologies to plants.

One of the aims of this research is to produce a piece of work that can inform future policy decisions related to agricultural and environmental applications of GM technologies in Australia and elsewhere. I hope that the discussion presented here goes some way to achieving this goal and that it provides a coherent and plausible articulation of the issues.

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To Barbara, the most courageous person

I have ever known

"Philosophy recovers itself when it ceases to be a device for dealing with the problems of philosophers and becomes a method, cultivated by philosophers, for dealing with the problems of men."

John Dewey (1960) The Need for Recovery in Philosophy, in On Experience, *Nature and Freedom*, Richard Bernstein (ed) pg. 67

# Introduction

## Framing the GM debate: Some scope and background

*"Like it or not, ready or not, the age of agricultural ethics has arrived."*

Ferré, 1994.

Recent advances in novel gene technologies across several disciplines, most notably medicine and agriculture, have led to vigorous public and academic debates about how best to utilize (or in some instances, avoid) new gene techniques that are becoming increasingly available. Despite the promise of numerous benefits to society from applications of these technological advances, investment in research and development of genetically modified (GM) plants has attracted fierce criticism. This thesis seeks to better understand the arguments put forward in favour of, and in opposition to, the use of novel gene technologies in the agricultural sector, with a special focus on the role they play in the debate about the ethical acceptability of GM technologies.

The majority of arguments put forward by those opposed to the use of these technologies are arguments against the consumption of food that has been genetically modified, but the ethical issues do not always refer to the use of novel gene technologies to produce food for human consumption. By contrast, the majority of arguments in favour of using of these technologies, particularly in the industrial world, centre on the benefits of GM plants for purposes other than food, namely, environmental bioremediation, crop protection or the production of biofuels. This conflict has often confused the debate with the consequence that "the debaters do not really speak to each other" (Zimdahl 2006:139).

Despite the sceptical and often cynical views expressed by opponents of agricultural biotechnologies, opposition towards the use of genetic biotechnologies in medicine has been restrained (Comstock 2000; Kleter et al. 2001). The development and use of (genetic) medical biotechnologies such as biopharmaceuticals (for example, for the production of genetically modified insulin or edible plant vaccines), and genetic therapies such as somatic gene therapy, has been largely supported by the public (Kirk and McIntosh 2005). One explanation for this disparity may involve consumer choice and the perceived lack of personal autonomy with respect to the introduction of GM food.

Humans have an intimate relationship with their food. Not only is it required to sustain us, but it is often the centre of human interaction. Food has social, biological, and cultural significance (Pascalev 2003) and a large proportion of our daily lives are spent sourcing, purchasing, preparing and eating food (Pence 2002; Federoff and Brown 2004; Singer and Mason 2006). Some of the arguments that feature prominently in the debate against GM food, such as the call for mandatory labelling of products derived from biotechnology, are primarily fuelled by the widely-held conviction that choosing what one eats is implicit.

'Tampering' with food, by inserting foreign genes into food products, thereby altering food at the molecular level, makes the widespread use of agricultural biotechnology a highly controversial topic, particularly when most consumers have only one viable source of food – the supermarket. The lack of consumer benefits from the majority of currently available modified products are seen as evidence for the widely-held public conviction that the majority of products in development serve the interests of agribusinesses – through lower manufacturing costs and increased profitability – rather than serving the wider community.

Lay consumers often distrust arguments for GM products because of past failures by regulatory authorities and attendant public relations disasters such as BSE[1] and foot and mouth disease in Britain. Adding to this mood of consumer distrust of agricultural biotechnology are: the perceived potential for environmental harm; a potential threat to smaller organic and often local producers from the marketing power of large biotechnology and agribusiness organizations; and a general lack of understanding and appreciation of genetics and genetic techniques.

By comparison, many applications of medical biotechnologies such as genetic diagnostic tests and GM produced insulin present relatively constrained and understood risks to the individual and the environment, and offer the consumer authentic and clear benefits such as improving health – arguably the most important and valued end for many individuals. Decisions about the use of these technologies are generally informed and understood, and risks and benefits are weighed against individual values. There is a general perception in the community that medical advances are a desirable social good and that investment in this area is both necessary and on the whole, morally justifiable.

This thesis is chiefly concerned with applications of novel plant technologies produced from recombinant DNA technology such as *gene splicing*[2], with the aim of introducing a novel trait or protein into the genome of the host organism. The desired gene(s) must firstly be identified, isolated, cloned, and inserted into a vector (transport vehicle), most often a bacterial plasmid. The transfer and reintroduction of genomic material from one organism to

[1] Bovine spongiform encephalitis or BSE has been found to be *a* cause (though not the only) of Creutzfeldt-Jakob disease in humans, a rare progressive neurological disease associated with the consumption of infected meat.
[2] Gene splicing refers to the combining of fragments of DNA from one or more organisms to form recombinant DNA. The recombined DNA is then integrated into the genome of a new organism. A 'transgenic' organism is one that has undergone such a process.

another can be achieved by a variety of methods. One method is to introduce the recombinant DNA material through microinjection processes. This may include the use of ballistic technology that rapidly inserts the desired gene(s) into the host's genome, or through bioelectrical stimulation which penetrates the organism's cell membrane so that the foreign DNA can be taken up by the organism.

There are several conventional selective breeding techniques that can achieve similar results to genetic modification (although the transfer of genes from one organism to another, using traditional methods, is usually only successful when applied to closely related species of the original (donor) organism). The advantages of using genetic technologies over conventional methods include more accurate insertion into the desired chromosome, and significant speeding up of the hybridization process[3].

I have opted to use the most widely adopted phrase in the GM debate, 'genetic *modification*' in favour of the phrases, 'genetic *manipulation*' or 'genetic *engineering*' for a number of reasons. One of the aims of this research is to discuss the issues raised by the various sectors of the community who have a stake in its production. This includes scientists, various industries, business, growers and consumers. The scientific community prefers to adopt the more precise term 'engineered' rather than 'modified' since gene splicing is an exact procedure requiring certain conditions before an organism is considered viable. The general community however, readily understands the phrase, 'genetically modified' to signify an organism that has been altered at the genomic level. I have also limited the use of the phrase 'genetic manipulation' in this thesis predominantly because it is often chosen by those in total opposition to research and investment in novel gene technologies (often for reasons that are

[3] Presently, few genetic techniques carried out in the lab are time and cost efficient. It is assumed that once the processes are better understood and the technology better utilized, the benefits of using GM over conventional propagation methods will outweigh efficacy considerations.

based on a misrepresentation of the evidence). ‘Genetic manipulation’ also carries negative connotations and is most commonly used in conjunction with emotive terms such as ‘tampering’, ‘contamination’ and ‘unnatural’.

The majority of volumes dedicated to the discussion of issues surrounding plant genetic technologies published to date, take the discussion in one of two directions. Discussion either focuses on the various scientific techniques used in the development of genetic technologies, or discussion is directed at an examination of the potential benefits and harms of their application in various contexts. This thesis accepts peer reviewed evidence on the potential for novel plant biotechnologies and accepts that there are problems that may emerge from this technology but it attempts to use a forward-looking, pragmatic approach to the concerns raised. It sets out to clarify the issues involved, explore the most salient, and determine the best way to move forward. Each chapter in this work discusses a particular concern about the development, dissemination or application of novel plants and attempts to find a way through the concerns raised. A chief goal of this research is to move the discussion forward into an arena suitable for policy development.

At present, discussions about the ethics of agricultural biotechnology are at times entrenched in ideological debates that have little hope of contributing to the development of sound public policy. The potential contributions of useful applications of novel genetic techniques to social goods such as food security, healthcare and environmental bioremediation are enormous. Realising these potential benefits is likely to yield many advantages. For developing nations, the advantages of adopting novel genetic biotechnologies include economic development at local and national levels, access to life-saving biopharmaceuticals, and decreased environmental degradation. For industrial nations, the most likely benefits of novel plant biotechnologies include increased agricultural productivity from the adoption of pest-resistant or drought-tolerant crops, opportunities for environmental bioremediation in over-cultivated areas, and the development of genetically modified animals for food production (such as beef cattle) or medical purposes (such as transgenic pigs for use in xenotransplantation[4] procedures)[5].

Adopting a pragmatic approach to a discussion of the problems raised by novel technologies has many advantages. It acknowledges that some applications of science are in fact objectionable to some sectors of the community whose deeply-felt concerns should not be ignored. A pragmatic approach sets out to work through these concerns in a spirit of compromise, utility and resolution. Some of the conclusions reached in this work recognize that many opponents, as well as proponents, have vested interests in the regulation of novel technologies. There exist numerous lobby groups within the general community that fundamentally oppose research into novel gene technologies and their potential applications. It will be argued that many of their arguments rest on misguided or distorted estimates of risks. Yet some of these concerns stem not from the potential hazards associated with applications of GM, but from distrust of governments who have in the past failed to protect the public from potential risks.

This work accepts at the onset that GM technologies offer considerable benefits to society that are morally and socially desirable. These applications are those that benefit society by contributing to the production of nutritious food for consumption, preventing environmental

[4] The transplantation of cells or tissue from one species to another species.
[5] Appendix 1 provides a comparison of the more immediate uses of novel gene technologies in developing and industrialized contexts.

harm, or aiding in the remediation of the agricultural environment[6]. For the purpose of this work, technologies that are morally or socially desirable are those that on balance do not unnecessarily harm the individual, the community or the environment. This work acknowledges that there are many obstacles to the application of GM technology. These obstacles include but are not limited to: concern about the lack of real opportunities available for developing nations to benefit from GM biotechnologies; consumer autonomy and labelling of GM products; and potential environmental damage resulting from unintended transgenic flow. The thread of resolution that appears throughout the work makes the project both novel and a foundation to be built upon.

This research has a number of underlying aims. The first, is to investigate the saliency and coherence of the arguments put forward both in opposition to, and in favour of, developing and using genetic plant technologies[7]. By doing so, I hope to expose the many myths generated by proponents and opponents alike and to examine in depth the salient points which need to be addressed.

By using a pragmatic approach in analysing the concerns raised, a second aim of this work is to present the reader with a way forward through the current impasse between strongly polarised viewpoints. For example, in chapter eight, I re-interpret the most common ‘playing God’ arguments put forward against novel gene technologies in a way that injects meaning and opens discussion beyond the traditional stalemate imposed by such absolutist claims.

[6] There are of course other benefits of plant biotechnologies that are not the focus in this research such as the production of biofuels, etc.

[7] Although the majority of this research is focused on issues raised by GM *plant* technologies, many of the arguments put forward are also applicable to discussions about the ethics of using GM animals in agriculture. The use of GM animals in agricultural and aquacultural food production systems has the potential to offer consumers improved products as well as address current environmental concerns. One such example is the development and breeding of GM fish (particularly salmon) in an effort to ease the pressure on diminishing fish stocks.

A third aim is to produce a piece of work that not only provides a useful starting point for discussions about the risks and benefits of novel genetic biotechnologies, but presents the information in a way that that can be used in future policy development. Hence my focus on finding positive and practical solutions to some of the problems posed by novel biotechnologies and their applications.

There are numerous ways to divide the sections of a thesis that seeks to present various arguments for and against the adoption of a new technology. I have organized each section in a way that explores one or two related concerns that frequently appear in the debate. The chapters are organised in groups that address environmental, human health and social concerns relating to the adoption of agricultural biotechnologies in various contexts. The individual chapters are organized so that proponents' and opponents' views are alternated. This ensures that the work provides a balanced coverage of the views expressed by both sides of the debate.

Chapter one discusses the nature of gene flow and its likelihood in various contexts. The role of the "organic agriculture community" in public debates about GM is also discussed. I argue that recent unfavourable events in transgenic research, coupled with unrelated global food scares about BSE, have established a strong consumer following for organic food. These events have had a negative effect on public discussions about the prospects of GM products and raised doubts about the benefits these products may offer. I conclude the chapter by suggesting that specific applications of GM may in fact be compatible with some organic agricultural practices under current organic definitions.

In chapter two I expand the analysis of environmental issues raised by GM products by arguing that some applications of genetic technologies are potentially compatible with sustainability. I contend that traditional approaches to environmental ethics are not helpful in public deliberations about emerging biotechnologies. Nor do they assist in the development of policy. By contrast, pragmatism as an environmental ethic facilitates deliberative discussions about GM and its consequences.

To date, no study has found that GM products are harmful to human consumption. Assuming that there are few, if any, harms, the third chapter argues that no moral obligation exists for the mandatory labelling of products manufactured using novel gene technologies, if products derived from such technologies are deemed safe for human consumption. I argue that cultural reasons are not sufficient to warrant the mandatory labelling of products containing novel genes although labelling products may be advantageous to business in that they may serve as advertisements for any positive environmental (or other) benefits of these products .

Chapter four investigates the role of “substantial equivalence” (SE) in assessing the safety of GM food products. One concern often expressed about the safety of GM food is the probability that allergenic proteins will be transferred during the manufacturing process. Another is the public health effects of a perceived increased risk of antibiotic resistance as a result of using antibiotic resistance markers in the production of GM foods. Both of these issues are discussed in terms of their probability and the reliability of the food safety mechanisms that exist to prevent such events.

There is a widely held perception among its opponents that agricultural biotechnology is a high-technology, monocultural, export-driven and corporate-managed enterprise (Comstock

2000). In chapter five I demonstrate that, on the contrary, agricultural biotechnology can be integrated into local developing communities through projects developed in rudimentary laboratory conditions on a modest budget. The development of genetically modified disease-free cassava in Kenya is just one example of an application of genetic biotechnology that has the potential to positively benefit communities through capacity-building (Wambugu 2001).

In this chapter, a case is made for using specific GM products in the third world. I use Peter Singer's duty of rescue to argue for the careful and considered use of GM crop technology and the dissemination of food produced through gene technology, on the grounds that doing nothing might worsen the current food crises in developing countries. The case is strengthened by an application of the Precautionary Principle (PP). This chapter also introduces the use of genetic technologies for the development of oral plant vaccines for use in preventative medicine.

GM policies are most likely to affect the environments of countries whose regulatory systems are not sophisticated. Chapter six explores the social, cultural and economic considerations central to the global diffusion of novel biotechnologies. It discusses the cultural and economic effects of the World Trade Organisation's (WTO) Trade Related Aspects of Property Rights agreement or TRIPs, on developing world agricultural communities and their capacity to benefit from new varieties of GM crops. There are numerous and significant challenges faced by developing countries in developing the infrastructure necessary to establish independent research institutes that are focused on developing GM crops that are suitable for third world agricultural environments. In the previous chapter I made a case for a moral duty to make available the benefits of novel biotechnologies to poorer countries. In this chapter, I review the practical obstacles that make the task so difficult and complex.

Chapter seven considers in more detail one of the possible uses of GM products in the industrialized world. “Functional foods” have been promoted by advocates of GM food as one way to significantly reduce the negative health effects of overnutrition in developed countries, such as, obesity diabetes and cardiovascular disease. I question the legitimacy of this claim and the consequences of marketing such products as ‘health-saving’ or ‘disease-preventing’ and use a primary health care approach to illustrate the complexities of diet and eating behaviours.

The final chapter in this work, chapter eight, attempts to make sense of four common in-principle objections to research and investment in novel agricultural biotechnologies. It does so by re-interpreting some popular arguments that GM foods involve ‘playing God’. I agree, along with the majority of commentators, that some naturalistic objections of this type are irrational, absolutist and ambiguous. By unravelling the most common of these, I attempt to show that not all such objections are meaningless and that a number of ‘playing God’ arguments against the use of novel biotechnologies contain useful information about public understandings of the potential consequences of using these technologies.

There are many uses of genetic technologies – food being only one of them[8]. Current GM crop technology (as food) appears to have its widest use in developing world agricultural settings, along with the use of such technologies for crop protection, bioremediation and primary healthcare. Although there may be substantial advantages in applying GM technologies in industrial contexts, growing GM crops for the sole purpose of wholefood products is perhaps not one of them. The use of GM plants in the production of food

[8] The use of GM animals in the pursuit of innovative medical technologies such as xenotransplantation or improved agricultural production is also a realistic use of novel gene technologies.

ingredients such as cooking oil, the development of plants that can be used as biofuels, and crop protection against biotic and abiotic stressors are the most likely uses of novel plant technologies in the industrial world.

The final section of this work reviews the conclusions drawn in each of the chapters and offers some points for consideration in terms of future directions for novel plant biotechnologies. I consider ways in which agricultural biotechnologies can be utilized for the benefit of social progress, and also circumstances in which the use of such biotechnologies pose undesirable cultural, social or economic risk.

## Prologue

## Prospects and promises: Determining the real potential of GM Plants

The speed at which biotechnology has advanced in the past two decades, particularly in the field of genetic engineering, is staggering. Numerous technical difficulties have been mastered in the past five years but many more remain to be overcome. This opening segment aims to establish exactly what is currently possible as a result of current practices in genetic plant technology. For the most part, the potential benefits postulated by advocates of novel plant biotechnologies are at least theoretically possible[9]. There are significant political and legal obstacles yet to overcome with respect to the functional applications of GM, such as those that demonstrate significant output potential, like the widespread dissemination of fortified rice to malnourished populations in South East Asia and Africa. These obstacles reduce the prospects of this technology of being of any real use[10]. Still, applications of GM technologies considered to be beneficial in terms of reduced agricultural input, such as those that improve a plant's tolerance to weed and pest attack, are widely available and currently used in many parts of the industrialized and developing world. Other applications of novel plant technology, such as improvements in the aesthetic qualities of cut flowers, although now in only limited use, are increasingly finding markets in developed settings. Whether the latter application of GM addresses a genuine need in society is open to argument. This thesis will limit the discussion to those applications of plant genetic technologies that aim to improve essential agricultural, environmental or food production systems. That is, those biotechnologies that propose to resolve or improve a current agricultural or environmental problem and therefore purposefully contribute to society.

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[9] See Figure 1 in appendix 2 for a diagrammatic representation of various potential GM technologies.
[10] These issues are further discussed in chapter six on the social, cultural and economic consequences of novel biotechnologies.

Genetic modification of plants (particularly, crops) confers several advantages over traditional agricultural methods of plant modification[11]. Improvement in agronomic traits such as pest resistance, herbicide tolerance, salinity tolerance and viral and fungal resistance have the potential to improve or increase yield quantities while limiting significantly the amount of toxic pesticides that are currently used in conventional agricultural practices worldwide[12]. Herbicide resistant crops can also potentially reduce the need for tillage practices, thereby reducing labour output and soil degradation (Zimdahl 2006).

Applications of GM plant technologies are commonly divided into various categories depending on their intended purpose. A primary aim in using agricultural biotechnology techniques is to improve a plant's performance in its natural environment by increasing its tolerance to external environmental interference. A primary aim for biotechnologists and agriculturalists alike is to enhance a plant's phenotypic characteristics[13] for the purpose of improving a plant's ability to withstand biotic and abiotic stressors[14]. Examples of desirable traits in plants include increased growth rate, plant architecture and stress tolerance[15] (Goff and Salmeron 2004). For example, in late 2005, a joint collaborative project involving

[11] It is interesting to note that plants have traditionally been crossbreed for centuries, effectively giving them very similar characteristics to transgenic plants developed using advanced biotechnologies. Some of the advantages of inserting desirable traits into plants in the lab include improved accuracy in inserting the desired gene(s) into the recipient's genome, predicting with greater accuracy the result of the insertion and speeding up the transgenic process. Chemical mutations, as well as the use of gamma rays and other non-GM breeding techniques 'disturb' the plant's genome much the same way as GM. These methods are also highly unpredictable but they have not received much coverage in the media.

[12] 2001 estimates of the impact of insects in the developing world concluded that 15% of the world's pre-harvest food is lost to damage caused by insects. Further, more than 11 million hectares are cleared annually by third world farmers in search of more productive land. See Herrera Estrella & Alvarez-Morales (2001), Genetically modified crops: Hope for developing countries, *Embo Reports*, 2(4), 256-8.

[13] The phenotypical characteristics of an organism refer to the observed features of that organism, such as plant height or meristem (plant feature) production.

[14] Biotic stressors are those that are caused by the natural (biological) surroundings of an organism's environment such as pest infestation. For example, GM provides protection from pests by increasing the plant's tolerance to pest attack. Abiotic stressors are those that are caused by the abiotic processes in an organism's environment such as drought, frost and soil salinity.

[15] Growth features include grain size or number and maturation speed; plant architecture includes height, branching and flowering; stress tolerance includes resistance to abiotic and biotic stressors such as drought, disease and herbicides and; nutrient content refers to the quality of starch, proteins, lipids and vitamins available in the plant.

scientists in China and the US identified a gene in a species of rice that has since been linked to salt tolerance[16]. The ability to grow rice crops in saline soils may significantly improve crop quality worldwide especially considering the current impact of global warming on the environment.

More advanced applications include the fortification of food crops through the introduction of novel genes (isolated from non-related species for their desirable traits) to enhance nutrient content, and the development of plants that express proteins that can be harvested for the manufacture of oral plant vaccines. Enhancing the nutrient content of crops has the obvious advantage of potentially reducing malnutrition in developing countries. One example of this application is the enrichment of protein, zinc and iron content in wheat, currently under study in China[17]. Improvements in a crop's nutrient content may also benefit other aspects of agriculture such as animal production. For farmers in developing countries, the occurrence of disease in animals bred for agriculture is a significant burden to subsistence and small-scale farmers. Mexican researchers have genetically modified maize to protect poultry from succumbing to Newcastle disease – a major contributor to stock loss in many poorer farming communities[18].

Attempts to genetically modify tobacco plants to produce a protein for a vaccine against amoebiasis (dysentery) – a disease that causes over 100,000 human deaths per year, predominantly in developing nations – met with success in the US in early 2007[19]. A far more

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[16] See http://www.scidev.net/News/index.cfm?fuseaction-readNews&itemid=2359&language=1 accessed 19 September 2005.

[17] See http://www.scidev.net/News/index.cfm?fuseaction=readNews&itemid=3247&language=1 accessed 29 November 2006.

[18] See http://www.scidev.net/news/index.cfm?fuseaction=readNews&itemid=3058&language=1 accessed 27 August 2006.

[19] See http://www.scidev.net/news/index.cfm?fuseaction=readNews&itemid=3404&language=1 accessed 13 February 2007.

distant application of GM plant technology (and one that is in very early stages of research) includes the development of plants that assist bioremediation projects by restoring the soil to a healthy state after environmental stress.

Various public scientific institutions (such as the CSIRO[20]) have ensured information describing the various processes and implications of GM technology are broadly accessible to a wider audience. Neither side of the GM debate dispute the discoveries published in the available mountain of peer-reviewed literature citing the accomplishments of applying novel gene techniques to plants and the potential applications of doing so. What is disputed in debates about novel technologies applied to plants in general, and crops in particular, is the possible risk of harm to humans and the environment caused by the interaction of novel genes with systems (such as other genomes, for example) not traditionally exposed to foreign genetic material. This thesis will test the saliency of the claims offered on both sides of the GM debate with the intent of moving the discussion forward in an inclusive and pragmatic way.

[20] Australia's Commonwealth Scientific and Industrial Research Organisation

## Chapter 1

## Setting up inviolable boundaries: The (not so deep) philosophical divisions between organic and transgenic agricultural practices

*"Killing monarch [butterflies] is nearly the emotional equivalent of hunting Bambi and clubbing baby seals"*

C. Neal Stewart, 2004, p. 598.

### *1.0 Introduction*

Radical environmental groups such as *Earthfirst!* and *Greenpeace* continue to make bold predictions about what they claim will be the harmful consequences of releasing large-scale commercial GM plots into the immediate and surrounding environments[21]. This fear is driven in part, by the perceived potential of 'transgenes' (as opposed to conventional genes), to invade nontransgenic ecosystems. One inevitable harmful consequence of this 'contamination',[22] it is postulated, is the creation of a 'superweed' and the consequential injury to non-target farmland and wild species and therefore the ecosystems of which they are a part (Murray 2003; Stewart 2004). One of the aims of this chapter is to critically assess these speculative and provocative claims.

[21] See http://www.earthfirst.org and http://www.greenpeace.com.au

[22] The terms, 'contamination' and 'genetic pollution' are used widely to describe gene flow in the humanities and social sciences literature. I will try to limit my usage of this term as far as possible because of its emotive connotations and use the more technical phrase, 'gene flow' throughout my discussion.

Contained within what I refer to as the *contamination argument*, are a number of assumptions largely based on what I argue are inaccurate interpretations of data or overstatements of risk. The first is the belief that releasing GM crops creates a novel category of risk to the environment (as opposed to the risk posed by conventional crops), in that transgenes are more hazardous than conventional genes. This perceived risk is based on a fear of the consequences of horizontal gene flow, or the movement of genetic material between different organisms independently of normal heredity mechanisms.

The belief that transgenes are more 'pervasive' than non-transgenes is counter to scientific evidence. "Studies have generally shown no difference or reduced fitness among GM plants compared to non-GM plants" (Glover 2002:12). Gene flow is a natural process mainly occurring as the product of cross pollination between related species that results in the production of viable seed, a process known as outcrossing. It is generally believed that outcrossing from conventionally grown crops to wild species, otherwise known as vertical gene flow, has occurred for millennia (Glover 2002; Chapman and Burke 2006). Unfortunately, the media have tended to limit its attention to issues solely related to the negative consequences of transgenic crops, rather than on the potentially negative environmental effects of intensive large-scale agriculture in those areas where plots are in close proximity to naturally diverse or sensitive environments.

The second assumption is based on the belief that the release of GM crops will not be controlled by appropriate regulation and risk assessment processes. On the contrary, agricultural systems that use transgenic processes in the production of GM plants for food or other purposes undergo complex risk assessments that are designed to test potential impacts on the environment. It is true however, that these risk assessment processes are not uniformly applied to conventional and 'organic' agricultural systems. With respect to food safety, no stricter regulations for food production systems exist than for GM foods (Pence 2002; Singer and Mason 2006). Foods derived from novel technologies undergo more testing than exotic fruits and vegetables, foods sold in local markets and even foods sold and consumed within the hospitality industry[23] (Pence 2002).

The third assumption is that GM and non-GM farming systems are mutually exclusive, that is, they are incommensurable. This claim can be used in one of two ways to argue against combining transgenic processes with other agricultural systems. First, it can refer to the inappropriateness of using transgenic processes within the one agricultural system, for example, by using crops that have been enhanced by herbicide tolerant genes to enhance conventional crops. Second, it can mistakenly refer to the conviction that pursuing conventional, organic and transgenic agricultural production systems in the one geographical area is mutually exclusive. On the contrary, several small scale studies have demonstrated the potential for commercial crops to be grown in various ways, and co-exist profitably without compromising the market integrity of other crops[24] (Byrne and Fromherz 2003; Brookes 2004).

This chapter will discuss the nature and probability of horizontal gene flow between GM crops and non-GM related species. Measures that serve to limit gene flow will be introduced in the lead up to a discussion of the possible co-existence between agricultural practices traditionally perceived as mutually exclusive. A definition of 'organic' will be chosen in a discussion of the historical role that the organic movement has played in the GM debate. I

[23] Chapter four on regulatory approaches to food safety assessment discusses in more detail the processes novel foods undergo for a determination of 'safe for human consumption'.
[24] Market integrity in this sense includes seed certification programs and other conditions which some markets, such as organics for example, must abide by under certification requirements.

will argue that recent unfortunate events in transgenic research history, coupled with unrelated global food scares, have helped the organic movement to establish a strong consumer following. These same events have had a negative effect on public discussions about the prospects of GM products and any perceived benefits these products may offer.

The consequently hostile public response to novel plant biotechnologies has been detrimental to efforts made by supporters to promote GM agriculture as a potentially environmentally beneficial endeavour. The organic community has exploited public concerns to promote organic produce as the safest and most environmentally friendly alternative (Bruce 2003). I conclude the chapter by denying the incommensurability claim made by the organic movement about agricultural practices that use novel biotechnologies. I contend that certain GM agricultural practices are in fact complementary to an organicist philosophy[25] and should be considered in the light of their potential value to the environment rather than be rejected on the basis of absolute definitions of 'naturalism'.

### *1.1 The nature of gene flow*

In a comment about lay perceptions on gene flow, Said Klaus Ammann, curator of the Botanical Gardens at the University of Bern, Switzerland, described popular views of gene flow in the following way:

> The debate on genetic engineering 'forces' us to focus in an unfortunate way on gene flow as a basically negative effect, as if pollen would have learned to fly

[25] Of which I provide a definition below.

with the transgenes. [Gene flow] has always occurred between different landraces and between different new varieties of crops. Despite this, varieties of apples or cereals have been stable over many years and specific traits have not disappeared. Pollen has always flown (Fedoroff and Brown 2004:231).

The probability and long-term success of pollen transfer, hybridization and subsequent introgression[26] is highly dependent on a multitude of factors such as climate, pollen vectors and genetic drift, hybrid genotype and gene flow between populations, and reproductive systems (Glover 2002; Fedoroff and Brown 2004; Stewart 2004; Biotechnology Australia 2005; Chapman and Burke 2006). Each of these (macro) factors are in turn dependent on a variety of (micro) factors that need to be in place before hybridization and subsequent introgression can occur. For example, the success of pollen transfer is dependent on the size of the pollen source as well as the receptor plot, the distance travelled for both wind and insect dispersal, and the possibility of vertical dispersion of pollen. Wind direction and velocity impacts on this scenario, as do environmental conditions such as the type of pollen movement (some pollen bounces), the mass, volume and structure of pollen (Glover 2002; Fedoroff and Brown 2004; Biotechnology Australia 2005).

The probability of successful introgression following outcrossing is very low (Glover 2002). It is “selection and not overall rate of hybridization [that] is the primary factor governing the spread of a particular transgene” (Chapman and Burke 2006:434). Successful gene flow resulting in hybrid formation and subsequent introgression is uncommon even between different but related species and very rare between distant species (Glover 2002). “Cultivated

[26] Introgression describes the successful integration of the novel gene(s) into the chromosome of the related species. It is important to note that hybrid formation does not necessarily lead to successful integration of the novel gene(s) in the chromosome of the related species. Newly hybridized plants usually have lower fertility but this can vary widely. Naturally occurring introgression is rare but possible. See Glover, J. (2002). Gene Flow Study: Implications for GM Crop Release in Australia. Canberra, Bureau of Rural Sciences.

crops are usually so domesticated that their overall fitness in terms of their ability to survive and regenerate outside cultivation is low" (Glover 2002:12).

"The significance of gene flow depends on whether transgenes offer weeds a selective advantage" either in agriculture or the natural environment (Glover 2002). Gene flow between GM crops and related species (non-GM, weedy relative, and native) cannot be completely eliminated (Stewart 2004; Firbank, Lonsdale et al. 2005; Chapman and Burke 2006). However, the risk can be minimized by preliminary crop assessments of their suitability for planting in the surrounding environmental conditions. "Since 1996, 38 trillion plants have been grown in the US alone without corresponding ecological ill effects" (Stewart 2004).

An added complexity in assessing a crop's potential effect on the surrounding environment is the "large variation between gene flow detected in different studies of the same crop plants" (Glover 2002:4). Laboratory simulations and small scale studies are not accurate predictors of the likely outcomes of large-scale trials. As Stewart (2004) points out

> there is one sizeable difference between wild-to-crop gene flow (conventional breeding) and crop-to-wild gene flow (transgenic) escape: breeders impose 'hard' selection on the hybrids to make sure the genes will be passed on to the new plants, while nature's selection is almost always softer (Stewart 2004:58).

Aside from the use of varying methodologies, factors that have influenced the results of studies to date include differences in local topographies, variations in local arthropod[27] populations and climatic variables (Glover 2002).

Given the conditions that are necessary for successful introgression, gene flow is highly unlikely to create a superweed that not only demonstrates adequate fitness for survival in the wild, but also possesses tolerance to every known herbicide and tillage practice (Stewart 2004:46).

Table 1 demonstrates the complexities inherent in successful outcrossing between GM and non-GM varieties of six common Australian crops.

[27] Arthropods are invertebrate animals found in the air and soil of farmland ecosystems such as insects, arachnids, centipedes and crustaceans.

| Level of Outcrossing | Low potential for impact on farm or local environment | Significant potential for impact on farm or local environment |
|---|---|---|
| **High** | Maize is an outcrossing species but gene flow from GM maize into the environment is limited by the lack of close weedy or wild relatives in Australia.<br><br>Gene flow between maize crops would have implications for the co-existence of GM and non-GM crops. | Eucalypts have a high degree of outcrossing, large numbers of close relatives, and hybridization between closely related species is common.<br><br>*If* transgenes are more pervasive than genes from conventionally-bred trees, the release of GM eucalypts in Australia would need careful consideration and stringent measures to minimize gene flow[28]. |
| **Medium** | Cotton is predominantly self-pollinating but outcrossing occurs at varying rates depending on the presence of insect pollinators and environmental conditions.<br><br>Cotton pollen is most commonly dispersed very close to the pollen source.<br><br>Australian native flora contains many relatives of cotton but fertile hybrid formation between these relatives is very unlikely.<br><br>Neither cotton nor its relatives are significant problem weeds in Australia. | Canola is predominantly self-fertile with some potential for outcrossing. Cross-contamination by cross-pollination can be attainable with the introduction of appropriate crop management plans.<br><br>Canola has some close relatives that are weeds in the Australian environment and there is some potential for gene flow into these weedy species. However, the frequency of hybrid formation between canola and significant problem weeds is very low.<br><br>The potential impact of any gene flow will depend on the transgene, the trait that it encodes and the environment of the plant to which it flows. |
| **Low** | Wheat is primarily self-pollinating, producing small amounts of pollen with a short viability period.<br><br>Potential gene flow is minimal at distances >1m from the source plant and this is reflected by the absence of separation distances between wheat crops for certified seed production.<br><br>Wheat is not a significant weed in Australian and does not have any closely related relatives. | Oat crops are predominantly self-pollinating and require no separation distance between crops for certified seed production.<br><br>Oat crops have weedy close relatives that are significant weeds in the Australian cropping system.<br><br>Although one study has shown a low level of gene flow between species, circumstances could be envisaged where such gene flow from GM crops could have a high impact on the farm environment. |

*Table 1 Case studies of six crops for potential impact of gene flow in Australia*[29]

[28] It is generally believed that transgenes are no more or less pervasive than non-transgenes (i.e. conventional genes). A myriad of factors are responsible for successful hybrid formation. Successful transgenic trait expression including hybrid viability is possible in the natural world but only under specific conditions.

