Ethical Issues of New and Emerging Technologies

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FINAL REPORT TO THE MINISTRY OF RESEARCH, SCIENCE AND TECHNOLOGY

Ethical Issues of New and Emerging Technologies

The authors wish to make it clear that the views contained within this report are theirs alone, there has been limited consultation with other people. The authors recommend that the views of other scientists, lay-people, and representatives of Maori and non-western cultures be sought to gain a more comprehensive view about how ethical issues of new and emerging technologies might be addressed in New Zealand.

EXECUTIVE SUMMARY

- Governments who wish to invest funds into scientific discovery are increasingly being confronted with resistance by the public to uptake of technologies arising from these discoveries. If Governments are to obtain a return on investment (most likely through an improved standard of living), there is a need to ensure the public recognise which new technologies are beneficial with minimal risk to themselves, others and the environment and those which require caution or delay before implementation.
- The public at large is increasingly distrustful of people previously held in high regard (including scientists, lawyers and politicians).
- Contributing factors to this increase in distrust are likely to be: a poor understanding of the science involved, of ethics and of risk evaluation and an increasing focus on individuality rather than a community orientation.
- A framework of questions is developed in an attempt to ensure each person considering a new scientific technique or technology will address potential impacts not only on themselves, but also on other people and cultures, animals and the environment at large. In addition, questions relating to a timeframe of immediate effects to long-term effects are asked.
- A brief description of 23 new and emerging technologies is provided. Several of these technologies are already subject to significant public debate while others require attention. The purpose of the framework of questions is to draw attention to possible areas of concern where further debate is needed.
- To improve the uptake of new technologies, a two-pronged approach is suggested. First, in the long-term, there needs to be improved education of the public in scientific matters. However, this approach will take at least a decade to impact on public perceptions. The second approach must be more immediate, and includes direct consultation (using a variety of approaches) with the public by scientists, science-fund providers and government agencies.
- A Maori perspective to the ethical issues of new technologies must be sought. We recommend that in the spirit of The Treaty of Waitangi, there be direct and ongoing consultation with Maori.
- This report does not address how Maori wish to debate ethical issues surrounding new technologies. Rather, it is recommended that Maori be provided this report as a starting document, and asked to develop their own framework. It may well be that after modification, the framework explained in the following sections will provide the basis of an approach for Maori (and indeed other cultures).

BACKGROUND

A scan of recent media material would reveal an apparent wariness about a number of technologies (cloning, genetic engineering, microwave repeater stations, irradiation of food, etc) by the public. Some commentators have suggested that this is a recent phenomenon caused by the rapid growth in knowledge about the physical world. This knowledge is then being translated into a dazzling array of new technologies. However, public concern about new technologies is not new. For example, the promotion of smallpox vaccinations in 1796 by Edward Jenner was accompanied by dire warnings (see appendix 1). In the 1940s, artificial insemination in livestock was greeted with a less than enthusiastic response by some sectors of society. Thus, it would appear that public concern about new technologies is not new, although there are at least two issues that might have increased the apparent frequency with which the public are speaking out.

First, the increasing number of new technologies becoming available is likely to result in larger numbers of people voicing their concern, even if only the same proportion of people comment on any given technology. Secondly, the public appears to have less faith in scientists being able to pass judgement on behalf of the public. In some cases this has led to open distrust of scientists. It is unlikely that this distrust is a phenomenon that has appeared suddenly. It has more likely been generated over a long period of time, with events such as nuclear bombs and mad cow disease tarnishing the reputation of scientists.

We could summarise the current situation in New Zealand under the following questions:

- What is being asked?

  How will this technology affect:
  - my family or me immediately and in the future?
  - my values and priorities?
  - my business?
  - animals?
  - the environment?

- Who is asking and why?

  The public feels they are disenfranchised from the decision making.
  The government wants to ensure its investment in research is usable.

- Who is being asked?

  The public are asking the government why it is funding (as they see it) ill-advised research.
  The government is asking scientists to justify the research they are undertaking.
  Companies are querying scientists about whether being associated with some new technologies might have a negative impact on their sales.

- Who makes the decisions about what is right?

  This includes decisions based on law, decisions made by individuals, and decision made by business. Many of these decisions are made outside New Zealand.

OBJECTIVES OF THIS REPORT

1. Provide readers with an introduction to the use of ethics to aid resolution of differences of opinion.

2. Suggest a mechanism by which Government Ministries, research funders, science providers and individuals might assess the potential ethical issues raised by a particular piece of scientific research or technology.

3. List and briefly comment on a number of new and possible future technologies.

4. For these technologies, describe some of the ethical issues that might be of concern to the public.

5. Suggest possible actions to decrease public concern over new technologies.

INTRODUCTION

Trust

A recurring concern being voiced by the public is that they no longer have faith in scientists to remain unbiased when their research funding, and possibly their salaries, are dependent on the commercialisation of their science. This concern is regularly mentioned in the public submissions about science, such as occurs with the Environmental Risk Management Authority evaluations of genetically modified organisms. Anecdotal evidence would suggest that Universities are still perceived as being relatively free from commercial bias. In addition, the legislated right of "Academic Freedom" gives the public some comfort that University staff will act as a critic and conscience on behalf of the public. However, as Universities generate more of their income from commercialisation of their science to subsidise the education of students, they may begin to suffer from increasing public distrust.

Scientists are not alone in facing an increasingly distrustful public. The legal and medical professions and indeed politicians are also being increasingly challenged by the public to justify their stance on issues previously seen as their sole preserve. One reflection of this distrust is the use of referenda to resolve issues of note, rather than the elected representatives making a decision on behalf of the public. Added to the distrust of previously esteemed members of our society is the reduced reliance of the majority of New Zealand's population on religious morality.

The above would suggest that New Zealand society is in a period of accelerated social and ethical evolution. This, in conjunction with an increasing rate at which new technologies are being delivered to the public, has conspired to deliver an unprecedented period of public confusion and concern.

Individual Benefit versus Collective Responsibility

A primary conflict that regularly arises in any society is what benefits the community versus what benefits the individual. An example is the collective value, through reduced illness and maybe decreased incidence of deaths, of immunising a population against bacteria and/or viruses versus the individual risk of an allergic reaction to the vaccine. It is well recognised that as diseases are brought under control through widespread immunisation that individuals will choose not to be vaccinated. This is because of the higher risk to the individual of an adverse reaction relative to the risk of succumbing to the disease because of its (now) lower prevalence. However, if sufficient members of the population do not get vaccinated, it is highly likely the disease will again increase in prevalence. Indeed, this occurs in approximately five-year cycles with whooping cough.

The Value of Science

The freedom of scientists to pursue knowledge without constraint and for its own sake needs to be considered against the alternative of regulated knowledge-gathering in areas pre-determined, perhaps, by public agreement. The reality is that while "public agreement" may be sought, it is unlikely that a consensus will ever be obtained because there are potential or actual hazards to every scientific discovery and/or technological application. One way to address this conflict is to require that safeguards be put in place to protect the public from the malicious use and/or the well-intentioned but incautious use (retrospectively judged as "misuse") of science and technology.

It needs to be recognised that no matter what safeguards are put in place, every scientific advance will be interrogated for its value in both "positive" and "negative" applications, however these are judged. For instance, the discovery, isolation and commercial production of erythropoietin used positively to treat some forms of anaemia and blood loss due to traumatic injury, and its questionable (illegal) use to enhance athletic performance by increasing red blood cell production pharmacologically and not by high altitude training.

The public typically desire the benefits of science without exposing themselves to any risk, whether that risk is a personal one (e.g. health) or some damage to something else they value (e.g. employment prospects, financial viability or reputation). However, there are few human activities that are risk-free. Effort is needed to improve public education about *minimal* risk approaches as opposed to *no* risk approaches, and about risk analysis.

ETHICS

Introduction

Science and technology are human activities. They do not take place in isolation from the community which supports them and which makes use of their achievements. Even the basic processes of discovery, theory testing and explanation take place in a social context and, as the history of science shows, are more conditioned by that context than scientists themselves often realise. In this section we shall outline the relevance of ethical thinking to science and technology in that light.

To be consistent with recent practice in philosophy, the word *morals* will be used to refer to beliefs about good and evil which guide our behaviour, and the word *ethics* will refer to reflective thinking and theorising about morals. However, terms like "codes of ethics" already in general use will retain their usual meaning.

Ethical Challenges

Many emerging technologies present ethical challenges. For example, the genetic modification of food has been much discussed recently, and it raises a number of ethical questions. Are people entitled to know exactly what they are eating? How much should commercial secrets be protected? How should we balance the danger and cost of heavy pesticide use, the loss of production if pesticides are used sparingly and the unknown risks of eating food that has been genetically altered? And this is only a partial list of problems with one new technology. This report will discuss, largely by way of examples, how to recognise and understand ethical challenges, so that scientists, technologists and their managers can turn them into opportunities to demonstrate ethical integrity, and hence earn improved public trust.

There are two aspects to recognising ethical challenges in emerging technologies and making appropriate choices in response. One is awareness of the facts and the relevant theories of science.

The other is awareness of the specific ethical problems presented by the technology and the relevant theories of ethics. This introduction will give a brief overview of ethical theory with some brief examples. Others will occur later in the report [Examples of New and Emerging Technologies]. It is however our intention to point out where ethical problems may arise, rather than to present a solution to them. We seek to inform discussion, not to replace it.

Science and Ethics

Although some people think of science as a body of secure, objective knowledge which can be understood with precision and clarity, and think of ethics as vague, subjective and largely undisciplined, both these views are inadequate. Science, particularly at its developing frontiers, must often cope with confusion and uncertainty. Its theories are constantly probed and questioned. It grows and changes, often in surprising ways. Ethical thinking also has a history of growth and development, and includes theories intended to overcome narrow subjectivity.

Most people would be aware that scientific theories each cover only a part of the enormous field of enquiry making up the whole, and though they often overlap somewhat, they generally have areas where they are appropriate, and areas where they are not. Ethics might be seen in rather the same light. Indeed, most people's moral thinking is a mixture of ideas coming out of the long history of ethics. This eclectic thinking is perhaps no more to be regretted in morality than it is in science. The various theories to which we shall refer each command a reasonably perspicuous view of some parts of the territory, but are less useful in others.

Making Choices

In practical terms, ethics is about making choices – as individuals, or perhaps as members of research teams or funding bodies, or as politicians, bureaucrats or voters. A farmer may choose to deploy a rabbit virus which a government department has not yet chosen to release officially. A group of scientists may choose to test a crop of genetically altered potatoes in search of possible risks, and a band of worried and possibly frightened radicals may choose to dig them up. All these people could lay claim to having a moral defence for their choices. It is the business of ethical theory to suggest ways of reconciling such conflicting claims. Often it will succeed. Sometimes it will fail. Ethics, like science, does not claim to have said the last word.

Reasons for Choices

We make choices in many ways, not all of them obviously connected with ethics. A list of possible types of reason for choice would probably be very long indeed, but here are a few typical ones, divided into three groups.

- Personal preference, self-interest, interests of your group [e.g. family, team, company, nation];
- Laws of the land, commandments of your religion, duties;
- Habits, customs, etiquette.

The history of ethical thinking shows that all of these, and indeed any other grounds for choice that you might add, are grist to the ethicist's mill. To mention an important example, if we think of the whole spectrum of rules for human conduct as ranked according to the consequences of infringing them, we may feel that those rules generally regarded as ethical fall somewhere between law and etiquette. However, ethical considerations are frequently what drive reforms in law, and philosophers have usually regarded ethics as providing rules that override all others.

Reasons to know something about Ethics

Ethics is a major growing point of society. What we value determines our priorities, and our priorities determine where we put our greatest effort. Since the ethics of any society of thinking people is unlikely to be static, developments in ethical thinking will thus be a major influence upon the development of the society as a whole. Also, science and technology provide the means to make our efforts effective, and any modern society will have a strong science base. Ethicists and scientists are therefore wise to be aware of progress in eachother's fields. Even people whose ethical views are relatively rigid for some reason will find it useful to understand something of theories of ethics other than their own if they are to enter into a constructive dialogue with other people. Those with less rigid attitudes can find it enlightening to recognise the origins of some of the diversity, or even confusion, of their own thinking.

Moreover, difficult cases, such as those where ethical demands seem to conflict [e.g. an individual or public right to know and a commercial or professional need for confidentiality] require deeper understanding of ethics than is usual among people who have always held to one doctrine. Some familiarity with the range of ethical thinking in the culture we inherit can help in such cases.

The Social Purpose of Morality

One way to view morality which many people find helpful, is to see it as a human institution – a social artefact. This raises the question: What are its purposes? Some frequently suggested answers relate to the idea of overcoming limitations in such things as information, rationality or sympathies. We are sometimes faced with having to make a choice in the absence of full information, or in circumstances that are too difficult to think through in the time available, and we sometimes ignore the circumstances of others, especially those who are remote from us. Morality can be seen as offering guidance in such cases. Other answers to the question about the purpose of ethics relate to social needs and interests, principally the need to resolve conflicts.