[29] This table is reproduced (albeit in abbreviated form) from Glover, J. (2002) *Gene Flow Study: Implications for GM Crop Release in Australia*. Bureau of Rural Sciences, Canberra.

*1.2 Measures that serve to limit gene flow*

Complete genetic isolation is impossible to achieve in practice but the risks associated with gene flow between related species are equivalent for GM and non-GM crops and they can be minimized by using specific agricultural techniques (Peterson, Cunningham et al. 2000; Glover 2002; Fedoroff and Brown 2004; Stewart 2004; Chapman and Burke 2006). There are currently several crop and seed management practices already in place for ensuring seed integrity such as those used for organic seed certification. These same containment principles can be applied in the case of GM crops (Biotechnology Australia 2005).

Measures that serve to limit gene flow between species can be divided into two categories: those that limit gene flow through conventional agricultural practices; and those that limit gene flow through the use of novel gene technologies. The suitability of each practice would need to be assessed alongside the overall aims of the producer. For example, the use of some novel biotechnologies may not be acceptable to producers who depend on nil external input, such as those farmers who grow produce solely for sale within the certified organics industry. This is primarily because exposure to transgenes has the potential to violate certification requirements. Conversely, GM seed certification would also require purity of seed in that contamination with other external traits would not be desirable in terms of marketability of the product.

One conventional agricultural measure that serves to limit gene flow by minimizing the opportunity for pollen travel is temporal separation. Crops are grown at different times of year to enable farmers to better control pollen travel by minimizing the time period in which sexual maturity of plants coincides. The use of barrier crops is another technique that assists in the control of pollen flow. The planting of a crop of a different species that acts as a separation zone between two potentially outcrossing crops can also be used to minimize the risk of pollen travel. Isolation zones may also assist farmers in controlling pollen travel and subsequent flow[30]. Finally, the employment of traditional crop rotation practices can also be used to preserve crop integrity (Glover 2002).

Novel biotechnologies that are capable of reducing gene flow are in early stages of research and development. These technologies generally have two functions and can be separated into two categories: those that limit or reduce gene flow; and those that reduce hybrid survival. Application of the latter are also know as genetic use restrictive technologies (GURTs) or "terminator" technologies. Plants that are restricted in this way produce sterile seed that hampers or prevents hybrid formation. Other applications of flow reduction technologies include the control of gene expression sites, targeted interference with normal floral development and the promotion of male sterility (Glover 2002).

### *1.3 The rise and rise of the organic movement*

In Australia, currently 2% of agricultural production is certified as "organic" while internationally, the demand for organic products is increasing by 10% annually[31] (Singer and Mason 2006). "Organic farming" can be described as an agricultural system that attempts to improve various elements of soil health. Crops certified under Australian standards are required to be free from any synthetic inputs such as synthetic pesticides, fertilizers and

[30] However, results of some field trials suggest large isolation distances may actually encourage gene flow by affecting insect foraging behaviour. See Glover, J. (2002). Gene Flow Study: Implications for GM Crop Release in Australia. Canberra, Bureau of Rural Sciences.
[31] The total amount of organically grown product in Australia and elsewhere is actually much higher but not all of it is formally certified.

herbicides. Animals sold as organic produce must be fed on organic feed, be free from antibiotics and hormones and must be free to pasture without restraint during daylight hours (Singer and Mason 2006). An organic philosophy also attempts to minimize the use of non-renewable resources.

The Food and Agricultural Organization (FAO), the agricultural arm of the World Health Organization (WHO), formally defines organic agriculture as

> a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system (FAO and WHO 2001:5).

Some of the practical measures used in organic farming to increase biological diversity involve: increasing and maintaining soil fertility; recycling plant and animal waste; relying solely on renewable resources for farming; and maintaining organic integrity throughout the production and handling process (FAO and WHO 2001). Organic practices are claimed to promote long term environmental sustainability and preserve cultural aspects of farming in the form of preserving local agricultural knowledge and engagement in fair trade practices. “Much of the current organic literature combines the sovereignty of food and trade environment into what has been termed the organic movement” (Reed and Holt 2006).

For many members of modern organic communities, including consumers of organic products, there is a belief that organics is more than just the proactive omission of chemicals from farming practices. Some sectors of the organic movement argue that it actually refers to an ethical way of life which includes practices based on the principles of social justice, community building, fair trade and transparency (Singer and Mason 2006).

As a standardized agricultural system, the modern organic movement has a relatively short history, although aspects of organic farming have no doubt been practiced for millennia. J. I. Rodale, founder of *Organic Gardening* magazine in 1942 is widely considered the father of the organic movement, although The Soil Association is recognized as the principal organization where organics was originally formalized (Reed 2006; Singer and Mason 2006). The voluntary standardization of organics began in the 1950s but it was not until the 1980s that statutory regulation of organic farming commenced (Reed 2006). Organic practices have enjoyed public prominence for the past three decades[32].

Although many aspects of organic farming are widely believed to contain environmentally beneficial properties, there is mixed comment in the literature on the potential health benefits of consuming a diet consisting solely of organically produced food compared with consuming crops that have been bred using traditionally selected breeding techniques. The majority of peer reviewed articles have concluded that there is insufficient evidence to support the claim that organically-produced food is nutritionally superior to transgenic or conventionally-grown crops[33]. A review of biochemical testing revealed no major differences in desirable

[32] Permaculture is another example of a holistic system of agriculture where the use of trees, shrubs and livestock are specifically designed to create an interdependent and dynamic system of food production.
[33] One exception to this literature is Heaton (2003-4). Granted, this article was published in an organicists' magazine, it is nevertheless worth noting the claims made. The first is that organic produce contains the same level of macronutrients as conventionally grown produce, but contains higher levels of micronutrients such as magnesium, calcium, selenium, copper and zinc. The consumption of micronutrients is essential for good health

nutritional values between the different agricultural production systems (Woese, Lange et al. 1997).

Research conducted in Germany has found conventionally cultivated vegetables contain significantly higher nitrate content than their organically produced counterparts (Woese, Lange et al. 1997). Lower pesticide residues were found in organically produced fruit and vegetables yet conventionally grown produce contained less than statutory limits (Woese, Lange et al. 1997). Finally, in terms of general crop quality, no significant differences have been found between crops fertilized with inorganic substances, and those fertilized with organic manure (Biao, Xiaorong et al. 2003). The majority of research to date has concluded that the most notable difference between conventionally and organically produced food is primarily environment-related. That is, organic farming systems are far more compatible with sustainable agricultural systems than conventional food production systems (Woese, Lange et al. 1997) as a result of practices that promote, for example, soil preservation as opposed to practices that promote yield quantity as a primary goal.

A number of factors impact on the accuracy and significance of comparative studies between organic and conventional produce including extraneous variables such as climate and soil conditions (Adam 2001). Epidemiological studies large enough to determine whether there were significant differences in human health from solely eating organically produced food

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however, even if these results are true, comparison studies would need to demonstrate the benefits of consuming organic food in the wider context of diet and lifestyle considerations. Another claim made in Heaton's (2003-4) feature article is that conventionally grown produce is primarily selected on the basis of commercial factors such as potential tolerance to pests or yield quantities, rather than on the basis of nutritional quality. Increased variety of produce, it is postulated, would necessarily lead to increased nutrition. It can be countered that individuals choose the varieties of foods they eat, something that is not governed by organic or conventional agricultural methods. One final reason put forward for the higher nutrient content of organically grown crops compared with conventionally grown crops is that synthetic nitrogenous fertilization promotes rapid growth the consequence of which is higher water content in the produce. Organically grown produce, it is argued, contains higher amounts of drier matter which would necessarily contain higher nutrient content. This is probably the most plausible reason offered for higher nutrient content, although nutritionists have not formed consensus on the significance of these findings in terms of overall health benefit.

would be very expensive and unlikely to yield meaningful results. It is likely that consumers who choose an organic diet also consume a wide variety of nutritious food and are also more likely to be involved in other healthy lifestyle habits such as regular exercise, not smoking cigarettes and good work-life balance.

There are a number of contaminants within organic food that are present as a direct result of particular organic practices and have been linked to potentially harmful effects for humans. While organic produce contains fewer chemicals than conventional produce, the presence of *E coli* and potentially harmful mycotoxins[34] in organic food has been raised as a serious concern (Pence 2002; Singer and Mason 2006). The use of rotenone, a refined yet naturally occurring pesticide, commonly used by organic farmers to protect apples, pears and tomatoes has also been demonstrated to be potentially toxic to humans (Pence 2002).

A number of more general ethical concerns have been raised against organic agriculture. Singer et al. (2006) point out that conventional farming generally enjoys a higher yield for a given area of land (Singer and Mason 2006). Higher yields conceivably prevent further land use and therefore might serve as a more environmentally sound policy. However, a good environmental policy might consider practices that encourage good soil health to be superior to decreased land use[35]. Another point made by Singer (2006) is that organic produce is generally unaffordable for the poor. Granted this argument is presented within the context of equity in consumer choice, as with all relatively new markets, it is generally expected that in

[34] The use of fungicides in organic farming is discouraged although not using fungicides can result in the formation of mould on food that contain mycotoxins, substances that are potentially toxic to humans at certain levels.

[35] It is interesting to note that conversion from conventional agricultural to organic agriculture in industrial systems produces lower yields, whereas yields are considerably higher when applied to developing agricultural contexts. This is based on the understanding that increased yields are more likely to be achieved if the departure point is a traditional system, even if it is degraded. See FAO and WHO (2001). Guidelines for the production, processing, labelling and marketing of organically produced foods. Codex Elimentarius, Food and Agricultural Organization and World Health Organization, The International Council for Science (2003). New Genetics, Food and Agriculture: Scientific Discoveries - Societal Dilemmas. G. J. Persley. Paris, France.

time, prices will decrease as market demand increases and there are improved efficiencies in methods of production.

Another concern raised primarily within intensive commercial production systems, is that organic practices are generally labour intensive and require considerable investment in manual labour to be successful. This might encourage commercial growers to reduce labour costs by hiring unskilled workers, particularly in poorly regulated working environments[36] (Pence 2002).

Some would argue that the growth of intensive large-scale organic production in Australia and elsewhere has compromised the original organic philosophy of respect for holistic, harmonious ecology. "The organic label is no guarantee that a particular product comes from a farm that is in harmony with its natural environment" (Singer and Mason 2006:182). Trewavas (2002) provocatively argues

> "The only justification left for buying organic food [on environmental grounds], (since it is less efficient and wasteful of land) is that farmers apply less pesticide in its production. That is precisely what the current GM crops offer us but at conventional food prices" (Trewavas 2002:155).

On the whole however, in comparing intensive conventional agricultural practices with organic agricultural practices, the latter interacts with the environment in a more ecologically sound and sustainable manner. Organic farming methods maintain soil health, foster biodiversity both within the farm and external to it, reduce pollution, particularly via nitrogen

[36] This is an issue especially relevant in developing world agricultural systems where many families are affected by chronic diseases such as malaria and AIDS.

runoff, avoid heavy use of synthetic chemicals that have the potential to adversely affect the environment, and generally use less non-renewable energy for a given yield compared with conventional farms (Singer and Mason 2006).

*1.4 Organic Objections to GM technologies*

The organic farming community generally rejects GM technologies but it is not clear on what basis they do so. If we assume that these divisions are philosophical in nature, there is little in the general organic literature that establishes philosophical differences other than a statement that external inputs are undesirable. Neither the FAO stipulations on what constitutes organic agriculture, nor the Australian Organic Standard – the regulatory arm of the Biological Farmers Association - provide clear reasons for the blanket disapproval of novel gene technologies in both plant and animal agriculture production systems.

Two common principles enshrined within organic philosophy are the notion of *organic purity*; and the rejection of practices that interfere with organic produce using *external inputs*. Theoretically, these two conditions might be used to justify a rejection of GM practices on the grounds that such technologies compromise or violate these principles.

Within organic agriculture, external inputs generally refer to the use of practices deemed external to the farming ecosystem on which holistic organic agriculture depends. These might include the use of synthetic fungicides and fertilizers, or the use of sophisticated food processing techniques anywhere in the supply chain used in conventional food processing, such as food additives. Organic standards do, however, allow the use of conventionally propagated insect-resistant plants to control damage to crops caused by pests. It is difficult to objectively distinguish any clear boundaries between what external inputs are and are not permitted in complementary agriculture. There is no morally significant difference between using pest resistant cultivars that have been manually propagated over many years, and using time-efficient technology that achieves more accurate results over a much shorter period. The increasing use of sophisticated sowing and harvesting machinery on large-scale intensive organic farms might be considered to push the boundaries of a praxis that attempts to be in harmony with natural processes.

The principle of organic purity has analogies with religious understandings of purity that are unattainable in practice and very similar to traditional notions of “naturalness”. A condition of purity is better understood if applied within normative understandings of naturalism. Assigning normative value to naturalism within a specified (organic) setting has the effect of giving it valorised meaning. In the final section of this chapter, I apply Verhoog (2003) and colleagues’ adaptation of the concept of naturalness in an attempt to demonstrate that GM agriculture should be acceptable to the organic community if transgenic farming practices are implemented in an environmentally and socially responsible manner.

### *1.5 An unreasonable expectation of incommensurability: The organic movement’s creation of inviolable boundaries*

The last two decades has seen an increase in the demand for both GM and organic crops (Byrne and Fromherz 2003; Brookes 2004). Increasingly there has been a need for growers to find mutually acceptable practices in an effort to co-exist successfully. Co-existence is not a new concept and only becomes an issue if there is a distinct demand for non GM crops, as is the case for the organics industry (Brookes 2004). The European Union's definition of coexistence in this context relates to the

> economic consequences of adventitious presence of material from one crop in another and the principle that farmers should be able to cultivate freely the agricultural crops they choose, be it GM crops, conventional or organic crops (cited in Brookes 2004:189).

The expectation by some organic growers for absolute non-interference from other agricultural growers is unreasonable and unjustifiable given the complexities of modern agriculture and surrounding ecosystems. At present, the accidental presence of up to 1% GM material in organic crops is currently tolerated in EU law without the organic grower being penalized, yet there is presently a push within the organic movement to lobby for a determination of 0% transgenic presence in organic crops both within the UK and Australia (Bruce 2003:598). US regulation allows for some movement in the content of GM in crops sold as 'organic' although 96% of growers have reported not experiencing any loss of organic sales or downgrading of produce as a result of GM adventitious presence in their crops (Brookes 2004). Any market losses to date have been the result of poor segregation practices (Brookes 2004).

The principle of justice needs to apply to both systems of agriculture in the spirit of fair enterprise (Bruce 2003). Conventional growers have a duty to ensure that the risk of pollution is minimized. Similarly, organic farmers have a right of protection against avoidable transgene flow. These expectations should be based on shared norms (Bruce 2003). The current 1% rule is compatible with this ideal. An expectation of purity, that is, a determination of 0%, is not only beyond currently available analytical capabilities, but

> goes beyond normal societal expectations…short of withdrawing from the world into a restricted community, where one only grew food, used energy and other resources of one's own making, in a tightly defined location, nothing we eat could be called absolutely pure any more than it could be said to be absolutely safe (Bruce 2003:602).

Byrne and Fromherz (2003) describe a public process where shared responsibility for the co-existence of GM and organic crops grown on publicly owned open space farmland was encouraged. This endeavour took place in Colorado, an environment that has low humidity and frequent high winds, both factors that encourage pollen flow. Simultaneous cultivation of GM and organic crops were observed from 1996 to 2000 (Byrne and Fromherz 2003). The study found co-existence was workable provided farmers shared responsibility for it. This was achieved without government intervention through the employment of practical measures that limited pollen travel. The study concluded that "shared responsibility for co-existence is a practical and desirable strategy if based upon an acceptably low level of cross-pollination rather than a 'zero tolerance' level" (Byrne and Fromherz 2003:216).

The organic community cannot set standards that exclude other agricultural systems from participating in legitimate agricultural activity, especially if the sale of GM foods is acceptable to a significant proportion of consumers (as is the case in many non-European and non-British countries)[37]. And especially not when agricultural co-existence has been successfully practiced in certain geographical locations (Bruce 2003; Byrne and Fromherz 2003; Brookes 2004).

### *1.6 Death of the monarch butterfly, UK Farm Scale Evaluations and other controversies*

Numerous controversial events in recent history have arguably influenced consumer rejection of transgenic technologies and consumer take up of food produced by organic means. The most notable of these events are: the widespread European consumer backlash of the 1990s to GM crop trials in the absence of public consultation; the publication and subsequent withdrawal of a peer reviewed study allegedly demonstrating the environmentally harmful effects of Bt corn[38]; the British government's ambitious attempt at generating conclusive results from the heavily funded UK Farm Scale Evaluations; and the British BSE beef crisis of the 1990s. All of these events occurred within the span of one decade and (inadvertently or otherwise), produced negative or inaccurate information about the potentially harmful effects of novel biotechnologies and exposed inherent weaknesses in the regulation of the food industry.

During the 1990s, the EU permitted a number of small-scale private transgenic field trials to go ahead for the purpose of researching the commercial viability of GM agriculture. Following publication of preliminary results, a public outcry ensued that was partly generated by the European media and partly by the efforts of anti-GM campaigners. Any potential

[37] This argument is dependent on whether citizens find growing GM crops advantageous as a food source, a feed source or some environmental good. Sole agribusiness commercial gain would not qualify.
[38] Bt corn is the common term used to describe transgenic corn modified with the soil bacterium, *Bacillus thuringiensis*, which has the effect of enhancing a crop's fitness to withstand attack from certain insects and arthropods by delivering toxin to such predators.

benefits that small-scale trials of GM crops may have offered in Europe were quickly forgotten following widespread public backlash against research on GM technologies occurring without sufficient public consultation (Bruce 2003).

In 1999, Losey et al. (1999) published an article in *Nature* that was thought to conclusively demonstrate the harmful effects of Bt corn on the larvae of the Monarch butterfly. The authors set out to demonstrate that milkweed, a plant that grows in and around cornfields and is the sole food supply of Monarch butterfly larvae, was harmful to these larvae when it was contaminated with pollen from Bt corn. Losey et al. (1999) dusted milkweed with undisclosed amounts of Bt corn pollen and compared its effects on the feeding habits and survival rates of larvae compared with that of larvae that consumed milkweed dusted with non-transgenic corn pollen (Fedoroff and Brown 2004; Stewart 2004). Consequently, most of the larvae died as a result of contact with Bt pollen. The authors argued from these findings that Bt corn posed a significant danger to Monarch butterfly populations. Among the methodological criticisms of the paper was the undefined amounts of Bt pollen used and the use of non-choice feeding conditions that were not representative of conditions in real-life cornfields (Stewart 2004).

A follow-up study conducted by other researchers found corn pollen travelled minimally and that the link between larvae mortality and pollen load was not significant. Pollen travel decreased with distance indicating that the risk of harm to butterflies rapidly diminished with distance from cornfields (Stewart 2004:102).

Following Losey's (1999) article, a multi-site project was launched to determine the effects on Bt corn pollen on the larvae of monarch butterflies (Fedoroff and Brown 2004). The subsequent publication of six scientific papers in *The Proceedings of the National Academy of Sciences USA* (PNAS) coincided with the September 11 terrorist attacks in New York and consequently received little publicity (Fedoroff and Brown 2004). "Consequently, the image of dead monarch butterflies lingers in the public consciousness as the unacceptable face of GM technology" (Fedoroff and Brown 2004:207). Nevertheless, findings of the original study led to more stringent regulatory controls (Fedoroff and Brown 2004).

Following the Monarch butterfly controversy, the British government invested substantial resources in attempting to determine the environmental effects of transgenic crops. This venture led to the establishment of what is now commonly referred to as the UK Farm Scale Evaluations (FSEs). Between 2000 and 2003, the British government invested $10m in a study that sought to determine if transgenic herbicide tolerant crops, coupled with their appropriate herbicide, decreased biodiversity on farms. The study yielded mixed results. Weeds found in transgenic sugar beet and canola plots were controlled more effectively compared to non-transgenic plots but the opposite was true for corn (Stewart 2004). It has since been proposed that the use of atrazine, now a banned herbicide in Europe, was responsible for this finding. Overall however, greater numbers of arthropods were observed in conventional beet and canola plots compared with their transgenic counterparts but interestingly, the opposite was true for corn (Stewart 2004). One surprising finding was that there were greater differences among individual crops in the same plot than there were between fields of transgenic and non-transgenic plots. The strongest conclusions that can be made following the FSEs is that the numbers and varieties of arthropods is governed by crop choice, weed control, and insecticide use (Stewart 2004). "The FSEs tell little about how individual organisms interact as populations and communities in these habitats and nothing about the biodiversity of the larger surrounding ecosystem" (Chassy, Carter et al. 2003).

The British beef crisis of the 1990s further compromised the reputation of manufactures of novel products if only by increasing distrust of large multinational suppliers of food products. Addressing uncertainty was probably the biggest failing of the British authorities in the bovine spongiform encephalitis (BSE) crisis of the 1990s (Jensen 2004). A lack of scientific consensus on the probability and nature of the risk, coupled with poor communication strategies between policy-makers and the public, and a reluctance by authorities to inform the public of a possible risk for fear that it would cause undue alarm, led to one of the largest health crises of the twentieth century (Gregory 2000; Hails and Kinderlerer 2003; Jensen 2004). Organic producers in Britain enjoyed increased public support for their products in the wake of public outrage over the BSE scare of the 1990s (Adam 2001).

The Monarch butterfly controversy, the UK FSEs, and the BSE scare in Britain have had the unfortunate consequence of attracting negative media attention to the GM cause. While harming the 'pro-GM movement', these same events benefited the organic movement in its search for a larger market share of the food industry. It is widely known that consumers generally turn to organic food following major food scares (Pence 2002). It *is* speculative whether certain events and reactions following each of these crises benefited the organic movement in that it turned consumers away from purchasing or consuming 'unnatural' food that had been tampered with. Determining whether reactions from certain sectors from the organic community were deliberately staged, is certainly beyond the scope of this thesis. What can be claimed however, is that the public response to the first major food crisis to hit the biotech industry in the early 1990s benefited the organic industry.

Poor public relations management, coupled with inadequate handling and accountability processes, damaged the conventional food processing and biotechnology industries to a point where the potential benefits of novel technologies need to be demonstrated before the public will trust further innovations. Until then, the organic industry will continue to prosper both at an economic level and as safe, environmentally sustainable producers of food.

### *1.7 A possible point of convergence: compatibility between transgenic and organic agricultural practices*

The public backlash generated by events such as the monarch butterfly review and the British beef crisis of the 1990s, has generated momentum for the organic movement to establish and strengthen its position as a viable, safe and environmentally friendly industry (Reed 2006). Yet, under clearly defined conditions, the use of GM agricultural practices is arguably harmonious with these same values[39]. It is reasonable to expect that if transgenic agricultural practices function under similar conditions specified by the organic food industry, then GM agriculture should be acceptable to the organic movement. These conditions might include only engaging in agricultural practices considered sustainable, such as planting novel crops that preserve soil integrity or have the potential to remediate over-cultivated soil.

A means of resolving the conflict between transgenic practices and organic philosophies might be to broaden what we mean by the term ‘organic’ when comparing organic agriculture to other systems. I argue that transgenic agriculture is in fact complementary to organic

[39] Examples of situations under which the use of novel biotechnologies is both viable and environmentally friendly are those where consideration is given to their purpose, their perceived benefits and risks, fair trade policies and their effects on the local community. This thesis has dedicated chapter six to the discussion of social, cultural and economic issues related to novel genetic biotechnologies.

practice when we use Verhoog (2003) and colleagues' conception of naturalness as a criterion to assess the impact of agriculture on the external environment. This argument depends on transgenic agriculture not only satisfying the naturalness criterion formulated by Verhoog et al. (2003), but also on a number of other socially acceptable conditions such as engaging in fair trade practices and deliberative community consultation, among other criteria[40].

Using a combination of normative and qualitative research methodologies, Verhoog et al., (2003) conducted semi-structured interviews of respondents' views of normative statements that relate to conceptions of naturalness among key stakeholders in the organic industry. The authors interviewed key stakeholders to explore what was generally understood by naturalness in various contexts[41] and found that "with naturalness as a criterion, the no chemicals approach is not sufficient to distinguish organic farming from an environmentally friendly, sustainable, and integrated form of conventional agriculture" (Verhoog, Matze et al. 2003:46). The authors concluded that three characteristics of naturalness were needed to capture what is meant by organic and what should be applied in organic agriculture. These three characteristics were: the no chemicals (inorganic) approach; respect for ecological principles; and respect for the integrity of nature (Verhoog, Matze et al. 2003). I will argue that carefully considered applications of GM are compatible with these three components of naturalness in organic philosophy. This has implications for the conduct of both GM and organic industries in negotiating a voice in contemporary, integrated agricultural practices. I

[40] The elements of socially acceptable, fair trade policies and what constitutes deliberative community consultation, can be found in the chapters concerning social and cultural considerations of GM, and environmental pragmatism, chapters 6 and 2 respectively. Other considerations include sound environmental risk assessment practices and real world benefit.

[41] The concept of naturalness was explored using contexts such as sustainability, ecosystem health, animal husbandry, arable cropping, food and nutrition, biotechnology and bioethics. See Verhoog, H., M. Matze, et al. (2003). "The role of the concept of the natural (naturalness) in organic farming." Journal of Agricultural and Environmental Ethics **16**(29-49).

will argue that an integrated approach is the most desirable method in securing the most socially and environmentally sound agricultural policies.

According to Verhoog (2003) and colleagues, the first measure by which we can compare organic and transgenic agricultural systems is the inorganic approach to farming. This includes refraining from using synthetic pesticides and fertilizers in favour of more ‘natural’ substances. The use of natural (non-transgenic) herbicide-resistant cultivars is common practice for maintaining crops that can withstand biotic stressors such as crop damage from insects. There are numerous concrete examples in the scientific literature that have demonstrated the potential for transgenically produced plants to confer pest resistance. If traditionally cultivated insect-resistant crops are acceptable to organists, the fundamental difference with transgenically altered plants is the use of sophisticated technology – essentially a leap forward in time – a criterion that cannot reasonably be of sufficient moral significance to justify disallowing its use. One of the benefits of pest resistant GM crops is an environmental one. The “no chemicals” criterion yields the same environmental benefits whether applied to transgenic or organic agricultural practices.

The second criterion for inclusion into an organic framework of practice is an ecological approach (Verhoog, Matze et al. 2003). The ecological approach to agriculture recognizes the farm as a complex, sustainable and balanced agro-ecosystem (Verhoog, Matze et al. 2003). It requires a broad approach to farming where “solutions are based on rational, experiential, and experimental ecological knowledge” (Verhoog, Matze et al. 2003:42). Arguably, the employment of specifically-designed transgenic technologies to individual contexts is sound agricultural policy. Adopting best practice risk assessment principles to well-researched agricultural applications is what the ecological criterion requires. Novel biotechnologies are better placed to contribute to sound ecological practices because they can be controlled at the molecular level more so than conventionally-based agricultural practices. This capability is arguably advantageous in achieving ecological goals.

The third criterion, referred to as the integrity approach, is slightly broader in its purpose and intention. It encapsulates notions of agricultural systems that promote socio-economic equity, animal welfare, holistic and community-driven farming practices. Respect for ecological principles not solely within the farm environment (plants; animals) but also socially and economically sound practices are implied in the integrity approach to agriculture (Verhoog, Matze et al. 2003). No doubt some current GM practices, such as those enforced by monopolistic policies in developing agricultural systems do not comply with these ethical principles[42]. Carefully considered applications of GM agriculture would satisfy the integrity criterion according to widely held notions of naturalness. This is more of an argument against intensive farming of any type, whether conventional, organic or transgenic, than a fundamental objection to transgenic agriculture.

Conventional, organic and transgenic agricultural practices each have qualities that are favourable to a socially and environmentally responsible food production system. Conventional farming has the advantage of being the most refined form of agriculture, producing high yields of produce that benefit consumers. Organic agricultural practices offer a holistic approach to the farming environment, one that is necessary in managing

[42] I elaborate in chapter six the conditions necessary for applications of transgenesis to be deemed ethically acceptable in terms of its wider social and economic impact. One example of a policy that might have detrimental effect on the social, economic and cultural aspects of agriculture is the enforced implementation of GURTs in developing world contexts. Such corporate agreements would serve to transfer economic and cultural sovereignty from subsistence farmers to large agribusinesses and would therefore have a devastating effect on the local community. See Pretty, J. (2001). "The rapid emergence of genetic modification in world agriculture: contested risks and benefits." Environmental Conservation **28**(3): 248-62.

environmental sustainability. Novel biotechnologies can complement both of these systems in that transgenics can isolate desirable traits that confer advantages in the environment and introduce them into species that are likely to benefit. This has numerous potential advantages for agriculture including promoting crop stability in harsh environments, eliminating crop damage from biotic stressors and assisting in bioremediation.

One environmental threat not addressed by the organic community is the threat from traditionally selected and bred herbicide tolerant varieties. The same standard of research demanded by the organic community to determine ecological safety with transgenic crops has not been undertaken within the organic community. On an evolutionary scale, the effects of the use of herbicide tolerant (organic) crops are unknown[43], yet the organic community demands that transgenic crops meet standards that it does not apply to itself.

The incommensurability claim made by the organic movement is arbitrary. Crop feasibility studies along with risk assessment processes can determine whether certain crops carry too much risk of pollen travel within a given setting. Co-existence between conventional, organic and transgenic agricultural systems is not mutually exclusive and is in fact environmentally and socially compatible if clearly defined management practices are applied.

It is not clear on what grounds the organic movement has renounced the use of transgenic techniques despite their potential environmental benefits. This chapter has attempted to launch a discussion on some possible areas of common ground between transgenic and organic farming systems. Ultimately, investment in agricultural practices that are flexible,

[43] Following a discussion with my supervisor, I am of the opinion that the 'evolutionary effects' of herbicide tolerant crops might perhaps be somewhat trivial when compared with the potential contribution greenhouse gases make to global warming, for example.

integrative, based on principles of equity, and environmentally sustainable will provide the most desirable outcome.

## Chapter 2

## Environmental pragmatism: Reconciling concerns about new genetic technologies with the broader goals of sustainable development

*"We have to get along without certainty; we have to solve practical, not theoretical problems, and we must adjust the ends we pursue to the means available to accomplish them. Otherwise, method becomes an obstacle to morality, dogma the foe of deliberation, and the ideal society we aspire to in theory will become a formidable enemy of the good society we can achieve in fact."*

Mark Sagoff, *The Economy of the Earth*, Cambridge University Press, 1988, p.14

### *2.0 Introduction*

Proponents of GM crop technology advance three chief claims about its potential benefits: (1) that GM crops can contribute to environmental sustainability by, for example, reducing the impact of agriculture on the environment; (2) that GM plant technology can reduce malnutrition especially in the third world by developing plants that are resistant to pest-derived disease or abiotic stress such as soil alkalinity or drought conditions; and (3) that GM crop technology can deliver better healthcare through the development of second-generation GM crops such as biopharmaceuticals and edible plant vaccines. This chapter will explore the plausibility of the first claim namely, that GM plant technology can play a significant role in promoting environmental sustainability and in particular, sustainable development.

A primary aim in this chapter is to show that, contrary to the claims of opponents that GM plants can adversely affect the environment and are opposed to any notion of sustainability, there is good empirical evidence in the scientific literature that many applications of GM plants are in fact compatible with a notion of sustainability and sustainable development[44,45]. What makes the opposition's argument less plausible, is that some claims used in their defence are based on scant or fragmentary evidence. While *it may be the case that some applications of GM technology may not be sustainable in the long term*, there is better and stronger evidence to suggest the contrary[46].

In this chapter I intend to show that some applications of genetic technologies are compatible with sustainability. I do this by first providing an operational definition of sustainability and sustainable development which can be applied in both industrialized and non-industrialized contexts. I then show that traditional debates in environmental ethics contribute little to contemporary environmental disputes such as those problems associated with the adoption of GM policies. I conclude the chapter by introducing *environmental pragmatism* as a strategy for use in evaluating GM applications or products and their potential contribution to the broader goals of sustainable development.

### *2.1 Defining sustainability (and sustainable development) in the context of GM*

The *un*sustainability of modern (traditional) agricultural practices and their impact on the wider environment is well documented. Among the negative consequences of modern

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44 There are also some applications of GM technology that might be argued to be neutral to a notion of sustainability, such as the development of GM foods for the sole purpose of enhancing their flavour or colour.

45 Various applications of novel genetic technologies that are compatible to a notion of sustainability are discussed in the prologue to this work.