Four Major Ethical Theories

There are four very influential attitudes to ethical thinking which most people in New Zealand today would recognise. One involves an emphasis upon seeking the best outcome for yourself. Another emphasises considering the consequences of our actions for everyone who will be affected, another emphasises rights and duties, and the fourth lays stress upon the concept of virtue. In this section we shall outline each of them briefly. In the next section we shall refer to some other ways of thinking about ethics.

Egoism

This theory is enjoying a modern revival, especially in capitalist economic theory. In this context the egoist is not necessarily a conceited person, but rather someone who seeks their own personal welfare above all else. Of course if someone is imprudent enough to simply grab everything they want without regard for anyone else, their own long-term interests will be damaged, and a prudent egoist will take such things carefully into account. It is quite likely they will be reasonably good neighbours, especially if they have normal friendly human sentiments, and also if they believe their lives will be the better for living in a cooperative community, so they are not as evil as they sound, or as simplistic in their egoism as some economists assume. In particular, an egoist who performs in a business or professional context in such a way as to lose the trust of other people, is likely to find that the gains of such imprudent egoism are short-lived, and outweighed by longer term losses. This point is currently receiving increasing attention in business and professional ethics.

Utilitarianism

One basic idea held by utilitarians in common with egoists, is that what counts above all from a moral point of view is the consequences of your actions. What sets utilitarians apart is the principle that you should try to maximise the total good consequences [and minimise the bad ones], for **all** those affected by your choices. This theory is often expressed in a slogan: *seek the greatest good for the greatest number*. The early defenders of utilitarianism claimed that this closely resembles the Golden Rule [see section on Absolute Values]. However it is all too often given a weak interpretation which makes it look like a simplistic cost-benefit analysis, in which as long as the good flowing from your choice is outweighed by the bad, the choice is acceptable. [The end justifies the means.] This is a misinterpretation. The slogan, for instance, says "great**est**", not "great**er**". The only choice utilitarian theory approves is the one in which the good outweighs the bad to the greatest achievable extent, which is a far stricter requirement. A more accurate analogy would thus be a **comparison** of the cost-benefit analyses of every possible choice open to the agent.

One difficulty often remarked upon with utilitarianism is that it seems to condone purchasing a maximum of total good at the expense of a small number of victims. The weak, cost-benefit analysis version is certainly open to this objection, but utilitarians argue that the strong, comparative cost-benefit analysis version is much less vulnerable to it.

Utilitarianism faces another serious difficulty also, which is that the process of arriving at a decision, involving as it does the performance of a thorough accounting of all the consequences of all the choices open to the agent, presents an impossibly huge task. Performing the calculation might take many years, but you might have only moments in which to decide. The response has been to develop a two-tier procedure, called **Rule Utilitarianism**, which separates the task of moral appraisal from the task of choosing what to do. It requires you to make your choices according to rules which have already been evaluated and approved by utilitarian criteria. Moreover you review the results of each decision to see if you can learn from experience something about how to improve the rules. This resembles the process by which law evolves, with case law putting flesh on the bones of statute law, and statutes being occasionally reformed. Thus a community of utilitarians will evolve rules which serve more and more satisfactorily to maximise the general welfare, and the problem of not having enough time to cogitate will become less and less pressing.

Rights and Duties

A very different way of making moral choices is to emphasise rights and duties. We have many legal rights and duties, but some people have thought that there are moral rights and duties also. One example is the so-called Natural Rights listed in the UN Charter. Another is the duty to nurture your children, whether the laws of the land require it or not. Those who think in these terms will tend to judge the moral status of a situation not according to the acceptability of its results, but according to whether it came about by the action of proper procedures, such as doing your duty.

The idea implied by the name Natural [sometimes Inalienable] rights is that they are moral rights that all people have, whether or not any political process has conferred them in the form of legal rights. Rights, especially fundamental rights, are a concept more beloved by politicians than philosophers. They have more to do with power than with reason. However they can be a bulwark against tyranny by majority, which is the weak point of democracy, and the language of rights is often used in the political arena as a way of reducing that problem, by setting limits to how far any powers, even those of the ballot box or of utilitarian calculations of the greatest achievable good, may infringe individual or minority autonomy.

Nevertheless, we have only to imagine a conflict between two people each claiming fundamental rights that cannot both be granted in practice, to see that in order to resolve their dispute we would need to look deeper than the concept of rights. So it seems that rights cannot be a truly fundamental moral category, and that rights claims can provoke conflict rather than solve it. For reasons like this many philosophers view the concept with some suspicion. One way to see the problem is that to claim a fundamental right is to say that nothing else is ever going to matter enough to count against it, not even things you haven't thought of yet. That seems dangerously close to a recipe for fanaticism.

Virtues

Another view of ethics comes from asking a different question. Instead of asking, "What should I do?", we ask, "What sort of person should I be?" Virtue ethics, which has a very ancient lineage, is enjoying a substantial revival in modern times. It provides a way of thinking that is particularly suitable to the task of developing your character as a good person, hence its title. The idea is that you are constructing your own moral character throughout your life by the history of your deeds and decisions. In practice, people who think about ethics in this way will often model their behaviour on that of exemplars – saints or heroes.

Other Theories of Ethics

In this section we shall mention more briefly a number of other ethical theories that form part of our cultural heritage. Some are ancient, some very recent, and some are associated with other aspects of culture. The list is, of course, not complete.

Absolute Values

From ancient times we have a view that ethical behaviour is governed by Absolute Values. Plato is famous for having believed that, between incarnations as physical human beings, we encounter all knowledge in a transcendent realm of ideas or forms, the chief of these being the Form of the Good. When we are born we forget all that, and during our lives in the world of mere appearances, this world, our task is to remember. We can see echoes of these ideas in some religions, where, roughly speaking, the world of the forms is heaven and the Form of the Good is God, the moral absolutes or natural law being revealed to us, for example in the Ten Commandments and the Sermon on the Mount. A central part of this tradition would be familiar to most New Zealanders as the so-called **Golden Rule**, often expressed as *Do as you would be done by*.

It is interesting to note that, if we regard conflict resolution as a significant purpose for morality, we may find the concept of absolute values unacceptable, because they seem to rule out the possibility of negotiation, which makes them more likely to produce conflict than to resolve it. Religious wars are an unfortunate example of this problem. Of course not all those people whose morality is closely associated with religion are bigots, and indeed many ethical traditions, including secular ones, have a rule similar to the Golden Rule.

The Ethics of Care

In recent years, a number of feminist writers on ethics have drawn attention to the concept of caring as a fundamental aspect of ethical thinking. Not surprisingly, these ideas have been given particular emphasis in the caring professions, such as nursing. The emphasis is timely, even though the new ways of thinking are still at an early stage. One way to view this development is to remember the second part of the Golden Rule: not just *Do as you would be done by*, but also *Love your neighbour as yourself*. This emphasises an important point about the motivation usually associated with the Golden Rule as distinct from, say, utilitarianism. Though both recommend the abandonment of selfishness, one does so in favour of a warm positive regard for others on a one-to-one basis, and the

other for a cool, disinterested pursuit of an optimal distribution of goods. We might also see the ethics of care as not so much offering an independent theory, on a footing with, say, virtue ethics, as drawing attention to important gaps in thinking that have arisen due to an emphasis, in professional philosophy otherwise, upon information and rationality, at the expense of sympathy, and upon reactively resolving conflict as distinct from proactively promoting a better world [see The Social Purpose of Morality]. This point will be taken up again in the conclusion.

Maori ethics

While it would be inappropriate for a report such as this to speak for the ethics of a whole people, as if they were uniform and static and could be properly understood from the outside, there is an aspect of Maori thinking on ethical matters which has been referred to in published writings, and from which much can be learned. In common with many other people, Maori lay great emphasis upon the concept of balance. Indeed, it is often very helpful to see ethical problems, especially those that result in conflict, as related to a disturbance in the proper balance of things. In this case, solution of the problem resides in restoration of balance, and indeed avoiding problems may well be a matter of preserving balance. Beyond that comment, we would suggest that if the ethical views of any group of people are of interest, for example to planners, the survey tool provided by this report is a better way to discern those views than any anticipation of them here could provide. Moreover, variations of opinion, between groups, from place to place or over time, can be tracked by means of such a tool.

There are a number of significant publications that address aspects of Maori ethics. The paper prepared by Nici Gibbs entitled "Genetically Modified Organisms and Maori Cultural and Ethical Issues" for the Ministry for the Environment (June 1996) provides a useful introduction. This paper should be made more widely available, possibly by placing it on the web. Its existence could also be promoted to (in particular) professional scientific societies and science managers. In addition, Dr John Patterson's book entitled "Exploring Maori Values" (Dunmore Press, 1992) provides a general discussion for interested readers.

However, as suggested above, the only culturally appropriate way of assessing the moral views of a whole people about such a broad topic as emerging technologies, is to seek information directly from a representatively wide selection from time to time. The views of Maori people, just as much as those of Pakeha or of any other large group, will be diverse, and will develop over time. We suggest that the survey tool provided in this report be used not only to gauge opinion in the present, but also to track changes in opinion on specific issues, for instance those that might occur after public education and debate.

Environmental ethics

Environmental ethics is another recent development of ethical thinking which often receives separate attention. It may be possible to regard this as ethics applied to a set of particular problems and topics rather than a completely new idea of how to think ethically, but nevertheless some new ways of looking at the world from an ethical point of view have arisen from this emphasis. It is worth noting here that one important aspect of environmental ethics is the notion of [human] custodianship. It extends the notion of moral patient [those to whom we owe a duty of care, you might say] to include not only other sentient species, but all species of animals and plants, and the natural environment and its ecology. In particular, the concept of maintaining a proper balance, and restoring it when it has been disturbed, is of central concern, so that the aspect of Maori ethics referred to above has particular relevance here.

Conclusion

The treatment of all these topics has been extremely cursory; there is no such thing as instant wisdom. Interested readers should consult a modern textbook on ethics.

Utilitarianism is a theory which in recent times has often supported thinking on matters of public policy, but [especially with the weak version, see section entitled Utilitarianism] there are dangers. The needs and interests of particular groups and of individual people need to be borne in mind as well as the aim of maximising general welfare in some global sense. Hence the place of the concept of rights [bills of rights, e.g.] in the political arena. Other theories of ethics are also often deployed by various people seeking to moderate or even reverse decisions supposedly based on securing an overall improvement of life for all or most of us in the long term, but seen as violating more particular ethical requirements. Debate intensifies in the presence of varying opinions as to what will in fact conduce most effectively to the general welfare, because such opinions are themselves often contestable on factual as well as ethical grounds. Political or economic theories provide typical examples here.

Many debates over public policy can be viewed in that sort of light. The debate over genetically modified organisms [GMO] is a good example. There will be people who see the greatest good of the greatest number as the highest good, who think overall economic prosperity is an appropriate measure of that good, and who approve of GMO because they are persuaded that the savings to be had from their use will be very great. There will be business corporations which take the view that the only business of business is to maximise its profits and that GMO will help them do that. There will be believers in the natural order who feel that GMO will unbalance it, or even usurp the prerogative of God. There will be people who believe that the risks associated with this technology have not been studied and managed carefully enough. There will also be secondary disputes, for example between defenders of business rights to commercial secrecy and of consumers' rights to full information. And none of these lists is complete.

Ethical theory has no instant solution to such problems; the going is tougher than that. It offers instead an account of the thinking that typically lies behind the various positions taken, and hence the possibility of a more reasoned and reflective debate: more light, less heat, but no magic bullet.

Faced with the unwelcome conclusion that for difficult cases, thinking ethically provides no ready decision procedure, the first response of busy people might be to abandon such thinking as a waste of effort. This problem has also been addressed by ethicists, though one example will have to suffice here: the ethics of care invites us to be deeply concerned about ethical problems, and in particular the individuals involved in them, so that we don't abandon the quest for resolution.

Nevertheless, there will often be situations involving new science or technology where there is a great need for a period of public education, consultation and debate. Inevitably, this will take time. If scientists and technologists are to retain a high level of public trust, they will often need to allow time for that process, even though they may otherwise be ready to move ahead. There is, however, a practical difficulty here, which is that in other parts of the world where ethical concerns are viewed more lightly, the work may be taken up without delay, especially if the innovation becomes widely known as part of the debate. One solution has been to appoint expert committees of review which can act in the public interest to monitor ethical concerns without breaching confidentiality. Such committees then bear a heavy burden of responsibility, and their track record must in the long run be seen to be very satisfactory if the public is to be expected to trust them. Fortunately, New Zealand has some good precedents in this regard.

While the ethical performance of corporations is not directly the business of this report, it may be that the public will expect some regulation of business activities in the area of new technologies, and that

does then become an area of government interest. To continue with the GMO example, corporations wishing to use GMO will need to earn a very high level of trust to avoid public disapproval. Those taking the line that the only business of business is to maximise profits, can hardly expect the public to trust them.

THE ROLE OF THE MEDIA IN SCIENCE COMMUNICATION

The majority of the public receives their first contact with scientific "breakthroughs" through either written media, radio, television articles or more recently the internet.

From a scientific perspective, there is a hierarchy amongst journalists (this term being used to refer to those involved in visual, spoken and written communication). First, the scientist publishes a scientific paper to be read by their fellow scientists. Secondly, there are science journalists who read these papers and produce articles/programmes aimed at the "science literate" sector of society via magazines such as New Scientist, radio programmes such as Eureka or television programmes such as Our World. In the main, the accuracy of these articles/programmes is of a high standard. This accuracy is, at least in part, due to the importance of credibility to these journalists; it is not in their long-term interests to get scientific details wrong. However, the works prepared by these journalists influence a minority of people.

The third tier of journalists are those who produce articles/programmes for consumption by the majority of the public. Typically, this material has to "sell" the magazine or paper, radio or television station. As a consequence it has to be brief and preferably sensational (possibly by being controversial). Most of these journalists will have limited education in science. Sometimes, the mixture of the need to be brief and sensational and the limited science background of the journalist can lead to misrepresentation of the science to the public. Accuracy is of less importance to this group.

A recent case in point was the purported cancer-curing properties of the green-lipped mussel extract, Lyprinol. The messages from the scientists interviewed were consistent (that the extract killed cancer cells during in-vitro tests), and they insisted that clinical trials were required before the efficacy of Lyprinol against cancer in humans could be proven. However, sales of Lyprinol reportedly reached $2 million in New Zealand in the days following the media promotion of Lyprinol. While the journalists did not break any law, the ethics of such reporting were certainly doubtful, as people suffering from cancer would likely try almost any cure.

The internet has to be treated as a special case of media dissemination because it is possible for individuals to publish their thoughts with (virtually) no censorship. Thus, the internet offers a wide range of material from scientific publications to ill-informed opinion on all technological matters. However, one positive aspect of the internet must not be forgotten. It is a quick and (relatively) cheap means of making information available to a large number of people almost anywhere in the world.

The emphasis of this report is on the ethical issues raised by the use of new technologies but, as the above points indicate, the ethics of journalists are interwoven into this process, because of their role in informing the public about science and technology. Therefore, it might be expected that either media companies or individual journalists should establish a formalised set of professional ethics, possibly embodied in a code of ethics/practice. For example, the British Broadcasting Corporation (BBC) has a code of ethics for programme makers called the "Producer's Guidelines". These guidelines provide advice on the scheduling of sensitive material, upholding standards of accuracy, impartiality and depth of enquiry, as well as sensitivity in reporting traumatic events. While Radio New Zealand does not have any formal code, the Radio New Zealand Charter does include comment that account should be

taken of "recognised standards of excellence", and that broadcasting should be "independent, comprehensive and of a high standard". While none of the major daily newspapers in New Zealand publish their standards via the web (all searched for did have websites), the American Society of Newspaper Editors (ASNE) website had a comprehensive set of codes for 36 papers or national newspaper groups. It might be considered disappointing that Wilson and Horton who advertise themselves as "New Zealand's premier news and information company", do not seem to have room on their website for a comment regarding ethics or code of practice.

However, there is no mechanism that is easy to implement to ensure that the media function according to these various codes. An alternative might be for media groups to have an organisation that "licences" either radio stations, papers, television stations or individual journalists, such as that provided by the Licensed Motor Vehicle Dealers or Master Builders Association.

Some useful websites include:

- www.bbc.co.uk/info/editorial/prodgl/contents.htm
- www.radionz.co.nz/au/au.htm
- www.asne.org/ideas/codes/codes.htm
- www.wilsonandhorton.co.nz/
- www.masterbuilder.org.nz/

Any attempt to improve public perceptions of science needs to be achieved, at least in part, through the media. Consideration will have to be given as to how this might be best achieved. Scientific institutions are now making use of media to advertise their reason for being and their successes. Likewise, government agencies are also using media to extend their ideas to the public. Unfortunately, both of these groups are using second-tier journalists, and a large sector of society is likely to be untouched by these communications. Given the millions of dollars invested by the government in funding science on behalf of society, it would appear sensible for the government to also be involved in promoting science through the media, but at the third tier level.

IDENTIFYING TECHNOLOGIES WITH ETHICAL IMPLICATIONS

To avoid delays in the introduction of useful new technologies, it is desirable to identify potential public concerns well in advance. This should then allow informed debate, both in public and within expert committes, leading to either the introduction or abandonment of the new technology, with or without conditions, or to a delay to allow further discussion and the development of improved safeguards.

It is instructive to consider whether the recent public concern over genetically modified organisms (GMOs) and genetically modified foods (GMFs) could have been identified at an earlier time, thereby allowing debate and possible avoidance of the current furore. The manipulation of the genome at the molecular level is a relatively recent phenomenon, being dependent on knowledge of the chemical structure of DNA (discovered in 1953) and the discovery of site specific restriction endonucleases in 1968. By the mid-1980s, scientists had inserted functional human genes into other species, and the possibilities of gene therapy and a wide range of potential applications for "farmocology" (the insertion of human genes into farm animals to allow the production of human proteins in milk or eggs) was being discussed in the scientific community.

It is unlikely that the original discoveries of the chemical structure of DNA and restriction endonucleases in themselves would have been adequate to signal the need for public consultation about gene therapy and the like. However, it would seem that by (say) 1984, asking the right questions could have led scientists to be concerned about the ethical issues of GMOs and GMFs. Nevertheless, who could have been asked, and what questions should they have been asked, still remain to be elucidated.

In New Zealand, Foundation for Research, Science and Technology (FRST) bids citing objectives which included genetic modification of livestock for human benefit were present by the early 1990s. Therefore, a range of people knew by then about GMO science, including the scientists themselves, their science managers, the fund managers, ministers in science-related portfolios and even the science-aware public. Yet there was no significant public outcry in New Zealand until the late 1990s. Most likely this occurred because all those who knew about GMOs were "comfortable" with the science, and did not query the outcomes from the perspective of an increasingly "science-suspicious" public. Any one of the above-mentioned categories of people could have raised the advisability of public consultation, but it is likely that none of them saw it as their job, especially in the post-1984 age of scientific "efficiency".

It is the scientists themselves who really need to be targeted to think about how their science might be received by the public. In particular, they will be the ones who can provide the maximum lead-time for public consultation. But, they often do not know what might constitute a problem for society, or indeed a society subset such as a particular culture.

Research can be divided into many categories, but for the purposes of this report, "basic", "strategic" and "applied" are useful types. Basic research advances knowledge, while strategic research advances knowledge with the specific expectation that it will be helpful in the medium term (say 5 to 10 years). Applied research represents the application of established knowledge to solve specific problems or to achieve useful outcomes in the short term (say 2 to 4 years).

The provision of funds for applied research should require the applicants to address ethical issues in a systematic way. While basic research might be excluded from this requirement, consideration needs to be given as to how strategic research should be treated. Systematic (and quasi-legal) processes are already in place for experiments involving either humans (Human Ethics Committees) or animals

(Animal Ethics Committees), whereby proof of approval has to be supplied to the fund provider before any payment can be uplifted.

A STRATEGY FOR ADDRESSING IMPACTS OF ACTIONS

Background

In arriving at an opinion on whether some (bio)technology is useful, respondents will draw on their lifetime of experiences. They may also attempt to assess the impact of the technology not only on their own lives, but also on those of people known to them (such as family and their immediate community), their environment, their nation and even the entire globe. Some of these experiences can be quantified, such as level of education relevant to the technology in question. Other experiences will relate to cultural or religious expectations, which are more difficult to quantify, but should receive recognition together with technical competence.

There is a need to encourage respondents to think as broadly as possible about not only themselves in the short-term, but the well-being of the world (in its broadest sense) for future generations. To ensure that such a wide range of issues are addressed, any respondent could be encouraged to consider the potential impact of a technology by a set of standard questions.

Not all respondents will be completely familiar with the technology being considered. Having made an assessment of how they feel about the implementation of a new technology, respondents should be asked about whether the provision of new information might be useful to their decision making.

Finally, after considering all of these issues, the respondent should be asked to arrive at a decision.

Implementation

This will involve a framework of questions (see below) which the respondent will be asked to complete. Consideration needs to be given as to who should fill out this framework of questions. This could range from one person to the whole population. By default, New Zealand currently has a model whereby only a small number of people are addressing a subset of the proposed questions. These are the scientists and technologists who are seeking to implement the new technology. In recent times, some sectors of society have reacted to this method of decision making by protesting to the government and/or directly to the scientists.

There is no doubt that the maximum lead time in identifying new science that might raise ethical issues for society will be provided by the scientists who are involved in the exploration. However in recent times, society has indicated that it is not comfortable with the views of scientists alone. Therefore, there would seem to be a need to provide a mechanism by which society at large can have input.

If scientists are to be asked to answer the framework of questions, a number of issues will need to be addressed. For example, when is the appropriate time to ask about the ethics of the work, will scientists answer in an unbiased fashion, what level of science is to be addressed? Also, what about new science that is imported from overseas?

In answering the proposed questions, respondents will be asked to note that an action is something that requires human intervention. An action might be a biological manipulation such as cloning, or it might be the result of an integrated set of actions such as might result in electronic surveillance.

Assessment of Effects

The following matrix in table 1 is an attempt to provide a checklist within which the possible impacts of any action might be tested. The columns provide the level of focus for the respondent's perspective.

It starts with the impact on the individual completing the checklist and expands to the respondent's view on how the action might impact on the entire globe.

The rows are things that might be affected by the particular action being tested. They are grouped by physical human effects, intangible human effects, effects on non-human animals (in the broadest sense), effects on other living organisms, effects on the environment and effects regarding the Treaty of Waitangi.

Rather than just considering harms, it is suggested that these effects be thought of as having a range of impacts from harm to benefit. It would be possible for each cell to include a number ranging from 1 to 5 (for good to bad). However this approach might lead inexperienced respondents to the wrong conclusion and to a spurious aura of precision. The following are therefore suggested as preferred alternatives, "+", "-", "0", "?" and "blank" for positive effect, negative effect, nil effect, not sure and not applicable. Note that not all cells will require checking for each different type of action.

Usefulness of New Information

Having answered the above framework of questions, respondents should be asked whether they felt that more information might help them to arrive at a decision. The purpose of this is for the assessor of the responses to get some insight into what knowledge base the respondent is using.

This is addressed in table 2 by asking the respondent whether new information would be helpful in arriving at answers for the questions in table 1.

An Overall Result

After having completed the primary questions (table 1) and considered whether the provision of new information might be useful for the respondent to draw a conclusion (table 2), the respondent must be asked to arrive at some recommendation.

Identifying the most Important Issues in Reaching a Decision

As noted earlier in this section, arriving at an overall conclusion will require the respondent to implicitly weight each response. This weighting might range from being equal for every cell to having markedly heavy weightings on some individual cells. Information is gathered on these inherent weightings through use of table 4. The respondent is asked to identify (up to) three most important potential benefits and (up to) three most important potential harms. Opportunity is given for the respondent to rank the benefits and harms from 1 (most important) to 3 (less important), and to provide additional written explanation.

Having identified the most important issues to each respondent in reaching a decision, the final step is to explore why they are the most important issues. This information could either be obtained by asking another question in the current framework, or might only be sought after several responses have been obtained.

Arriving at a National Conclusion

What will be obtained from the above process is a series of responses from a range of people. The final step is to make a national (possibly a global) decision as to whether the technology in question should be pursued and/or implemented. How this should be done and by whom will be a critical process. For example, should we deny a technology to those who need it desperately, because the vast majority does not want it, and may even find the technology morally abhorrent?

Some of the applications presented to the Environmental Risk Management Authority (ERMA) provide an illustration of the above issue. Both the PPL application to farm sheep with a human transgene at Whakamaru and the AgResearch application to produce cows with a human gene drew numerous negative submissions. However, both also received a small number of submissions in

favour of the genetic modifications. While the negative submissions cited religious, cultural and scientific uncertainty as the main reasons for not letting the trials proceed, the positive submissions emphasised the benefits to human health. These benefits are expected to accrue (note there have been no human clinic trials to date) either through alpha 1 antitrypsin alleviating the effects of cystic fibrosis and emphysema or through human myelin basic protein alleviating the effects of multiple sclerosis. The decision to favour these two GMO examples is made somewhat easier by the risks being minimised due to the involvement of large animals (easily identified and traced, and breeding easily controlled) and the health benefits being significant. This is in contrast to (for example) flowering plants, which rely on wind pollination (enabling easy spread of the modified genome), and where the benefit is mainly economic. Comments on the above applications can be viewed at ERMA's website (http://www.ermanz.govt.nz/).