46 I cannot empirically prove or disprove either position. This is not the task of the present discussion. Unfortunately, there have been documented instances of unintentional gene transfer between fields of GM and non-GM crops. Since then, researchers have pursued ways to prevent any further cross-contamination. To my knowledge, all cases of foreign gene transfer have occurred within a monitored and contained setting and research is currently under way to prevent cross-species gene transfer on a number of GM crops at the molecular level. However, the types of catastrophic claims about gene transfer made by some anti-GM lobbyists are not well supported in the literature. Chapter 1 in this thesis provides an exposition of issues relating to gene flow.

agricultural practice are an ever-decreasing availability of arable land, a significant reduction in soil quality, and a reduction in the biodiversity of crops grown (Caldwell 1998). Third world agriculture accounts for much of the 80% of annual world deforestation while industrialized systems are largely responsible for an over-dependence on water for irrigation (Caldwell 1998). There are many texts dedicated to discussing sustainability in various contexts but finding a commonly accepted normative position on sustainability is surprisingly difficult.

Discussions about sustainability appear in a myriad of contexts and different methodological approaches underlie the diversity with which it is defined[47]. For example, economic discussions about sustainability have considered substitutability of natural resources and capital growth to be legitimate goals, while social and political theorists have highlighted issues concerning political conflict and governance as of central importance to sustainability. The following discussion will predominantly focus on sustainability in the agricultural and environmental contexts in view of the broader purpose of this thesis[48].

As a starting point, we can borrow two uncontroversial features of a definition of sustainability from a provisional definition offered by Newton (2003). There are two objects of value important in any definition of sustainability: the first is the non-human environment; the second are future generations'[49,50] interests in sustaining themselves (Newton 2003).

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[47] See *Encyclopedia of International Development* (2005) Tim Forsyth (Ed), Routledge: London.

[48] Some readers may perceive a conflict in grouping environmental and agricultural sustainability together since historically, many agricultural practices have been detrimental to the environment. The current discussion seeks to highlight the factors that contribute to their compatibility. It is my view that sustainable agricultural practices that take account of socioeconomic and environmental aspects in addressing an environmental issue or problem, actually *contribute* to the sustainability of the environment.

[49] It is implied that a definition of sustainability includes present generations as a given in its domain of value.

[50] Exactly what is meant by 'future generations' or how many generations we should extend moral consideration to, is not described in most definitions of sustainability. I would expect that most definitions hold a medium-term view of the future (that is, 2 or 3 generations) since this measure is tangible to most of us. A more long-term measure of sustainability has been offered by Lisa Newton (2003) and David Suzuki (1997). Newton

What kind of value (other than utility) the non-human environment has, or whether it deserves special consideration, varies greatly in definitions of sustainability and have been topics of debate among environmental philosophers since the 1970s. Further, there is no agreement on what level of consideration might be accorded to intergenerational equity other than a vague acknowledgement that we have *some* obligations to future generations in ensuring our use of natural resources are sustainable. This is an obvious omission in many descriptions of sustainability. Further, most (if not all) definitions of sustainability imply some level of 'use' of the environment or natural resource to which the definition applies (Norton 2003).

These three core features are implied in the most often-cited definition of sustainability which appears in the Brundtland Commissioner's Report (1987). Sustainability here is framed in the context of sustainable *development* where it is defined as "development that meets needs of the present without compromising the ability of future generations to meet their own needs" (Norton 2003:169). The term 'development' as used here includes improvement of the 'general lot' and should not be equated with 'growth' as is sometimes intended in economically-derived definitions of sustainability. Sustainable *development* (SD henceforth) in the context of this discussion, aims to ensure that the basic needs of the poor are met so that communities as a whole benefit from any endeavours promoting sustainability. This is in contrast to sustainable *growth* (SG) which aims to increase wealth in general (though not necessarily for all sectors of the community) and where benefits most often accrue to those

(2003) cites the American Indian tradition of ensuring that any action that results in a change to the environment must be able to support 7 generations (210 years)- as a good benchmark for measuring the sustainability of any action. On this view, the seventh generation must be able to derive the same benefits from similar activities as the present generation. David Suzuki argues a similar stance in *The Sacred Balance: Rediscovering Our Place in Nature, 1997, Allen and Unwin: St. Leonards, NSW.* Although this measure is somewhat arbitrary, it nevertheless provides a focal point to discussions about the longer term future, so I will use it here.

already in privileged positions[51,52]. The chief pronouncement of the Brundtland definition is that sustainable development implies that there are limits imposed on the extent of human activities by the stability of the natural environment.

Many criticisms can be made of the Brundtland Report's characterization of sustainability[53]. Norton (2003) argues the Brundtland definition presupposes a very strong principle of infinite intersubstitutability of resources- a principle at odds with most environmentalists (Norton 2003). Traditional understandings of sustainability are formulated within the context of economics as a measure of capital whether this be human, man-made or natural capital (Attfield 2003). If we measure the natural environment in terms of capital, we are confronted with the problems that a limit to substitution entails. As Attfield (2003) correctly points out, the ozone layer cannot be substituted.

The Brundtland definition lacks clear guidelines relating to process[54] but perhaps the most glaring deficiency in the Brundtland definition is its omission of any overt recognition of limits (Attfield 2003). Respect for ecological integrity is required for any serious definition of sustainability (Barrett and Grizzle 1999). "Besides physical efficiency, and economic

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[51]Under this definition, support for projects such as the release of GM begonia (with the attribute of providing prolonged freshness), under the banner of SD, might be problematic simply because of the environmental risk involved in doing so. Economic benefit might be provided to some, and for others GM Begonia might provide aesthetic qualities, but it is arguable whether the release of GM begonia will improve the 'general lot' of a community or meet the needs of the poor.

[52] Although the goals of SD are fairly easily conceived in third world contexts where poverty is widespread, it is just as applicable in industrialized environments such as Australia. Appendix 6 illustrates the potential benefits that can incur from embracing a SD approach to an Australian environmental problem.

[53] Both the Rio and Brundtland Reports were originally formulated as policy guides only and were designed to be used as starting points for discussions about a concept of sustainability inclusive of the human and environmental impact of technological progress. In this capacity, the definitions offered by the Reports are highly interpretative and not easily operationalizable, much like the Precautionary Principle. It is one aim of the current discussion to find a workable definition that might be applied to specific environmental issues or problems.

[54] Interestingly, many of the same criticisms levelled against policy-directed definitions of the Precautionary Principle can be made of attempts to define sustainable development. The role of the Precautionary Principle in the GM debate is discussed in depth in chapter five.

viability, any assessment of biotechnology or other agricultural advances include a check on its compatibility, both in intensity and scale, with the stability of ecological processes" (Giampietro 1994:677). This omission in the Brundtland Report was addressed in The Rio Declaration on Environment and Development (1992) where it was recognized that any improvements in a quality of life must be within the carrying capacity of supporting ecosystems (Attfield 2003). The Rio Declaration (1992) also asserted that "governments have a global responsibility for resolving conflicts over the environment in ways that protect the interest of humanity and nature" (Myhr and Traavik 2003:318). The problem of substitutability has led environmentalists to clearly distinguish between two versions of sustainability. *Weak* sustainability sets few limits to replacing natural capital with human-made capital whereas *strong* (or radical) sustainability recognizes ecological limits thereto (Attfield 2003). Table 2 illustrates this distinction.

| Radical Interpretation of Sustainability | Weak Interpretation of Sustainability |
|---|---|
| Strong, egalitarian bottom-up approach to sustainability<br><br>Recognition of inherent value of the natural environment (which supplies a foundation for environmental limits)<br><br>Acceptance of environmental limits, applies the precautionary principle (PP) when necessary<br><br>Recognition of ecosystem vulnerability<br><br>Involves (in its process) an opportunity for participation, consultation and inclusion for resolution of environmental problems | Narrow, non-egalitarian top-down approach to environmental decision-making<br><br>Trade-off between growth and environmental protection<br><br>No explicit mention of an inherent value of the non-human environment<br><br>Understanding of sustainability as a measure of capital (human, man-made or natural)<br><br>Accepts the principle of indefinite intersubstitutability<br><br>Values economic development over global environmental sustainability |

*Table 2 Two conceptualizations of sustainability*

Three further dimensions of a comprehensive definition of sustainable development emerged from The Rio Declaration: a genuine definition of SD must include environmental; economic; and social considerations if it was to serve the interests of the non-human and human environments equally (Karlsson 2003). One benefit of including broader social considerations in decisions relating to sustainable environmental practices is that it ensures that solutions to problems caused by populations in industrialized environments are not blindly applied to non-industrialized contexts. Setting environmental agendas that overlook local traditions and local needs would not be acceptable as a goal of SD that sought to be inclusive of factors relating to geocultural and socioeconomic norms.

Michael Jacobs (as cited by Attfield (2003)) identifies two conceptual definitions of sustainable development (SD) which may provide a clearer perspective of its potential operational value: the first, (and the most favourable to an operational definition of SD), is a strong, egalitarian, bottom-up approach to SD; the second version of SD can be characterized as a weaker, non-egalitarian, top-down narrow interpretation of SD. Based upon the above discussion, we can characterize two distinct versions of sustainability: one which I'll refer to as *strong* and the other as *weak*.

The strong version of SD involves reduced dependency on inorganic inputs, use of fewer resources and less energy, utilization of natural, local resources, and preservation of local knowledge and cultures[55] (Myhr and Traavik 2003). GMOs that improve crop yields in poor countries or alleviate malnutrition is "likely to support sustainable development from both an environmental and socio-economic point of view and is therefore ethically justifiable" (Karlsson 2003:56).

Factors that are often argued to threaten SD from environmental or socio-economic perspectives include the use of terminator technology (also known as GURT) by agribusiness (particularly in developing world contexts), the development of crops that have little direct consumer benefit, and the potential decrease in biodiversity following the overuse of herbicide tolerant plants. The latter consequence of genetic technology is more speculative. Conceivably, genetically modified organisms can increase, decrease or be neutral to a notion of SD (Karlsson 2003).

[55]Florence Wambugu has demonstrated the success of such projects in local Kenyan communities. See Wambugu (2001) *Modifying Africa: How Biotechnology Can Benefit the Poor and Hungry, a Case Study from Kenya*. Nairobi: Kenya. Wambugu's work is discussed in greater detail in chapter six.

Environmental issues raised by applications of GM technologies arguably require an operational, pragmatic view of sustainability. This is because many aspects of the GM debate, such as consumer product labelling or the regulation of GM crop trials are strongly tied to public opinion. The development of public policies on these issues needs to address public concern. The strong version of sustainable development would be better suited to this goal.

Following a brief review of the potential traits that new plant technologies might offer to sustainable development practices, a vehicle for environmental discussion is proposed that might foster better dialogue between disputants about some of the ethical concerns raised by the adoption of these technologies.

*2.2 Potential GM traits compatible with sustainable development practices*

Salinity and drought tolerance are two agronomic traits currently under study that are compatible with a sustainable approach to agricultural practice. Examples of candidate crops that have been chosen for transgenic modification for the purpose of improved drought and salinity tolerance are cotton and wheat. Crops that contain such traits are ideally suited to the harsh Australian landscape as well as other similar environments in both industrialized and unindustrialized countries[56,57].

[56] The reader should be aware that using transgenic technologies to enhance the growth of plants in hostile environments is not the only method that can contribute to a sustainable approach to agricultural practices. Dr. Gordon Sato, a US molecular biologist was recently awarded the 2005 Blue Planet Prize for his contribution to research for the development of salt-tolerant grasses grown specifically for animal fodder. Consequently, the impoverished (and often malnourished) populations of Eritrea are being provided with the capacity to feed themselves. For more information, see http://www.eritreadaily.net/news/article20041823.htm (accessed online 4th July 2005).

Transgenically produced improvements, such as pest resistance and herbicide tolerance, may promote sustainable development in some of the following ways: a reduction in inputs in terms of labour and machinery costs; a reduction in the use of potentially harmful agrochemicals including pesticides[58]; and a reduction in the amount of land required for cultivation because of an increase in yield. Assuming that the risk of gene transfer is negligible or otherwise controllable, there are a variety of GM applications that have the potential to allow certain crops to flourish in harsh environments, mitigate the negative impact of current practices on the environment or perhaps restore over-cultivated environments to their original condition (Duvick 1995). All of these applications of GM are arguably compatible with a sustainable development approach to agriculture and the environment and they can be applied in both industrialized and developing nations.

However, not all genetically-derived technologies developed for use in plants are favourable to practices compatible with SD in all contexts. One unfortunate consequence of the modern intellectual property movement for the subsistence farmer is the emergence of Genetic Use of Restrictive Technology or GURT; an 'inbuilt' feature of some genetically modified products that prevents farmers from reusing seeds and thereby requires them to purchase seed from agribusiness every season[59]. The forced widespread use of GURT would arguably *not* be compatible with a principle of equity and therefore incompatible with the socioeconomic dimension of sustainable development, especially for farmers in developing countries (Karlsson 2003)**.** The potential use of innovative plant biotechnologies must be viewed from

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[57] A case example using Australian cotton and the potential impact genetic modification may have on the environment with respect to sustainable practice appears in appendix 6.

[58] Studies following the adoption of herbicide resistant technologies in Australian cotton farming have shown a reduction in pesticide use by 50%. See Kalaitzandonakes (2003).

[59] Although in this context the use of GURT does not encourage socioeconomic sustainability, GURT used in other contexts can be advantageous. For example, GURT may minimize the risk of gene flow of specific GM crops to surrounding environments, thereby minimizing its spread to weedy relatives.

a broader perspective that encompasses other equally important aspects of agriculture including its potential socioeconomic impact[60].

*2.3 Shortcomings of traditional approaches to discussions about environmental problems: Some foundations for good environmental policy*

Traditionally, environmental ethics has been primarily concerned with the preservation of the natural environment or its restoration. The aims of sustainability (in general) fit well into this characterization, but it is perhaps more difficult to argue that sustainable *development* fits well within environmental ethics. One reason for this might be that as a term, *development* has a clear anthropocentric flavour that conflicts with the focus of environmental ethics on promoting nonanthropocentrism in order to preserve the non-human environment. Proponents of GM have in the past used arguments that relate to sustainable development to justify benefits of adopting policies in favour of GM crops yet this has been at odds with how traditional environmental approaches to environmental problems.

In thinking about the types of disputes contained in the GM debate and the resolutions required, it is perhaps difficult to see how traditional approaches to environmental problems (such as those raised by the adoption of GM crops), can effectively contribute to strategic environmental policy-making. There are two chief reasons for this. The first relates to the shortcomings of traditional monistic approaches to environmental ethics which have failed to produce a coherent set of principles capable of yielding a 'right answer' to each quandary (Norton and Hargrove 1994). The second, and more general criticism that can be made of

[60] Chapter six discusses the socioeconomic and cultural impacts of genetic plant technologies in greater depth.

attempts to apply traditional ethical theories to contemporary problems such as the adoption (or prohibition) of GM technologies, is the failure to meet the onus to yield resolutions to contemporary real life environmental dilemmas or disputes[61,62].

The latter criticism can be attributed to what Norton and Hargrove (1994) have identified as a distinction between *applied* and *practical* philosophy. To Norton and Hargrove (1994), applied philosophy consists of “applying general philosophical principles in adjudications among policy goals and options - the goal of which is to develop general, abstract and universal principles and then apply these to specific cases” (Norton and Hargrove 1994). The role of the practical philosopher, on the other hand, is the more problem-oriented one of generating principles *from* practice. Theories for the practical philosopher serve as tools for understanding that are developed to resolve specific policy controversies (Norton and Hargrove 1994). Practical philosophers only introduce theories to help understand specific management problems (Norton and Hargrove 1994). The process of practical philosophy works much the same way as the Rawlsian goal of ‘reflective equilibrium’. As the authors expound it,

> The prevailing tendency of environmental ethicists to see problems in environmental policy as interesting cases with which to test philosophical principles rather than as real problems requiring rational resolution has isolated environmental ethics from policy discourse and debate. Given the

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[61] The same criticism can be made of both monistic *and* pluralist approaches to solving environmental problems on a pragmatic level. Norton and Hargrove (1994) have argued that pluralism has the added advantage of allowing agreement on specific cases without requiring agreement on the ethical principles that underpin them. However, this still falls short of actually contributing to environmental policy formation –arguably a basic goal for any serious environmental philosopher.

[62] For an interesting empirical study investigating the types of values that underpin the preferences of a chosen group of inhabitants in North America facing a contemporary environmental problem, see Minteer, et al. (2004) Environmental ethics beyond principle: The case for a pragmatic contextualism, *Journal of Agricultural and Environmental Ethics*, 17: 131-56.

> urgency of environmental problems and the serious controversies about what should be done in difficult cases, the goal of environmental ethics and environmental philosophy should be to contribute to resolving real debates. A greater emphasis on the facts of disputed cases and an eagerness to find common moral and philosophical ground among disputants – a move away from applied philosophy toward practical philosophy – would redirect environmental ethics away from abstract debates and toward resolution of urgent and important public controversies (Norton and Hargrove 1994:241).

Adopting some key tenets espoused by environmental pragmatists, I want to argue that environmental pragmatism (EP henceforth), as an environmental strategy, is better suited to incorporating sustainable development (in the context of the GM controversy) than more traditional environmental ethical theories. In particular, EP serves as an ideal foundation for discussions about promoting sustainability using applications of GM technology for the following reasons. First, EP is "agnostic concerning the existence of nonanthropocentric natural value or the relative superiority of one form of natural value versus another" (Light 2002:560). Abstract approaches to environmental concerns do not provide useful starting points to solving environmental problems, potential or otherwise. As Light (2002) argues, "we need to rethink the utility of nonanthropocentric arguments in environmental moral and political theory, not necessarily because the traditional nonanthropocentric arguments in the field are false, but because they hamper efforts to contribute to the public discussion of environmental problems, in terms familiar to the public" (Light 2002:556). As Norton and Hargrove (1994) perhaps bluntly avow, "abstract philosophical theories often introduce value categories that are useless for the problem at hand" and therefore have no traction in policy debate (Norton and Hargrove 1994:237).

Second, EP provides a *vehicle* for public discussions about environmental issues that moves away from traditional discussions about value theory (including "centrisms") which have generally proved unintelligible to the general public (Light 2002). Third, advocates of EP recognize that there is empirical evidence that humans perceive environmental problems predominantly in anthropocentric and utilitarian terms. That is, the general public readily identifies and relates environmental problems (and solutions) in an anthropocentric manner (Light 2002). One example of this is the commonly held view that preserving nature is an obligation we have towards future generations and not one that originates innately from any intrinsic perspectives of the value of nature. Other popular human-centred descriptions of the value of nature and the environment, as pointed out by Norton (1987, 1994), include the view that nature possesses aesthetic or *transformative* value[63]. According to both Norton (1987, 1994) and Light (2002), these approaches to discussions about environmental ethics are more readily understood by morally motivated people who do not resonate with a more abstracted view of intrinsic value to describe our obligations to the environment. The following section aims to expand some key features of the EP approach to environmental decision-making.

### *2.4 Four key tenets of environmental pragmatism as an environmental ethic*

The following statements about environmental pragmatism might serve as key tenets for its use as an environmental ethic:

[63]Transformative value as described by Norton (1987) relates to the experiential aspect of nature and its potential to "make better people of us".

1. Environmental ethics (as a discipline of philosophy) requires a greater purchase on environmental policy and practical decision-making about real environmental problems.

Public debates about environmental problems have tended to ignore the contribution that environmental philosophers can make to environmental policy and decision-making. A number of reasons may be responsible for this: (1) traditional philosophical jargon is inaccessible to many people including key stakeholder groups in environmental debates such as environmental lobbyists, policy-makers, environmental assessors and the general public; (2) debates that predominantly focus on discussions about value theory (or conventional 'centrisms') have a limited role in tackling difficult and concrete environmental problems such as water conservation and; (3) empirical studies have shown that the majority of people resonate with a weak anthropocentric view of the non-human world where concern for the welfare of future generations remains the priority for the majority (Light 2005). This has not been the focus of the majority of debates in contemporary environmental ethics where the concentration of debate has been on discussions about the plausibility of largely nonanthropocentric theories such as biocentric or ecocentric views of nature. As Light (2005) points out,

> A public and pragmatic environmental ethics would not rest with a mere description of, or a series of debates on, the value of nature…A public environmental ethics would further question whether the non-anthropocentric description of the value of nature which dominates the philosophical work of most environmental ethicists today is likely to succeed in motivating most

> people to change their moral attitudes about nature taking into account the overwhelming ethical anthropocentrism of most humans… (Light 2005:345)

The majority of objections endorsed by the public about GM crop technology have tended to focus on one of two issues. The first is the perception that products derived from GM technology are 'unnatural' and therefore unsafe to consume. The second major criticism levelled at supporters of GM is that novel technologies have a (real) potential to significantly harm the environment by either compromising established natural surroundings or, agricultural industries as a result of (novel) gene escape.

Despite these objections being empirically unfounded, their origin is anthropocentric because they are concerned with the impact that GM has on humans and human activity. Traditional non-anthropocentric responses to these criticisms are unlikely to generate workable environmental policy options that resolve these concerns. Environmental pragmatism offers an arena for concerns about GM to be voiced, understood and debated. Environmental ethicists, policy makers and the general community can collaboratively discuss policy options with a view to clarifying issues or developing plans of action.

2. Environmental decision-making requires a deliberative mode of democracy to be successful (that is, open public deliberation of public concerns).

What makes environmental pragmatism distinct from traditional environmental approaches to environmental problems is that it is more conducive to participatory approaches in resolving local environmental issues and supports a strong (radical) approach to sustainable development. Environmental pragmatism, as a public philosophy, aims to engage the public through a consultative and participatory process with a chief purpose of discussing, solving and managing current and future environmental problems. Conceivably, this could be achieved through a variety of means including citizen juries or consensus conferences. The primary purpose of public consultation in this context would be to *engage* rather than simply inform or educate the citizenry[64].

Karlsson (2003) expounds the view that a participatory process inevitably gives weight to different stakeholder perceptions and values. This is an essential component of environmental decision-making in the context of the GM debate (Karlsson 2003). Precisely because applications of GM have a strong public policy component, and debates about GM technology have tended to be viewed by the public in a negative light, there is a strong need to move environmental ethics to a more accessible and applicable arena so that policy decisions about regulatory aspects of the GM debate such as consumer labelling, for example, are better understood and solutions for specific problems are better formulated.

Participation in an equal exchange of ideas can be realised by the adoption of a participatory risk communication model discussed in the previous chapter on labelling and consumer autonomy. This style of public engagement values and encourages the exchange of information within a dialogue that is motivated by a spirit of consultation, collaboration and resolution[65]. Environmental pragmatism presents an opportunity to engage with the community in this way.

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[64] There are numerous models describing ideal processes to achieve public engagement on issues of public policy. Traditionally, the deficit model of public understanding has been used to describe the knowledge *gap* between scientists or other professionals and the lay community. It assumes that in order for the public to contribute meaningfully to public policy decisions, they require some level of education so that they understand the 'facts' essential to forming an opinion about the acceptability of a particular action. The deficit model of public understanding undervalues a lay community's perspectives particularly when it is solely based on subjective individual values.

[65] Models of public engagement and their various functions are further discussed in the following chapter.

3. Diverse moral claims must be accorded equal respect.

EP as a vehicle for discussions about contemporary environmental dilemmas needs to value stakeholder perspectives equally. The phrase, 'democratic respect' has been used to describe the attitude required of various actors involved in the resolution of environmental disputes.

Objections to GM traditionally viewed as obstructionist such as, for example, absolute formulations of playing God arguments[66] have in the past been devalued by some analytical thinkers. According respect to diverse moral claims need not refer to the blanket acceptance of objections (to GM) found to contain little useful or meaningful information. Nor does it refer to the adoption of policies based on assumptions that are not empirically sound. Democratic respect simply attributes diverse moral claims equal value in a multiple stakeholder environment. Negotiation and compromise will almost certainly be required in order to reach consensus on any one issue. However, operating within a participatory mode of analysis and communication will more likely foster social trust and empowerment in the risk communication process and result in a more informed and accommodating citizenry.

4. EP is anthropometric: the human organism is inevitably the one that measures value and all value emerges from human experience.

[66] Chapter eight discusses the role of traditional naturalness objections to novel technologies. Although I consider these types of objections as unhelpful and often nonsensical, they nevertheless serve as a guide to how the public perceive the implications of GM. Upon studying the motivation behind typical playing God arguments, I make the conclusion that some (though not all) formulations of such arguments contain meaningful information such as that can be interpreted as expressions of lay risk perceptions. Lay risk perceptions are very much connected with the level of public trust a community has in its leaders. Public confidence in policy decision-making has recently plummeted due to the inadequate response of authorities to communicate risk related to several food-related crises such as BSE.

In the article, *Taking Environmental Ethics Public* (2002) Andrew Light describes why traditional debates about the locus of (natural) value are generally unhelpful in public discussions about the environment:

> Claims about the value of nature as such do not appear to resonate with the ordinary moral intuitions of most people who, after all, spend more of their lives thinking of value, moral obligations, and rights in exclusively human terms…if environmental philosophers continue to pursue their work as a contribution to value theory only, they cut themselves off from the rest of the environmental community, which seeks to provide practical solutions to environmental problems…The principal task for an environmental pragmatist is not to philosophically obviate the metaethical and metaphysical foundations of current trends in environmental ethics, but rather to impress upon environmental philosophers the need to take up the largely empirical questions of what morally motivates humans to change their attitude, behaviours, and policy preferences toward those more supportive of long-term environmental sustainability (Light 2002:557).

If this is so, and people generally think about their environment in anthropometric (and therefore anthropogenic) terms, then discussions that attempt to solve environmental problems must accommodate this conviction. Norton's *convergence thesis*, or the claim that policies serving the interests of humanity as a whole, will in the long run also serve the interests of the non-human environment might be appropriate here (Attfield 2003). The convergence thesis would make separate appeals to non-human interests redundant – a problem historically occupying the great bulk of environmental ethics scholarship (Norton and Hargrove 1994; Attfield 2003). "The pragmatist's rejection of intrinsic value is not based on the argument that only instrumental values exist, but rather on the argument that it is possible to treat all values as if they were instrumental" (Norton and Hargrove 1994:244).

*2.5 Conclusion*

In this chapter I have attempted to show that some applications of genetic plant technologies are compatible with the social, economic and environmental demands of a strong version of sustainable development. I have argued that traditional approaches to discussions about environmental problems offer little if our aim is to resolve contemporary real life environmental disputes such as those posed by applications of novel genetic technologies. Introducing environmental pragmatism as a practical strategy to accommodate public concerns about the impact of GM may facilitate deliberation on some of the key issues.

GM polices that serve the interests of humanity as a whole arguably also serve the interests of the non-human environment. The development of novel plants that remediate the soil following decades of agricultural (over) use is clearly a benefit for agriculture as it is for the environment. Conversely, poor environmental risk management policies that negatively impact on the environment will not serve the best interests of humanity. The key tenets of an approach to environmental ethics that has the potential to advance discussion in a meaningful way are: acknowledging that traditional approaches to environmental ethics offers little in providing a platform for discussion about aspects of the GM debate; and accepting that environmental problems posed by GM can only be addressed if they discussed within a deliberative mode of democracy where democratic respect is accorded to all stakeholder groups.

## Chapter 3

## Labelling, risk, and the consumer autonomy argument

*"Neither openness, independence, nor scientific excellence are sufficient to establish trustworthy scientific advice"*

Karsten Klint Jensen, 2004, p. 421.

### *3.0 Introduction*

A chief concern propounded by opponents of novel GM plant technologies is the potential risk to human health as a consequence of consuming foods derived from these plants[67]. This concern has prompted consumer lobby groups to call for the mandatory labelling of all food products derived from biotechnology. This concern is driven in part by a fear of products considered 'unnatural' and therefore dangerous, and in part by the belief that citizens in a democracy are entitled to choose what types of foods they consume. Put another way, in most cases, a call for mandatory labelling of products derived from biotechnology stems from the somewhat contentious claim that the ability to choose what one eats is an 'inalienable right'[68] (Zimdahl 2006). This chapter explores the origins of this concern. My main task in this chapter is to assess the plausibility of the claim that a system of mandatory labelling is necessary to preserve consumer autonomy.

An overview of the nature and role of lay risk perceptions will open the discussion. I will introduce two opposing models of risk communication in order to illustrate how these

[67] To reiterate a point made earlier- to date, no credible evidence has been produced to suggest that foods derived from genetic technologies are harmful to human consumption.

[68] A reviewer has pointed out that on the contrary, we often alienate out right to choose what we eat. One example of this is the acceptance of a dinner invitation.

strategies influence public trust and confidence in innovative biotechnologies. Following a comparison of various international labelling regimes, the merits of a mandatory labelling system will be discussed in light of the view that the mandatory labelling of GM food products protects consumer autonomy – a right considered by many as fundamental to any democratic system of governance.

### *3.1 Lay perceptions of risk*

Traditional assessments of risk have typically involved group expert analysis whose chief goal is to provide tangible risk advice based on ‘objectively sound’ scientific observations (Finucane 2002). This approach is consistent with the ‘narrow’ view of risk in which risk is calculated as “the chance of injury, damage or loss” (Finucane 2002:32). More recently, psychological research on public (or lay) perceptions of risk has established that public conceptions of risk are far more complex and are mostly guided by the ‘personality’ characteristics of hazards. That is, people generally observe risk according to their own personal categorizations of hazards as consisting of a broad range of features, primarily affecting the individual, and often embedded in socio-cultural values. Since successfully engaging the public about risk is critical to the broader public acceptance of new biotechnologies, a sound risk assessment and management policy needs to acknowledge and understand public perceptions of risk and their role in decision-making about risk.

The main qualitative features that drive lay risk perceptions are those judgments that contain an element of *unknown* risk (a measure of the level of uncertainty present in a decision involving risk)[69] and *dread* risk (a measure of the level of uncontrollability present in a potentially catastrophic scenario)[70] (Finucane and Holup 2005). Decisions about the acceptability of genetically modified food are decisions that contain an element of uncertainty in that the long-term effects of consuming genetically modified food are unknown. For predominantly agrarian societies like those in sub-Saharan Africa or Central America, the potential threat to local livelihoods and ecological (perhaps also cultural) harm from planting monocultures produced by multinational agribusiness, is an example of dread risk. These are valid concerns and should not be downplayed, despite the expert view that the chances of such scenarios occurring are minimal.

The characteristics of GM crop production are harder to accept when the public sees little or no benefit to themselves and a future threat to their children or the environment (Department of Health 1998). For the past decade, there has been strong emphasis on the development of GM products that are favourable to the agricultural industry in saving on production costs without providing direct benefits to consumers. In this context, it is interesting to compare the public acceptability of GM foods and GM medicines. The public has, in general, has been sympathetic to the development of medical therapies using novel gene technologies. The

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[69] Individuals use different contexts and experiences to inform their decision making under conditions of uncertainty. Unknown elements of risk involve those features of risk that relate to unfamiliar or unobservable features of a decision. For example, British research has shown that some consumers use 'safety scales' based on geographical location to determine how safe a product is. The closer the producer is situated to the consumer's residence, the more likely the consumer will judge the product as safe. The 'invisibility' of genetically modified components in GM products is another illustration of the 'unobservable' or 'inescapable' features of lay perceptions of risk that have the potential to fuel consumer distrust of modified products. See Finucane and Holup (2005) for further discussion of various psychosocial and cultural factors affecting public understandings of risk.

[70] Dread risk can be characterized by hazards that not only adversely affect the person exposed but have the potential to also affect their descendants. These risks are in most cases involuntary, uncontrollable and potentially inequitable. For example, a legitimate concern has been expressed by farmers situated in landlocked nations in Europe who are potentially at threat of cross-border contamination from GM crops. It has been suggested that the British BSE crisis is responsible for inciting elements of dread in European judgments about potential health risks association with the consumption of GM foods. See Hails, R. and J. Kinderlerer (2003). "The GM public debate: context and communication strategies." Nature Reviews Genetics **4**: 819-25.

purpose of genetically modified medicines (and/or therapies) is arguably for the direct benefit of the individual who uses them, and consent to their use is a necessary condition of their use. Consumers of GM medicines are also well-informed about their intended purpose, effect and possible side effects, all of which make their sale and use very different to that of GM food products (Finucane 2002). Decisions about the use of GM medicines contain quantifiable elements of risk that can be contained within set boundaries. These features are absent from decisions about the use of foods produced by novel gene technologies applied to crops. Failure to address public uncertainty about risk was probably the biggest failing of the British authorities in dealing with the BSE crisis of the 1990s (Jensen 2004). Unless uncertainty is acknowledged and communicated, the development and use of GM food will continue to attract public trepidation about its safety and necessity.

Specific cultural values also influence lay perceptions of the risks of GM food, adding to the complexity of understanding public understandings of risk (Finucane 2002). For example, in many Indigenous populations, there is a dynamic relationship with food, the body and the environment. For many cultures, maintaining the genetic integrity of food is essential to spiritual, environmental and physical well-being. The genetic modification of foodstuffs is thought to compromise the integrity of local cultures, communities and ecosystems and thereby threaten their survival.

The dichotomy between lay and expert perceptions of risk can lead to very different outcomes in risk communication (Trautman 2001). There have been two common responses to the disparities between lay and expert perceptions of risk. Some social scientists have concluded that risk is a ‘social construct’ and that risk judgments of experts deserve no greater respect than those of lay persons (Trautman 2001). Risk analysts, by contrast, argue that the public are misinformed and therefore need to be educated to make their views more consistent with those of experts (Covello, Sandman et al. 1991). This particular version of risk communication "aims at engineering public consent" (Trautman 2001:1131). The following section will consider two opposing models of risk communication to better understand some of the underlying assumptions implicit in the labelling debate.

### *3.2 Two very different models of risk communication*

Traditionally, risk analysis has involved the following processes in the following order: risk assessment, risk management and finally, risk communication. Contemporary studies of effective risk communication practices, by contrast, have found successful risk communication to be an integral part of risk assessment and management processes (Department of Health 1998; Trautman 2001). A successful risk communication process therefore, is one that allows multiple stakeholders to express a diverse range of views in fora that are open, honest and fair (Trautman 2001). This section will briefly describe two opposing models of risk communication in order to highlight the aims and outcomes of each.