Examples of Application of the Framework of Questions

Two examples of how the framework of questions might be applied are presented in Appendix II. The first example is that of cloning human organs, the second the application of nanotechnology to human health. Two (imaginary) respondents are used for each of the examples.

Table 1. Assessment of the effects of _____ .

You should answer each question for how you think _____ will affect you, your family, your community, New Zealand and the globe. You should use a "+" for a beneficial effect, "-" for a negative impact, "0" for neutral affect, "?" for not sure and leave the box blank if _____ does not impact on the issue queried.

	You	**Your Family**	**Your Community**	**New Zealand**	**Global**
1. Health, fitness and well-being of people What do you think the impact of _____ will be health, etc: ♦ during the next 2 years? ♦ 10 years from now? ♦ on future generations?					
2. Guiding values or principles What do you think the impact of _____ will be on: ♦ moral, religious or ethical values? ♦ cultural integrity, standing or safety? ♦ social harmony? ♦ professional integrity?					
3. Freedom, safety and social standing What do you think the impact of _____ will be on: ♦ privacy? ♦ security or safety? ♦ image, standing or influence?					
4. Economic and financial matters What do you think the impact of _____ will be on: ♦ earning power, financial viability and financial security? ♦ economic development and competitiveness?					
5. Animals What do you think the impact of _____ will be on: ♦ humane treatment of animals? ♦ animal health and welfare? ♦ animal productivity or usefulness? ♦ future generations of animals?					

6. Plants What do you think the impact of _____ will be on: ♦ the availability or usefulness of plants generally? ♦ the food and health-enhancing value of plants? ♦ the availability of plants used for building, paper or fuel? ♦ future generations of plants					
7. The environment, climate and atmosphere What do you think the impact of _____ will be on: ♦ the environment generally? ♦ air? ♦ soil? ♦ water (fresh, salt and ice)?					
8. Issues pertaining to the Treaty of Waitangi What do you think the impact of _____ will be on: ♦ Taonga? ♦ Mauri? ♦ Kaitiakitanga? ♦ Mana and Rangatiratanga? ♦ Other issues you see as important in the context of the Treaty					
9. Other issues (Give a brief account)					

Table 2. Would more information about _____ have been useful in making your decisions in table 1?

Overall, how would you rate your knowledge of _____ : none, a little, average, a lot, expert, in relation to your assessment in table 1? Reconsider the same areas of enquiry, but now state whether new information could be useful in reconsidering your initial response. Place a "Y" for yes, "N" for no, "0" for unsure and leave blank for not applicable.

	You	**Your Family**	**Your Community**	**NZ**	**Global**
1. Health, fitness and well-being of people					
2. Guiding values or principles					
3. Freedom, safety and social standing					
4. Economic and financial matters					
5. Animals					
6. Plants					
7. The environment, climate and atmosphere					
8. Issues pertaining to the Treaty of Waitangi					
9. Other issues					

Table 3. Arriving at a conclusion.

Having completed tables 1 and 2, place a tick (✓) alongside the option that best reflects your feelings.

Outcome	**Decision**
Made available with no restrictions	
Made available with legal restrictions	
Considered via a referendum	
Availability delayed pending further scientific study	
Availability delayed pending further public discussion	
Availability delayed pending further development of improved safeguards	
Banned	
I cannot make an informed decision	

Table 4. Identify the most important issues in your decision making.

Select up to three of the most important potential benefits and up to three of the most important potential harms by placing a tick (✓) in the appropriate boxes. If you wish you may provide a ranking by using 1 for the most important and 3 for the least important. Additional comment may be provided in writing.

Issue	Most Important Potential Benefits	Most Important Potential Harms
1. Health, fitness and well-being of people		
2. Guiding values or principles		
3. Freedom, safety and social standing		
4. Economic and financial matters		
5. Animals		
6. Plants		
7. The environment, climate and atmosphere		
8. Issues pertaining to the Treaty of Waitangi		
9. Other issues		

EXAMPLES OF NEW AND EMERGING TECHNOLOGIES

The following is an introduction to a variety of technologies identified by the authors. It is not an exhaustive list, but an attempt was made to include technologies from a range of scientific disciplines. A list of the technologies to be discussed is given in table 5. There are several areas in which technologies of interest exist, but in which the authors have little knowledge. These areas have been listed in table 6, but no comment has been made on them. Undoubtedly, readers will identify other technologies that deserve ethical evaluation. It is hoped that one result of this report will be to stimulate such responses.

The technologies have been listed in alphabetical order.

It is difficult to define "a technology". Often a technology is the culmination of many scientific processes, each of which could be considered a technology in its own right. Furthermore, some of these scientific processes might appear in multiple technologies. The question then needs to be addressed regarding at what level ethical issues arise. For example, the ability to transfer genes between species can result in genetically modified humans, animals, plants, microbes or foods. Is it the transfer of genes itself that is causing the ethical dilemma, or is it the unknown risks to human and/or biota health that are an issue? The level at which technologies are debated requires consideration.

Some Technologies of Immediate Interest

There is already substantial debate surrounding the new genetic technologies, although there has been little discussion on the commercialisation of the human genome. Technologies that the authors believe deserve attention due to likely ethical concerns, by at least some of the public, have been italicised in table 5.

Table 5. A list of technologies raised in this report.

- *Animal welfare*
- *Artificial wombs or media for tissue growth*
- Automotive technologies
- *Cloning*
- *Commercialisation of the human genome*
- Communication
- Extended life
- *Food irradiation*
- *Gene Therapy*
- *Genetically modified foods*
- *Genetically modified organisms*
- *Genetically targeted vaccines*
- Influencing the biosphere from space
- Intellectual property
- *Mice as human sperm producers*
- Mind modification
- Miniature technology and biomedicine
- *Nanotechnology*
- *Privacy - electronic and satellite tracking and surveillance – automatic ID*
- Robotics and artificial intelligence
- Suspended animation
- Technologies for energy sources
- *Xenotransplantation*

Table 6. A list of technologies identified as raising ethical issues, but not discussed.

- Atmospheric science technologies and the environment
- Information and data processing
- Information technology
- Oceanography technologies
- Space and military technology
- Technologies that enable exploitation of Antarctica
- Technologies to assist with the reclamation of deserts or the avoidance of desertification (deforestation)
- Waste disposal technologies
- Water usage technologies

i) Animal welfare

Description: The avoidance of negative states and the promotion of positive states whereby the nutritional, environmental, health (disease or injury), behavioural and mental needs of animals are met. Major progress has been made over the past 50 years in defining the nutritional, environmental and health needs of animals and in providing protection in these areas. As a consequence, behavioural and mental needs are now receiving increased attention.

Public perception of the sensitivity and responsiveness of animals to harm is increasing and is leading to greater questioning of the ways we use animals and the safeguards we have in place on their behalf. The Animal Welfare Act (1999) reflects this, and emphasises our "duty of care" rather than, as in previous legislation, the mere avoidance, detection and punishment of those involved in cruelty.

Important scientific issues:

- What does an animal "feel"?
- What positive states can animals experience?
- How can suffering in animals be detected, prevented and alleviated?
- What are the humane limits to each form of animal use on farms and elsewhere?
- What are the animal welfare implications of applying new technologies to animals?

Important societal issues:

- Are the safeguards on behalf of animals adequate?
- Will urbanised societies continue to condone current farm animal practices?
- Will meat eating continue at its current level?
- Should particular animal species (e.g. Great Apes) be accorded "rights" akin to human rights?

Timeline:

- New legislation enhances protection for animals.
- Welfare issues already exist.
- New welfare issues will continue to arise as society becomes further urbanised and as new technologies are applied to animals.

Ethical evaluation:

- There will be a need for ongoing public debate over animal welfare issues.
- The new legislation before Parliament, the (National) Animal Welfare Advisory Committee, the National Animal Ethics Advisory Committee and MAF mean that this issue is well catered for at a political and practical level.

ii) Artificial wombs or media for tissue growth

Description: The current intent is to create an environment capable of sustaining growth of animal tissue without direct connection to an animal. Rather than aiming to produce a baby-factory, the artificial womb would be used to produce organs, skin, muscle or bone for transplant purposes. The potential to connect an artificial womb to an animal (female or male) will undoubtedly be explored.

Important scientific issues:

- The complexity of hormones, substrates and enzymes required to grow and sustain organs in culture or to sustain a whole pregnancy.
- How to turn on specific genes to grow particular tissue types and/or organs.
- Functional integrity of artificially produced body parts.

Important societal issues:

- What form should safeguards take?
- Non-natural production of human parts.
- The source of cells – foetuses, new-borns, adults.
- Potential to generate an entire individual without biological parents.

Timeline:

- Various growth media for tissues already available.
- Artificial womb already under study.

Ethical evaluation:

- Need to separate discussion of growth media for tissues from artificial wombs.
- Need to formulate and explore relevant ethical questions.
- Immediate need for debate and education.

iii) Automotive technologies

Description: A large proportion of the human population uses some form of motorised transport, including buses, trains, cars and aeroplanes. There are a number of problems arising from the increasing mobility of the human population including delays due to congestion and injury and death due to accidents. It is highly likely that these problems could be eliminated, or at least reduced, by removing the majority of decisions from the human operator, either to a computer operator or to an expert operator located remotely. Automotive technologies to achieve this vision will require integration of computer software with automated steering and possibly satellite positioning. This technology is in use for planes and trains, but has yet to shift to terrestrial modes of transport without tracks.

An example of a new mode of transport is the skycar currently being developed by Moller International. The intention is to fly the skycar within several metres of the ground, but at speeds of up to 600 kph. It will have the option of an entirely computer-controlled flying system, which is being developed by NASA. The skycar would also alleviate some other problems associated with road travel, such as congestion and road maintenance.

Important scientific issues:

- What error rate (resulting in accidents) is acceptable?
- Can software be made virus resistant?
- Can software be user-friendly and resistant to tampering?

Important societal issues:

- What form should safeguards take?
- Will people be able to trust non-human control of their vehicle, whether it be their car, bus or plane?
- Is it necessary to have a human back-up in the event of a computer failure?
- Is it necessary for the majority of people to own a vehicle?

Timeline:

- Already available, e.g. new parts of the London Underground train service are driverless.

Ethical evaluation:

- The error rate of an autopilot system is likely to be less than that of most humans. Should legislation impose the use of autopilots to reduce accident rates?
- The projected price of a skycar is less than that for large trucks, making them attractive for freight.
- Unlikely to be an immediate problem for much of New Zealand, although councils of the larger cities need to be aware of new developments.

iv) Cloning

Description: until recently, cloning was considered by most biologists to represent the splitting of cell-masses soon after fertilisation into several entities, each consisting of many cells. Each mass was then inserted into a cell whose nucleus had been removed, and grew into genetically identical individuals. However, cloning is now understood to be the generation of an individual using DNA obtained from a cell without unique reproductive cell division (meiosis) being involved.

There is also the possibility that individual organs might be cloned. This will be dependent on an understanding and development of several other technologies, for example an artificial womb (see technology (ii)).

Cloning has also been expanded to include the growth of new tissues such as skin, cartilage and muscle (and possibly bone and blood). It is likely that the growth of these tissues will be scientifically achievable in the near future.

Important scientific issues:

- The genetic material of the new animal is (almost) genetically identical to the animal that donated the cell from which the DNA was obtained.
- The clone will not necessarily look or perform exactly like the donor (eg some colour patterns are caused by random inactivation of genes, and the environment is unlikely to be exactly the same for donor and clone).
- Cloning may allow individual organs to be grown (especially if an artificial womb can be developed).

Important societal issues:

- What form should safeguards take?

- Scientists playing "god".
- If humans are cloned, will they have the same rights as non-clones?
- Clones already occur naturally (eg identical twins and armadillo litters).
- The clone will not necessarily look or perform exactly like the donor (eg some colour patterns are caused by random inactivation of genes, and the environment is unlikely to be exactly the same for donor and clone).

Timeline

- Cloning of animals has occurred.
- Cloned human embryos have been grown to 14 days of age before termination.
- Cloning of organs has not occurred and is likely to be some years away.

Ethical evaluation:

- Potentially large benefits to individuals requiring organs and/or tissues.
- Large cultural differences in acceptability of technology.
- Will impact on longevity and hence population demographics.
- Immediate need for education and debate.

v) Commercialisation of the human genome

Description: The "information" that makes up the human genome (sequences of 4 nucleotides) is currently being defined by the Human Genome Project. As this information becomes available, it will be used in a variety of applications, most of which will be expected to provide a financial return to the investor. Includes patents on the functions of human genes, patents on animal-human chimeras, lineage tracking, forensic science, correction of defective genes (already covered under gene therapy) and using gene screening results to set insurance premiums.

Important scientific issues:

- Does the presence/absence of the "gene" equate to definite onset of illness
- What is a gene?
- The biological status of animal-human chimeras.

Important societal issues:

- What form should safeguards take?
- Ethical use of animal-human chimeras, they could be used to explore the ocean, the solar system, etc.
- The concept of collective insurance by society.
- Who owns genes?
- What is abnormal - are dwarfs or people with colour blindness abnormal?
- Selection of embryos without "abnormalities" before implantation.

Timeline:

- Already happening

Ethical evaluation:

- There is urgent need for debate about commercialising the human genome.
- Should insurance companies insist on a genome scan to assist in setting insurance premiums? This debate has been ongoing in the USA for much of the 1990s.

vi) Communication

Description: Communication between people who are physically distant from each other has been revolutionised in recent times with the introduction of cellular phones. This has provided business opportunities for many people who do not work near an office. It has also provided security for isolated people, including children. Miniaturisation of this technology will mean it is conceivable that everyone in the world could be contactable at any time through wearable communication devices.

Important scientific issues:

- What are the physical limitations of miniaturisation?
- Effects of emissions from remote communication devices on human tissue.
- Will signals interfere with eachother?

Important societal issues:

- What form should safeguards take?
- Privacy.
- Do emissions from remote communication devices cause cancer or other diseases?

Timeline:

- Ongoing.

Ethical evaluation:

- Privacy issues need to be debated. Can an employer require that an employee be accessible 24 hours a day 365 days a year? Should invasive advertising be forbidden?
- Promotion of debate is needed now.
- Legislation may be needed to protect privacy.

vii) Extended life

Description: Better techniques for identifying and curing health problems and the cloning or growth of body tissues have the potential to dramatically extend the life of humans. It has already been predicted that children born in the last decade might expect a life span of nearer to 120 years, rather than the currently expected mid-70s. Nanotechnology (item xviii) may deliver currently unimaginable increase in life span.

Important scientific issues:

- Are all bodily functions capable of being extended?
- New diseases likely to emerge.

Important societal issues:

- Is extending the lifespan *per se* an acceptable objective?
- What form should safeguards take?
- Population growth is faster than predicted therefore resources under greater pressure, including superannuation and health services. Will people be expected to work longer or have a very long retirement period?
- Is quality of extended life acceptable?
- Cost of medical procedures will require choices to be made between individuals who need treatment. Who will make the decisions, and on what basis?

Timeline:

- Life expectancy will be made up of many factors, several of these are ready for implementation.

Ethical evaluation:

- Should, or can, all life extending techniques be equally available to everyone?
- Need for immediate debate.

viii) Food irradiation

Description: There has been a steady increase in the number of food-related illnesses in humans. Bacteria such as camphylobacter, salmonella, listeria and E.coli cause the majority of these illnesses, and the increase in incidence is related to the use of fresh foods and poorer personal hygiene. One proposed method of reducing the contamination of food with bacteria is to expose it to low-level irradiation from cobalt-60, cesium-137, accelerated electrons or X-rays. Medium doses of 1 – 10 kilograys (kGy) will control pathogenic microbes responsible for food-borne illnesses and also extend shelf-life of refrigerated foods.

Important scientific issues:

- The process by which food irradiation occurs precludes the possibility that food could become radioactive.
- What level of irradiation is necessary to sterilise the food?
- The safety of irradiation plant for operators.
- Disposal of waste.
- Can irradiated food be detected?
- Is there any degradation of the nutrient value of irradiated foods?

Important societal issues:

- What form should safeguards take?
- Many still believe food will become radioactive.
- How safe is food that has been on the supermarket shelf for an extended time?
- Should irradiated food be labelled?

Timeline:

- Can be and is being done now.

Ethical evaluation:

- The benefit of reduced illness outweighs the risks, if the process is properly conducted.
- The use of irradiation to produce safer foods should be promoted.

ix) Gene Therapy

Description: Where the DNA sequence for a gene that produces a faulty product is known, it may be possible to either correct the DNA base sequence or provide a new working copy of the gene. These modifications could occur either in the (body) somatic cells, and hence would not be passed to future generations, or in the reproductive (germ) cells and could be passed on to the next generation.

Important scientific issues:

- Stability of modified/ introduced DNA.
- Targeted insertion of DNA into genome.

Important societal issues:

- What form should safeguards take?
- For germ cell therapy, some religious and cultural groups will interpret this as “playing god”.

Timeline:

- Somatic modification of human cells has already occurred.
- Germ cell modification has occurred in laboratory animals.

Ethical evaluation:

- It is important to separate somatic from germ line modifications.
- The tools are ready for application, debate is needed now.

x) Genetically modified foods

Description: While most foods currently consumed by western society can be considered genetically modified in some way, this description is popularly used for foods derived from animals or plants that have been genetically modified using molecular genetic techniques rather than the traditional breeding methods.

Important scientific issues:

- Is the expression of a new protein in the food chain likely to increase the incidence of allergic reactions?

Important societal issues:

- What form should safeguards take?
- Which GMFs safe to eat and which are not?
- Should labelling be mandatory?
- Can labelling be entirely accurate?
- Is the consumption of DNA with the same sequence as a human equivalent to cannibalism?

Timeline:

- Genetically modified foods are already available.

Ethical evaluation:

- Urgent education and debate is needed over the safety and labelling of genetically modified foods.

xi) Genetically modified organisms

Description: The Hazardous Substances and New Organisms Act (1996) states that a genetically modified organism (GMO) is any organism in which any genes or other genetic material have either been modified by in vitro techniques, or are inherited, or otherwise derived, through any number of replications, from any genes or other genetic material which has been modified by in vitro techniques.

The tools of molecular genetic modification include: DNA, enzymes that cut DNA in known patterns; a means of replicating all or some of the DNA (polymerase chain reaction or PCR); a method of transferring a piece of DNA into the target organism (there are several techniques); a means of selecting which organisms have taken up the new DNA and a means of measuring expression of the new DNA.

The potential uses for GMOs is very diverse, and only a small number are mentioned below.

For discussion purposes, GMOs can usefully be divided into micro-organisms, plants, insects and animals. The genetic modification of humans has already been discussed in item (iv).

Micro-organisms: a wide range of MOs have been altered using molecular genetic techniques. Intended uses include: storing genetic material from other organisms so it can be analysed for structure; modified MOs in the rumen of cattle or sheep to reduce methane production; modified E.coli to produce growth hormone or insulin; modified MOs to study basic biochemical pathways.

Plants: a wide range of plants has also been modified. For example, to change flowering patterns and colour, to increase resistance to chemicals, to improve temperature tolerance, for protection against insects and to deliver vaccines to humans.

Insects: some have been modified to express human genes that generate proteins for medical purposes.

Animals: most effort in the genetic modification of animals has centred on mice and rats, to enable the development of techniques that can then be applied to either humans or animals of economic interest such as cattle and sheep.

Important scientific issues:

- More accurate targeting of the insertion of DNA.
- Stability of inserted DNA.
- Impact on biodiversity.
- What are future effects on population?

Important societal issues:

- What form should safeguards take?
- There is a wide range of possible genetic modifications, and not all of them will carry the same risk or ethical value.
- Religious and cultural abhorrence.
- Status of animals with human genes.

Timeline:

- It is now possible to genetically modify any species.

Ethical evaluation:

- Ongoing education and debate required.

xii) Genetically targeted vaccines

Description: As the human genome becomes better understood, it will be possible to produce vaccines that are targeted to a particular genetic make-up. The genetic make-up could be at an individual level, by race or maybe other groups. Targeted vaccines will elicit a better immune response and hence result in improved health.

A less benign consequence of knowing these genetic differences is generating knowledge that could (in theory) be used to design biological agents that would only target a particular group of humans (potentially based on race) with either a debilitating or lethal agent. In the case of a lethal agent, this has been referred to as a biocide.

Important scientific issues:

- Efficacy of targeted vaccines.

Important societal issues:

- What form should safeguards take?
- The level of protection provided by targeted vaccines.
- Potential for unethical use.

Timeline:

- Genetic differences between races are being identified as a consequence of the Human Genome Project.

Ethical evaluation:

- Vaccines are already widely used and accepted in society.
- It would be sensible to inform the pubic of new developments in this field.

- Military activity in New Zealand is minor, and therefore the Armed Services are unlikely to support such biocide research.
- However, the Government ought to be aware of potential abuse on an international scale.

xiii) Influencing the biosphere from space

Description: Examples of the impact of manmade objects in space affecting the earth's biosphere already exist. At the simple level, space trash is regularly falling from orbit. More complex issues such as the Russian space mirror that was intended to reflect sunlight onto a Russian city at night-time will undoubtedly occur with greater regularity in the future.

Important scientific issues:

-

Important societal issues:

- What form should safeguards take?

Timeline:

- Is happening now.

Ethical evaluation:

- New Zealand unlikely to be at the forefront of this technology.
- New Zealand may be affected by the actions of other nations.

xiv) Intellectual property

Description: The commercialisation of ideas has led to a rapid rise in inventors who wish to protect their concepts to enable them to benefit financially. The concept of intellectual property is now well entrenched in most research institutions and universities.

Important scientific issues:

- Was the idea discovered only by the person or company who stands to benefit from protection of the intellectual property?

Important societal issues:

- What form should safeguards take?
- Who paid to educate the scientist?

Timeline:

- It is a problem now.

Ethical evaluation:

- Needs debate and ongoing discussion towards an acceptable resolution.

xv) Mice as human sperm producers

Description: By placing human testicular material into mice testes, it has been possible to generate human sperm. These sperm could then be used for in-vitro fertilisation of human eggs. Clearly this, or a similar, procedure will be attractive to some infertile men.

Important scientific issues:

- Are the human sperm free from either genetic or disease contamination?
- Can the host mouse have human genes incorporated into its genome?
- What is the long-term impact on the fertility of the human population?

Important societal issues:

- What form should safeguards take?
- Ethical considerations.
- Who owns the mouse that produces the sperm?
- Safeguards against disease transmission and genetic contamination.
- Cultural aversion.

Timeline:

- sperm already produced by this method (in Italy).

Ethical evaluation:

- Of significant interest to infertile men.
- Likely to incur cultural barriers.
- Explore whether ethical impact is limited to the families using the technology.
- If the infertility is genetically-based, there could be an accumulation of genetic problems in the population overall.
- Need for immediate debate and education.

xvi) Mind modification

Description: As the biochemical processes by which events are imprinted in the brain become elucidated, it may be possible to artificially imprint events into the mind.

Important scientific issues:

- Who will it be tested on?
- Is there a danger of wiping/over-writing existing memory?

Important societal issues:

- What form should safeguards take?
- Could be used inappropriately.

Timeline:

- It will take many more years to untangle the way in which a brain works.

Ethical evaluation:

- Serious consequences for all of society.
- Will need public debate in the future.

xvii) Miniature technology and biomedicine

Description: The miniaturisation and insertion of replacement or control devices to substitute for failed or disordered organ functions in the body offer huge opportunities to advance treatments.

Important scientific issues:

- Do the devices meet the therapeutic need fully enough?
- Can the devices be inserted with minimal harm?
- Is the lifespan of the devices once inserted adequate?

Important societal issues:

- What form should safeguards take?
- To what extent might cost affect general availability?

Timeline:

- Such devices are already being researched.
- Limited by the capacity for miniaturisation, which is advancing rapidly.
- Limited by the capacity to make "active" connections to body tissues, especially nerves.

Ethical evaluation:

- Cost-benefit analysis for effective deployment of limited medical resources on a national basis.
- Improper use by autocratic powers to control "subversives" and criminals.

xviii) Nanotechnology

Description: Nanotechnology refers to the manufacture of biological or inanimate objects one atom at a time. Dimensions in the nanometre range may be only 3 to 4 atoms wide. It is impossible to cover the potential developments that might emerge from the application of nanotechnology in this brief statement. However, a visit to a website such as the following is enlightening.

http://nanozine.com/WHATNANO.HTM

Possible developments listed at this site include:

- Self-assembling consumer goods.
- Computers billions of times faster.
- Extremely novel inventions (impossible today).
- Safe and affordable space travel.
- Medical Nano - virtual end to illness, aging, death.
- No more pollution and automatic cleanup of already existing pollution.
- Molecular food syntheses - end of famine and starvation.
- Access to a superior education for every child on Earth.
- Reintroduction of many extinct plants and animals.
- Terraforming here and the Solar System.

Important scientific issues:

- How to control nano-robots (nanots or nanobots).
- How to coordinate the efforts of many nanots.
- Checking the foods produced by nanots have the same comprehensive nutrient value as those they replace.

Important societal issues:

- What form should safeguards take?
- Will people be comfortable with minuscule nanots moving around inside their body?
- If we can assemble food from molecules in the atmosphere, will society except the farming of animals for food production?