Adoption of the traditional technocratic model of risk communication assumes the primary purpose of risk communication is one of social utility and paternalism (Jackson 2000). The purpose of public consultation under this model is to test how much the public knows based on what the experts think they ought to know (Scherer and Juanillo 1992). The instruments used here are usually made up of standardized and highly structured questionnaires and focus groups where questions (and therefore, answers) are purposefully constructed and consequently controlled (Levitt 2003).

The chief goal of the technocratic model of risk communication is one of public persuasion. Persuasion is thought to be achieved when the public accepts messages conveyed by risk communicators and acts upon them accordingly (Scherer and Juanillo 1992). The following assumptions are embedded in the technocratic model of risk communication:

(1) Scientist and other "experts" are the only accurate, rational and therefore valid sources of risk information and analyses (Scherer and Juanillo 1992).

This assumption is based on the idea that issues relating to risk are far too complex for the lay public to understand so must be left solely to the experts to consider and make decisions about. According to Scherer and Juanillo (1992), also linked to this assumption is the notion that the public tend to frame risk in a micro format rather than the macro format necessary for social issues (Scherer and Juanillo 1992). In other words, the public generally view risk in a ways that affect them directly, rather than using a broader societal perspective. Various studies have shown this assumption to be false (Scherer and Juanillo 1992). The public are more than able to reflect and respond to complex issues when presented with a problem in a non-technical way[71].

The second assumption intrinsic to the technocratic model of risk communication is that:

[71] This is evident in the way the Australian public have reacted to the pressing need to address issues that affect global warming. Without any empirical data, it does appear that the current federal government is being lobbied by the Australian public to be more proactive in addressing issues such as carbon emissions, water conservation and recycling, and alternative energy sources. Once provided with accurate information, presented in a simple but informative manner, the public are able to understand and willingly respond to issues that have global ramifications.

(2) Science alone can provide unbiased conclusions since the findings are reached by the scientific process.

In response to this assumption, risk assessments use methodologies that are based on subjective judgments and often depend upon conflicting value-laden theories (Scherer and Juanillo 1992). Other less precise methods used in risk assessments to date include the questionable formulation of possible responses recently used in the British survey instrument, *GM Nation?* where participant responses were skewed towards answering the proposed questions in predictable ways. Statistical biases presented in self-selecting and self-reporting data also devalue survey findings.

The final assumption inherent in the traditional expert model of risk communication is the belief that:

(3) If only the public were willing to listen and learn, they would accept expert risk information (Scherer and Juanillo 1992; Levitt 2003).

This assumption shares similarities with assumption (1). It stems from the belief that the public are simply misinformed and need to be educated to make their views of risk more consistent with those of experts (Levitt 2003). This view is based on inaccurate information and it ignores the significance of public trust in risk communication.

A more inclusive and interactive model of risk communication advocates a participatory approach to decision making about issues of public concern. As Finucane (2002) clearly articulates,

> Both hard-learned experience and considerable research suggest that approaching risk analysis without the involvement of the public is a doomed enterprise. This situation exists because (1) risk decisions are much more likely to be implemented successfully if they have broad public support, (2) the wisdom relevant to optimal risk management is not confined to scientific specialists and (3) from a normative viewpoint, government should obtain the consent of the governed, who have a right to participate in decision processes (Finucane 2002:36).

A participatory model of risk communication embraces a notion of *ethical* risk management that consists of three core elements: truthtelling; information; and democratic choice (Jackson 2000). Referred to as the interactive model of risk communication, it favours public participation and in the context of the GM debate, consumer autonomy. Under this model, consumer autonomy can be satisfied by the provision of mandatory labelling on products derived from novel gene technologies. The interactive model is a continuing process based on consultation, negotiation and informed consent. In this way, it differs significantly from the technocratic approach to risk communication with its underlying paternalistic ideal. The purpose of an interactive model of risk communication, by contrast, is to find out what the public feels and what they think is important. Participants shape the focus of discussion in natural settings and the findings emerge from the data.

The interactive model of risk communication is however, dependent on social trust and will only be effective if the public have confidence in their knowledge and trust the manufacturers of GM products. A lack of trust is a major contributor to the gap between expert and lay assessments of risk (Finucane 2002). The role of trust in risk management, particularly risk communication, is a critical element in public confidence in purchasing and consuming products made using novel gene technologies.

### *3.3 The role of social trust in risk management policies*

A major ethical challenge for risk communicators is telling the truth about a potential risk to human health or the natural environment when uncertainty exists about whether there is a risk and if so, how large and serious it is (Department of Health 1998). The challenge is in communicating these uncertainties in ways that do not cause either alarm or provide false reassurance. Governments and industry officials may minimise risk, arguing that this is necessary to avoid alarm but paternalistic risk communication of this type usually fails, at the cost of creating distrust (Covello, Sandman et al. 1991).

Effective risk communication is not always achieved by simply telling the truth to the best of one's ability while acknowledging uncertainty. It is just as important for government and industry to be seen to be telling the truth. As Slovic (1993, 1999) and others have shown, the public often refuse to accept accurate accounts of risk because they do not trust the source.

Various factors are central to fostering trust in public-agency relationships. Slovic's asymmetry principle demonstrates that trust is difficult to build and easily destroyed (Poortinga and Pidgeon 2004)[72]. Cvetkovich (2002) demonstrated people generally attached more value to (and therefore have more confidence in), negative information than positive

[72] The asymmetry principle is based on the notion that negative information is more informative than positive information. See Slovic (1993) Perceived Risk, Trust and Democracy in *Risk Analysis* for further discussion about the asymmetry principle.

information, reflecting a 'negativity bias' (Poortinga and Pidgeon 2004). Expertise is not trusted unless it is accompanied by other characteristics, such as accountability (Finucane and Holup 2005). The more accountable an institution is, the more likely the public will be to trust the veracity of its messages. A review of the literature on the extent of social trust by Finucane et al. (2005) has shown that the British and European public generally trust consumer and environmental agencies the most and have only moderate trust in industry. Politicians, scientists and other experts were afforded the least amount of trust (Finucane and Holup 2005). In Europe, agency-public relations have been strained since the BSE scare of the 1990s because the authorities not only demonstrated poor regulatory oversight, they also initially failed to accept accountability.

Given the complexity of lay risk perceptions and the role of public trust in recent food crises, it is perhaps not surprising that opponents of GM biotechnology have been the strongest advocates of a mandatory labelling policy on all products containing novel genes. Following a brief description of international labelling regimes, their purpose and underlying philosophy, the next section discusses the claim that mandatory product labels are necessary to ensure consumer autonomy.

### *3.4 Mandatory labelling of GM products: A case of consumer autonomy?*

Countless studies have claimed to demonstrate strong consumer opposition to GM food[73]. According to some authors, negative attitudes towards food produced by novel gene technologies reflect a need for mandatory product labelling. Several studies cited by

[73] See Einsiedel (2002) for a review of some of these.

Einsiedel (2002) have determined that 9 out of every 10 consumers in the UK, Australia and New Zealand prefer mandatory product labelling with 3 out of 4 European consumers holding a similar position[74] (Einsiedel 2002). By contrast, other studies have shown negative consumer attitudes towards GM products are more linked to market issues with surveys in some countries showing a strong association between price and a willingness to purchase the product, rather than opposition to the manufacturing process or final product[75] (Smyth and Phillips 2003).

Townsend et al. (2004) demonstrated that 93% of participants recruited to a topic-blind study were willing to taste an apple that they had been told was genetically modified (Townsend and Campbell 2004). In an effort to take account of differences between purchaser and non-purchaser attitudes to GM products, Townsend et al. (2004) found that over 85% of non-purchasers were happy to taste a GM apple suggesting that general opposition to GM food may not be based on a perceived risk to human health but on factors such as cost (Townsend and Campbell 2004).

Debate about the mandatory labelling of genetically modified products has evolved from a broader public concern about the safety of products made from novel technologies to a more specific defence of consumer sovereignty. International labelling regimes are somewhat complicated and continually in flux. Existing legislative requirements are being continually

[74] The majority of studies investigating consumer attitudes and behaviours to GM products can be accused of methodological bias in that such studies are more likely to attract respondents who express strong views about GM technologies. Respondents with more moderate views are less likely to participate in research that they are less passionate about, thus leading to inaccurate findings. The recent highly publicized British *GM Nation?* survey has been accused of such statistical bias. See Campbell (2004) How to make a minority look like a majority, *the Skeptic*, pp. 15-9.

[75] Consumers in Norway and Japan have shown price to be of more concern in purchasing GM products. See Smyth & Phillips (2003) for further discussion.

debated as new scientific and regulatory information comes to hand. Table 3 shows major international labelling regimes that are presently in place.

| Major Elements of Labelling Regimes in Various Countries | | Examples of Countries |
|---|---|---|
| **Fully regulated mandatory labelling regimes** | Method of production labelling – mandatory labelling of all foods derived from or containing ingredients derived from organisms produced using gene technology. | European Union |
| | Composition of food labelling – mandatory labelling of all GM foods and ingredients where novel DNA and/or protein are present in the final food. | Australia/New Zealand, Russia |
| | Composition of food labelling (narrow capture) – mandatory labelling if designated food items that contain GM foods or ingredients as major components of food only where the novel DNA and/protein are present in the final food. | Japan, Chinese Taipei, Korea, Thailand and Malaysia (proposed) |
| **Mix of regulatory and voluntary approaches** | Equivalence labelling – mandatory labelling of GM food only where it is significantly different from its conventional counterpart. | Canada, USA |
| | Voluntary labelling – voluntary regime (where GM is similar to conventional counterpart) reliant on general provisions in food or fair trading law relating to false, misleading and deceptive labelling or advertising and an Industry Code of Practice developed to assist compliance. | Canada, USA, Hong Kong (proposed) |
| | Other - no regulation in place. Allow for voluntary labelling but no evidence of guidelines or Code of Conduct | Philippines, Singapore |

*Table 3 International comparisons of GM food labelling regulatory approaches*[76]

Since June 2003, Food Standards Australia and New Zealand (FSANZ) have required that all products containing novel compounds grown and sold in Australia and New Zealand adhere to *positive* product labelling regulations[77]. This rule applies to products that have undergone genetic modification, contain ingredients that have been modified, or are likely to contain traces of modified compounds as an unintentional by-product of food processing. Few purposefully modified direct-to-consumer products are presently on the Australian market although a number of products available for purchase contain traces of GM derivatives in the final product[78]. The majority of GM crop varieties approved for sale and use in Australia and New Zealand have been modified for resistance to plant disease or herbicide tolerance rather than for any real consumer benefit although this may change in the near future[79] (FSANZ 2003).

In April 2004, the European Commission (EC) followed FSANZ and introduced sophisticated labelling regimes applicable to all products derived from or containing ingredients produced using novel gene technologies. This requirement holds irrespective of whether the novel products contain *detectable* genetically modified material[80] (Craddock 2004). The legislation is made more complex in practice if one accepts the view that there are

[76]Table reproduced in its entirety (minus typographical errors) from the *Report on the Review of Labelling of Genetically Modified Foods*, Food Standards Australia and New Zealand, 2003, Canberra, pg. 29.

[77]'Positive' product labels are those that simply state that the final product contains some genetically modified ingredient. 'Negative' labels, by contrast, are those that deliberately market a particular product to be 'GM-free' or 'GE-free'. Mandatory requirement of negative labels are favoured by anti-GM lobby groups including Greenpeace, Earthfirst and almost all pro-organic organizations.

[78] Vegetable cooking oils such as canola and cotton are examples of products containing a component of genetically modified material in their final product.

[79] There are currently 21 crop varieties approved for sale in Australia of which most include pest tolerant varieties of soybean, canola, corn, potato, sugarbeet and cotton.

[80] Some problems are becoming increasingly evident in the new European legislation. For example, animal products such as meat, milk and eggs that are fed GM feed do not fall within the new rules.

"no validated analytical methods that can distinguish refined GM derivatives from their traditional counterparts" (Craddock 2004:384).

The origin of the European approach to labelling GM products stems from earlier non-GM health-related crises such as the contamination of beef products in the BSE crisis of the 1990s and the outbreak of Listeria in dairy products in the late 1980s and 1990s (Gregory 2000; Craddock 2004). Europeans have learned from these risk communication disasters that "not labelling products as modified, offers no exit from consumption for some time before regulatory agencies issue warnings" and begin the difficult process of product recall (Chadwick 2000:196).

In Canada, the current food labelling philosophy is based purely on risk assessment of the product, irrespective of the process. The doctrine of substantial equivalence is applied to products on a case-by-case basis[81] (Einsiedel 2002). Labelling of GM products is voluntary and there are no plans in place to introduce mandatory labelling. The US also considers the determination of substantial equivalence as sufficient (Einsiedel 2002; Zimdahl 2006). In the US, it is assumed that a mandatory system of labelling is considered to place an unnecessary burden on business and policy-makers have repeatedly demonstrated their preference for voluntary labelling regimes.

The past three years have seen a shift in favour of mandatory labelling policies both regionally and abroad. In March 2006, 132 signatories to the Cartagena Protocol agreed to new international trade labelling rules for products that had undergone genetic modification

[81] Substantial equivalence is a term used to describe the process that novel food products undergo when determining their categorization. Testing is based on a notion of composition equivalence where the novel product is compared to its closest naturally occurring counterpart. The concept is widely misinterpreted by opponents of novel technologies as one of safety and is therefore viewed as being inadequate in determining human safety. Chapter four discusses the concept of substantial equivalence and its role in regulatory processes.

or contained ingredients that had been modified or were likely to contain traces of modified compounds in their final product[82]. This agreement requires all shipments that contain genetically modified products to be labelled as such, including products that *may* contain unintended modified compounds. These products must carry the "contain" [genetically modified derivatives] label. Unfortunately, and to the detriment of the new guidelines, two of the largest exporters of GM products, the US and Argentina, are not parties to the Protocol.

Several arguments exist in favour of detailed product labelling. The first is that labelling provides consumers with information they need to exercise informed choices in their purchasing decisions. The hope is that labelling will boost consumer confidence in products made using gene technologies. Second, a mandatory labelling regime enables the longer term health impacts of consuming GM foods to be monitored (Einsiedel 2002). Ensuring a system is in place so products can be reliably traced back to the manufacturer is a benefit of mandatory labelling that is accepted by both sides of the debate.

Opponents of mandatory labelling argue that producers of GM products will incur exorbitant production and distribution costs and labelling may mislead consumers. This argument assumes that GM food does not pose any danger to human health. Labelling products as genetically modified, the argument goes, would not provide consumers with meaningful information but have the unintended effect of alarming them (Jackson 2000). Considering that to date, no credible evidence has been established that GM products are harmful to human health, the motivation behind this argument is reasonable.

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[82] See http://scidev.net/news/index.cfm?fuseaction=printarticle&itemid=2747 accessed March 2006.

Hansen (2004) argues that consumer autonomy does not justify the labelling of GM foods more than non-GM foods because a manufacturer has no obligation to label a product that is not considered harmful to human health. According to this view, protecting consumer sovereignty can be achieved by labelling either GM or non-GM foods. Hansen (2004) goes on to make the controversial point that it may make more economic sense to label non-GM products since foods that contain GM derivatives might actually be the majority of products.

The claim that biotech labels could potentially frighten consumers is not an argument against the practice of mandatory labelling *per se*. Food manufacturers have a responsibility to provide information labels on products they wish to sell. A manufacturer of GM products is not under any obligation to label a product that may be undesirable say, for religious reasons. Labelling in this case may be advantageous to the producer, but is not morally obligatory[83].

There is a widespread lack of truthful disclosure about products. Deceptive food storage and marketing practices are prevalent and in general, consumers are not well informed. One only has to examine information provided on traditional food labels on non-GM products (particularly those that contain concentrated levels of sugar, salt or saturated fat) to find deceptive practices by food producers. Current nutritional standards in Australia and New Zealand require percentage based quantities of sugar, salt and fat content, among other nutrient information. For example, current marketing practices allow the word, 'lite' to appear on the product label to indicate features of the product's colour, taste or texture, rather than denote the actual fat content[84]. Another deceptive practice is to market products as

[83] An example of widely used product label that can be considered as advantageous to business is the labelling of products produced using methods based on *hilal*. For Muslims, the preparation of food products (especially meat) must be in accordance with Islamic tradition. Promoting hilal products is advantageous to business since it assures consumers that they have undergone processes considered important to the consumer.

[84] Recent attention on the rising 'obesity epidemic' has prompted Food Standards Australia and New Zealand (FSANZ) to investigate this practice.

containing 'less than x' amount of fat (commonly advertised as less than 5% fat) when contemporary nutritional advice recommends consuming products that contain less than 3 grams per fat/100grams as part of a healthy diet.  Finally, the practice of gas flushing, (injecting a combination of $CO_2$, $O_2$, and $N_2$ into meat) in order to enhance shelf life is becoming increasingly popular. This process which allows meat to be stored for up to 4 weeks is currently used in about 10% of meat products, predominantly in remote areas and by smaller retailers. Most consumers are not aware of these practices despite being more informed about many food products than ever before.

Some commentators have claimed that cultural reasons may be sufficient for preserving autonomy by labelling food products. Product labels that contain various types of information about the product, the argument goes, enable consumers to make purchasing decisions using various personal criteria. For example, product labels may contain information about country of origin, animal welfare assurances or fair trade statements. Some applications of GM plant technology involve the insertion of species-foreign genes into an organism introducing what Reiss and Straughan (1996) describe as 'ethically-sensitive' genes. Examples of such transgenic applications include tomato and potato crops modified to include genes from cold-water fish species such as flounder or salmon to allow the plants to flourish in environments where they would otherwise fail to thrive. Reiss and Straughan (1996) make the point that such modifications have the potential to offend minorities such as animal welfarists or religious groups simply because this type of transgenesis involves the instrumental use of animals (Reiss and Straughan 1996).

In response to this concern, a requirement that GM products be labelled on cultural grounds is not consistent with the reality of food labelling practices currently in place for conventional food products. However, the provision of information that enables a consumer to make a more informed choice about the product on offer may be desirable for business. A case is made later in the chapter for such a practice.

There are also consumers who are politically motivated to avoid GM foods. These individuals may not be concerned with the safety of GM food *per se* but prefer to support smaller local businesses (Streiffer and Rubel 2004). The 'yuk factor' is a recently described phenomenon referring to the feeling of disgust that some people experience to the 'impurity' of GM products; it is another reason used to strengthen autonomy claims[85]. "The idea that crossing genes is a violation of purity rules comes readily to many and they are at least psychologically justified in feeling somewhat queasy about genetically engineered food" (Thompson 1997:73)[86].

The autonomy argument must first define the purpose labels serve for conventional products. *If* current labelling policies are in place for ensuring consumer sovereignty, then an argument for mandatory labelling of novel products may be valid on the same grounds (Streiffer and Rubel 2004). Jackson (2000) argues that currently products are labelled for many informational reasons primarily because "the US government deems it necessary to ensure the terms of valid consent in the exchange between consumers and producers. The motivation for instituting biotechnology labelling is consistent with these considerations" (Jackson 2000:326). Zimdahl (2006) puts it this way:

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[85] Although opinion related to the 'yuk factor' shares many similarities with typical 'naturalness' objections, and can therefore be shown to be weak if not irrational in its formulation, it nevertheless holds value as an expression of lay risk perception that adds weight to the consumer autonomy argument in democratic societies.
[86] Thompson published a second edition of *Food Biotechnology in Ethical Perspective* in 2007, but unfortunately this updated edition was not available in Australia in time for inclusion in this thesis.

> The freedom to choose [a non-GM product over a GM one] is fundamental in a democratic society and a refusal to label based on scientific evidence that may be unknown to consumers, not understood if available, or unavailable, denies that freedom (Zimdahl 2006: 156).

The deceptive nature of some food labelling practices such as those mentioned above tends to undermine this effort. Nevertheless, for markets where there is increasing availability of GM products, such as in the US, the provision of (truthful) *positive* labels may be beneficial to business. If modified products are in fact cheaper than those on the market, or contain environmental benefits, then why not advertise the fact? Any additional expenditure on positive product labels may be absorbed into the marketing budget of many businesses.

Consumers purchase products for numerous reasons based on various personal criteria, one of which may include the impact a particular product has on the environment. Some GM products may require less energy to produce, while others may replenish nutrients in poor soils. Purchasing GM products for some consumers may be comparable to purchasing products and services that use renewable sources of energy, or engage in socially responsible investment practices. It is reasonable to think that producers of GM products might pride themselves on the contribution their products make to the wider community. The requirement for product labels may provide a good opportunity for producers to advertise the environmental or other benefits of their products to consumers who purchase products made using novel manufacturing methods.

The cost of labelling may therefore be considered part of advertising costs that are absorbed by the general marketing budget. Of course, this would only work if GM products do in fact provide benefits to the consumer or benefit the environment, etc (and are widely available). At the present moment, many producers are manufacturing products that primarily reduce production costs for producers (although this should flow on to consumers in reduced costs). There are few manufactured goods containing GM ingredients as a significant component of their final product that are currently available to consumers. Until a significant proportion of the market allows for the sale of products considered to contain benefits to consumers, the requirement by a manufacturer to provide negative labels within a mandatory labelling regime, may be disadvantageous to businesses in that labelling acts much like a warning. (This effect may be attributed to a lack in public trust rather than to any real concerns about safety). A lack of trust is a major contributor to the gap between expert and lay assessments of risk (Finucane 2002).

### *3.5 Conclusions*

In summary, there is no compelling public safety or health risk argument to support the mandatory labelling of GM products because there is no evidence, after extensive rigorous research, that such products are harmful to human health. However, though no credible evidence to date of a risk to public safety has been published, like any new technology some adverse effects may only become apparent in the longer term and so a general caution is warranted about GM foods as applies to any new technology that may potentially adversely affect human health.

A lack of trust is a major contributor to the gap between expert and lay assessments of risk (Finucane 2002). In this climate, the provision of negative product labels may cause unnecessary alarm primarily because many GM products that are currently on the market do not contain any direct-to-consumer benefits. Several health-related scares in Europe and Britain have eroded public confidence in food production processes and regulation. The provision of positive labels can be advantageous to business if the process of genetic modification does in fact contain benefits to the consumer (such as, for example, a more competitive price).

Lessons can be learnt from the British beef crisis. A poor or non-existent risk communication strategy, coupled with a general resistance to food labelling regardless of its motivation, will fuel public distrust in new biotechnologies. A participatory model of risk communication is one that is inclusive, informative and fosters public trust. A mandatory labelling policy on all GM products is not necessarily informative to consumers, nor does it automatically lead to consumer sovereignty. Nevertheless, GM food producers should consider actively advertising the benefits of their products to consumers. This may have the added benefit of fostering stronger consumer-producer relationships as well as restoring public confidence in the motivations of food-related industries.

## Chapter 4

### Food safety assessment, allergenicity, and antibiotic resistance markers

*"Overall, the present system for testing food is more than a bit hypocritical about the safety of traditional food and more than a bit hysterical about genetically modified veggies. As always, people fear the new kid on the block, especially if his name is 'Gene'".*

Gregory Pence, 2002, p. 122.

#### *4.0 Introduction*

Along with the impact of GM crops on the environment, the safety of GM foods developed for human consumption is arguably the most prominent of public concerns about the production of foods derived from novel biotechnologies. A product derived from genetic engineering must meet various safety protocols and assessments before it is granted permission to be released on the market irrespective of whether the product is intended for human or animal consumption. For a product to be successful in the market, the public must have confidence in the product's safety prior to commercial release.

It is difficult to engender public trust in the food safety assessment process when the public carry false expectations about food safety. A belief held widely in the community is that the safety of food is absolute and can be guaranteed (Taylor 2003). On the contrary, historically, "food is considered safe based on experience" (Taylor 2003). Human safety assessments assist in the information-gathering stages of testing in which the doctrine of *substantial equivalence* plays a key role (particularly in the testing of novel foods). It is conceivable however, that despite strict adherence to safety processes, a food product (either GM or conventionally-bred) can adversely affect health in the post-market release phase. One such example is the unintended expression of allergenic proteins in novel food.

Lobbyists opposing the development and release of GM crops have canvassed public support in campaigns by making claims that they involve tampering with natural genomic processes and pose potential threats to local, mostly organic industries. Many of these claims are based on a misinterpretation of the potential applications and limitations of plant genetic technologies. In response to this backlash, biotechnologists and manufacturers of novel products have in some instances expressed over-confidence in current safety assessment processes that have been established to prevent adverse events. This chapter will explore one tool – the determination of substantial equivalence - used in the preliminary testing of novel foods prior to commercial release. It is the application of this concept that has attracted the majority of criticism by opponents of GM foods who demand fail-safe safety assessment practices for products derived from novel biotechnologies.

### *4.1 The role of the doctrine of substantial equivalence in the safety assessment of novel foods*

The concept of *substantial equivalence* was first described in 1993 and implemented by the Organization for Economic Cooperation and Development (OECD) in 1998 as a comparative tool in the safety assessment of foods derived from novel biotechnologies (Pouteau 2002). It has been used by the Food and Agricultural Organization (FAO) of the World Health Organization (WHO) since 1996. Under this concept, a novel product is comparatively assessed using biochemical profiles of foods that are considered to be its conventional counterpart and have already been determined to be safe for human consumption. If the novel product falls within the natural variation range of existing biochemical profiles, then a determination of substantial equivalence can be made (Taylor 2003; Pouteau 2002). Internationally, its use differs considerably. Generally, the European Union (EU) has rejected the underlying purpose of the doctrine of substantial equivalence and has significantly redefined its role in the testing of GM foods, while the US has embraced it (Zimdahl 2006). Interestingly, these differences have not influenced the direction of the debate about the role of the substantial equivalence in safety assessments in any observable way.

The purpose of equivalence testing is that it "aids in the identification of similarities and differences between existing and novel products" (Kuiper 2004). The concept is used as one tool (a preliminary one at that) in the many tools available for the safety evaluation of novel products. It essentially provides the biotechnologist with a reference point from which to begin a comparative study of the novel product. A determination of substantial equivalence is not a safety assessment *per se*. Its role is to allow a novel product to be subjected to a broader compositional assessment typically consisting of a case-by-case analysis that focuses on the established differences between the novel product and its conventional counterpart (Council for Biotechnology Information 2001).

Even though equivalence testing is not intended to be used as a definitive safety assessment tool, its critics argue that it is inadequate in identifying potential risks associated with GM foods. Opposition to the use of the concept of substantial equivalence in the safety assessment of novel foods generally stem from four sources of concern. The first is a general misunderstanding of the concept and its role in food safety evaluation (Federoff and Brown 2004). Despite its intended use as a comparative and reference tool, lobbyists have continued to oppose its employment in the belief that it plays a critical role in determinations of safety.

The role of equivalence testing *is* critical in understanding how novel foods compare to well-known and similar products. However, there is general agreement in the scientific community that equivalence testing has only a preliminary role and foods are subject to further testing irrespective of the outcome of equivalence tests.

The second criticism follows on from the first. It stems from an underlying belief that genetically modified organisms (GMOs) are so vastly different to conventional foodstuffs that they cannot be compared in this way[87]. It is derived from the perception that the uses of recombinant DNA techniques are so vastly different from conventional breeding techniques and therefore carry significant inherent risks (Ho and Steinbrecher 1998). As Norberg et al. (2002) describes it,

> The idea of 'substantial equivalence' grows out of the argument that because people have been inter-breeding plants and animals for many thousands of years, genetic engineering is simply an extension of traditional practices, rather than a radical new method that requires extreme caution and its own strict rules (Norberg-Hodge et al. 2002: 202).

Genetically modified plants *are* novel. The processes involved offer more accurate and speedy integration of desirable traits into the genome of the host organism. Even when it is granted that some instances of GM exceed the taxonomic limitations placed on conventional-breeding methods, the processes essentially yield the same outcome.

[87] A belief held by a majority of Europeans.

Another criticism of the use of substantial equivalence is the view that the concept is ill-defined and vague (Millstone et al. 1999). A specific deficiency in its design is that it fails to define the point at which a novel product is no longer substantially equivalent (Levidow et al. 2007). The lack of a universal definition, it is claimed, is useful for the biotechnology industry but unacceptable to the consumer (Millstone et al. 1999). Millstone and colleagues (1999) have also mistakenly claimed that a determination of equivalence justifies no further biochemical or toxicological testing (Millstone et al. 1999). Schilter and Constable (2002) counter that such a determination can only be made about products that contain modified ingredients, or are derived from modified ingredients (such as oil); it cannot be made of wholefoods (Schilter and Constable 2002). Furthermore, such products must be shown to be within the limits of the natural diversity of their traditional counterpart in its compositional characteristics.

Efforts at better defining the concept of substantial equivalence and its role in safety assessment processes have made some headway in standardizing its use internationally (Levidow et al. 2007). A weakness in the concept raised by some scientists is the lack of consensus among biotechnologists about which conventional food counterparts to use as comparators to yield useful information (Taylor 2003). The choice of comparator is critical in the determination of substantial equivalence (Taylor 2003). The construction of an internationally accepted and comprehensive compositional database containing profiles of conventional counterparts capable of generating useful conclusions would be a valuable tool for food biotechnologists. This is presently one of the challenges for biotechnologies charged with the responsibility of determining the overall safety of novel foods (Taylor 2003).

The safety testing of new varieties of foods derived from conventional breeding methods are not generally subject to food safety assessment (Schilter and Constable 2002). If it is prudent to require that all novel GM foods undergo safety assessment processes then it also seems prudent to impose the same demand on novel foods derived from traditional selective breeding methods. As Taylor (2003) points out:

> There is an international consensus that says that the products of plant biotechnology are not inherently less safe than those developed by traditional breeding....because we don’t do extensive safety assessment of conventionally bred plants, it’s also possible to make the argument that extensive safety assessments conducted with plant biotechnology products provides equal or greater assurance of the safety of these products (Taylor 2003: s136).

Biotechnologists and regulators continue to face challenges in designing safety assessment processes that are capable of identifying potential risks as well as engendering public confidence in the safety of foods approved for commercial release. Unreasonable expectations of stakeholders contribute to the complexities posed by non-prejudicial, rigorous safety assessment practices. Improved dialogue between interested parties may go some way towards finding common ground.

### *4.2 The transference probability of allergenicity to novel foods*

Food allergies are estimated to affect 2-8% of the population. They are primarily derived from about eight foods or food groups (Lehrer and Bannon 2005). Current medical practice cannot offer an effective cure for an individual experiencing an adverse allergic reaction following consumption of an allergenic food product and dietary avoidance of allergen-producing foods is the best health management strategy currently available to individuals who are known to be susceptible[88] (Mepham 2001; Lehrer and Bannon 2005).

To date, no allergic reactions have been recorded to novel proteins expressed as a product of genetic engineering processes (Lehrer and Bannon 2005; Skurray 2006). Nonetheless, the majority of potential consumers of GM food are concerned about the likelihood of it happening. Scientists have identified three possible categories of allergy risk to consumers as a result of the development of products containing novel proteins (Lehrer and Bannon 2005). The first, and the most risk-laden, is the direct transfer of a known allergen to a food as a result of genetic modification. Several screening processes are in place to detect such an event even though no known allergenic-producing genes are permitted to be used in the production of novel foods (Taylor 2006). The second conceivable risk to consumers involves an increase in the endogenous allergenicity of a GM product due to the modification process (Lehrer and Bannon 2005). Theoretically, this occurrence presents an intermediate level of risk but little evidence has been presented to justify this concern. The final category of risk associated with the genetic engineering of food, and the concern most widely expressed by opponents, is the expression of potentially allergenic novel proteins present in foods consumed by individuals sensitive to such allergens (Lehrer and Bannon 2005). Categorization of this risk is low and there are robust national and international testing procedures in place to ensure such foods do not reach the market (Taylor 2006; Metcalfe 2003).

[88]The immediate administration of adrenalin is currently the best treatment available for individuals experiencing an allergic reaction to a particular food product.

Allergenic proteins are abundant in food, yet only a few are stable enough to survive cooking and resistant enough to withstand metabolism by stomach acids (Federoff and Brown 2004). Scientists have so far been successful in identifying and isolating protein allergens and several novel food projects have been ceased precisely because allergens were searched for, located, and identified (Federoff and Brown 2004). Allergy scientists and food biotechnologists are rapidly improving their understanding of the role allergens play in novel food development and there is continuing research into the most effective methods to detect the expression of potentially allergenic proteins in food items. All of these methods, however, carry limitations and further research is currently underway to improve the processes involved[89] (Lehrer and Bannon 2005).

Current opinion on the potential risk of an allergenic protein expressed in foods derived from novel biotechnologies has established that the risk is very low (Lehrer and Bannon 2005; Taylor 2006; Metcalfe 2003). In light of this evidence, community discussions on this topic would be better addressed in the context of food manufacturing and promotion practices rather than focused solely on products derived from genetic technologies. For example, the adoption of a more comprehensive (i.e. truthful and detailed) food labelling regimes discussed in chapter 3 may assist in allaying community concern.

### *4.3 Superbugs and novel foods*

The use of antibiotic marker genes in genetic engineering processes has also received wide media attention. Marker genes help indentify whether a new gene has been successfully

[89] The use of validated animal models has been identified as playing a key role in allergenicity testing of novel food products. See Taylor (2003), (2006).

incorporated into the host DNA. However, marker genes carry antibiotic resistance as this feature confers an advantage in the selection of the desired genes (Skurray 2006). Opponents of genetically modified foods hold two concerns regarding the effects of antibiotic resistance markers on humans. The first is that the antibiotic resistance feature inherent in marker genes will transfer from GM plants to intestinal bacteria and then onto mammalian cells where expression of novel proteins will take place – a concern widely expressed in the context of feeding GM maize to ruminants (Thomson 2001).

The second concern involves the belief that marker genes, upon entering the human digestive system, may transfer to disease-causing bacteria, effectively increasing the risk of infectious disease by compromising the effectiveness of orally administrated antibiotics in medical settings (Skurray 2006; Thomson 2001). The overwhelming majority of recently published reviews in the scientific literature evaluate this risk as virtually zero, with the impact on human health were it to occur, negligible[90] (Taylor 2003; Thomson 2001; European Federation of Biotechnology 2001).

According to the European Federation of Biotechnology, the risk of transmission of antibiotic resistance by antibiotic resistance markers can be minimized in one of two ways: first, the selection of marker genes can be limited to those that already occur frequently in natural microbial populations; and second, their use can be limited to those that confer resistance to a narrow range of antibiotics with limited application in human and veterinary medicine (European Federation of Biotechnology 2001).

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[90] Taylor (2003) has estimated this risk to be between $10^{-14}$ and $10^{-27}$.

Experts from various disciplines deem the main cause of the spread of antibiotic resistance in humans to be the general overuse of antibiotics in human medicine (Taylor 2003; Federoff and Brown 2004; European Federation of Technology 2001). Moreover, the use of resistance markers in genetic engineering is now being phased out in favour of alternatives currently in developmental stages (Taylor 2003; European Federation of Biotechnology 2001). Given this, the level of community concern seems disproportionate to the potential risk to human health.

### *4.4 Australian food safety assessment standards: how do they compare?*

Public confidence in the safety of GM foods as expressed in surveys is surprisingly low (Schilter and Constable 2002). This is despite the lack of good evidence for any of the putative risks of novel foods such as the transfer of allergenicity, the impact of antibiotic resistance on human immunotherapy, and concerns arising from the perceived inadequacy of safety protocols such as those allegedly posed by the adoption of equivalence testing. This section aims to describe the Australian approach to GM food safety assessment primarily to compare its robustness against established and respected international models on the assumption that a strong regulatory system will build public confidence in food biotechnology practices in Australia.

The basis for approval of GM foods in Australia is outlined in the S*afety Assessment of Genetically Modified Foods Report* published in 2005 by Food Standards Australia and New Zealand (FSANZ). It embraces all of the elements previously discussed in this chapter.

The main element of food safety assessment in Australia consists of case-by-case analysis of each GMO proposed for release. This requires full consideration of each component, along with the examination of all intended and unintended effects of the modification process[91]. A GM product is approved for commercialization iff there is evidence that:

1. the genetic material is stable and has been passed into the host DNA in a predictable way;

2. the new proteins have not shown to cause toxicity or allergenicity in animal models;

3. the nutritional composition of food is substantially equivalent to a conventional counterpart; and

4. a public consultation process has been carried out.

Jaffe (2004), Schilter and Constable (2002) and others, have identified a number of necessary components of a strong regulatory system that ensures product safety and engenders public trust in the assessment process. These include: a mandatory pre-market approval process using established safety standards[92]; a transparent and open public participation process that includes the provision of useful information presented in a manner conducive to good decision-making; the use of independent scientists for expert advice; robust post-approval activities and finally; ample resourcing for regulatory and enforcement agencies to reinforce compliance with safety protocols (Jaffe 2004; Schilter and Constable 2002).

[91] With the majority of unintended effects being readily predictable. See Taylor ( 2003).
[92] Note that not all transgenic crops in the US are subject to a pre-market food-safety process.

If the standards set out by FSANZ are met, the Australian approach to food safety assessment is compatible with the criteria advocated above. It contains what Jaffe (2004) and others maintain are necessary elements of a strong and accountable regulatory framework. However, other factors may influence positive public opinion towards investment in novel biotechnologies. For example, a general disapproval of agricultural biotechnology may stem from the conviction that genetic engineering practices undermine natural processes established by God. Such intrinsic objections to biotechnology are held by a significant proportion of the community. Before surveying the most popular naturalistic objections to genetic engineering, the use of agricultural biotechnologies in two very different contexts will be discussed.

# Chapter 5

## A case for a duty to feed the hungry: GM plants and the third world

## Part 1

*"The Europeans who reject biotechnology do so on full stomachs"*

Dr. Florence Wambugu, 2001, p. 64.

*"It is of grace and not of ourselves that we live civilized lives"*

John Dewey, 1988, reprinted in Huge Lafollette's World Hunger article in Companion to Applied Ethics, p. 245.

### *5.0 Introduction*

Proponents of GM crop technology typically advance three chief claims about its potential benefits. The first is that GM crops will encourage environmental sustainability by reducing the impact of agriculture on the environment. The second is that GM plant technology will reduce malnutrition especially in the third world by developing plants that are resistant to pest-derived disease, abiotic stress such as soil alkalinity and drought conditions and developing plants with enhanced micronutrients such as beta-carotene enriched rice. The third and more ambitious claim is that GM crop technology will contribute significantly to improved human health through the development of second-generation GM crops that produce biopharmaceuticals or, edible plant vaccines.

The first part of this chapter will be concerned with a discussion of the plausibility of the second claim namely, that GM technology has the potential to provide the hungry with sufficient food for subsistence. Following a brief discussion of the potential applications of GM in this context, a brief history of the green revolution and its impact will be discussed in relation to the current developing world agriculture situation. After a brief look at the concept of malnutrition in the developing world, I will discuss the claim that GM technology has the potential to provide the hungry with sufficient nourishment to determine whether scientists in developed countries have a moral obligation to pursue this end if and only if the technology proves safe and effective.

In the latter part of this chapter, I examine the saliency of the third claim namely, that GM crop technology has the potential to contribute significantly to the delivery of health-care through the development of second-generation GM crops such as biopharmaceuticals or, edible plant vaccines. The role of biopharmaceuticals in the developing world, and their feasibility in terms of their widespread use will be discussed. My discussion is framed by the possible existence of a moral obligation to receive emergency food aid, under the proviso that doing nothing is worse for the current situation and is therefore morally culpable.

### *5.1 From Green Revolution to Gene Revolution*[93]

The release of traditionally crossbred high yielding staple crops such as rice and wheat to developing countries in the 1950's and 60's is referred to as the *Green Revolution*. A

[93] The following two sections provide an historical and empirical context to the proceeding discussion. This background I believe is essential to understanding the motivations for some of the claims put forward by discussants of the debate.

concerted effort led to the founding of two international agricultural research centres (IARCs)[94] whose purpose was to produce cultivars less likely to succumb to pest-derived disease or which had improved architectural characteristics that increased grain production. The IARC's primary objective was to produce plants that would reduce hunger and therefore poverty given that: (1) rice, wheat and corn accounted for most of the world's caloric intake (Goff and Salmeron 2004); (2) more than 70% of food-insecure people lived in rural areas; and (3) farming in developing countries was primarily focused on subsistence production and was small in scale and resource-poor (Davies 2003). For all practical purposes, this ambitious undertaking worked.

Yield was improved in a number of ways. In rice, for example, the incorporations of genes for photoperiod insensitivity allowed planting all year round, regardless of day length. Plant maturation time therefore decreased and greater pest resistance was achieved (Davies 2003). Resistance to abiotic stressors on plants was also improved by the development of traits that provided resistance to unfavourable soil conditions such as alkalinity, salinity and iron and boron toxicity (Davies 2003). The effects of these advances were dramatic for world cereal production. The green revolution created higher plant productivity that generated higher employment, increased trade, transport and construction (Davies 2003).

In retrospect, the green revolution also caused some unintended problems as a result of transgenesis[95]. High-yielding varieties such as those developed to grow in Latin America and Asia required substantial amounts of water and fertiliser. Where fertilisation was not adequate, new varieties did worse than traditional varieties (Foster and Leathers 1999). New

[94] The first two major public research centres to be founded was the International Rice Research Institute in the Philippines (IRRI) and the International Center for Wheat and Maize Improvement in Mexico (CIMMYT).
[95]Transgenesis refers to the altered state of an organism following the integration of foreign genetic material into an organism's genome.

varieties were also resource-intensive which was unfavourable to resource-poor farmers. Over-fertilisation resulted in lodging, where the plant height increased dramatically with nitrogen application and the plant fell over. Leaves then decayed in the water and the plant did not receive sufficient sunlight (Foster and Leathers 1999). The IARC's response to the problem of lodging was to locate genes for shortness from other plants and breed these genes into plants to create semi-dwarfs,[96] but this had little impact in decreasing the amounts of fertiliser used. The type of fertiliser commonly used only contained a fraction of the essential nutrients required by the plant and needed for human health. The result was the production of plants poorer in nutrients than traditional staple crop varieties.

There were also increases in pest-derived diseases in high-yielding varieties that required prophylactic applications of insecticides and fungicides (Davies 2003). A concentration of modern varieties required farmers to gradually decrease land space usually saved for other crops, a practice which allowed the soil to replenish itself through cycles of rotation. These new practices resulted in poorer soil health and poorer human health overall even though caloric intake per capita increased significantly.

Unfortunately, the green revolution produced little benefit in developing regions such as Sub-Saharan Africa where the arid climate could not support modern varieties of rice and wheat. For these regions, staple foods consisted of root crops such as cassava and tropical maize and little research was directed at improving these crops until the late 1980's (Evenson and Gollin 2003).

[96]Another trait plant characteristic developed during this period was the relocation of the seed cluster or the panicle, in rice and wheat. Traditional varieties send their cluster of seeds high into the air shading the highest leaves on the plant, the flag leaf, and preventing the plant from receiving maximum energy. Scientists bred the modern varieties to send the flag leaf high above the panicle to allow the plant access to the maximum amount of sunshine Foster, P. and H. D. Leathers (1999). The World Food Problem: Tackling the Causes of Undernutrition in the Third World. Colorado, Lynne Reinner Publishers..

One of the criticisms of plant biotechnological advances resulting from what has been referred to as the *gene* revolution is that unlike the green revolution, the majority of gains produced primarily benefit agribusiness. Davies (2003) points out that "current traits exploited commercially in transgenic crops relate to crop protection and product senescence" rather than features that benefit developing world agriculture (Davies 2003). One such exception is the development of beta-carotene enriched rice, or *Golden Rice*[97]. Golden Rice has been genetically modified to produce beta-carotene, an essential component in the production of Vitamin A. Since a vast proportion of the world's poor consume rice as a staple food, the distribution of 'Golden Rice' would, theoretically, improve the nutritional quality of rice and therefore improve the overall health of individuals in developing countries.

Other examples include the development of pest-resistance in crops grown in developing countries such as viral-resistant cassava in Africa or nematode-resistant potato in Bolivia[98]. Overcoming infrastructural problems such as seed distribution and adequate information provision may significantly limit the capacity of transgenic crops to reduce poverty but there is certainly scope for revision of practice in the following areas:

> "First, public agricultural research must be better supported. Second, a clearer division of labour and better collaboration between public and private industry is required. Third, domestic policies must be in place to strengthen the agricultural sector, to support a domestic seed industry and to develop adequate markets. These tasks are the responsibility of national governments, donor agencies and private industry" (Tripp 2001:93).

[97] See the case discussion of Golden Rice in appendix 4.
[98] See the case discussion of the Bolivian nematode-resistant potato in appendix 3.

Sceptics argue that efforts made by the agrobiotechnology industry to fund research into GM crops that benefit the third world is a political response to growing public opposition to GM foods in developed countries[99]. Nevertheless, economic and political issues aside, the industry has demonstrated that (1) GM technology has the potential to produce crops that benefit the third world significantly and (2) private and public sectors can work together to create products that can improve malnutrition in the third world, of which *Golden rice* is an example.

### *5.2 The nature of hunger in the third world*

According to estimates of the United Nations Millennium Project Hunger Taskforce, approximately 842 million people are food insecure worldwide. The vast majority (798 million) reside in developing countries[100]. More than half of the world's malnourished live in Asia and the Pacific but Sub-Saharan Africa has the highest number of malnourished per capita with 33% of the population in this region considered to be undernourished (Millennium Project Task Force on Hunger 2004).

There are various forms of malnutrition: (1) *overnutrition*, a condition not commonly thought of as an example of malnutrition, occurs predominantly in developed countries and commonly leads to illnesses associated with high-caloric intake such as heart-disease,

[99] It might even be argued that the agrobiotechnology industry has successfully appeased public opposition to GM in some sectors by directing research in this direction. This might be true, but irrelevant to the truth of claims about the benefits of GM crops in the third world.

[100] The estimated number of people who are malnourished in countries in economic transition such as Latin America and the Caribbean is 34 million while developed countries contain approximately 10 million undernourished people.

hypertension and diabetes; (2) *secondary malnutrition* occurs from an inability to absorb or digest food usually as a consequence of disease such as diarrhea, intestinal parasites or respiratory illness; (3) *macronutrient malnutrition* which refers to insufficient protein-calorie intake, is usually characterized by acute hunger that results in undernourishment over a distinct period that is reflected in physical wasting and starvation and (4) *micronutrient malnutrition* that is caused by a diet lacking in sufficient primary micronutrients such as iron, vitamin A, iodine and zinc (Foster and Leathers 1999). This type of malnutrition is often referred to as 'hidden hunger' and involves constant undernourishment, or recurring seasonal undernourishment, that results in poor child physical and mental development and high child mortality due to hunger related diseases but not starvation (Millennium Project Task Force on Hunger 2004). Hidden hunger refers to micronutrient and or vitamin deficiencies found in vast numbers of people who otherwise have access to adequate calories and protein.

Contrary to popular belief, most hunger-related deaths occur from secondary disease caused by insufficient micronutrient or macronutrient intake rather than from insufficient caloric intake. Children are the most susceptible to micronutrient deficiencies and generally die first, followed by pregnant and lactating women[101].

Other macro and micro contextual influences on hunger include the HIV/AIDS pandemic, particularly in developing regions, other infectious diseases such as malaria, human displacement due to conflict, the sudden impact of natural disasters, and vulnerability to

[101]The global burden of disease attributable to undernutrition is staggering. Undernutrition in children aged under 5 years for example, has been estimated to cause 3.6 million deaths annually. Vitamin A deficiency for example, among children, is associated with an estimated 20% of measles mortality, 24% of diarrhoea mortality, 20% of malaria incidence and mortality and 3% of mortality associated with other infectious causses of disease. Iron deficiency (anaemia) contributes substantially to increased risk of mental disability, while zinc deficiency has been found to significantly compromise healthy immunological development in children. See Chapters 2-5 entitled Childhood and Maternal Undernutrition in *Comparative Quantification of Health Risks* (Vol 1), Majid Ezzati, Alan Lopez, Anthony Rodgers and Christopher Murray (Eds), WHO, Geneva, 2004.

policies set down by the International Monetary Fund, the World Bank, and other financial donors (Muula and Mfutso-Bengo 2003; Sachs 2005). In such cases, undernourishment[102] can be both a cause and a consequence of poverty[103].

I will argue that if GM crop technology has the potential to provide the third world with the means (in whatever form) to grow crops that are resistant to abiotic stressors (such as frost, salinity, drought, etc) and biotic (pest-derived) stressors, then this should be used for the alleviation of malnutrition and therefore hunger. It may also potentially decrease environmental degradation. Further, if the risk to human health of consuming GM crops can be measured and found to be within safe limits, then we have a duty to use it to assist victims of hunger and poverty. In doing so, I will use Peter Singer's *duty of moral rescue* argument to establish an obligation to rescue the poor suffering from malnutrition in the third world and assess the potential contribution that GM technology can make to alleviating some of this suffering.

### *5.3 Singer and the duty of moral rescue*

Thirty years ago, Peter Singer defended the controversial view that we have a strong moral obligation to rescue those in need of assistance (Singer 2002). A rudimentary version of the argument asserts that

> P1 Absolute poverty is bad.

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[102] I use the terms, undernourishment and malnutrition synonymously.

[103] It must be noted that an increase in the production of food using genetic modification is not a panacea for world hunger- but it may help to alleviate it.

P2 If we can prevent some of this suffering (*without sacrificing anything of comparable significance*), then

C we ought to assist[104].

*Absolute* poverty differs from *relative* poverty in that people who suffer from relative poverty still have access to uncontaminated drinking water, emergency healthcare, or some nominal level of nourishment[105]. Singer illustrates this argument using the following hypothetical scenario:

> If I am walking past a shallow pond and see a child drowning in it, I ought to wade in and pull the child out. This will mean getting my clothes muddy, but this is insignificant, while the death of the child would presumably be a very bad thing (Singer 2002:573).[106]

Singer makes two further points regarding the preceding argument. The first is that consequentialists and non-consequentialists alike should accept the above conclusion (i.e. that we have a duty to rescue those in need if it is of little cost to ourselves) since both theorists would affirm that we should promote what is good and prevent what is bad (in harmony with a theory of rights) (Cullity 1994). Secondly, a duty to assist the poor and hungry would only be morally obligatory if the assistance we provide alleviates suffering to some degree, in other words, if it is efficacious[107].

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[104] See "Famine, Affluence and Morality" in *Ethics in Practice: An Anthology*, pg. 572.
[105] For example, in Australia, the poor (incl. the homeless) suffer relative poverty since many still have access to charitable organizations that provide clothing, food and emergency healthcare.
[106] See "Famine, Affluence and Morality" in *Ethics in Practice: An Anthology*, pg. 572.
[107] Singer maintains that if the aid that is provided by individuals does not serve its purpose well, then our obligation no longer remains since the alleviation of hunger, suffering, etc. will not eventuate.

There have been two areas of contention in discussions of this scenario. The first relates to whether the analogy between a victim of calamity (in this case a drowning child) and victims of chronic poverty, is in fact a fair one. The second and perhaps more complex area of dispute relates to the nature and scope of any obligations we have towards victims who are in need of assistance.

There are three main schools of thought relating to our obligations (or lack of them) to those in need of assistance. The first group can be identified as proponents of Singer's analogy and thus maintain that we have some obligation to do what we can to help those less fortunate than ourselves, although the strength (or weakness) of this obligation varies considerably among different commentators in this category. A second group of thinkers believe that assisting those in need of rescue is a supererogatory[108] act or an act of charity and hence not one that we are under any obligation to perform. A third group of commentators argue that we have an obligation *not* to provide assistance to the destitute for reasons that are primarily neo-Malthusian[109].

*5.4 Demographic Transition Theory*

At this point, it is important to recognise that Singer's reasoning, and that of many writers who have commented on its soundness, presupposes the truth of a theory of the drivers of population change. Until recently, demographers had not reached consensus on this issue but it is now generally accepted that the sociologically-derived demographic transition theory

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[108] An act that is morally praiseworthy when performed but not morally blameworthy when omitted.

[109] Neo-Malthusians maintain that the giving of aid to the poor is counter-productive and results in further over-population. This argument is often taken further by arguing that an increase in population leads to an increase in net suffering since provisions are scarcer still when the population increases. The conclusion is made that it would be wrong to give aid since in the long term it would only increase suffering.

(DTT) best describes population change[110]. According to DTT, rates of population move between four distinct stages (LaFollette 2003).

In the first stage, a combination of high birth rate and high death rate produces a stable rise in population. This is typical of the current situation in the developing world. The second stage occurs as death rates decline and birth rates remain high, (perhaps due to reduced exposure to common causes of disease and improved access to healthcare and food). In this stage population size increases explosively. The third stage sees a more rapid decline in birth rates than in death rates (possibly attributed to increased education and economic freedom for women) and population increases at a much slower pace. The fourth and final stage is manifest when low birth rates parallel low death rates thus reaching a type of equilibrium now present in many developed countries (LaFollette 2003). Current worldviews on population change accept the Demographic Transition Theory as a plausible method for explaining the evolutionary processes that populations undergo[111].

*5.5 Responses to a duty to rescue*

Reactions to Singer's argument for a duty to assist those in need of rescue vary dramatically. For simplicity, I have grouped responses to Singer's proposal into three categories[112]: The first group consist of those who agree to some extent with Singer's analysis namely, that

[110] The DTT calculates population rates of change when aid is provided and population growth stabilizes. (Aid is typically measured as accessibility to a minimum standard of healthcare, access (entitlement) to food and economic stability.)

[111] I mention its significance here because Peter Singer, as well as many modern commentators on population change use the DTT as an authoritative model in debating the issues.

[112] Singer's original work on this subject attracted a myriad of responses. I have only chosen to review a limited number of commentators for obvious reasons. The views I have chosen are the most commonly expressed in the literature.

people should generally assist others in need if the cost to themselves is insignificant[113]. In my discussion I will refer to this group of proponents as *philanthropists.* The second group of respondents to Singer take issue with the analogy Singer uses to buttress his argument, or with the strength of his premises, or they find fault with the empirical foundations on which a duty to aid the poor supposedly rest[114]. I refer to this group as the *sceptics*. The final group of respondents to Singer's proposal can be classified as *antagonists* who claim that we have a Malthusian-based duty to *not* assist. I will discuss each group of commentators in turn.

### *5.5.1 The Philanthropists*

Philanthropists have concentrated on denying claims made by antagonists and sceptics that immediacy (physical proximity of victims, directness and effectiveness of aid and urgency) is morally important and thus has some bearing on the legitimacy of Singer's analogy[115]. Critics of Singer's analogy claim that there are distinct and morally relevant differences between the two scenarios that include urgency of need, proximity to the individual in need of assistance,[116] and the effectiveness of aid.

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[113] I shall include in this group those that maintain that giving aid to the poor is a charitable act and is not morally obligatory.

[114] Including the (inaccurate) conceptualisation of hunger and poverty and futility of the solutions offered.

[115] For consequentialists, such as Singer, a moral duty to assist is not a supererogatory act or imperfect duty, nor are any distinctions warranted between the proximity of a victim in need of assistance or causal responsibility relating to agency.

[116] See Kamm, F. M., (2000) Does distance matter morally to the duty of rescue? *Law and Philosophy*, 19:355-81.

Cullity (1994) insists that the non-immediacy distinction in Singer's analogy[117] is simply a methodological objection. Arguing from the supposition that there is a general, non-contextual reason to help those in need of assistance he asserts that:

> "Non-immediacy in no way countervails any reason we may have to act to avert a threat to someone's life…non-immediacy is irrelevant, ethically, to our obligation to aid others, just as race is" (Gomberg 2002:34).

Using a similar line of argument, Peter Unger (1996) addresses differences brought about in Singer's analogy using the concept of emergency. Unger distinguishes between 'chronic horror' suffered by victims of poverty and the extraordinary situation of emergency present in the case of the drowning child. He maintains that cases of chronic malnutrition are more dire since in these situations people have (generally) suffered for extended periods of time whereas emergencies are more exceptional occurrences which, all things being equal, are more likely to be endured by those who have had an easier life (Gomberg 2002). Unger insists that we are less disturbed by remote chronic horrors than proximal situations of emergency (which he views as a moral deficiency on our part). He considers this to be the reason for our lack of concern towards victims of hunger (Gomberg 2002).

Responsibility and causality for an event also feature in philanthropic claims that we have a duty to assist the needy. John Harris, as reported by Susan James, argues that intuitively we think "causal responsibility for an event or state of affairs is a condition of moral responsibility for it. We readily accept this with respect to commissions, yet we are more hesitant doing so with respect to omissions" (James 1982). Harris produces an account of

[117] A moral distinction antagonists are keen to defend as being relevant to its plausibility.

negative responsibility by arguing that "whatever considerations mitigate our responsibility for positive acts, ones with equal force are required for negative acts" (James 1982).

LaFollette (2003) takes this further and offers a rather unconvincing set of reasons why we have a strong duty to help the poor, one of which is that we are (at least partly) responsible for their plight. LaFollette offers the following argument for his conclusion. First, no one person or country is self-sufficient and even strong and developed economies are dependent on trade (LaFollette 2003). Then, by applying Goodin's account of collective and individual responsibility,[118] LaFollette argues for a *duty to rectify injustice* based on the assumptions that we (collectively)

(a) play a contributory role to their suffering and therefore should be assigned partial responsibility,

(b) actively sustain their impoverishment by creating a market demand for fresh fruits, coffee and spices at low prices (while preventing local farmers growing staples for their local population) and therefore

(c) benefit from certain practices that cause their suffering (LaFollette 2003:245).

From these premises, Lafollette concludes that we have a positive duty to feed the poor. This line of reasoning is perhaps the most extreme in the philanthropists' camp.

[118] The crux of Robert Goodin's argument is that "our obligation to assist the vulnerable is not a unique positive responsibility, but rather a general moral duty that ungirds all special sole responsibilities" LaFollette, H. (2003). World hunger. A Companion to Applied Ethics. R. G. Frey and C. H. Wellman. Malden, Blackwell**:** 238-53.

*5.5.2 The Sceptics*

Causation and responsibility are at the heart of sceptics' objections to Singer's putative duty to assist the poor. In *The Fallacy of Philanthropy*, Gomberg (2002) disagrees with Singer's analogy by arguing that rescuing victims of calamity comes from a learned social norm to assist which is not present in chronic cases of poverty. Gomberg (2002) argues that our response to examples of rescue is the result of a social norm (shared ethical norms cannot be violated on consequentialist grounds) and massive human suffering (in the form of poverty) does not address adequately our shared ethical understandings. Further, he argues that in instances of calamity, there are elements of exceptionality that make it different from rescuing the poor. For example, when we encounter a calamitous event, we are usually only required to rescue individuals or small groups, not entire populations.

The differences between the two situations relate to the causes and consequences of alternative responses to poverty (Gomberg 2002). Moreover, calamity, at some time or another in our lives potentially affects all of us where poverty does not. Through a sophisticated set of arguments, Gomberg concludes that acts of philanthropy unjustly detract from the real political and institutional causes of poverty and suffering (Gomberg 2002).

John Arthur (2002) takes issue with Singer's suggestion that individuals should aid the hungry by using a property rights view. Although theoretically Arthur accepts Singer's analysis of a duty to assist, he disagrees with Singer that providing aid is at a cost that is insignificant or justified:

> We should require people to help strangers when there is no *substantial* cost to themselves, that is, when what they are sacrificing would not mean *significant* reduction in their own or their family's welfare. Since most people's savings accounts are not insignificant, peoples entitlements would outweigh others' needs (Arthur 2002:590).

This more pragmatic sceptic accuses theoretical philosophers of abstracting famine and famine relief from the complex web of hunger and poverty.

> Singer's way of describing world hunger is misleading and leads us to ask the wrong questions….whether we (the affluent West) should give food or aid to (the starving Third World)…incorrectly implies that the sources of hunger are (a) starvation caused by famine[119] rather than chronic malnutrition and (b) lack of food rather than lack of access to food (Arthur 2002:590).

Another sceptic, David Crocker, propounds this exact line of reasoning. Crocker (2002) recognises that quantifying the extent of hunger, identifying a cause and remedying the problem involve a complex set of interrelated issues. For example, there are inherent differences in combating various forms of malnutrition (including overnutrition) such that a country may be free from famine and yet suffer endemic malnutrition, as in the case of India. Conversely, it is possible for a country to enjoy a high level of nutritional well-being and yet to be stricken by famines, for example, China (Crocker 2002). The central issue requiring attention is *accessibility* to food and food security. As Crocker sees it, we need to reject the

[119] Traditionally, 'third world hunger' has been understood as chronic episodic shortage of food rather than the intake of insufficiently nourishing food.

idea that chronic and persistent hungers are derived from a lack of food availability and food distribution and instead move towards the concept of *entitlement* to food[120]. The question, Crocker insists, should be- do households and individuals have an operational entitlement[121] to food (Crocker 2002)?

> Entitlement to food is the ability to legally or socially acquire food by producing it, trading for it, buying it or receiving it in a government food program…what is needed is the provision of security over food entitlements (Crocker 2002:596).

Further to food security, Crocker emphasizes that people must be accustomed to the food on offer and require adequate sanitary and health care so that they are immune to the parasites that causes malabsorption of nutrients (Crocker 2002).

One final view that might be added to the pragmatist sceptic camp is the common belief that "charity begins at home". This is the view that giving aid to those in need who are closest to us is a more sensible and prudent policy. A rejoinder might be that, in general terms, those who are poor in Australia suffer *relative* poverty rather than the absolute poverty that affects many who live in the third world. Even the poorest in Australia have some access to healthcare and services provided by charities[122].

[120] The term entitlement used here is descriptive rather than prescriptive.

[121] Operational entitlement here refers to physical, unobstructed access to food or the opportunity to acquire it by reasonable or equitable means.

[122] One response to my rejoinder might be that suffering poverty (and hunger) is miserable in any terms. The nature and origins of poverty are often complex. For example, one might argue that poverty experienced by remote communities is somewhat worse compared to poverty experienced by those living in towns and cities where the provision of services provides greater opportunity and choice. Conversely, those that suffer poverty in more heavily populated regions might experience 'institutionally-driven poverty' where welfare is stopped for trivial or bureaucratic reasons. Such practices can also result in hunger.

### *5.5.3 The Antagonists*

In the antagonists' camp, two commentators have dominated the debate. According to Gomberg (2002), in *Methods of Ethics* (1981) Sidgwick defends a desert-based theory of entitlement and argues that while governments may have a duty to relieve the suffering of the poor, private individuals only have a duty to aid the victims of unforeseeable events, not a general duty to aid the destitute. He goes on to argue that the rich are not required to give their superfluous wealth to the poor since it is the failings of the poor that have led to their poverty[123]. Therefore, we only have obligations to rescue individuals who are victims of events that are unforeseeable, disastrous, and which there is no opportunity of averting (Gomberg 2002). However dogmatic and simplistic this line of reasoning may seem, Gomberg asserts that this view is nevertheless popular[124] (Gomberg 2002).

The most widely discussed contributor to this debate is arguably Garrett Hardin. Hardin uses a consequentialist non-assistance argument now commonly referred to as *lifeboat ethics*. Hardin's analogy can be expressed in the following way: one is to imagine 50 people on a boat that has the carrying capacity of 60. One hundred people are swimming nearby and want to climb on board to escape drowning. Hardin reasons that admitting everyone would result

[123] Sidgwick's reasons that it is the sole responsibility of the man in the family to provide adequate resources for his family's well-being using any means possible. Unless a disastrous event prevents him from doing so, this obligation is his and nobody else's.

[124] John Kekes defends a contemporary version of Sidgwick's view on responsibility and prevention. In Kekes words, "individuals are responsible for the size of their families. It is an easily foreseeable consequence of their actions that if they increase the size of their families, they will have to divide their resources among more people….If people increase the size of their families and end up in or perpetuate their absolute poverty, then they are responsible for their own and their children's easily foreseeable suffering. Increasing the size of their families is clearly a voluntary action because they could refrain from sexual intercourse, they could enjoy sex without it leading to conception, they could practice such traditional methods of contraception as are available in their context, and they could abort unwanted foetuses. If overpopulation is the major cause of poverty, then it the imprudent voluntary actions of people living in absolute poverty that is a major contributing factor to their own and their children's suffering" Kekes (2002) On the supposed obligation to relieve famine, *Philosophy*, 77, 503-17. The most obvious response to Kekes is that he ignores the impact of poverty and child mortality in the third world and its role in overpopulation. Moreover, his suggestion that resolution is as simple as the provision of contraception is overly simplistic and misguided.

in disaster (i.e. everyone drowns). Admitting 10 people onboard would take the total onboard to 60 thereby eliminating the safety zone from which emergencies could foreseeably be handled. Admitting no-one would preserve the safety zone. Therefore, the most prudent course of action would be to admit no-one[125]. Hardin uses this same analogy to contest Singer's claim that we have a duty to rescue by taking the neo-Malthusian stance namely, that the giving of aid to the poor (whether active or passive) is counter-productive and results in further over-population (Ryberg 1997).

Ryberg identifies two premises in Hardin's argument. The first is that we should perform the action that produces the lesser evil. The second, is the assumption that non-assistance constitutes the lesser evil (Ryberg 1997). A number of objections can be levelled at Hardin's analogy. The most obvious is that it wrongly assumes that overpopulation is a primary cause of hunger. Second, there are many lifeboats and the argument ignores the often-complex relationships between them. The extension of the lifeboat analogy to countries in poverty ignores the fact that countries are often interdependent on each other and rarely exist in isolation. Murdoch and Oaten reinforce this point observing that realistically, economic, historical and colonial relations between countries contribute in various ways to a particular state of affairs, such as poverty. Since these interrelations are not considered, Hardin's analogy is too simplistic (Ryberg 1997).

In a postscript to the original *Famine, Affluence and Morality*, published in 2002, Singer defended his original argument but restated the importance of the *effectiveness* of aid. Singer

[125] Jan Narveson argues for a maximised utility approach to aid. Founded on a concept of mutual aid, Narveson thinks it's in our best interest to aid those in need if the benefit exceeds the cost of doing so. This policy, he argues, "puts some kindness in the bank for when we need kindness from someone- a basic, You Never Know" approach to mutual aid. See Jan Narveson (2003) We don't owe them a thing! A tough-minded but soft-hearted view of aid to the faraway needy, *The Monist*, 86(3), pp. 419-34. From a mutual aid position, saving 9 people from a maximum 10, your chances of returned favours for the future are maximised.

reiterated our individual duty to assist the hungry through the giving of aid if the cost to ourselves is materially insignificant *and* if the aid we contribute is effective in ameliorating suffering. Singer argued,

> That there is a serious case for saying that if a country refuses to take any steps to slow the rate of its population growth, we should not give it aid. …if after a dispassionate analysis of all the available information, we come to the conclusion that without population control we will not, in the long run, be able to prevent famine or other catastrophes, then it may be more humane in the long run to aid those countries that are prepared to take strong measures to reduce population growth[126]… (Singer 2002:580)

If we accept this condition on giving aid, all we are basically required to concede is that third world governments shoulder some responsibility for ensuring that greater long term economic strategies are put into place that provide, for instance, greater food security thereby diminishing the need for third world families to reproduce at a rate that sustains the welfare of older generations (Singer 2002). If the aid we give is not effective, then we are not morally obligated to continue to provide it.