Timeline:

- Research is advancing.
- Delivery will likely be by 2015.

Ethical evaluation:

- Potential applications are extensive.
- Huge impact on existing social structure has been forecast.
- Is New Zealand investing in this field?
- Debate needed.

xix) Privacy - electronic and satellite tracking and surveillance – automatic ID

Description: Several technologies are and will be used to identify where a person has been or where they are at the present time. These include satellites, video cameras, electronic banking cards, cellular phones and microchips that might be implanted in a variety of personal effects including cars.

Important scientific issues:

- Quantity of data to be handled.

Important societal issues:

- What form should safeguards take?
- Who should have access to your whereabouts – your family, your employer, the police?

Timeline:

- Many techniques are available now – the buying patterns of many people are already being tracked through the use of credit cards and schemes such as “Fly-Buys”.

Ethical evaluation:

- Potentially serious issues for privacy.
- Debate is needed now.

xx) Robotics and artificial intelligence

Description: The use of robotics has been seen as a way of freeing humans from repetitive (e.g. welding) and/or dangerous (e.g. bomb disposal) tasks. More recently robots have been used to provide assistance for delicate tasks such as invasive surgery.

So far, all that has been achieved with artificial intelligence is to mimic some of the functions of the body, and a very small subset of the simpler functions of the brain. Public fear would be much reduced if people knew how far the smartest robots really are from genuine intelligence.

Important scientific issues:

- How to mimic human brain?
- What is the risk of robots performing tasks inaccurately?

Important societal issues:

- What form should safeguards take?
- Will people be prepared to euthanase robots with artificial intelligence?
- What is the risk of robots performing tasks inaccurately?

Timeline:

- Smart robots are available now.

- Artificial intelligence is likely to be unavailable for some years.

Ethical evaluation:

- The public need to be aware of what scientists are trying to achieve.

xxi) Suspended animation

Description: The ability to hold animal life forms at either zero or low metabolic rates, thereby extending their life span. This might be only for a short period of time for medical purposes (eg major surgery or cancer treatment). However, longer periods of suspended animation would be required if the intent is to allow deep space exploration.

Important scientific issues:

- What damage might occur to memory?
- What damage might occur to tissues during suspension?

Important societal issues:

- What form should safeguards take?
- Will the person be capable of joining in society after extended periods of suspended animation?
- Is this the equivalent of death – implications for inheritance, divorce, life insurance?
- Can or should a person with terminal illness be placed under suspended animation, pending the development of a cure?

Timeline:

- Short term suspension already in use for some surgical procedures.

Ethical evaluation:

- Short term suspension is likely to be viewed as another form of anaesthesia.
- Long term suspension will require debate.

xxii) Technologies for energy sources

Description: Fossil fuels will become exhausted at some time in the future. Efforts to find sustainable, environmentally friendly alternatives have resulted in a variety of possible alternatives including water, solar, wave, wind and hydrogen.

Important scientific issues:

- Impact on environment.

Important societal issues:

- What form should safeguards take?
- Cost of new energy sources.

Timeline:

- These alternative sources are available now.
- New scientific discoveries will make some alternatives financially more attractive.

Ethical evaluation:

- The privatisation of power generation in New Zealand means that decisions about power generation will be made on a financial basis.
- Government needs to ensure environmental costs are known and applied to the generation process. This should encourage the consideration of alternative sources.

xxiii) Xenotransplantation

Description: With improvements in surgical techniques and better understanding of immunology, it has become possible to consider a wide range of tissue transplantation, not only between humans, but also from animals to humans (xenotransplantation). However, it is likely that xenotransplantation will be only a medium-term solution until the cloning of tissue and organs becomes a reality.

Important scientific issues:

- Transfer of disease between animals and humans.
- Rejection of organ.

Important societal issues:

- What form should safeguards take?
- Reduced waiting period for replacement organs.
- Animal welfare and acceptability of such animal use.
- Transfer of disease from animals to humans.
- Impact on psychology of recipient.

Timeline:

- Organ transfers have occurred between pigs and monkeys.

Ethical evaluation:

- Heart valves from pigs have already been transplanted into humans.
- International assessment of process is underway.
- New Zealand needs to address cultural issues urgently.

THE WAY FORWARD

1. The framework of questions presented in this report to identify technologies that are likely to raise ethical issues needs to be debated by scientists and lay-people.

When arriving at a decision about the value of new technology, people will tend to focus on how the technology will impact on them in the near future. By asking a standard set of questions, everyone can be encouraged to think about wider issues over a variety of timeframes.

The range of questions asked in the framework needs to be explored by different groups in society. This should identify any areas that are not covered but may be of concern to the public at large.

The way in which the questions are asked, and indeed the questions themselves, will vary for Maori and non-western cultures. We cannot speak for such people ourselves, but we suggest they be invited to consider this first report and contribute to an ongoing process of developing successors to it.

2. The method of getting the framework of questions answered by an appropriate group of people needs to be addressed.

As stated earlier in the report, the longest lead-time for identifying technologies with possible ethical concerns for the public will be gained by directing the questions at scientists themselves. However, scientists working on components of what will become a technology (when combined with other components of science), may not be able to identify what the likely concerns are. Also, scientists have (generally) not been educated to realise that being a "conscience for society" is one of their roles. Indeed, foisting the suggested questions on to every scientist in New Zealand is unlikely to be greeted with enthusiasm. Furthermore, the framework of questions needs to be developed as suggested in item 1 above, for it to do a thorough job of identifying concerns.

However, an approach which highlights the importance of scientists demonstrating their wish to participate in discussion about safeguards and applications of their science might be more successful. This would especially be so if it were preceded by clear public promotion of the notion that to remain credible and retain public support scientists must contribute to discussions about the value and ethical content of their work. Moreover, scientists should be encouraged to see that they have a pivotal role to play in those discussions.

There are a variety of mechanisms by which the public can be encouraged or invited to debate technologies that have raised ethical concerns. These include focus groups, workshops, public lectures, and the like. A current example of the application of reference and focus groups is that of "Possum Biocontrol" which The Parliamentary Commissioner for the Environment is leading. The introduction to this project is contained in Appendix III. The Independent Biotechnology Advisory Committee (see item 4) is also gauging public opinion on biotechnology by requesting feedback to a booklet that has been widely circulated throughout New Zealand.

3. A plan is needed to reinstate public trust in the scientific community.

The groups who have a vested interest in this process include the scientists themselves, the employers of the scientists and the government. While the public should also have an interest in being able to trust scientists, it is unlikely that they will be proactive.

Scientists themselves must take a lead in improving their image with society. There is no magical cure; rather there will be many small actions that either individual scientists, or their managers or their professional societies should initiate to solve the problem. Both through the approach outlined here,

and others that should be devised, the public relationship with scientists can be returned to one of trust. Openness and a willing participation in public discussion where scientists take public concerns seriously and are not dismissive would be helpful in correcting this thinking. The Code of Professional Standards and Ethics promulgated by The Royal Society of New Zealand (see website http://www.rsnz.govt.nz/front.html) provides an excellent starting place for scientists who are serious about addressing the issues of image and trust.

Scientists must take a more active role in communicating science and scientific issues to the public at large. The means by which this can be achieved will be limited by the amount of discretionary time the public have available, and the level of interest that can be inspired in the public. Possible approaches for getting a science message across include via the classroom (most likely via study packages for teachers), through television programmes, and by having interesting and interactive web sites. As mentioned earlier in this report (The Role of the Media in Science Communication), if a goal of government is to improve the standard of living of New Zealanders by investing in research, and there is a blockage in uptake of new ideas by society, it would seem sensible for the government to assist in removing that blockage. Currently the government is not actively involved in communicating science through the third tier of journalists discussed in the above-mentioned section.

Finally, because the nation will benefit from having trust in the scientific community, it would be helpful if the servants of the public also made an effort to collectively improve their understanding of scientific matters.

4. If the Government is expecting to continue investing in scientific research, it should also be committed to investing in science education to achieve a measure of scientific literacy among the public. This should facilitate informed and rational debate.

The long-term approach to addressing the problem of a "science-challenged" society is to ensure that members of the society have a better science education. Clearly this education has to take place within the compulsory section of education, that is at primary, intermediate and early secondary levels.

To promote advice and informed public debate regarding biotechnology in the more immediate future, the Government has established the Independent Biotechnology Advisory Committee (IBAC). The objectives of IBAC are stated as first, to stimulate dialogue and enhance public understanding about biotechnology, and secondly to inform Government's consideration of the environmental, economic, ethical, social, and health aspects of biotechnology (see website at http://www.ibac.org.nz/).

5. If scientists are to play a part in identifying ethical problems related to their expertise, they will need some understanding of ethics.

The tertiary education of scientists has generally been focussed on science, and hence narrow in outlook. Little or no time has been devoted to studies not directly related to their special subject areas. Yet in their professional lives scientists will increasingly be expected to be aware of ethical problems and make ethically responsible choices. Education in these matters needs to become an integral part of their degree programmes.

6. The application of the framework of questions suggested in this report may suffice to capture the ethical issues arising from research in New Zealand. However, it will not capture those discoveries happening overseas.

Continuous advances in technologies associated with communication and travel have resulted in new scientific discoveries moving around the world very quickly. For example, less than 2 years after Dolly (the sheep) was cloned in Scotland, the first cloned animal was produced at AgResearch,

Ruakura, in New Zealand. Given the small size of the New Zealand scientific community, it is reasonable to expect that the majority of technologies new to New Zealand will be imported ones. Any consideration of the ethics of new technologies needs to take account of the importation of technologies and/or ideas from offshore.

Because New Zealand is an importer of ideas and technologies, the imposition of a moratorium on some particular technology requires careful consideration. If other countries do not place a moratorium on the technology in question, is this to New Zealand's benefit or detriment? It could be argued that New Zealand should continue research with the technology to enable the public to assess the risks and benefits based on experience in New Zealand. On the other hand, maybe other countries should be left to make the errors, and New Zealand is then able to import the sanitised version of the technology.

There are few formal ways to become informed about overseas research. The obvious people to identify the likely scientific advances are scientists, science managers and technology company representatives. It is unlikely that technology company representatives will wish to divulge their international findings, since they will likely be used for commercial gain. Most scientists and academics are required to submit reports to their institutions on any overseas leave, and they could be asked to outline new developments in these documents. Even if the scientists reported new developments of interest, there needs to be a mechanism by which they are captured and considered nationally. However, it would be easy to see a centralised group being formed that gets overwhelmed by paperwork! This does not seem to be a sensible option.

An alternative would be to form a group of informed scientists whose task would be to keep abreast of international science. This could be similar to what was the National Research Advisory Council (NRAC).

Another aspect of the globalisation of science, is the existence of many groups around the world who are working on ethical issues related to new technologies. In some situations, there has been significant public debate and analysis of issues that are also of interest to New Zealand. For example, the USA has had several years of public, political and commercial debate about the use of human genetic screening to assist insurance companies in setting life insurance and health benefit insurance premiums. There is much to be learned by being familiar with what the rest of the world has already deliberated on.

Appendix I: An extract from “Smallpox: The triumph over the most terrible of the ministers of death”. Barquet, N. and Domingo, P. (1997) *Annals of Internal Medicine* **127**:635-642.

Edward Jenner

Edward Jenner (1749 to 1823) (Figure) was the third child of Reverend Stephen Jenner, vicar of Berkeley, Gloucestershire. At 13 years of age, he became an apprentice to Daniel Ludlow, an eminent surgeon in Sodbury, near Bristol. It was there that Jenner heard a dairymaid say "I shall never have smallpox for I have had cowpox. I shall never have an ugly pockmarked face" (57). This belief was part of common lore. At 21 years of age, Jenner was apprenticed to John Hunter in London. With Hunter, Jenner learned surgical techniques and, more important, use of the scientific method, which his instructor summarized as follows (58): "Why think & emdash; why not try the experiment?" Jenner was also interested in natural science; he classified a species that Captain Cook brought back from his first voyage. In 1772, Jenner declined Cook's offer to take part in the second voyage and returned to Gloucestershire. At Hunter's suggestion, Jenner wrote several scientific studies; the most important of these was "Observations on the natural history of the cuckoo," published in 1788 (59). For that work, Jenner was named Fellow of the Royal Society (60).