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[126] Singer does not elaborate on the means that might be employed to reduce population growth other than suggesting that dispensing contraceptives and conducting sterilizations may play a role in a broader strategy to create conditions in the third world under which people do not need to have so many children to feel secure in old age. The free dispensation of contraceptives, the provision of family planning services and a creation of greater economic security are acceptable forms of population control. However, the idea that *performing sterilizations* might also feature as an acceptable form of population reduction, does not seem to fit comfortably within Singer's original purpose. There is no further discussion in Singer's postscript about this suggestion so comment is made difficult. Suffice to say that not providing aid because such drastic measures of population control are not undertaken, would be inconsistent and immoral.

For the remainder of this chapter, I want to spend some time bolstering Singer's duty to assist by introducing another possible avenue for justifying the provision of GM crops (or GM crop technology) to the third world under the banner of *philanthropic assistance*. I want to argue that the alleviation of poverty (malnutrition), may justify the introduction of GM crops in the third world by invoking the *Precautionary Principle* that not doing so might generate a much worse situation[127].

*5.6 The precautionary principle and GM crops*

The *Precautionary Principle* (PP), is found in both international and national environmental law and has been interpreted in widely disparate ways, ranging from extreme of risk aversion to more refined and moderated expressions of concern. All interpretations of the PP are intended to provide guidance for decision-making on issues of social concern. Most recently, the PP has been applied to debates about the acceptability of new genetic technologies and in particular, GM crops.

The PP's central concern is that caution should be exercised in advance of obtaining conclusive scientific proof that a particular development may have adverse or irreversible effects. A challenge for advocates of the PP has been to define its scope and its purpose and this to make it operationalizable. Vagueness and ambiguity make concrete formulation of the PP problematic, but the following general claims arguably capture the spirit of the PP.

[127] This of course is based on a number of assumptions outlined a little later- one of which is the requirement for an acceptable and in some sense measurable account of the relative safety and efficacy of distributing GM crops or the means by which to grow them.

(1) There is often insufficient scientific evidence to make an unequivocal judgment about the particular outcomes of a proposed course of action.

(2) We ought to exercise rational prudence towards the environment.

(3) Living systems are valuable.

(4) We ought not degrade or impoverish items of value.

Implicit in these statements is the conviction that the natural environment has intrinsic value; and that when we make decisions that could detrimentally or irreversibly affect the environment or the welfare of future generations, we should exercise caution (Parker 1998). Also contained in formulations of the PP is a caution against accepting the view that the environment possesses an unlimited capacity to recover from damage inflicted upon it.

Using perceptions about levels of risk, the extent and probability of harm and desired outcome as indicators, we can roughly divide versions of the PP into two categories - *strong* and *weak* formulations[128]. Table 4 illustrates some key differences between strong and weak versions of the PP.

[128] This is a simplification of a more complex situation. Arguably, there are many possible PPs of varying strength, and for simplicity I have depicted examples from opposite ends of a spectrum.

| | ***Probability of Harm*** | ***Extent of Benefit*** | ***Level of Risk*** | ***Burden of Proof in Determining Safety*** | ***Implicit in its Form*** | ***Type of Acceptable Action*** | ***Recent Case Example*** |
|---|---|---|---|---|---|---|---|
| **(Absolute) Strong PP** | Possible | Irrelevant | Serious, potentially irreversible. Irreversibility is considered a disvalue | On the potential perpetrator or polluter | Notion of good citizenship; environmental stewardship; concern for future generations | No action permitted without empirical evidence of safety | Ban on GM foods in Europe |
| **Weak PP** | Possible | Relevant: benefits are taken into account if they are viewed as potentially significant | The level of risk is calculated then prioritised | On the regulator or environmentalist | Cost-effectiveness; potential benefits ensued and; the execution of risk management models[129] | Proceed with caution; invest in research into alternative methods | Kyoto Protocol |

*Table 4 Two versions of the Precautionary Principle*

A key distinction between the strong and the weak PP is that the strong version affirms that environmental risk is the sole consideration for any proposed action. It also requires that no action is permissible unless it is certain that no harm will prevail. This very high level of risk aversion sets a standard that is impossible to achieve since in many cases, it is effectively impossible to obtain conclusive evidence of safety.

[129] Theoretically, advocates of the weak PP would acknowledge the same implicit features as the strong version of the principle but would consider and attempt to calculate the risks and benefits of action versus non-action.

A major assumption of the strong version is that any action (whether direct or indirect) *will* result in damage, that damage is irreversible, and that irreversibility is a disvalue. However, the belief that doing nothing in all cases is itself without risk, is clearly unwarranted. There are easily imaginable instances where doing nothing would result in considerable harm to the environment. One could also imagine instances where harm to the environment is not always irreversible, or cases where irreversibility is not necessarily a disvalue.

Another assumption made by the strong version of the PP is that any benefits that may accrue from a direct action are largely irrelevant - no matter how great the benefits may be. Under this view, no technological advances that pose some level of risk would be acceptable, including those advances that could potentially alleviate suffering.

The weak version of the PP on the other hand, is more pragmatic. It acknowledges that scientific certainty is not a necessary condition for action when deciding matters of environmental risk and it allows for weighing up the putative benefits and environmental risks of the technology. It is sometimes referred to as the *active* PP because its fundamental objective is to push ahead with a particular proposal despite the possibility of negative consequences, by applying sound risk minimisation strategies and using alternative modes of technology where appropriate.

As with the strong version, the weaker form of the PP acknowledges that any potential action affecting the environment has the possibility of producing harm. However, the weaker version recognises that damage to the environment is a potential and perhaps significant risk with respect to some actions, and thus recommends that all actions should proceed with caution. The weaker version achieves this by supporting investment in research into alternative methods that may bring about similar benefits with less risk.

Unlike the strong version whose upshot is restrictive -- recommending strict regulation, moratoria or bans -- the weaker version aims to introduce pragmatic risk management principles that work towards compromise between risks and benefits. Benefits are taken into account if they are viewed as potentially significant and the recognition is made that failures to act have attendant risks[130].

Suppose we accept that

> (1) GM technology has the potential to decrease future environmental degradation through the planting of crops that are resistant to abiotic and biotic stressors;
>
> (2) the application of GM technology has the potential to return micronutrients to soil that has been depleted of these elements and thus provide farmers with crops that are high in nutrient content and;
>
> (3) *some* responsibility falls on the shoulders of third world governments to provide the means to achieve this.

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[130] Parallels should not be drawn between a weak version of the Precautionary Principle and a standard cost-benefit approach to environmental management. The weak version of the PP described here does apply a cost-benefit calculus to environmental uncertainties. The difference however, is that the PP approach contains within it, an implicit understanding that the environment possesses intrinsic value, that is, that living systems are valuable in themselves. Further, when we make decisions that could detrimentally or irreversibly affect the welfare of future generations, we should exercise caution. Also contained in a weak PP approach (that is not necessarily contained in a standard cost-benefit analysis), is a caution against accepting the view that the environment possesses an unlimited capacity to recover from damage inflicted upon it.

We might then argue that there is a moral imperative (through the application of a weak version of the PP) for third world nations (where significant numbers of malnourished people live) to receive whatever emergency food aid, GM crop technology or nutraceutical can be made available to them. By using a weak version of the PP to argue for feeding the hungry, we could justify the introduction of some GM technology or products derived from GM technology *on the grounds that doing nothing might be worse for the current situation*[131,132]. This argument could also be extended to include GM crops that aim to replenish soil nutrients, are disease resistant, increase yield, or tolerate abiotic stress such as frost, aridity or excessive moisture.

There is some caution warranted when using this line of reasoning widely to justify the use of any technology that may assist the poor. It would be morally questionable for example, to command that malnourished people consume GM food or medicine that is in pre-clinical experimental stages[133]. It would also be morally dubious to coerce developing world farmers into growing hectares of non-staple monocultures that benefit the developed world but are potentially detrimental to their own economic and nutritional well-being and the local

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[131] By 'doing nothing' I mean a failure or omission to act either by placing prohibitions or restrictions on growing or distributing GM crops or a similar undertaking that has the same result.

[132] It might be iterated at this point that introducing GM plant technology is certainly not the only way of alleviating malnutrition. There are generally four widely recognised strategies for reducing malnutrition. These are; specifically targeted supplementation programs, food fortification, dietary diversification and disease reduction. Just as reliance on supplementation programs alone is not an effective means of eliminating malnutrition and poverty due to limited seasonal access to remote areas and sheer expense, so the planting of GM crops will not solely provide a solution to hunger. See Bouis, B (1996) Enrichment of food staples through plant breeding, *Nutrition Reviews*, 54(5), pp. 131-7. Other ways of increasing food security might include improved infrastructure such as better roads, the creation of regional markets for exporting local crops, and providing small loans to farmers in order to allow them opportunity to establish small lots. See Wambugu (2004) *Modifying Africa: How Biotechnology Can Help the Poor and Hungry, A Case Study From Kenya*.

[133] Recently, the media incorrectly reported that Zambia refused emergency food aid for exactly this reason. There are two points to be made here: evidence of safety was established in the literature some time before the offer of emergency food aid was made. Second, later investigations revealed the reason Zambia refused food aid from the United States was politically driven. The Zambian government at the time believed it was not in the country's trade interests to malign itself with Europe by accepting GM food since the European public and later, the European government, voiced strong objections to the distribution of any GM products. See Christou, P. & Twyman, M. (2004) The potential of genetically enhanced plants to address food insecurity, *Nutrition Research Reviews*, 17:23-42.

environment[134].

A precautionary approach to the introduction of novel GM crops to the third world might recognise that:

> provided technological expectations are met......the use of Golden Rice can be justified by a reasonable application of the precautionary approach, if alternative methods are less cost-effective and unable to achieve the aim of preventing VAD [vitamin A deficiency] (Nuffield Council on Bioethics 2004:59).

It has been pointed out by Vandana Shiva, that alternative methods of preventing VAD may in fact be more cost-effective than the widespread seed distribution of Golden Rice[135]. The current strategy to prevent VAD consists of delivering expensive vitamin supplementation to remote areas that are difficult to reach and delivery is often disrupted by civil conflict (University of Toronto Joint Centre for Bioethics 2002). It has been estimated that "fewer than half of all children in countries with endemic vitamin A deficiency are estimated to receive these supplements" (University of Toronto Joint Centre for Bioethics 2002:64).

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134 It must be noted here that I am by no means assuming that the introduction or production of GM plant technology or GM crops will alone result in a decrease of mortality and morbidity rates in the third world. I am simply arguing that GM crops may assist in alleviating some hunger or some poverty or some environmental degradation and that this desirable.

135 See *The "Golden Rice" Hoax – When Public Relations Replaces Science* by Vandana Shiva available from http://online.sfsu.edu/~rone/Geessays/goldenricehoax.html accessed 12 October 2004. Vandana Shiva suggests one alternative to preventing VAD is biodiversity conservation and propagation of plants naturally rich in Vitamin A. Some common locally produced and consumed crops common to Indian diets, for example, are amaranth, curry and coriander leaves, vegetables such as spinach, pumpkin and tomato and fruits such as mango, oranges and jackfruit. Although this is a desirable solution in the long term, it is somewhat impractical in the current circumstances and may not prevent VAD in the short term primarily because available land and soil quality could not support such diverse crops without other intervention. However, just as GM plant technology is not a panacea for the world's food problems, nor would the planting of traditionally grown crops in current environments provide a complete solution to VAD. A more sensible approach may be to combine these and other methods of farming in a bid to increase overall Vitamin A intake and prevent malnutrition.

Recent biotechnological advances have enabled the development of GM crops that confer several advantages over conventional breeding methods. I have argued that GM crops may potentially alleviate, to some extent, malnutrition in the third world as well as potentially decreasing environmental degradation that has mostly resulted from current agricultural practices. I have applied Singer's duty of moral rescue to the present third world situation and after considering responses to Singer, supported its application within the context of GM crops and the third world. Provided that certain conditions are met, I have argued that Singer's argument can be strengthened by using a weak version of the Precautionary Principle. My argument is based on the claim that doing nothing (when opportunity exists for doing something) may well be worse for the current situation.

The next section extends this duty of rescue to broader uses of GM technology in the developing world and discusses the progress and role of various GM products aimed at benefiting the wider population by decreasing the presently high burden of disease.

**Part 2**

*5.7 Golden Rice, Edible Plant Vaccines and Emergency Food Aid: An Obligation to Receive?*

In this section, I will discuss other potential uses of genetically modified plant technology including nutraceuticals[136] and biopharmaceuticals. Both of these applications of GM technology yield very different benefits and are promoted with very different purposes in mind. My discussions of nutraceuticals will be limited for the time being as these uses of GM are promoted as predominantly benefiting the developed world such as Golden rice. Other applications of GM products that potentially function as 'fortified foods' will be addressed in more detail in the next chapter.

*5.8 Some potential advantages of developing and administering vaccines produced by genetically modified plants*

Developing countries experience the effects of poorly coordinated prevention strategies and deficient medical infrastructure (Mason, Warzecha et al. 2002). In most countries in the developing world, 70% of children do not receive their full set of vaccinations (Castle and Dagleish 2005). In Sub-Saharan Africa, for example, a child has a 10-fold greater chance of

[136] One approach to defining nutraceuticals, and probably the more common one, is to categorise nutraceuticals as derived from food but sold as pseudo-pharmaceuticals. This definition is a derivation of the two terms, (nutrition + pharmaceutical), used to coin the term, 'nutraceutical'. Under this definition, nutraceuticals do not resemble conventional foodstuffs and mostly include preparations or food supplements in the form of pills or powders. See Ruth Chadwick (2003) for more detailed definitions of nutraceuticals and biopharmaceuticals.

dying from a vaccine-preventable disease than a child in an industrialised country[137] (Ehreth 2003). Neonatal tetanus is one example of a major source of mortality in the developing world with an estimated 400,000 deaths per annum (Ehreth 2003).

Edible vaccines are sub-unit vaccines where selected genes are introduced into the plant that is then induced to manufacture the encoded protein[138] (Tripurani, Reddy et al. 2003). There are several advantages over using plants to manufacture specific proteins (plantibodies) including lower production costs and the opportunity to produce proteins on a larger scale compared to using more traditional animal proteins for vaccine production (University of Toronto Joint Centre for Bioethics 2002). Theoretically, edible plant vaccines would be more affordable and accessible to third world populations than currently available live vaccines.

Edible plant vaccines reduce the need for skilled personnel to administer injections and obviate the use of needles – a potential source of transmission of infectious disease (Tripurani, Reddy et al. 2003). Some live attenuated vaccines are destroyed by heat and therefore require continuous refrigeration (Webster, Cooney et al. 2002). Maintenance of a cold-chain storage system is more difficult in developing world environments. Edible plant vaccines negate this need since an effective dosage could be obtained by consuming fresh or processed foodstuffs. Freeze-drying vaccine preparations is also under consideration as a viable form of vaccine production (Peterson and Arntzen 2004).

Subunit vaccines have extra safety features compared with traditional vaccines (Mason, Warzecha et al. 2002). Mammalian-based protein production carries with it risk of pathogen

[137] One in four children still remain without vaccination against one or more of the six most common, potentially fatal, vaccine-preventable diseases including tetanus, diphtheria, polio, measles, pertussis (whooping cough) and tuberculosis. See Ehreth (2003) The global value of vaccination, *Vaccine*, 21:596.
[138] A case example of an edible plant vaccine appears in appendix 5.

transfer. Using plants as production factories also allows researchers to develop complex proteins that cannot be produced using mammalian cell cultures.

Two distinct techniques are used in the production of biopharmaceuticals for oral consumption. The first, is to genetically modify plants so that they produce therapeutic proteins and then refine these compounds through processing. The second technique involves modifying a specific plant so that a vaccine is produced and administered orally (Nuffield Council on Bioethics 2004).

Tobacco plants are ideal plants in which to demonstrate proof of the concept[139]. They have high yielding capacity and the plant's systems are well-researched (Giddings, Allison et al. 2000). The most valued advantage of using tobacco, lettuce and alfalfa as expression systems, is sheer productivity- they are fast-growing (Daniell, Streatfield et al. 2001).

Some research examples to date include the expression of Norwalk virus capsid protein in tobacco and potato, Hepatitis B virus surface antigen in tobacco and potato, and cholera toxin-B subunit in potato (Tripurani, Reddy et al. 2003). Food vaccines can also be used to suppress autoimmune disorders such as type-1 diabetes, multiple sclerosis, and rheumatoid arthritis. Foods currently under study include lettuce, rice, legumes[140], corn, and bananas. Bananas are a particularly good candidate for an edible food vaccine since they are eaten raw, are generally favoured by children, are inexpensive to produce and native to many developing countries.

[139] The presence of alkaloids and other toxins in tobacco plants excludes it from being used as a direct conductor of vaccine to humans.
[140] Legumes such as soybean and alfalfa are among the most efficient plant systems for recombinant production (Mason, et al., 2002) Many legumes are used in field trials because of their economy and high biomass although they are difficult to initially manipulate Fischer, R., E. Stoger, et al. (2004). "Plant-based production of biopharmaceuticals." Current Opinion in Plant Biology **7**: 152-8..

One potential obstacle to oral vaccine expression is the possibility of degradation of protein components in the stomach and gut before they can elicit an adequate immune response (Tripurani, Reddy et al. 2003). Another is inconsistent dosage between plants of the same species. Identification of fruit containing the vaccine and fruit not containing vaccine may also present researchers with technical challenges (Tripurani, Reddy et al. 2003). Oral vaccines also require a higher antigen dose than traditional vaccines[141].

Plant-derived, orally administered vaccines that effectively immunize against diseases such as Hepatits B will potentially provide the developing world with a means to reduce the incidence of vaccine-preventable disease.

### *5.9 Emergency food aid and the obligation to receive*

A significant issue in the developing world is the provision of genetically modified food aid by industrialised governments. The refusal of a US offer of GM food as emergency food aid by a number of third world nations ignited considerable argument. Entangled within this were suspicions about hidden political agendas and antagonism connected with misunderstandings about the causes of hunger and food shortages. A number of points are worth considering thus far into the debate: first, there has been no evidence produced to date that human

[141] Personal communication with Professor James Dale, a leader in plant biotechnology from the Queensland University of Technology, revealed that realistically, there may only be two or three diseases for which it is conceivable edible plant vaccines would be truly effective. This is due to the current difficulties in maintaining effective mucosal immunity through oral dose as well as other, more practical concerns. Likely disease candidates for vaccine development include rotavirus, human papilloma virus (HPV), polio and possibly hepatitis B.  The technology required for their development is most likely to be sourced and distributed 'in-country'.

consumption of GM food harms human health[142] (Zimdahl 2006); second, GM food aid that has thus far been offered by the U.S. to Africa has been of the same quality and origin that has been sold in domestic and international markets; and third, *processed* (that is, whole) food donations are unlikely to cause harm to local environments[143].

In summary, if we accept that GM plant technology:

(1) can potentially decrease further environmental damage through he creation of crops that are resistant to abiotic and biotic stressors;

(2) can potentially return micronutrients to soil that has been depleted and provide farmers with crops that are high in nutrient content;

(3) can provide developing world populations with emergency food aid and consequently prevent people from starving and;

(4) and if it is recognised and accepted that some responsibility falls on the shoulders of third world governments in providing the means to achieve these benefits then;

we can argue that there is a moral imperative (through the application of a weak version of the PP) for developing nations (where significant numbers of malnourished people live) to

[142] During my scholarship, I did not find one peer-reviewed and published article that has established that the consumption of GM food is harmful to human health. There are a small number of authors who claim that it is unsafe to consume food that has been genetically modified, but none of these studies have received extensive peer commentary or have not been successfully verified elsewhere.

[143] This was one objection levelled at the U.S. in response to suggestions made about the donation of GM seed to some African countries. Understandably, the distribution of GM seed in unfamiliar environments could potentially be detrimental to local environments particularly considering many developing nations have undeveloped biosafety regulations or the infrastructure to test the safety of GM seed.

receive whatever emergency food aid, nutraceutical or biopharmaceutical can be made available to them. By applying a weak version of the PP in arguing for the alleviation of suffering of the malnourished, we can justify the introduction of some GM technology or products derived from GM technology *simply because doing nothing might well be worse for the current situation*.

# Chapter 6

## Social, cultural and economic considerations central to the global diffusion of novel biotechnologies

*"For well-known traits, we need to move away from a model of assessing risk to one of assessing the degree to which the new technology improves, or detracts from the delivery of social, economic and environmental aspirations."*

Firbank et al., 2005, p. 1475.

### *6.0 Introduction*

Revolutions in agriculture rarely occur in isolation to social, economic, cultural, and political changes (Krimsky and Wrubel 1996). Most major technological innovations cause some socio-economic imbalances that require policies to redress potential inequities, and provide infrastructure to secure real benefits (Pascalev 2003). With 70% of the world's poor reliant on agriculture for subsistence, and 26% of the world's GM crops situated in developing countries (Sampath 2005), international agricultural biotechnology policy must not create difficulties that further hinder the poor's ability to obtain food security. Nor should access to the agricultural applications afforded by such biotechnologies be frustrated by inadequate investment in the tools and resources required for the realization of potential benefits.

Research and investment in agriculture are critical to the economy of developing nations (Pray and Naseem 2007). All global agricultural systems face social, cultural and economic challenges related to the widespread use of novel plant biotechnologies, irrespective of their place in the global market place[144]. However, the impact of agricultural biotechnology developments and policies is more far-reaching and deeply affects the livelihoods of millions of the world's poor. This is no more apparent than when such policies are applied to economic and political systems that have not traditionally functioned under sophisticated property rights and trade law regimes.  This section reviews the wider social, cultural and economic effects of agricultural biotechnology on developing world communities. A chief aim in this section is to explore particular constraints and opportunities in benefiting from applications of agricultural biotechnology through the establishment of productive farming systems.

The previous chapter outlined some of the positive outcomes attributed to investment in public sector-led agricultural biotechnology research generated by the Green Revolution. The results of the Green Revolution were largely beneficial although some agricultural regions did not reap the same benefits as others, primarily because of climate variability and crop choice.  Since the Green Revolution, the majority of crops in the developing world have been developed and commercialized through private investment in agricultural biotechnologies (Pray and Naseem 2007). The production of technology in the developing world is largely driven by the private sector, with all crops developed and commercialized to date being the product of private investment - China being an exception to this trend (Pray and Naseem 2007). Current estimates place private investment in agricultural development in the vicinity of US$5B (Lalitha 2004). Public sector investment in third world environments total

[144] One example of the effect of the increase in adoption of biotechnology on industrialized regions, such as the US, is the decrease in the number of family farms – an effect perceived by some to erode traditional American values. While there has been a decrease in the number of family farms across the US, the size of farms has increased considerably primarily as a consequence of the intensification of agriculture and the perceived inefficiency of small-scale farming . See Zimdahl (2006), Krimsky and Wrubel (1996) and Pascalev (2003) for further discussion. While this effect is undesirable, it is not due to the adoption of novel biotechnologies but arises from the broader consequences of market competition. It is for this reason I have not chosen to explore this issue in any depth here.

approximately US$125M (Lalitha 2004). By contrast, research in industrialized countries has been evenly spread by involvement of both public and private research sectors.

A major driver of private investment has been momentum generated by the intellectual property rights movement of the 1980s, driven in large part by a US Supreme Court decision to effectively allow companies to profit from biological innovation. This has given private research institutes the opportunity to invest in profit-generating ventures. This has generally had a negative impact on the capacity for farmers in developing countries to benefit from such technological innovations; in some cases it has compromised food security (Shiva 2001).

Investment in agricultural technologies is critical to the economy of developing nations (Pray and Naseem 2007). The previous chapter established strong grounds for the existence of a duty to assist the poor in ways that are effective and provide opportunity for economic and social development. This chapter will review some of the current obstacles and challenges that influence our capacity to exercise this duty. These challenges do not stem solely from policies generated by industrialized countries towards developing countries. This chapter assumes both developing and industrial nations have some responsibility for establishing the resources required to better utilize currently available applications of agricultural biotechnology that are favourable to social progress.

### *6.1 Intellectual property rights and the diffusion of GM technology: Opportunities and constraints*

Not all critics of GM technologies believe that the technology itself is inherently unethical, but nevertheless argue against its use because of what they claim will be the adverse social and economic consequences of embracing the technology, particularly for developing nations. The majority of concerns focus around the effects of imposing an intellectual property rights system – such as a patent system – on economies not traditionally exposed to such constraints on trade.

Ironically, the underlying rationale for embracing a patent system is to manipulate the market place for the purpose of serving the public good[145]. The granting of a patent allows an inventor a monopoly on the use of their invention for a period of 20 years. In theory, a patent serves the public interest by: (1) providing incentives for future research and; (2) by rewarding innovation[146]. Advocates of a patent system argue that researchers working in the field of agricultural biotechnology should embrace a system that allows them protection of their intellectual property and enables them to recoup their research and investment costs.

Opponents of an international patent system argue that there are serious consequences of applying such a framework to third world environments (Shiva 2001). Of the many disadvantages, Shiva (2001) doubts the capacity for developing world inventors to legitimately recoup research and investment costs under a patent system, especially when industries originating from industrialized countries have historically recouped 15-20% of costs, while India has thus far managed to recoup only 0.5-2% of its costs (Shiva 2001). There are numerous challenging infrastructural and regulatory obstacles that undermine developing countries' ability to benefit from a patent system. Investment in infrastructural development, combined with continued capacity-building efforts, may afford developing

[145] Hall, W. (2004). Patents on human DNA sequences: Patently right or wrong? *Unpublished manuscript***.**

[146] Ibid.

countries a better return on their investments by providing an opportunity for recouping costs, as theoretically intended by a system of intellectual property rights.

Critics of patent systems, such as Vandana Shiva (2001), often misquote the decision handed down by the US Supreme Court in 1980 allowing the widespread patenting of genetic information as the first instance of the granting of a patent on a living organism. In fact the first such patent was granted to Louis Pasteur in 1876 on yeast (Nuffield Bioethics Council 2002). It is often argued by critics that this decision has enabled developed countries to exploit developing environments and cultures through acts 'biopiracy'[147] (Shiva 2001). Despite recent international efforts aimed at redressing the inequities experienced by some developing countries caused by the intellectual property rights movement, opponents of a patent system continue to lobby against the application of such a system on traditional agricultural trade.

For a patent to be successfully granted, two factors, among others, require determination: the first is *inventiveness*, and the second is *usefulness*. The primary objection to the patenting of biological material such as genetic information is that such data is discovered, rather than invented[148]. This is one major point of conflict between those supporting the global implementation of a system of intellectual property rights and those who oppose it. One disturbing trend in the granting of plant patents that stems from the requirement of a determination of inventiveness and usefulness is the potential unlimited scope of an interpretation of 'utility' when establishing a patent on an entire segment of genomic material[149] (Shiva 2001). The granting of a patent that is too wide in scope can be used in

[147] Biopiracy is defined by Vandana Shiva as the exclusive ownership and control of biological resources that have historically been used and owned by indigenous peoples.
[148] Hall, W. (2004). Patents on human DNA sequences: Patently right or wrong? *Unpublished manuscript***.**
[149] Ibid.

speculative prospecting practices where once a patent is granted, restrictions are effectively placed on the use of the patented material irrespective of its utility. This has the consequence of stifling rather than stimulating innovation[150].

Although there is presently a dearth of evidence on the social and economic costs of utility patents, the focus of discussion by commentators on both sides of the debate is on the consequences of adopting broad-based utility patents on seed saving practices.

Developing countries have traditionally functioned within a collective, communal trade environment that has been the fabric of successful local agricultural communities (Shiva 2001). The notion that intellectual property should be a thing protected and regulated is a foreign concept to developing world ideologies where dissemination of knowledge is governed by a spirit of collectivism (Butler 2002; Shiva 2001; Mascarenhas and Busch 2006). Nowhere is this conflict more apparent than in a patent systems' effect on the cultural practice of seed saving and sharing.

Historically, the saving and exchange of seed between farmers has allowed farmers to maintain biodiversity as well as food security (Shiva 2001). Through seed-saving practices farmers remain independent of seed companies breeding programs allowing them to save, store, and exchange seed specific to their local environment (Mascarenhas and Busch 2006). This independence allows farmers to retain food security, save money and avoid potential disruptions in the supply chain occasionally experienced as a consequence of adverse weather conditions (Mascarenhas and Busch 2006). It is a culturally-entrenched practice in many regions of the world that requires considerable skill, man-power and facility (Mascarenhas

[150] Ibid.

and Busch 2006; Shiva 2001). Seed saving, trading and sharing practices not only allow for the exchange of seed, but also allows exchange of specialized knowledge, culture and ideas (Shiva 2001). Intellectual property rights significantly impact on this practice and threaten many aspects of life for developing farmers. Under the FAO's TRIPs agreement, the practice of saving, trading or sharing seed is viewed to be theft (Shiva 2001). Considering that traditionally 60-90% of seed has been distributed externally to official markets, IPRs have the effect of privatizing food presently in the public domain and appropriating it under global patent law (Shiva 2001; Butler 2002).

"Plant breeding has now become a fully commercialized internationally operating business with close links to the biotechnology and chemical industries" (Butler 2002: 24). Under current intellectual property rights arrangements, developing world farmers would be legally compelled to repurchase seed every season and to use specific herbicides as the tools necessary for transgenic crops to thrive. This extends the cost of farming beyond the reach of many subsistence farmers and compromises food security if the crops fail to thrive.

According to critics of IPRs systems such as TRIPs, seed sterility technologies, more commonly known as *terminator* technologies, also potentially threaten food security[151] (Shiva 2001). Originally designed for controlling gene flow from GM crops to non-GM species, the use of terminator technologies under the auspices of intellectual property protection may compromise the capacity for farmers to save or store seed for later use.

[151] Chapter one discussed the merits of GURT in the context of minimizing environmental risk of gene transfer from transgenic crops to non-GM species. Viewed in this light, the technology has many advantaged. However, the use of terminator technologies solely for the protection of intellectual property rights, presents detrimental consequences to developing agriculture.

Advocates of IPRs argue that without globally compatible rights protection regimes, there are significant obstacles to private industrialized firms exporting new plant varieties that may benefit developing counties. IPRs protection in developing countries is rare (Butler 2002). One concern for industrialized firms in exporting new varieties to developing countries is that their products are not protected under intellectual property rights arrangements (Butler 2002). The application of terminator technologies, it is argued, may address this concern because it prevents seed sharing among developing farmers.

Since 2001, in response to sentiments expressed by international NGOs, developing world research centres and other lobby groups, there have been several attempts initiated by the FAO to remedy the inequities created by the effects of the TRIPs agreement on developing world farmers (Kaplan 2005). The International Treaty on the Plant Genetic Resources for Food and Agriculture, commonly referred to as the Seed Treaty, has incorporated a provision into the TRIPs agreement that is designed to protect farmers rights by compensating developing countries for the use of their genetic resources (Kaplan 2005; Butler 2002). This treaty aims to guarantee food security through the conservation, exchange and sustainable use of genetic resources, including the establishment of equitable benefit sharing provisions. This development has met with mixed success for several reasons, mostly because developing countries lack the sophisticated infrastructure required to manage their own genetic resources. The next section will review some of these obstacles in more depth.

### *6.2 Conditions necessary for a fairer system of rewarding genetic discoveries*

On the surface, it would seem that before amendments were made to international patent law in the late 1990s and early 2000s that recognized farmer's rights, Vandana Shiva's (2001), concerns about the adverse social and economic impact of novel biotechnologies on developing world farmers and their local communities seemed to be justified. Yet despite the recent inclusion of provisions in international IPRs regimes that are considered favourable to developing world farmers, enormous challenges remain for developing countries in benefiting from agricultural biotechnology. To date, efforts at rectifying the negative effects of IPRs systems on the sovereignty and economy of developing countries have, on the whole, been fruitless. There are a number of reasons for this.

There are two factors that negate the spirit of the Seed Treaty's recognition of farmers' rights. In addition to being subordinate to the FAO's TRIPs agreement, the farmer's rights provision is not compatible with other international legal frameworks (Butler 2002). Many developing countries are confronted with conflicting international regulations that govern the use of genetic resources and subsequently affect the diffusion of new technologies (Butler 2002). For example, in 1993, the Uruguay round of the Convention on Biological Diversity (CBD) recognized that countries have sovereign right over their own biological resources and are entitled to receive a fair share of benefits (Butler 2002). This allowed Argentina and Brazil, the largest developing world producers of GM crops, to only allow patents on microorganisms or microbial processes and exclude plant or animal genetic information from being patented (Lalitha 2004). However, the CBD is subordinate to other treaties and private parties are not bound by the CBD's requirements (Butler 2002).

Under new amendments to the WTO's TRIPs agreement, developing countries may choose to establish a *sui generis* patent system to ensure the protection of their intellectual property

(Lalitha 2004). Although native landraces are exempt from this requirement, poorer developing countries do not have the resources required to establish and regulate access and use of their own resources (Watal 2005; Butler 2002). Although TRIPs allows patent exclusion of inventions that protect human, animal or plant health, these exclusions do not extend to new plant varieties that are protected under plant breeders rights (Watal 2005).

Shiva (2001) and others have expressed concerns about the potential for international IPRs to ‘pirate and patent’ indigenous knowledge relating to biological resources in developing regions. In response to these concerns, the CBD has called for trading countries to enter into benefit-sharing arrangements for biological resources owned by developing farmers (Watal 2005). Yet to date, relatively few developing countries have entered into benefit-sharing negotiations that ensure protection of their own biological resources (Watal 2005). The obstacles most commonly encountered by developing agriculturalists include the limited bargaining power of developing country stakeholders and the existence of incompatible legal approaches (Butler 2002). Adding to this complexity, developing countries often fear that they will compromise existing trade relationships via the loss of trade benefits from European trade partners who disapprove of GM food (Butler 2002).