Regardless of Jenner's other successes, the connection between cowpox and smallpox continued to intrigue him, as his comments to Edward Gardner in 1780 reveal. By 1788, Jenner was convinced of the truth of the popular belief that cowpox protected against the human disease. He drew sketches of a milkmaid's hand that showed the characteristic cowpox marks and showed them to Hunter and other experts (61). By that time, Jenner must have been planning to test his hypothesis by inoculating persons with material from cowpox lesions and was waiting for an opportunity. **The moment came in May 1796, when a milkmaid named Sarah Nelmes developed cowpox through contact with a cow. On 14 May, Jenner extracted fluid from a pustule on Nelmes’s hand and used it to inoculate a healthy 8-year-old boy named James Phipps through two half-inch incisions on the surface of the arm. Six weeks later, Jenner variolated the child but produced no reaction. He performed the procedure again some months later with the same result (62).**

Despite this breakthrough and the "redoubled ardour" that Jenner promised in a letter to his friend Gardner, he was not able to resume his experiments until the spring of 1798 because no new cases of cowpox were recorded in the vicinity (25). **At the end of 1796, Jenner sent an article to the Royal Society describing 13 persons who had previously had cowpox in whom variolation had induced no reaction. It also described the experiment with James Phipps. However, Sir Joseph Banks, the President of the Royal Society, and Sir Everard Home rejected the manuscript for publication in Philosophical Transactions of the Royal Society. The Council of the Royal Society repulsed Jenner because he was "in variance with established knowledge" and "incredible." Jenner was further warned: "He had better not promulgate such a wild idea if he valued his reputation" (58).** Jenner added new material to his manuscript and revised it substantially. On the advice of friends, he decided to finance its publication himself. It finally appeared under the title "An inquiry into the causes and effects of the variolae vaccinae, a disease discovered in some of the western counties of England, particularly Gloucestershire, and known by the name of the cow pox." The word vaccinae was from the Latin vaca, meaning "cow." Jenner described 10 cases of vaccination and 13 persons who had had cowpox in whom variolation was unsuccessful (63).

The Controversy Surrounding "Inquiry"

The reaction to Jenner’s "Inquiry" was initially unfavorable, and his work was subjected to fierce criticism. Some physicians were skeptical; others had a financial interest in variolation. Shortly after publication of the article, Jenner went to London in search of volunteers for

vaccination; however, after 3 months, he had found none. In the capital, vaccination was made popular by other physicians, such as the surgeon Henry Cline (to whom Jenner had given material for use in vaccination); George Pearson, from St. George's Hospital; and William Woodville, from London's Smallpox and Inoculation Hospital (64). Jenner's findings were confirmed by Pearson, who began vaccinating in 1799; Jenner conducted a nationwide survey in search of proof of resistance to smallpox or to variolation among persons who had had cowpox. The results of this survey confirmed Jenner's theory (58). Woodville vaccinated about 600 persons in the first 6 months of 1799 (65); many of these persons developed generalized rashes that differed considerably from those found by Jenner. Jenner attributed this to the use of lancets contaminated with the smallpox virus (55). It is probable that mistakes were made during the development of the vaccine; on many occasions, smallpox rashes were confused with cowpox rashes, presumably leading to the use of smallpox material for vaccination. Another possible source of error was the contamination of the pustule fluid with the smallpox virus. This was always a danger because the same lancets were used for variolation and for vaccination.

Appendix II: Possible outcomes from the framework of questions.

Example One: Organ cloning

Cloning has received significant publicity since the scientists at Roslin Institute in Scotland generated Dolly. While animals of (almost) identical genetic make-up can be generated naturally or from splitting cells from the young embryo, Dolly was the first animal to be generated from a tissue cell of a grown animal. Since the arrival of Dolly was publicly announced in 1997, several research groups around the world have reported the arrival of cloned animals from a variety of adult cells.

While most of the public focus has been on the production of complete animal clones, the medical research community has been excited by the possibility of producing tissues and/or organs by the cloning process for repair or replacement of damaged tissues and/or organs. When this process is perfected, the need for organ donation from other humans or other animals (xenotransplantation) will no longer be necessary. Furthermore, most of the current ethical debate about cloning (the generation of an individual without two biological parents) will fade 10 to 15 years in the future, as issues are raised, discussed, and addressed by putting appropriate safeguards in place.

To illustrate this example, responses from two (imaginary) members of the public are recorded. The first is a mother whose 15-year-old son requires a kidney transplant; the second is an unmarried person without a particular interest in science, but with strong religious convictions.

The following are general points raised by the responses.

1.1 Questions 4, 6 and 7 do not require responses since they do not pertain to biological or animal matters.

The mother:

2.1 responds that there is a favourable return for health, fitness and physical well-being for herself, her family, New Zealand and globally. She felt there was no particular benefit for her community, because afflictions requiring organ transplants are relatively rare (however, if cloning is extended to production of skin, muscle, bone and blood, this may not be true). She realises there will be no benefit in the immediate future, as cloning organs is not yet possible.

2.2 believes that there will be no impact on the guiding values or principles for herself or her family, since they are ethically comfortable with the science of cloning. However, she records “unsure” for the community, New Zealand and the globe because she doesn’t feel well enough informed to respond on behalf of others.

2.3 is unsure about the effects of cloning on freedom, safety and social standing.

2.4 considers that animals will be better off, presumably because they will not be required to donate tissues to humans. Because the cloning only involves tissue production for repair or replacement, she feels that the effect of cloning on animal productivity or usefulness will be neutral.

2.5 generally considers herself to be well informed about how cloning would affect herself and her family. However she would consider new information useful to assist her understanding the impact on people beyond her immediate family.

2.6 draws an overall conclusion that organ cloning is useful, but should have some legal restrictions. The reason for her indicating legal restrictions probably lie in her being

unsure about the impact of organ cloning on guiding values or principles and freedom, safety and social standing for some sectors of society.

2.7 She is quite clear about the benefits of cloning, but is unsure as to whether there might be some negative issues to do with guiding values or principles.

The unmarried man:

3.1 responds negatively to all questions regarding health, fitness and physical well-being, except that he does not believe it will impact directly on himself within the next 2 years. This is partly because he is not aware that cloning is not just the production of an entire individual, and partly because he believes that cloning interferes with the physical integrity of the individual.

3.2 is concerned that guiding values or principles will be negatively affected for everyone.

3.3 is unsure whether freedom, safety and social standing will be affected.

3.4 considers that animals will also be affected negatively. This is because he has not been informed that the form of cloning being used only generates tissues or organs.

3.5 does not consider that new information will be useful, except for his understanding of the health, fitness and physical well-being of people nationally and internationally.

3.6 sees no benefits at all from cloning, but is quite clear about the potential harms.

Table 1a. Assessment of the effects of cloning (mother of son requiring a kidney transplant).

You should answer each question for how you think cloning will affect you, your family, your community, New Zealand and the globe. You should use a "+" for a beneficial effect, "-" for a negative impact, "0" for neutral affect, "?" for not sure and leave the box blank if cloning does not impact on the issue queried.

	You	Your Family	Your Community	New Zealand	Global
1. Health, fitness and well-being of people What do you think the impact of cloning will be health, etc:					
♦ during the next 2 years?	0	+	0	+	+
♦ 10 years from now?	+	+	0	+	+
♦ on future generations?	+	+	0	+	+
2. Guiding values or principles What do you think the impact of cloning will be on:					
♦ moral, religious or ethical values?	0	0	?	?	?
♦ cultural integrity, standing or safety?	0	0	?	?	?
♦ social harmony?	0	0	?	?	?
♦ professional integrity?	0	0	?	?	?
3. Freedom, safety and social standing What do you think the impact of cloning will on:					
♦ privacy?					
♦ security or safety?					
♦ image, standing or influence?	?	?	?	?	?
4. Economic and financial matters What do you think the impact of cloning will on:					
♦ earning power, financial viability and financial security?					
♦ economic development and competitiveness?					
5. Animals What do you think the impact of cloning will on:					
♦ humane treatment of animals?	+	+	+	+	+
♦ animal health and welfare?	+	+	+	+	+
♦ animal productivity or usefulness?	0	0	0	0	0
♦ future generations of animals?	+	+	+	+	+
6. Plants What do you think the impact of					

cloning will on: ♦ the availability or usefulness of plants generally? ♦ the food and health-enhancing value of plants? ♦ the availability of plants used for building, paper or fuel? ♦ future generations of plants					
7. The environment, climate and atmosphere What do you think the impact of cloning will on: ♦ the environment generally? ♦ air? ♦ soil? ♦ water (fresh, salt and ice)?					
8. Issues pertaining to the Treaty of Waitangi What do you think the impact of cloning will be on: ♦ Taonga? ♦ Mauri? ♦ Kaitiakitanga? ♦ Mana and Rangatiratanga?					
9. Other issues					

Table 2a. Would more information about cloning have been useful in making your decisions in table 1 (mother of son requiring a kidney transplant)?
Overall, how would you rate your knowledge of cloning: none, a little, average, a lot, expert, in relation to your assessment in table 1? Reconsider your initial response. Place a "Y" for yes, "N" for no, "0" for unsure and leave blank for not applicable.

	You	**Your Family**	**Your Community**	**NZ**	**Global**
1. Health, fitness and well-being of people	N	N	0	Y	Y
2. Guiding values or principles	N	N	Y	Y	Y
3. Freedom, safety and social standing	Y	Y	Y	Y	Y
4. Economic and financial matters					

5. Animals	N	N	N	N	N
6. Plants					
7. The environment, climate and atmosphere					
8. Issues pertaining to the Treaty of Waitangi					
9. Other issues					

Table 3a. Arriving at a conclusion about cloning(mother of son requiring a kidney transplant).

Having completed tables 1 and 2, place a tick (✓) alongside the option that best reflects your feelings.

Outcome	**Decision**
Made available with no restrictions	
Made available with legal restrictions	✓
Considered via a referendum	
Availability delayed pending further scientific study	
Availability delayed pending further public discussion	
Availability delayed pending further development of improved safeguards	
Banned	
I cannot make an informed decision	

Table 4a. Identify the most important issues in your decision making about cloning (mother of son requiring a kidney transplant).

Select up to three of the most important potential benefits and up to three of the most important potential harms by placing a tick (✓) in the appropriate boxes. If you wish you may provide a ranking by using 1 for the most important and 3 for the least important. Additional comment may be provided in writing.

Issue	Most Important Potential Benefits	Most Important Potential Harms
1. Health, fitness and well-being of people	1	
2. Guiding values or principles		✓?
3. Freedom, safety and social standing		
4. Economic and financial matters		
5. Animals	2	
6. Plants		
7. The environment, climate and atmosphere		
8. Issues pertaining to the Treaty of Waitangi		
9. Other issues		

Table 1b. Assessment of the effects of cloning (unmarried man with limited science familiarity and strong religious beliefs).

You should answer each question for how you think cloning will affect you, your family, your community, New Zealand and the globe. You should use a "+" for a beneficial effect, "-" for a negative impact, "0" for neutral affect, "?" for not sure and leave the box blank if cloning does not impact on the issue queried.

	You	Your Family	Your Community	New Zealand	Global
1. Health, fitness and well-being of people What do you think the impact of cloning will be health, etc:					
♦ during the next 2 years?	0	-	-	-	-
♦ 10 years from now?	-	-	-	-	-
♦ on future generations?	-	-	-	-	-
2. Guiding values or principles What do you think the impact of cloning will be on:					
♦ moral, religious or ethical values?	-	-	-	-	-
♦ cultural integrity, standing or safety?	-	-	-	-	-
♦ social harmony?	-	-	-	-	-
♦ professional integrity?	-	-	-	-	-
3. Freedom, safety and social standing What do you think the impact of cloning will on:					
♦ privacy?					
♦ security or safety?					
♦ image, standing or influence?	?	?	?	?	?
4. Economic and financial matters *What do you think the impact of cloning will on:*					
♦ earning power, financial viability and financial security?					
♦ economic development and competitiveness?					
5. Animals What do you think the impact of cloning will on:					
♦ humane treatment of animals?	-	-	-	-	-
♦ animal health and welfare?	-	-	-	-	-
♦ animal productivity or usefulness?	-	-	-	-	-
♦ future generations of animals?	-	-	-	-	-
6. Plants What do you think the impact of					

cloning will on: ♦ the availability or usefulness of plants generally? ♦ the food and health-enhancing value of plants? ♦ the availability of plants used for building, paper or fuel? ♦ future generations of plants					
7. The environment, climate and atmosphere What do you think the impact of cloning will on: ♦ the environment generally? ♦ air? ♦ soil? ♦ water (fresh, salt and ice)?					
8. Issues pertaining to the Treaty of Waitangi What do you think the impact of cloning will be on: ♦ Taonga? ♦ Mauri? ♦ Kaitiakitanga? ♦ Mana and Rangatiratanga?					
9. Other issues					

Table 2b. Would more information about cloning have been useful in making your decisions in table 1 (unmarried man with limited science familiarity and strong religious beliefs)?

Overall, how would you rate your knowledge of cloning: none, a little, average, a lot, expert, in relation to your assessment in table 1? Reconsider your initial response. Place a "Y" for yes, "N" for no, "0" for unsure and leave blank for not applicable.