For developing countries, the costs of a IPRs system are currently outweighed by its benefits (Butler 2002). Given the complexities associated with changes to the WTO’s TRIPs agreement, Watal (2003), Sampath (2005), Pray and Naseem (2007) and others have argued that developing competitive skills should be priority for third world farmers who want to benefit from the rewards offered for agricultural biotechnology. Yet here, too, there are numerous difficult obstacles to overcome before developing countries have the infrastructure to establish their own biotechnology resources and stimulate innovation. Following a brief consideration of some other issues relating to the widespread dissemination of crop technologies, in the final two sections I will discuss in more detail some logistical challenges presented by the diffusion of agricultural biotechnology to developing world environments.

### *6.3 Other considerations in the widespread dissemination of crop technologies*

Critics of a private property system of (technological) ownership applied to developing economies echo Kaplan's view that "intellectual property rights laws and international trade regulations to patent GMOs transforms the nature of farming from an activity required to sustain life to a profit-driven, high tech industry" (Kaplan 2005:70). The impact of science-driven (as opposed to need-driven) investment in agricultural biotechnology is a concern expressed by both advocates and opponents of the use of GM crops in the developing world. Current trends in both private and public sector research in agricultural biotechnology presently show a strong focus on developing crops that are high in input traits (herbicide tolerance) and low in output traits (nutrition capacity) (Sampath 2005). This is of concern to farmers in the developing world whose communities would benefit greatly from research into crops that contain a high degree of benefit other than the potential to generate increased profit.

A strong focus on investment in crops tailored to industrialized markets will negatively affect the competitiveness of developing world exports, further disadvantaging poor farmers and local economies (Nuffield Council 1999). Among the effects of a shift from planting subsistence crops to planting export varieties is the potential threat to food security (Kaplan 2005). To require subsistence farmers to use their agricultural space to grow monocultural crops intended primarily for industrial markets would be inequitable and unacceptable. Such practices would significantly reduce the capacity for local farmers to support their families and local communities. This concern has been raised by anti-GM lobby groups such as Greenpeace.

### *6.4 Challenges faced by developing world farmers in adopting transgenic technologies*

In addition to the legal and regulatory obstacles encountered by developing nations in taking advantage of an IPR system that benefits developing world agriculture, developing countries face major logistical difficulties in benefiting from transgenic technologies. Chapter five established the plausibility of a duty to assist the third world in accessing novel transgenic plants considering the detrimental effects of chronic malnutrition. Yet there are several factors necessary before the benefits of supplying genetic resources to the poor can be realized. These same challenges are faced by developing farmers who attempt to utilize GM crops and crop technology, irrespective of its source. This section discusses the more practical challenges developing farmers face with respect to benefiting from accessing, planting, growing, and profiting from GM crops.

The prologue to this project discussed the various potential benefits of utilizing GM crops including yield improvement, pest resistance and aridity tolerance. With ever-increasing knowledge about transgenic plants generated through field trials, experts have come to understand that the success of GM crops often depends upon whether several external conditions have been successfully met. These include climatic conditions, such as topography variables, annual rainfall, drought, and input conditions. Higher crop yields are almost always dependent on local environments (Sampath 2005). This is one of the major criticisms of the claim that GM crops can have a significant positive impact on third world communities. These factors are not often given a hearing by advocates in the scientific literature.

This is a crucial reason for investment only in context-specific crops that are well-suited to the local environment. The establishment of competent local research institutes that focus solely on local varieties has occurred in Africa, but these centres are often resource-poor and unable to sustain preliminary research activities (Sampath 2005). In some instances, African governments have funded educational and training programs that have produced large numbers of scientists without concurrent investment in the infrastructure required to resource their research activities[152] (Sampath 2005).

There are several other key conditions critical to the stimulation of biotechnology innovation in developing scientific communities. In Africa, 70% of agricultural production can be attributed to women (Sampath 2005). Women do not traditionally possess the bargaining power in society to ensure the equity of access to the marketplace required to manage and market transgenic crops for profit. This is primarily because many of the processes involved in the production of transgenic crops require complex trade or licence negotiations (Sampath 2005).

Access to competitive markets enables farmers to trade their produce at profitable prices. This requires access to reliable transport (Pray and Naseem 2007; Sampath 2005; Watal 2005). The lack of basic infrastructure in many developing regions acts as a deterrent to

[152] In July 2007, the media reported an initiative by the African Union to provide a more centralised approach to strategic planning and policy for the better diffusion of agricultural biotechnology. Over a 20-year period, the 'Freedom to Innovate' biotechnology plan aims to tackle the obstacles currently hindering developing countries from benefiting from GM technologies.

investment in agricultural biotechnology. Success in the production of GM crops also requires information to be freely disseminated among farming communities. This not only includes information relating to the specific crop but also information about the possible risks posed by gene flow to indigenous plants (Nuffield Council 1999; Sampath 2005).

Deficiencies in information dissemination act as a hindrance to the global diffusion of beneficial agricultural biotechnology in that developing countries often withhold the release of GM crops because of insufficient infrastructure to assess biosafety (Lalitha 2004). Other considerations that may impact on the successful transfer of technology to developing farmers include political instability, particularly in West Africa where conflict is rife. The impact of AIDS and other health epidemics prevalent in many parts of the developing world also greatly influences farmers' occupational capacity to ensure the successful production of GM crops.

### *6.5 The need for capacity-building at the local level*

One of the chief challenges for developing world agriculture is mobilising the limited resources a country has available to establish the necessary infrastructure to support projects that are beneficial to local economies (Pray and Naseem 2007). India, Mexico and China have competitive research facilities yet still experience significant challenges in realising the benefits of agricultural biotechnology (Sampath 2005). Development research has found the requisite policy required to ensure that developing countries have the opportunity to benefit from agricultural biotechnology is one which builds capacity at the local level (Watal 2005; Lalitha 2004; Pray and Naseem 2007). Various well-researched policies and practices working in tandem have the capacity to provide communities with the necessary infrastructure to establish successful agricultural programs.

Capacity-building initiatives must be established at the local level and should include carefully planned competent research institutes equipped with well-trained and well-resourced scientists; strong, effective and transparent regulatory systems that safeguard against the possible risks associated with the adoption of some technologies and foster and reward research partnerships (Pray and Naseem 2007; Sampath 2005). Presently, public sector funding for biotechnology is difficult because of the limited government resources available for such investments. Mustering support from non-government organizations (NGOs) is at times also problematic because many such organizations are sceptical of the benefits agricultural biotechnology that can provide and investment in agricultural biotechnology is given a lower priority than investment in health (Pray and Naseem 2007).

Incentives must be available for the private sector to partner with public research institutes in the development of biotechnologies that benefit the poor[153] (Lalitha 2004; Pray and Naseem 2007). One of the problems private firms currently encounter in establishing productive research relationships with developing countries is the limited opportunity for adequate appropriability mostly due to limited market size (Pray and Naseem 2007). The removal of regulatory obstacles on export items would create a larger market for these products (Pray and Naseem 2007). Tax incentives for private firms to invest in need-driven rather than science-driven research may also support productive private-public alliances (Pray and Naseem 2007).

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[153] For a parallel discussion about the development of such schemes aimed at generating private investment in the biopharmaceutical sector, see Pogge T. (2005) “Human rights and global health: A research program” in Christian Barry and Thomas Pogge (eds) *Global Institutions and Responsibilities: Achieving Global Justice,* Blackwell: Oxford: pp. 190-217.

The Nuffield Council on Bioethics Report (1999) recommends that in order for private-public partnerships to capture the potentially high returns on investment in agricultural biotechnology research needs to focus on staple crop options[154] (Nuffield Council 1999). These ventures must be supported by locally appropriate research planning and well-resourced regulatory frameworks built at the national level (Sampath 2005; Nuffield Council 1999).

According to Sampath (2005), preliminary studies have shown that a number of farmers have experienced decreased labour demand in the short-medium term following the planting of Bt cotton crops. In such circumstances, governments need to ensure that initiatives were in place to prevent job losses and create conditions for work while increasing agricultural productivity (Sampath 2005).

In *Modifying Africa: How biotechnology can benefit the poor and hungry*, Florence Wambugu (2001), a local scientist and advocate for the adoption of agricultural biotechnology in Kenya, lists a number of 'golden rules' that developing farmers and biotechnologists must follow in order to successfully introduce locally-appropriate agricultural biotechnology programs. Although these mirror similar guidelines to those suggested by researchers in the field, it is especially worth noting them here since Wambugu has experienced first-hand the challenges faced by developing agriculturalists in benefiting from innovation[155].

[154] One factor that might increase the bargaining power of public research institutes in establishing relationships with the private sector is that the germplasm of stable crops is already freely available through public-owned international agricultural centres such as IARCs (Butler 2002).
[155] I have condensed Wambugu's original 12 'golden rules' to 7 as some conditions can be grouped together.

Wambugu's (2001) 'golden rules' for successful *local* investment in agricultural biotechnology include:

1. The adoption of simple biotechnologies that meet farmers' or consumers' needs and will make an immediate and positive difference to farmers lives and local economies;

2. Investment only in biotechnology innovations that integrate current farming systems and practices;

3. A focus on priority national crops in order to achieve impact quickly, avoiding the temptation to take on too many crops at once;

4. The cultivation of effective R&D systems through the development of private-public partnerships that establish quality national and international networks;

5. Participation in knowledge sharing and dissemination of information to other farmers in the region;

6. The establishment of a transparent and credible regulatory system that not only does its job but *is seen to be doing its job* and;

7. Ensuring that scientists establish strong links with the media and invite groups hostile to biotechnology to collaboratively work through areas of concern (Wambugu 2001).

*6.6 Conclusions*

This chapter has reviewed the obstacles present for developing nations to benefit from innovations in agricultural biotechnology. If the biotechnology sector is committed to sharing the fruits of innovation with those that are most likely to benefit, it must move beyond the current 'rhetoric of promotion' and work towards establishing the necessary infrastructure essential to the widespread successful diffusion of agricultural biotechnology.

A number of strategies *working in tandem* are required to bring about successful outcomes in developing environments. First, investment in agricultural biotechnology needs to be contained to context-appropriate, nationally important crops (Wambugu 2001). Failure to do this will likely threaten food security in the long-term. Secondly, the technology must be integrated into current farming practices in order to better utilize existing farming infrastructure. Thirdly, developing farmers need access to independent information about the crops they are planting, and the potential risks that are associated with transgenic plants such as pollen transfer, input requirements, etc. (Sampath 2005).

A number of broader infrastructural improvements are required in order to create real opportunities for benefits to be realized but perhaps the more important is to ensure that in developing countries farmers are not exploited by GM technologies. Efforts need to focus on establishing effective public-private partnerships that stimulate innovation in need-driven areas (Pray & Naseem 2007). Although these relationships may exist nationally or internationally, research needs to be directed at development at the local level. Credible, transparent and well-resourced regulatory networks are also essential in overseeing biosafety and licensing issues (Watal 2005; Lalitha 2004). Finally, the creation of robust media-science alliances will foster community trust in the justifications for investing in agricultural biotechnology opportunities (Wambugu 2001).

## Chapter 7

## Functional foods and the not-so-poor: Considerations in the promotion of novel foods for the developed world

### *7.0 Introduction*

In a previous chapter, it was maintained that novel crops specifically engineered for the purpose of providing the consumer with essential vitamins and minerals (such as Golden rice), may potentially reverse malnutrition in the developing world, given the right circumstances. This chapter will investigate the claim that the consumption of similar *functional foods*[156] derived from novel gene technologies can help to address the various problems caused by *over*nutrition[157] in developed countries. Functional foods in this context, it is claimed, can positively ameliorate the associated negative health effects of overnutrition such as obesity, cardiovascular disease (CVD), diabetes and some forms of cancer.

The global functional foods market was estimated to be worth $4.7b in 2001 and is steadily rising (Sloan 2002). According to Sloan (2002), the demand for functional foods is driven in part by two emerging attitudinal consumer trends: the first is a diminishing confidence that a conventional diet satisfies all our nutritional needs; the second is an increasing trend towards healthy eating which has been accelerated by the self-care movement (Sloan 2002). In the UK, functional dairy products sales account for 3.7% of total dairy sales, while in the US this

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[156] The concept of functional food originated in Japan (Mepham 2001) and broadly refers to a food similar in appearance to its conventional counterpart that has been developed to have health benefits that reduce (rather than prevent) the risk of chronic disease. Commentators have in the past confused biopharmaceuticals (oral plant vaccines) with nutraceuticals (products derived from food but sold as pharmaceuticals) and functional foods (wholefoods fortified to produce a specific function). This section deals primarily with functional foods in the industrial context and on most accounts would exclude both nutraceuticals and biopharmaceuticals.

[157] Overnutrition can be described as consisting of several elements most notably, excessive caloric intake. A diet high in carbohydrates and saturated fat can also contribute to overnutrition. Essentially, overnutrition is a form of malnutrition in that the person does not obtain the necessary vitamins and minerals essential to healthy physiological functioning.

figure has increased to 5.7% (Frewer et al. 2003). The consumption of functional foods in Europe is less with no more than 3% of the total diet per capita consisting of foods that have been modified to express a specific function (Godfrey et al. 2004).

Globally, CVD accounts for over 17 million deaths per year (Clugston and Smith 2002). Overnutrition is considered to be a significant cause of its prevalence. Overweight and obesity have reached epidemic proportions in many industrialized countries (and some developing ones), with approximately 50% of adults and 25% of children considered overweight in the US (French et al. 2001; Clugston and Smith 2002). It is not surprising then, that the food manufacturing sector might want a share in the profits the pharmaceutical industry has increasingly enjoyed by developing and marketing drugs and other products which claim to treat the conditions caused by affluent lifestyles.

By definition, functional foods include consumable products that provide medical or health benefits beyond simple nutrition, and often include products that claim to treat or prevent disease (Chadwick, Henson et al. 2003; Kleter et al. 2001; Mepham 2001). These foods are generally marketed to consumers as providing positive health benefits beyond what might be obtained through a nutritious diet and regular exercise (Mepham 2001). Frewer et al. (2003) argue that the intended role of functional foods is to reduce the prevalence of disease rather than to prevent it, yet to date there has been little evidence demonstrated that functional foods deliver the benefits claimed for them (Frewer et al. 2003). “It is not always clear whether functional foods are aimed at improving the health of individuals suffering specific illnesses, or the health of populations, so that products are designed to influence the more generic ills that affect society” (Frewer et al. 2003: 714). Given that the most common conditions the public aim to treat with functional foods include weight control, hypercholesterol, and joint and arthritis pain (Sloan 2002), public policy warrants a critical analysis of the marketing claims made for these foods and the role that they play in the public diet.

The large majority of functional foods currently available to consumers are not derived from genetic technologies *per se* but have nevertheless been fortified to produce a desired benefit or function. Common examples of *non-GM* functional foods include folate-enriched orange juice which manufacturers claim reduces the risk of neural tube disorders in pregnancy and calcium-enriched milk that is purported to deliver increased amounts of essential calcium to expectant mothers, the elderly and those suffering from bone disease.

There are various categories of functional foods available to consumers, and these can be grouped according to their intended function. *Fortification* refers to the addition of compounds to foods that originally did not contain them or contained them in lower levels that were unlikely to benefit the consumer (Frewer et al. 2003). Nutrient-enriched foods that might appear in this category are bread, eggs and fruit juice fortified with omega-3 and iron (Nelson 1999; Sloan 2002; Clugston and Smith 2002; Mepham 2001). Margarines have been fortified with sterols or stanol esters that have been shown to reduce low-density lipoprotein (LDL) cholesterol in some people (commonly known as 'bad' cholesterol), thereby potentially reducing the incidence of CVD[158] (Clugston and Smith 2002; Dunwell 1998).

*Restoration* refers to the addition of nutrients that have been removed from processed foods during the manufacturing process (Frewer et al. 2003). Adding iron lost in the manufacture of cereal products is an example of restoration (Mepham 2001). The *elimination* of potentially harmful antinutritional effects such as allergenicity is another potential benefit of food

[158] Such health claims should be interpreted cautiously. Cholesterol-lowering foods have been shown to decrease LDL levels in the blood *in association with* healthy eating and regular exercise.

biotechnology[159] (Dunwell 1998). Food biotechnology can also be used in the maintenance of product integrity (a feature not generally considered to be of direct benefit to the consumer) in ways, for example, that can *control* the expression of synthetic proteins (a method designed to minimize the effects of freezing) (Dunwell 1998).

Functional foods can also include anutritional characteristics such as improved taste or colour. Purple cauliflower (originally designed to attract vegetable consumption by children) is one example of this category of food[160]. This chapter will primarily focus on a discussion of the potential benefits (if any), and impacts, of the widespread consumption of functional foods derived from novel genetic technologies. (Much of this discussion is also relevant to functional foods produced by other means).

Examples of genetically *modified* processes that allegedly benefit consumers include: the fortification of soybeans, corn and canola that express docosahexanoic acid (DHA), an agent believed to improve cardiovascular health (Mepham 2001) and; the reduction of saturated fat levels or carbohydrate content of a food for the purpose of improving a product's nutritional quality (Dunwell 1998). Food additives containing genetically modified enzymes may also be used in the processing of dairy products such as cheese and cream for the purpose of enhancing product stability, but this is not considered to benefit consumers (Skurray 2006).

Despite the currently limited availability of GM functional food products to consumers, the food biotechnology community is enthusiastic about the prospect of utilizing novel gene

[159] Ironically, novel biotechnology can also produce foods whose proteins express allergenic potential. This issue is discussed in more detail in Chapter 5.

[160] Other recent functional food consumption trends include lifestyle enhancers such as energy enhancing drinks and foods that require limited or no preparation and can be consumed 'on the go' such as breakfast shakes. Products that control satiety and appetite suppression and products that claim to enhance 'inner beauty' and retard the ageing process are also increasing in availability. See Sloan (2002) for a full discussion on current trends in the functional foods industry.

technologies to develop products that can be promoted as beneficial to consumer health[161] (Dunwell 1998; Kleter et al. 2001).

The fact that there is little or no direct evidence that consuming functional foods prevents diseases caused by affluence such as CVD or obesity at a population level (Clugston and Smith 2002; Frewer et al. 2003) raises several ethical issues about the promotion and marketing of these products. Two particular issues that merit discussion are: (1) the role of functional foods in encouraging healthy eating and; (2) the broader impact of a movement that promotes modified food as producing real health benefits in the absence of evidence. These issues are especially important for food regulators and food biotechnology companies that wish to improve their poor public image[162].

### *7.1 Ethical considerations in the promotion of functional food products derived from novel gene technologies as beneficial to consumers' health*

There is little evidence to support claims that consuming functional food produces any direct medicinal or health value. Given this, their promotion in industrialized contexts raises several ethical concerns. The protection of consumers from misleading health claims is of primary concern particularly considering the lack of direct evidence as to their efficacy in reducing or

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[161] Examples of functional foods that contain biopharmaceutical properties have also received some attention within this debate. The production of GM animals for the purpose of providing functional foods is in developmental stages. For example, GM cattle that secrete lactoferrin (a human milk protein), a protein that has anti-inflammatory properties has been demonstrated to contain positive benefits particularly for immunocompromised patients while bile salt stimulated lipase (BSSL) secreted through sheep milk has been used as a nutritional supplement for cystic fibrosis sufferers (Mepham 2001).

[162] As discussed previously, the general community is wary of companies that manufacture biotech products for several reasons. One reason is that consumers perceive no direct benefits of many products derived from novel technologies. Recent global food crises have also damaged the reputation of food producers, regulators and the biotech industry including several outbreaks of food contamination in the 1990s. As a result, the public are less trustworthy of such groups. A more detailed discussion of these events appears in chapters one and three.

preventing the incidence of disorder such as CVD or hypercholesterol (Mepham 2001; Frewer et al. 2003). This is relevant for food advertising regulators but is particularly salient with respect to products derived from food biotechnology in light of positive public sentiment towards such products.

The potential "long term cumulative effects of small changes in the composition of an increasing number of foods" has been highlighted by Mepham (2001). The safety of consuming substantial amounts of functional foods is unknown[163]. It seem especially problematic for functional foods such as fortified breakfast shakes to be promoted to busy people seeking 'fast food' options as an easy way to access products that require little or no preparation.

If we assume that no direct adverse effects are evident in the moderate consumption of functional foods, and some evidence is presented in favour of the claims made about their individual health benefits, the affordability of these products also requires consideration (Mepham 2001). On the whole, the cost of functional food products to the consumer is considerably higher than equivalent conventional foods. Social equity would require that these products be made widely available to all those that could benefit from them, not just those that are able to afford them.

For products that do not claim any direct health benefits but contain ingredients derived from a genetic process, the issue of consumer choice and product labelling is relevant. Today's discerning consumers are increasingly expecting full disclosure of not only the ingredients contained in food products but also the processes used to produce these ingredients. Whether

[163] The same argument can be applied to all processed food items, not just those derived from biotechnology. What makes this a valid concern with respect to GM food is the presence of positive health claims made in their promotion.

novel food manufacturers are morally obliged to label products that are not considered harmful to human health was discussed in chapter three. It is arguably in a food manufacturer's interest to disclose the perceived benefits (consumer or otherwise) of purchasing and consuming a novel product.

### *7.2 The merits of a primary healthcare approach to food regulation*

A primary health care (PHC) approach to public health that has been applied to health policy areas such as mental health promotion, can usefully be employed to discuss food regulation policy on the grounds that good public health policy should encompass the regulation of food marketing. A typical PHC approach to healthcare reflects a universal commitment to addressing health inequalities through remedying the social, structural, political and economic contributors to health and ill health (Talbot and Verrinder 2005). Central to this philosophy is the view that there are direct correlations between one's extrinsic environment and one's state of health (or ill health). A PHC philosophy subscribes to the view that social inequalities *determine* health outcomes, that is, there exists a direct correlation between socio-economic status, social opportunity, social support and health outcomes. The more access, choice and opportunity a person has to seek, afford and utilize a health service or good, the better their current health and their future health states.

Among other things, a PHC approach applied to food regulation policy, would acknowledge the potentially harmful effects of promoting individual functional food products to consumers when these foods do not offer any definitive health benefits. Particularly when one of the effects of this practice is the perpetuation of the myth that a single food item is intrinsically healthy (or unhealthy) and is capable of delivering real health benefits. In reality, the measure of a healthy diet is the composite of the "relative amounts of food components that make up the whole diet" (Frewer et al. 2003: 722).

A PHC approach to food policy would also emphasize the importance of combining other health-promoting lifestyle factors with diet, such as, regular exercise, moderate alcohol intake and normal sleep patterns, in achieving positive health outcomes.

Decades of research has firmly established that factors that influence healthy eating are complex and multifaceted (Frewer et al 2003; French et al. 2001; Turrell 2002). Environmental aspects that affect the kinds of foods purchased by consumers include physical access to healthy food outlets, general health literacy, food preparation skills, and access to transport (Caraher et al. 1998; French et al. 2001). Socioeconomic differences also contribute to dietary intake with people from manual occupations generally consuming foods with lower overall nutritional value (Turrell et al. 2002). In recognising that social inequalities play a direct role in determining health outcomes, a holistic approach to food policy would oppose the marketing of functional food products to consumers who were vulnerable to misleading health messages.

Adopting a PHC approach to food advertising regulation in general encourages the public to view a good diet as one important component of a healthy lifestyle. To promote individual food products as useful agents in reducing or preventing disease is misleading and irresponsible (Mepham 2001). To date, there has been little evidence presented in the public health literature that demonstrates the positive health benefits of such products. Food regulators have a responsibility to the public in ensuring products are marketed together with accurate product information in accordance with evidence, especially when health claims are made.

It is not in the economic or political interest of food biotechnology companies to mislead consumers about the effects of functional food products derived from novel biotechnologies. This is particularly so if the biotechnology industry wishes to improve its public image and reduce the public's hostility towards the development of such products and their suspicions of the biotechnology industry's motives in promoting them.

The majority of GM products offered to consumers thus far have been of little direct benefit to consumers and have primarily served the interests of businesses producing and promoting such products. Products that purport to contain specific health benefits to the individual have not generated evidence to suggest their nutritional efficacy. Given that an ethically desirable approach to food policy might encompass a PHC approach to healthy eating, the promotion of functional foods as 'health-saving' or 'disease-preventing' is unhelpful on a number of fronts.

Perhaps most importantly, it is not evidence-based. Functional foods may in fact deliver some of the benefits they claim *if* consumed in association with a healthy diet and regular exercise but there is insufficient evidence to suggest either claim is true. To promote foods in the absence of this evidence is misleading and morally questionable, particularly in view of the current level of public anxiety about disease prevention and treatment. Second, it fails to take into account the physical, cultural and socio-economic considerations that impact on healthy eating. Industrial world eating requires a complex multilayered response to food policy based on health promotion strategies which include health literacy, transport and access to quality food outlets, and the availability of inexpensive fresh produce (Caraher et al. 1998; French et al. 2001). Third, it perpetuates myths that impact negatively on consumer health. As Frewer et al. (2003) has pointed out, the promotion of individual food items distracts attention away from the concept of a 'healthy diet', to the concept of a 'healthy food item', a perception that is unhelpful in establishing healthy eating (Frewer et al 2003).

Until more evidence comes to light confirming the health benefits of particular products to individuals and the population as a whole, the promotion of such products as 'disease-reducing' or 'disease-preventing' is misleading and irresponsible. It is unclear what future research into such products reveals, but until such time the promotion of functional foods is risky business for the food biotechnology industry, particularly in the face of public suspicions of their motives in promoting such products.

There is no evidence to support the more general claim that functional foods have the potential to meaningfully contribute to decreasing the harmful effects of overnutrition in developed populations. At this stage, it is not obvious what the future role of functional foods (as wholefood products) will be in industrialized countries[164]. Regulators of both biotechnology and conventional food should be concerned about the continued promotion of the putative health benefits of food products. A health promotion approach to food policy that is based upon the principles of primary health care has several advantages that incorporate the complexities of healthy eating behaviours. Functional foods derived from novel biotechnologies remain best applied in developing world contexts where nutritional standards are so poor that many people succumb to diseases caused by chronic malnutrition.

[164] Although (wholefood) functional products presently have a limited market in industrialized contexts, biopharmaceuticals derived from novel technologies are likely to have a greater impact on the health of developed populations.

# Chapter 8

## Naturalistic objections to novel gene technologies: Some alternative interpretations

*"If humans are made in the divine image, and if God desires that we exercise the spark of divinity within us, then it should be no surprise that inquisitiveness in science is part of our nature. Creative impulses are not found only in the literary, musical, and plastic arts. They are part of molecular biology, cellular biology, and evolutionary genetics, too. It is unclear why the desire to investigate and manipulate the chemical bases of life should not be considered as much a manifestation of our God-like nature as the writing of poetry and the playing of sonatas should be."*

Comstock (2000) pg. 185

### *8.0 Introduction*

Debate about the acceptability and desirability of GM foods is multifaceted. Opponents of novel gene technologies often express their disapproval by appealing to principles based on claims about "naturalness". Commonly referred to as *in-principle* objections or 'playing God' arguments, naturalness claims are increasingly attracting criticism from the scientific community for being vague, proscriptive, and sometimes irrational (Streiffer and Hedemann 2005; Grey 2001). These characteristics are thought to obfuscate particular points of concern relating to the development and use of biotechnologies, rather than clarify them (Grey 2001). In an effort to show that some of these claims are indeed valuable to the GM debate this chapter will explore possible interpretations of four common in-principle objections to novel gene biotechnologies[165]. I contend that some formulations of 'playing God' arguments can reveal useful information for example, about: the role of popular perceptions of risk in public attitudes to GM; concerns about the potential for some biotechnology policies to foster

[165] The discussion will focus on novel gene biotechnologies applies to plants but can many of the arguments can be used in relation to other biotechnology applications such as human gene therapy.

inequities, particularly in the third world; or a general preference by consumers for purchasing food that supports local producers.

Having considered the majority of arguments offered against the development and use of novel biotechnologies in previous chapters, this section explores the plausibility of reinterpreting some popular naturalness claims as *in-practice* concerns. In doing so it is hoped that some naturalness objections, traditionally perceived as ambiguous, find some purchase in the debate in that they serve as more useful starting points for discussions about novel biotechnologies. In the case of those objections that are wholly founded on theistic hypotheses, the best outcome is to show that they are either ambiguous or empirically false.

### *8.1 The traditional role of naturalistic objections in biotechnology debates*

Prior to the pursuit of plant biotechnology as a feasible agricultural option, naturalness objections have been used by critics to oppose genetically screening embryos for genetic abnormalities, or the pursuit of human genetic therapies in the medical domain, such as somatic and germ line gene therapies (Carter 2002, Hedgecoe 2001).

In ethical discussions, a clear distinction is often made between in-principle and in-practice objections, otherwise known as intrinsic and extrinsic concerns, respectively. In-principle concerns about novel biotechnologies can be expressed in a number of ways. Most often, such concerns are expressed as beliefs that focus on the ‘inalienability’ of genomes and species and the importance of preserving the integrity of each. Other in-principle objections are grounded in theological objections based on the view that genes belong to God, not to humanity[166]. All in-principle objections consider the inherent rightness or wrongness of an action rather than the consequences it produces. In-practice concerns, on the other hand, relate to extrinsic objections about the application of some technology that often appear as consequentialist concerns. Critics who use consequentialist concerns to express their objection to some practice, often consider the pursuit of that end to be undesirable (Carter 2004).

I conjecture that the distinction between these two types of objections is not as clear as is often claimed. Some in-principle or naturalistic concerns are incorrectly labelled, and in fact represent in-practice concerns and should therefore not be dismissed as objections that are ambiguous, vague or theologically-entrenched. Such concerns contain useful information about many issues such as the way the general public perceive risk, community concerns about equity and market competition, and the effects of intellectual property rights on economic environments based on collectivist, rather than individualist principles.

Ruth Chadwick (1989) has suggested that 'playing God' claims generally consist of two components: the first applies to individuals who make decisions for other individuals in a significant and decisive way; the second use of the phrase applies to the power of biotechnology to alter God's handiwork (Chadwick, 1989). To many critics who discount the value of claims based on naturalism, 'playing God' arguments have the effect of introducing issues that are not open to resolution. The next section discusses in more detail some common criticisms of naturalistic objections to novel gene technologies.

[166] Hall, W. (2004). Patents on human DNA sequences: Patently right or wrong? *Unpublished manuscript*.

*8.2 Common criticisms of naturalistic objections to novel gene technologies*

Two criticisms commonly made about traditional formulations of 'playing God' arguments projected in opposition to the use of novel gene technologies include: that they are absolutist and paternalistic; and that they presuppose the truth of a theological premise that God exists (Hanson 1997; Comstock 2000) – a hypothesis that cannot be empirically verified or falsified. According to these critics, claims based on naturalism are absolutist because they often use principles that are immune to debate. This provides little scope for resolving underlying concerns. Such claims are also paternalistic because they assume superiority among competing views, effectively disregarding the plurality of values in modern liberal societies. These characteristics have the (perhaps unintended) consequence of stifling ethical debate and do little to improve understanding on either side of the 'GM divide' (Carter, 2002).

It is a mistake, however, to label all 'playing God' arguments as obstructive and unhelpful. Not only does it fail to respect the plurality of views in deliberative debates about technological processes that may influence the environment (as well as other systems), it also assumes that an expert approach to problem-solving is superior to other, more inclusive approaches of addressing the issues[167]. This approach to discussions about novel biotechnologies does little to engage various stakeholders and foster public trust. The theological assumptions that underpin some naturalistic objections to novel biotechnologies "may not be widely shared but similar sentiments may resonate more widely in the community, receiving a sympathetic hearing from many who do not share the underlying

[167] Chapter three discussed the relative merits and disadvantages of two opposing approaches to thinking about the issues.

theological beliefs" inherent to 'playing God' arguments[168]. It is therefore critical to the success of biotechnology policy to take seriously public concerns about its development and use.

The next section will survey several popular formulations of naturalistic objections in an effort to provide a more stable starting point for discussions about popular concerns regarding the potential impact of GM crops on valued aspects of society and the environment. I argue that reinterpreting these claims not only gives them meaning and purpose, but reveals genuine concerns about the development and use of novel biotechnologies. Reinterpreting such claims assists in moving past the current impasse created by naturalistic objections and provides a useful platform from which to discuss more serious underlying concerns.

### *8.3 Some new interpretations: Four popular formulations of naturalistic objections to novel gene technologies*

Naturalistic objections are commonly expressed as 'playing God' arguments. Opponents of transgenic plant technologies have argued that such practices cross the species barrier and therefore tamper with the divine order of things (Mae-Wan 1999). The more popular conceptions can be expressed in the following ways:

1. a) Transgenesis, or the *alteration of an organism's genome, is a transgression of an inviolable divinely ordained boundary*.

[168] Hall, W. (2004). Patents on human DNA sequences: Patently right or wrong? *Unpublished manuscript*, pg 6.

This claim is based on the “deep conviction that there is a providential divine or natural order” to the structure of the world and any alteration to this natural order is somehow immoral or wrong (Grey 1998: 529). The practice of biotechnology then, is an attempt to control this natural order and in the process, usurp God’s dominion (Comstock 2000). There are several problems with this way of reasoning. The first, identified by Comstock (2000), is that it assumes that the pursuit of knowledge (in this case the modification of organisms to better utilize desirable traits), is an immoral endeavour that God would disapprove of. Yet under this claim, other pursuits, relevant to other disciplines, are permissible in God’s eyes. Not only does this belief flout other popular conceptions of God, it is undermined by what has now become a minority view in today’s pluralistic society (Comstock 2000; Grey 2001).

> “In our post-Enlightenment state of knowledge this view does not survive inspection. Gene pools are more plausibly seen not as the product of divine providence, but as the piecemeal accretions of billions of years of accident, mishap, and good fortune” (Grey 2001: 338).

Secondly, it is empirically false. Some conventional breeding techniques transgress the same boundaries, are highly sophisticated, centuries old, have resulted in transgenesis, yet fail to be perceived as ethically unacceptable under very similar conditions. Granted that naturally occurring examples of transgenesis have taxonomical limitations, many modern agricultural varieties are nevertheless rarely successful in hybridization without intensive human manipulation – even if of the ‘more traditional selective breeding kind’.

A second formulation very much related to the first is;

b) *Novel gene technologies are unacceptable because they illegitimately tamper with nature*.

This claim does not appear to carry the same religious undertones as the first but nevertheless claims that genomic integrity is inviolable and thus deserves special consideration (Carter 2004). The scope of the consideration that must be accorded is unclear although this version seems to express a similar view to the first formulation in that it assumes that there is a natural order to the universe that deserves some ‘special consideration’ and respect[169].

This formulation ascribes to the belief that species are somehow fixed entities that should not be tampered with. Taken to its logical conclusion, proponents of this form of ‘playing God’ argument would oppose all forms of conventional breeding in the agricultural sector, the use of human gene therapies, and even natural evolutionary processes since all of these practices ‘tamper’ with the natural order of the universe.

Other senses of the ‘playing God’ objection refer to the concern that;

2. “*Certain actions* (such as those associated with novel biotechnology processes) *are liable to unforeseen, unpleasant or unpredictable consequences*” (Hayry and Hayry 1998: 414).

This formulation is often expressed as a naturalistic objection but stems from more consequentialist concerns about the possible risks associated with novel gene technologies. Many risks, such as the risk of environmental gene flow, for example, can be minimized

[169] The view that organisms, irrespective of their level of sentience, are morally entitled to special (moral) consideration was also used in the Australian debate on the use of embryonic stem cells for research. This view was never tested in the stem cell debate yet much weight was given to its validity.

using sound risk management practices[170]. Ways in which this can be achieved include correct assessment of a crop's suitability to its prospective environment including an awareness of the special features inherent to the crop that might aid in the unintended transfer of pollen, and the use of wider containment strategies used in limiting the risk of gene flow to unintended organisms.

One complication associated with this formulation is that it is based on lay perceptions of risk. Chapter three described lay risk perceptions as guided by the personality characteristics of hazards typically containing elements of dread and uncertainty. The public perceive the very small risk of unintended transfer of allergenicity during the manufacturing process of GM foods as potentially hazardous, despite the regulatory requirement that all novel foods undergo stringent safety assessment to test for such instances[171]. The low level of public trust in the manufacturing and advertising of GM foods assists in the perpetuation of fears about the impact of such products. Investment in authentic public consultation processes featuring dynamic and open dialogue may help to allay such concerns.

A third version of the 'playing God' argument appears as a:

3. General disapproval of biotechnology as a vehicle for the "*concentration of power in the hands of the few*" (Glover 1984: 47).

This objection to biotechnology can be interpreted in one of two ways. It can refer to disapproval of the private intellectual property rights (IPRs) movement and its effect on food

[170] Chapter one discussed some measures that can be employed to significantly minimize the risk of gene transfer to unintended species.
[171] Chapter four contained a discussion about the safety assessment processes and the risk of allergenicity transfer to humans, while chapter three examined the benefits of a transparent and informative labelling regime.

security in developing agricultural environments. Without appropriate safeguards, international patenting systems have the capacity to disadvantage poorer agriculturalists with strategies that prohibit traditional cultural practices such as knowledge sharing through seed saving[172]. Opposition to multinational corporate control of key GM technologies whose primary focus is on profit-generation may be another concern embedded in this formulation.

A second related interpretation of objection [3] is that it is simply a political objection expressed by those who may not be concerned with the safety of GM food per se, or the effects of IPRs on world agriculture, but simply a preference for smaller, local industries as opposed to multinational agribusinesses (Streiffer and Rubel 2004). Essentially then, the objection serves as a general disapproval of the intimidatory aspects of the organisational culture of large agribusiness firms in dictating food markets.

A final interpretation of 'playing God' objections can be characterized as a contamination form of 'latent purificationism'. This is the increasingly popular view that;

4. *"Crossing genes is a violation of purity rules"* (Thompson 1997: 73).

The 'yuk factor' is a recent characterization of the feeling of disgust some people experience as a reaction to the 'impurity' of genetically modified products (Thompson 1997). This way of reasoning has historically appeared in bioethics debates that involve alteration to an organism that is not necessarily genomic in scale. Opponents of xenotransplantation[173] and human gene therapy have employed the 'yuk factor' as a display of disgust with the crossing

[172] These issues were discussed in some detail in chapter six.
[173] The most debated scenario involves the transplantation of (transgenically modified) pig organs to humans.

of species boundaries, generally viewed as fixed or immutable. In this way, this formulation shares similarities with the formulation second version of formulation [1].

One way to address these concerns is to engage the public in consultative and open consultation processes. Well-designed consultation processes offer a forum for the community to express concerns but also allow an opportunity for the sharing of information. Chapter three discussed the importance of adopting a public communication process that was simply not an educational exercise but an opportunity for experts to better understand the nature of public concerns about GM technologies.

### *8.4 Conclusions*

'Playing God' arguments, some of which are represented here, have generally been described as unhelpful and obstructive by those wishing to press ahead with developing new biotechnologies. Beyond the traditional impasse associated with assuming the truth of a theological premise, such arguments also contain other characteristics that when acknowledged and addressed, may resolve public concerns about the risks associated with GM policies. For example, one can interpret elements of formulation [1a] and [1b] as a demonstration of the lack of public understanding about genetic and genetic processes. Formulation [2] contained elements that suggested that the public understood risk very differently to regulators. Risks can be communicated, assessed, minimized and avoided. Better labelling policies regulated through the use of transparent processes may help to allay public concerns. Formulation [3] demonstrates a justified concern about the potential for biotechnology to create social and economic inequities. Chapter six discussed the necessary strategies required to ensure such agricultural biotechnology policies do not unfairly burden vulnerable groups.

Not all formulations of ‘playing God’ arguments presented by opponents of GM technologies offer policy-makers the prospect for consultation and even resolution of the issues involved. With key conditions in place, the agricultural and food biotechnology sectors can assist in developing policies that incorporate novel technologies which benefit social, economic and political aspects of life in the 21st century.

In the following concluding chapter I will summarize the main findings of this work and offer an analysis of some of the ways we can realize the potential benefits of novel biotechnologies, as well as avoid courses of action that may prove to be detrimental to all stakeholders – both sentient and non-sentient.

## Conclusions: Ways forward, ways backward

*"There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy".*

Shakespeare, Hamlet, Act 1, Scene 5 cited in Zimdahl (2006)

A primary aim of this research has been to examine the quality of the arguments put forward in the debate on the role, and ethical acceptability, of novel plant biotechnologies. This project also sought to move the debate forward in specific areas where progress appeared to be bogged down. Many of the questions posed in academic and public debates about the ethical acceptability of novel gene technologies are presented as moral ones when in fact many can be addressed using empirical data (Zimdahl 2006). In broad terms, risks can generally be assessed and minimized, laboratory techniques can be altered, and provisions can be made to offset negative impacts. All new technologies require some trade-offs initially and I have taken this for granted in this project.

The three aims presented in the introduction to this work were: (1) to investigate the saliency and coherence of the arguments put forward in opposition to and in favour of the development and use of agricultural biotechnologies; (2) to use a pragmatic approach to move the discussion forward in areas that had approached a state of impasse and; (3) to present a piece of work that provided a foundation for policy development with respect to novel biotechnologies. With respect to testing the strength of the arguments offered in the debate, I have argued that some of the claims that feature prominently in the public debate against the development and use of novel plant technologies do not warrant the attention they have received. Two very popular claims often made by opponents include: the potential risk associated with the unintended transfer of allergenic proteins to novel foods and; the increased likelihood of GM crops creating ‘superweeds’ as a result of transgenic flow to the wider environment. Neither of these claims is well supported. Yet other issues, such as the impacts of intellectual property rights regimes on developing world agriculture, have not received the attention that they deserve in that discussion of them has largely been confined to specialist academic forums.

Along the way, I have shown that some of the claims made by advocates of novel GM technologies, such the alleged health benefits of novel foods to consumers in the developed world, are not well supported by evidence. Mistakes have been made on all sides of the debate. Many of the risks associated with GM biotechnologies are over-inflated and a few are under-stated. The public, in general, remain ignorant of many of the processes involved in risk assessment, and continue to doubt the motivations of biotechnology industries in their promotion of the products now available. This concluding section summarizes the main findings from the preceding chapters. Some space will also be dedicated to a discussion of how best to proceed in light of these findings.

It was established early in the work that given the right circumstances, agricultural biotechnology has the potential to achieve improvements in crop yield, develop plants that are pest resistant, climatic stress tolerant and herbicide tolerant. Novel biotechnologies can also fortify nutrient values in food, restore nutrient-deficient food, and utilize plants as pharmaceutical factories in the development of edible plant vaccines. The focus in developing GM plants that are high in output traits (such as pest-resistance) as opposed to input traits (such as high nutritional capacity) has largely suited industrialized agricultural environments. A continued trend in this direction will have negative implications for many developing farmers and their communities.

Food insecurity and malnutrition remains a problem for vast numbers of the world's poor. Chapter five established that we have a moral duty to assist, if this assistance is efficacious. I used Peter Singer's duty of moral rescue to establish this duty and bolstered my argument with the suggestion that a weak version of the Precautionary Principle obliges us to provide assistance to the poor using all available resources because doing nothing would be worse for the current situation. The 'efficacy' clause within the duty of moral rescue requires the establishment of various comprehensive policies working in tandem in order to ensure that the assistance we are morally obligated to provide, actually produces the benefits that agricultural biotechnology promises.

Guided by community development experts, chapter six reviewed the challenges for developing nations in building their capacity to benefit from innovations in agricultural biotechnology. Many of these obstacles have come about as a result of attempting to enforce a system of intellectual property right protection on environments ill-equipped to benefit from such agreements. A number of concurrent strategies are needed to bring about successful outcomes in developing environments. First, investment in agricultural biotechnology needs to be contained to context-appropriate, nationally important crops (Wambugu 2001). Failure to do this will likely threaten food security in the longer term. Second, the technology must be integrated into current farming practices in order to better utilize existing farming infrastructure. Third, farmers in developing countries need access to independent information about the crops they are planting, and the potential risks that are associated with transgenic plants such as pollen transfer, input requirements, etc. (Sampath 2005).

A number of broader infrastructural improvements need to be met in order to enable benefits to be realized but perhaps more importantly, to ensure that developing farmers are not exploited in entering into GM crop arrangements. Efforts need to focus on establishing effective public-private partnerships that will stimulate innovation in need-driven areas (Pray & Naseem 2007). Although these relationships may exist nationally or internationally, research needs to be directed at capacity-building at the local level. Credible, transparent and well-resourced regulatory networks are also essential in overseeing biosafety and licensing issues (Watal 2005; Lalitha 2004). Finally, the creation of robust media-science alliances will help to foster community trust in and justify investing in agricultural biotechnologies (Wambugu 2001).

There is a widely held perception that agricultural biotechnology is a high-technology, monocultural, export-driven and corporate-managed enterprise (Comstock 2000). In chapters five and six, I demonstrated that on the contrary, agricultural biotechnology can be integrated into local developing communities through projects developed in rudimentary laboratory conditions and on a modest budget. The development of genetically modified disease-free cassava in Kenya is just one example of an application of genetic biotechnology that has the potential to positively benefit communities through capacity-building (Wambugu 2001).

Early in this work, I investigated the use of the 'contamination argument' by opponents as a warning against large scale GM crop plantations. Opponents postulate that transgenes are more 'pervasive' than conventional genes and therefore pose a greater risk of 'genetic pollution'. A comprehensive literature review and analysis revealed that the success of gene flow was highly dependent on a number of macro and micro factors. The probability and long-term success of pollen transfer, hybridization and subsequent introgression is highly dependent on a multitude of factors such as climate, pollen vectors and genetic drift, hybrid genotype, gene flow between populations, and reproductive systems (Glover 2002; Federoff and Brown 2004; Stewart 2004; Biotechnology Australia 2005; Chapman and Burke 2006). Given these conditions, gene flow is highly unlikely to create a ‘superweed’ that has adequate fitness for survival in the wild and possesses tolerance to every known herbicide and tillage practice (Stewart 2004). There are a variety of measures available that serve to limit gene flow between GM and non-GM species and chapter one reviewed several of these.

Recent unfavourable events in transgenic research history, coupled with unrelated global food scares, have helped the organic movement to gain a strong consumer following. These same events have had a negative impact on public discussions about the potential beneficial uses of GM products. Chapter one also established that the criteria that the organic community uses to reject GM technologies are arbitrary and not evidence-based. It was argued that the demand from some organic growers for absolute non-interference by other (non-organic) agricultural growers is unreasonable and unjustifiable given the complexities of modern agriculture and surrounding ecosystems. Co-existence between conventional, organic and transgenic systems is not impossible and in fact desirable, providing clearly defined principles are followed (Byrne and Fromherz 2003).

Advocates of GM crop technology have claimed that GM can contribute to environmental sustainability, by, for example, reducing the impact of agriculture on the environment. Chapter two argued that the oft-used term, ‘sustainability’, while highly desirable, lacked clear operational guidelines. In response to this, I offered a strong version of sustainability that valued diverse public participation approaches to ethical decision-making about environmental issues. I argued that traditional approaches to environmental ethics offered little scope for stakeholder participation in the GM debate and even less opportunity for practical resolution of some of the issues. A new way of thinking about environmental ethics, environmental pragmatism, was introduced to address the challenges that traditional debates about environmental ethics do not.

Environmental ethics requires a greater purchase on environmental policy and practical decision-making about real environmental problems. Environmental decision-making requires a participatory mode of democracy to be successful. An approach based on environmental pragmatism, will better equip policy-makers in developing policy options that address real environmental concerns.

This theme was carried through to chapter three where issues arising from various labelling regimes of GM products were discussed in the context of consumer autonomy. Considering that to date, no peer reviewed published work has confirmed that GM products are harmful to human consumption, it was argued that there is no moral obligation to label GM products. There are however, cultural considerations that may affect the successful promotion of such products and these should be taken into account by manufacturers. Even though cultural considerations fail to provide a sufficient reason to warrant the mandatory labelling of products containing novel genes, labelling products adequately may be advantageous to business in that labels may serve as indicators for any positive environmental (or other) benefits such products may contain.

The safety of GM products was discussed in chapter four where claims about the impact of GM products on human health were tested. The doctrine of substantial equivalence has been condemned by opponents of GM products as a poor safeguard against the potential risks that

GM products allegedly pose. This chapter discussed the role of substantial equivalence in the context of safety assessment processes before reviewing the validity of two popular criticisms of GM foods: the immunotherapy effects of the transfer of antibiotic resistance markers to humans and; the risk of an adverse allergenic response in humans following the unintended transfer of allergenicity to novel GM products. Both of these risks are over-stated.

Advocates of food biotechnology claim that fortified foods provide the consumer with increased nutrition and therefore can be of use in chronically malnourished populations. Some advocates also make a strong claim that functional foods can also be developed to ameliorate the negative health effects of overnutrition such as CVD, diabetes, hypercholesterol and even cancer. Chapter seven examined this view and found little evidence to support these claims. The ethical implications of continuing to market functional foods in this way were discussed in chapter seven. There are several drivers that the public use in deciding to purchase such products which include: a diminishing confidence that the conventional diet satisfies all our nutritional needs; an increasing trend towards healthy eating which has been accelerated by the self-care movement (Sloan 2002); and a perpetuation of the myth that an individual food item is intrinsically healthy or unhealthy and is capable of delivering real health benefits (Frewer et al. 2003).

Debate about the acceptability and necessity of GM foods is multifaceted. Opponents of novel gene technologies often express their disapproval by appealing to principles based on claims about naturalness. Commonly referred to as *in-principle* objections or ‘playing God’ arguments, naturalness claims are increasingly attracting criticism from the scientific domain for being vague, proscriptive, and sometimes irrational (Streiffer and Hedemann 2005; Grey 2001). These characteristics are thought to obfuscate rather than clarify particular concerns about the development and use of biotechnologies (Grey 2001). In an effort to show that some of these claims are indeed valuable to the GM debate, chapter eight explored possible interpretations of four common in-principle objections to novel gene biotechnologies. Some formulations of 'playing God' arguments can reveal useful information about, for example, the role of lay risk perceptions in public attitudes to GM; concerns about the potential for some biotechnology policies to foster inequities particularly in the third world and; a general preference by consumers for purchasing food that supports local producers.

It was not the task of this project to make a determination of the safety of GM products for human health or the environment. The aims set out in the introduction to this work have been achieved. I have used a pragmatic approach to examine the quality of arguments offered in response to developments in novel agricultural and food biotechnologies in an attempt to move the debate forward in a positive direction – one that acknowledges the contribution novel technologies can make to valued aspects of society and the environment. In concluding this work, I suggest ways to pursue that may enable progress to be made, and ways to avoid because they will prevent this goal from being realized.

*Ways forward*

The following list is by no means extensive but it offers the reader some examples of practices and policies that will better utilize novel biotechnologies in the future.

- More transparent and open communication processes between regulatory authorities, biotechnology industries, and the general community will better foster public support for some GM products.  More informed awareness of the concerns and motivations of all stakeholders in the debate may help resolve some of the issues raised.

- Scientists need to make better use of the media to communicate their findings along with the anticipated benefits and risks of a particular GM application. This is critical in building public support for biotechnology projects in both developing and industrial environments.

- A commitment to better labelling practices may provide consumers with better information about the broader benefits of some GM products. A more general overhaul of deceptive food labelling practices is warranted given the mislabelling of many conventional food products.

- Continued efforts should be made to find ways to minimize the small risk of adverse environmental transgene escape through the use of appropriate seclusion zones during preliminary research phases.

- Investment in practicable biotechnology applications for real world problems.

*Ways of going backwards*

Again, this list does not include all of the ways biotechnology policies may negatively affect some aspect of society or the environment.

- There are significant equity considerations relating to the global diffusion of biotechnology. Trade-related regulations that aim to protect intellectual property rights may detrimentally affect societies whose regulatory systems are not sophisticated. Failure to provide the necessary infrastructure to enable farmers in developing countries to benefit from agricultural biotechnology and compensate them for their resources, will threaten food security.

- Poor public consultation processes, and those solely based on expert analyses of risk, will fail to engender public support for biotechnology in all its forms. This has been clearly demonstrated by the public backlash against GM in Europe.

- It is ill-advised to overstate the potential benefits of agricultural biotechnologies. Today's consumers are very discerning and capable of appreciating the broader benefits of biotechnology. Consumers will not necessarily be opposed to a particular application if direct consumer benefit is absent from a novel product. This has been demonstrated by the generally positive public response to the effects of climate change and the uptake of energy-saving and environmentally-renewable products.

Public confidence in the safety of GM foods is surprisingly low (Schilter and Constable 2002). This is despite the absence of good evidence that GM foods present risks to humans; via the use of antibiotic resistant markers in the manufacture of GM products, or the impact of antibiotic resistance on human immunotherapy; or the perceived inadequacy of safety protocols such as those allegedly posed by equivalence testing. It was suggested above that scientists and policy-makers, among other professionals, have a role in the diffusion of agricultural biotechnology that contain benefits to agriculture and the environment. Along with the media, professionals on both sides of the debate also have a role in the dissemination of accurate information about the methods used to test the safety of GM products.

The major contributors to a consumer backlash against novel biotechnology are complex and difficult to pinpoint but evidence suggests that they include: poor risk communication policies, a general lack of public trust in regulatory authorities driven by past failures and an unsophisticated understanding of genetics and genetic processes.

Regulators, lobby groups, the media, industry and the scientific community have a responsibility to engage the public in a way that fosters trust, promotes understanding and encourages meaningful debate about the potential benefits and risks of new biotechnologies. Consumers in the industrial world will continue to oppose research and investment into novel biotechnologies unless there are opportunities for their full participation as key stakeholders in regulatory decisions.

Public campaigns against the development and use of biotechnologies, orchestrated primarily by anti-GM lobby groups, continue to perpetuate myths about the risks and benefits involved in GM processes. The majority of claims made by such groups are based on misguided or distorted information. They also perpetuate public fear, and consequently deny opportunities to realize the agricultural and environmental benefits of novel biotechnologies.

The potential uses of GM (as well as the potential harms posed by GM) are best placed in discussions alongside other agricultural practices and policies, including conventional farming, organic farming and integrative pest management (IPM) practices. To isolate discussions about the potential positive or negative effects of agricultural biotechnology and its uses is misleading. Historically it has been to the detriment of good policy. Conventional, transgenic and organic industries are not mutually exclusive and cooperation between them is in some instances even desirable. Up until now, the public have made broad associations with various agricultural practices that are not entirely accurate[174]. It is in the interests of all agriculturalists to debunk these associations. All sectors of the community will benefit from this.

[174] Appendix 7 highlights some common public associations with respect to various agricultural practices.

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*Thompson published a second edition of *Food Biotechnology in Ethical Perspective* in 2007, but unfortunately this updated edition was not available in Australia in time for inclusion in this thesis.

# Appendices

**Appendix 1**

| **Developing world context** | **Industrial context** |
|---|---|
| The production of crops (wholefoods) through subsistence agriculture<br><br>Rudimentary crop protection against biotic stressors such as insects<br><br>Decreased chemical input, specifically the use of potentially toxic chemicals[175]<br><br>Environmental bioremediation<br><br>The development of biopharmaceuticals in the context of primary healthcare | Higher yields in intensive agricultural crops such as cotton<br><br>The production of high quality food ingredients such as cooking oil<br><br>Secondary crop protection against both biotic and abiotic stressors including salinity and frost<br><br>Environmental bioremediation<br><br>The development of GM animals for use in innovative medical procedures such as xenotransplantation |

*Table 5 A comparison of the more immediate and likely uses and benefits of novel gene technologies in developing and industrialized contexts*

[175]The excessive use of potentially toxic agricultural chemicals used for crop protection purposes in developing world farming environments has led to many poorer farmers being overexposed to harmful and sometimes lethal substances. A study published in *Science* showed that up to 11 per cent of Chinese farmers suffered ill effects of pesticide poisoning compared with no cases of poisoning among farmers who grew GM rice. See Huang, J., et al., (2005) Insect-resistant GM rice in farmers' fields: Assessing productivity and health effects in China, *Science*, 308, p. 688.

## Appendix 2

LARGE-SCALE PRODUCTION OF BIOFUELS

- Promotion of environmental sustainability

EDIBLE PLANT VACCINES

- More accessible forms of non-parenteral medications

**THIRD GENERATION GM PLANT TECHNOLOGY**

BIOREMEDIATION

- Increased use of marginal soils

NUTRIENT FORTIFICATION

- Fortification of food crops through the introduction of new genes for enhancing nutrient content

RESISTANCE TO BIOTIC AND ABIOTIC STRESS

- Protection against harsh environmental conditions such as frost, salinity, drought, etc.

**SECOND GENERATION GM PLANT TECHNOLOGY**

- Protection against infection from pests such as insects, fungal and viral disease, etc.

ENHANCEMENT OF AESTHETIC AND FUNCTIONAL QUALITIES OF PLANTS

- Introduction of new genes for enhancing desired traits and/or inactivation of other genes to 'knock-out' undesirable traits for the purpose of improved yields, for example.

IMPROVEMENT OF PLANT ARCHITECTURE

- Improvement to a plant's access to vital nutrients

**FIRST GENERATION GM PLANT TECHNOLOGY**

*Figure 1 Diagrammatic representation of the GM technology spectrum*

## Appendix 3

### The Bolivian nematode-resistant potato as a demonstration of the benefits of pest-resistant transgenic crops in developing countries

Potatoes provide the Bolivian population with up to 50% of the total calories consumed by rural households (Atkinson, Green et al. 2001). Nematode pests occur in 91% of the land available for potato-growing in the Andean region (Atkinson, Green et al. 2001). Since the majority of Bolivians rely chiefly on rural subsistence for food security, the importance of maintaining pest-free crops is vital to the Bolivian population.

97% of the Bolivian rural population are considered to be living in extreme poverty.

Potato cyst and false-root-knot nematodes, the two most frequently occurring pests in the Bolivian potato, are frequently overlooked by farmers because of their minute size and the lack of specific symptoms above ground. Nematode infestations produce severely reduced yields and require a considerable increase in land area for potato growing. Nematocides are simply unaffordable to most rural households.

Transgenic nematode-resistant, locally favoured potato varieties are now under development. Studies are also underway to investigate whether surrounding organisms are affected by the introduction of the transgenic varieties.

This research is headed by public-funded local research institutes and provides a means for subsistence farmers in developing countries to produce locally produced, pest-resistant staple food crops.

**Appendix 4**

**Golden Rice as a demonstration of the potential for transgenic crops to significantly alleviate micronutrient deficiencies in developing countries**

It is estimated that currently 2.4 billion women and children suffer from iron deficiency and 400 million children suffer from vitamin A deficiency causing diarrhoea and potential blindness. The development of Golden rice varieties specifically designed for growing in developing countries presents one way (amongst others) to prevent some of this suffering.

Golden rice is produced by splicing three foreign genes, two from the daffodil plant (giving the rice a golden hue) and a bacterium. The japonica rice variety is ideal for the production of nutrient-enriched rice because it responds consistently to genetic manipulation and grows commonly in temperate climates (a feature desirable for the majority of third world populations).

In more affluent populations, beta-carotene is obtained from a diet rich in fresh vegetables, whilst vitamin A is most commonly obtained from fresh milk, eggs, cheese, and liver.

Rice is the main staple for third world populations and although it contains some micronutrients, the milling process strips the grain of provitamin A (Potrykus 2003).

The many processes that Golden rice undergoes before it is functional as a nutrient-enriching variety, requires the use of various patented techniques. Ingor Potrykus has established his invention under “freedom to operate for humanitarian use” where subsistence farmers are permitted to grow or trade the rice varietal freely if income from the crop falls below US$10,000. Licences are also being made available freely to public research institutes for its development.

One criticism of Golden rice is that the amount of rice that must be consumed for benefit is significantly more than is normally consumed. Early varietals did in fact demonstrate that the expression of beta-carotene was insufficient to be of benefit but work undertaken since then has seen the improvement of nutrient levels.

Another criticism its effective metabolism requires healthy, well-nourished bodies and thus would be unsuitable for consumption by primarily malnourished people. The growing of Golden rice is one potential contributor to the reduction of malnutrition in the developing world. In association with other hunger-reducing programs, the free distribution of Golden rice varietals could significantly improve the current situation.

**Appendix 5**

**Hepatitis B antigen as a demonstration of the potential contribution edible plant vaccines can make in reducing vaccine-preventable mortality and morbidity in developing countries**

To date, oral immunogenicity to HBsAg has been established in both animals and humans (Mason, Warzecha et al. 2002). Proof of concept was originally demonstrated using tobacco plants. Successful expression of the antigen has been observed in potato and studies since have shown that oral consumption of the transgenic potato in mice generates an immune response (Mason, Warzecha et al. 2002).

More recently, clinical trials have demonstrated immunogenicity in humans following the oral consumption of transgenic lettuce (Daniell, Streatfield et al. 2001). Although the antigen expressed itself in too low doses to be effective and could not currently deliver an adequate immunogenic response, successes to date show promise.

Plant-derived vaccines, such as the HBsAg, would only be grown under strictly regulated conditions. The plants would conceivably be highly processed to yield uniform and stable doses delivered by health care professionals.

In order to minimize transgene escape to surrounding organisms, sterilisation technology would conceivably be used for transgene containment.

One criticism of continuing investment into the development of the HBsAg is that traditional Hep B vaccines are already a very effective, relatively inexpensive form of vaccination against the Hep B virus. In response, traditional vaccines require continuous cold storage- a facility not readily available for the distribution of vaccines in the developing world and an obstacle to vaccination in remote communities. Access to clean disposable syringes for administration is not necessary for plant-derived edible vaccines.

**Appendix 6**

**Drought tolerant cotton as a demonstration of the contribution GM cotton can make to sustainable agricultural practices in Australia**[176]

94% of Australian cotton is exported internationally and contributes approximately $1.2 billion to Australia's export economy. Aside from cotton's contribution to the textile industry, cotton and its by-products are used to manufacture products such as bank notes, rubber, plastics and foods like oil and margarine.

Although the cotton crop provides a higher value per megalitre of water used compared to other broad acre irrigated crops, and is a fairly drought tolerant plant, it nevertheless requires substantial moisture to produce profitable, high quality yields. The Murray Darling Basin provides 1.5 million megalitres of water to cotton farmers in the region where over 90% of Australian cotton growers are located. Annual rainfall contributes to about half of the crop's water requirements.

In a recent report commissioned by CSIRO, it was estimated that a lack of rainfall for the 2004-5 period will result in a drop to production from 3.1 million bales in 2002 to 2.5 million bales. Even though this is an increase on a devastating annual production of 1.4 million in 2003, it nevertheless represents a $5 million loss to the cotton industry.

Prolonged periods of drought in many parts of Australia coupled with a concern for increased water conservation and a decrease in reliance on irrigation from ecologically sensitive

[176] The majority of facts presented here was sourced from information provided by the Cotton Australia website available from http://cottonaustralia.com.au accessed 4 July 2005 and represents the most current industry statistics.

waterways has encouraged research to produce a genetically modified strain of cotton containing drought tolerant traits that could potentially increase water efficiency by 10-15%.

Australia is driving research on a number of fronts. A GM cotton variety (Siokra L23) has recently been confirmed to be more tolerant to water-stress than other varieties (Voloudakis, Kosmas et al. 2002). Furthermore, research recently published in *Nature* has revealed that ANU researchers have isolated a gene dubbed *erectus*, which is thought to be responsible for determining how many pores a plant will eventually have on its leaves. The number of pores a plant possesses is central to the amount of carbon dioxide it receives but also determines the amount of water lost to the plant. Regulating pore shape and frequency will theoretically enable scientists to control water loss as well as tolerance to other potentially damaging external elements such as salinity.

Conceivably, GM cotton could potentially provide significant economic advantage to the cotton industry. More importantly, GM crops such as Siokra L23 could potentially minimize the impact of current farming practices on the environment. Concern for water conservation in general, and a decreased reliance on irrigation sourced from river systems already under pressure in particular, is arguably complementary to sustainable farming practices that are in harmony with the harsh Australian environment.

**Appendix 7**

| | Organic Produce | GM Produce | Conventionally-Grown Produce |
|---|---|---|---|
| Origin | Locally grown; in harmony with nature | Interventionist, unnatural | 'Naturally-propagated', i.e., without the use of novel technologies |
| Market/trade | Fair Trade | Chiefly driven by commercial profit; little or no consumer benefit | Grown for profit but contains substantial benefit to consumers |
| Environmental impact | Pro-environment; holistic | Risky; harmful to ecosystem health | Varied |
| Human impact | Healthy lifestyle alternative | Harmful to human health | Safe to consume |

*Figure 2 Some popular associations made about organic, conventional and GM crops and farming practices in public debates*

**Appendix 8**

**Potential Impacts of genetically modified crops**

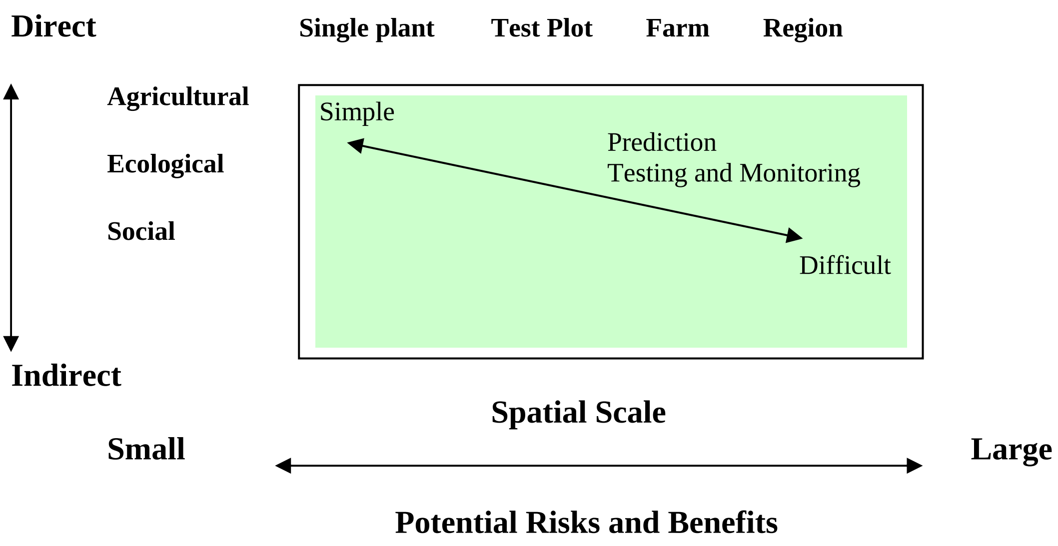


*Figure 3 Representations of direct and indirect effects of GM crops the difficulty of predicting, testing, and monitoring their potential impacts*[177].

[177]Figure directly sourced from Peterson, G., S. Cunningham, et al. (2000). "The risks and benefits of genetically modified crops: A multidisciplinary perspective." Ecology and Society **4**(1): 13-22.