	You	**Your Family**	**Your Community**	**NZ**	**Global**
1. Health, fitness and well-being of people	N	N	N	Y	Y
2. Guiding values or principles	N	N	N	N	N
3. Freedom, safety and social standing	N	N	N	N	N
4. Economic and financial matters					

5. Animals	N	N	N	N	N
6. Plants					
7. The environment, climate and atmosphere					
8. Issues pertaining to the Treaty of Waitangi					
9. Other issues					

Table 3b. Arriving at a conclusion about cloning (unmarried man with limited science familiarity and strong religious beliefs).

Having completed tables 1 and 2, place a tick (✓) alongside the option that best reflects your feelings.

Outcome	**Decision**
Made available with no restrictions	
Made available with legal restrictions	
Considered via a referendum	
Availability delayed pending further scientific study	
Availability delayed pending further public discussion	
Availability delayed pending further development of improved safeguards	
Banned	✓
I cannot make an informed decision	

Table 4b. Identify the most important issues in your decision making about cloning (unmarried man with limited science familiarity and strong religious beliefs).

Select up to three of the most important potential benefits and up to three of the most important potential harms by placing a tick (✓) in the appropriate boxes. If you wish you may provide a ranking by using 1 for the most important and 3 for the least important. Additional comment may be provided in writing.

Issue	Most Important Potential Benefits	Most Important Potential Harms
1. Health, fitness and well-being of people		✓
2. Guiding values or principles		✓
3. Freedom, safety and social standing		
4. Economic and financial matters		
5. Animals		✓
6. Plants		
7. The environment, climate and atmosphere		
8. Issues pertaining to the Treaty of Waitangi		
9. Other issues		

Example Two: Nano-bulldozers for removing plaque from arteries

Nano-technology will soon enable the construction of minuscule machines that will have a wide range of applications. They might arguably be the next growth area in "goods", particularly in the medical field. One example could be the targeting of plaque in arteries that causes arteriosclerosis. A number of these "nano-bulldozers" could be injected into the bloodstream and left to do their job 24 hours a day.

There would be a number of concerns for those who first use these machines. For example, who or what controls the movement of the machines, will they work on arteries in the brain, and can they be removed from the bloodstream?

To illustrate this example, responses from two (imaginary) people are recorded. The first is the daughter of a 50 year old man who has arteriosclerosis and has been told his life expectancy is about 5 years. The second is a tertiary Arts degree student who does not have a good grasp of science and technology, but is quite comfortable with computers and has read many science fiction books.

The following are general points raised by the responses.

1.2 Questions 4, 6 and 7 do not require responses since they do not pertain to biological or animal matters.

The daughter:

2.1 Considers there are benefits for all humans, except for herself in the immediate future (presumably because she is healthy).

2.2 Feels that the guiding principles and values for herself and her family will not be affected, but she is not prepared to make a judgement for those more distant from her.

2.3 Does not know how this technology will impact on freedom, safety and social standing.

2.4 Is open to considering additional information.

2.5 Indicates that nano-bulldozers for removing plaque from arteries should be made available, but with legal restrictions because she is unsure of how comfortable society at large is with the technology.

2.6 Is clear about the potential benefits being directly to the health, fitness and physical well-being of people. She is unsure as to whether there are any potential harms, but does indicate two possible concerns.

The tertiary arts degree student:

3.1 Indicates that he knows very little about the technology.

3.2 Is prepared to consider new information.

3.3 Agrees that he cannot make an informed decision.

Table 1c. Assessment of the effects of nano-bulldozers for removing plaque from arteries (daughter of 50-year-old man with arteriosclerosis).
You should answer each question for how you think cloning will affect you, your family, your community, New Zealand and the globe. You should use a "+" for a beneficial effect, "-" for a negative impact, "0" for neutral affect, "?" for not sure and leave the box blank if cloning does not impact on the issue queried.

	You	Your Family	Your Community	New Zealand	Global
1. Health, fitness and well-being of people What do you think the impact of nano-bulldozers will be health,etc:					
♦ during the next 2 years?	0	+	+	+	+
♦ 10 years from now?	+	+	+	+	+
♦ on future generations?	+	+	+	+	+
2. Guiding values or principles What do you think the impact of nano-bulldozers will be on:					
♦ moral, religious or ethical values?	0	0	?	?	?
♦ cultural integrity, standing or safety?	0	0	?	?	?
♦ social harmony?	0	0	?	?	?
♦ professional integrity?	0	0	?	?	?
3. Freedom, safety and social standing What do you think the impact of nano-bulldozers will on:					
♦ privacy?					
♦ security or safety?					
♦ image, standing or influence?	?	?	?	?	?
4. Economic and financial matters What do you think the impact of nano-bulldozers will on:					
♦ earning power, financial viability and financial security?					
♦ economic development and competitiveness?					
5. Animals What do you think the impact of nano-bulldozers will on:					
♦ humane treatment of animals?	?	?	?	?	?
♦ animal health and welfare?	?	?	?	?	?
♦ animal productivity or usefulness?	0	0	0	0	0
♦ future generations of animals?	+	+	+	+	+
6. Plants What do you think the impact of nano-					

bulldozers will on: ♦ the availability or usefulness of plants generally? ♦ the food and health-enhancing value of plants? ♦ the availability of plants used for building, paper or fuel? ♦ future generations of plants					
7. The environment, climate and atmosphere What do you think the impact of nano-bulldozers will on: ♦ the environment generally? ♦ air? ♦ soil? ♦ water (fresh, salt and ice)?					
8. Issues pertaining to the Treaty of Waitangi What do you think the impact of nano-bulldozers will be on: ♦ Taonga? ♦ Mauri? ♦ Kaitiakitanga? ♦ Mana and Rangatiratanga?					
9. Other issues					

Table 2c. Would more information about nano-bulldozers have been useful in making your decisions in table 1 (daughter of 50-year-old man with arteriosclerosis)?
Overall, how would you rate your knowledge of nano-bulldozers: none, a little, average, a lot, expert, in relation to your assessment in table 1? Reconsider your initial response. Place a "Y" for yes, "N" for no, "0" for unsure and leave blank for not applicable.

	You	**Your Family**	**Your Community**	**NZ**	**Global**
1. Health, fitness and well-being of people	N	N	N	N	N
2. Guiding values or principles	N	N	Y	Y	Y
3. Freedom, safety and social standing	N	N	Y	Y	Y
4. Economic and financial matters					

5. *Animals*	Y	Y	Y	Y	Y
6. *Plants*					
7. The environment, climate and atmosphere					
8. Issues pertaining to the Treaty of Waitangi					
9. Other issues					

Table 3c. Arriving at a conclusion about nano-bulldozers (daughter of 50-year-old man with arteriosclerosis).

Having completed tables 1 and 2, place a tick (✓) alongside the option that best reflects your feelings.

Outcome	**Decision**
Made available with no restrictions	
Made available with legal restrictions	✓
Considered via a referendum	
Availability delayed pending further scientific study	
Availability delayed pending further public discussion	
Availability delayed pending further development of improved safeguards	
Banned	
I cannot make an informed decision	

Table 4c. Identify the most important issues in your decision making about nano-bulldozers (daughter of 50-year-old man with arteriosclerosis).

Select up to three of the most important potential benefits and up to three of the most important potential harms by placing a tick (✓) in the appropriate boxes. If you wish you may provide a ranking by using 1 for the most important and 3 for the least important. Additional comment may be provided in writing.

Issue	Most Important Potential Benefits	Most Important Potential Harms
1. Health, fitness and well-being of people	1	
2. Guiding values or principles		✓?
3. Freedom, safety and social standing		✓?
4. Economic and financial matters		
5. Animals	2	
6. Plants		
7. The environment, climate and atmosphere		
8. Issues pertaining to the Treaty of Waitangi		
9. Other issues		

Table 1d. Assessment of the effects of nano-bulldozers for removing plaque from arteries (tertiary Arts degree student).

You should answer each question for how you think cloning will affect you, your family, your community, New Zealand and the globe. You should use a "+" for a beneficial effect, "-" for a negative impact, "0" for neutral affect, "?" for not sure and leave the box blank if cloning does not impact on the issue queried.

	You	Your Family	Your Community	New Zealand	Global
1. Health, fitness and well-being of people What do you think the impact of nano-bulldozers will be health, etc:					
♦ during the next 2 years?	?	?	?	?	?
♦ 10 years from now?	?	?	?	?	?
♦ on future generations?	?	?	?	?	?
2. Guiding values or principles What do you think the impact of nano-bulldozers will be on:					
♦ moral, religious or ethical values?	?	?	?	?	?
♦ cultural integrity, standing or safety?	?	?	?	?	?
♦ social harmony?	?	?	?	?	?
♦ professional integrity?	?	?	?	?	?
3. Freedom, safety and social standing What do you think the impact of nano-bulldozers will on:					
♦ privacy?					
♦ security or safety?					
♦ image, standing or influence?	?	?	?	?	?
4. Economic and financial matters What do you think the impact of nano-bulldozers will on:					
♦ earning power, financial viability and financial security?					
♦ economic development and competitiveness?					
5. Animals What do you think the impact of nano-bulldozers will on:					
♦ humane treatment of animals?	?	?	?	?	?
♦ animal health and welfare?	?	?	?	?	?
♦ animal productivity or usefulness?	?	?	?	?	?
♦ future generations of animals?	?	?	?	?	?
6. Plants What do you think the impact of nano-					

bulldozers will on: ♦ the availability or usefulness of plants generally? ♦ the food and health-enhancing value of plants? ♦ the availability of plants used for building, paper or fuel? ♦ future generations of plants					
7. The environment, climate and atmosphere What do you think the impact of nano-bulldozers will on: ♦ the environment generally? ♦ air? ♦ soil? ♦ water (fresh, salt and ice)?					
8. Issues pertaining to the Treaty of Waitangi What do you think the impact of nano-bulldozers will be on: ♦ Taonga? ♦ Mauri? ♦ Kaitiakitanga? ♦ Mana and Rangatiratanga?					
9. Other issues					

Table 2d. Would more information about nano-bulldozers have been useful in making your decisions in table 1 (tertiary Arts degree student)?

Overall, how would you rate your knowledge of nano-bulldozers: none, a little, average, a lot, expert, in relation to your assessment in table 1? Reconsider your initial response. Place a "Y" for yes, "N" for no, "0" for unsure and leave blank for not applicable.

	You	**Your Family**	**Your Community**	**NZ**	**Global**
1. Health, fitness and well-being of people	Y	Y	Y	Y	Y
2. Guiding values or principles	Y	Y	Y	Y	Y
3. Freedom, safety and social standing	Y	Y	Y	Y	Y
4. Economic and financial matters					

5. Animals	Y	Y	Y	Y	Y
6. Plants					
7. The environment, climate and atmosphere					
8. Issues pertaining to the Treaty of Waitangi					
9. Other issues					

Table 3d. Arriving at a conclusion about nano-bulldozers (tertiary Arts degree student).

Having completed tables 1 and 2, place a tick (✓) alongside the option that best reflects your feelings.

Outcome	**Decision**
Made available with no restrictions	
Made available with legal restrictions	
Considered via a referendum	
Availability delayed pending further scientific study	
Availability delayed pending further public discussion	
Availability delayed pending further development of improved safeguards	
Banned	
I cannot make an informed decision	✓

Table 4d. Identify the most important issues in your decision making about nano-bulldozers (tertiary Arts degree student).

Select up to three of the most important potential benefits and up to three of the most important potential harms by placing a tick (✓) in the appropriate boxes. If you wish you may provide a ranking by using 1 for the most important and 3 for the least important. Additional comment may be provided in writing.

Issue	Most Important Potential Benefits	Most Important Potential Harms
1. Health, fitness and well-being of people		
2. Guiding values or principles		
3. Freedom, safety and social standing		
4. Economic and financial matters		
5. Animals		
6. Plants		
7. The environment, climate and atmosphere		
8. Issues pertaining to the Treaty of Waitangi		
9. Other issues		

Appendix III: Introducing an investigation into public perceptions of possum biocontrols.

Ethical Issues of New and Emerging Technologies

Office of the
PARLIAMENTARY COMMISSIONER FOR THE ENVIRONMENT
Te Kaitiaki Taiao a Te Whare Pāremata

INTRODUCING AN INVESTIGATION INTO PUBLIC PERCEPTIONS OF POSSUM BIOCONTROLS

Background

This project will principally explore public attitudes to fertility-based biocontrol technology for possums. Biological control techniques, especially immuno-contraception, have been identified as an important potential advance for possum control. In the last 5-8 years researchers have made significant advances in the basic science necessary for developing such fertility controls. However, public understanding and discussion of this work has probably lagged far behind.

Soon, some important decisions will have to be made by research agencies and funders on which, if any, biocontrol techniques to concentrate on and develop towards application and delivery in New Zealand. It will become increasingly risky - from public interest, environmental and commercial perspectives - to make these further investments without reasonable prospects for public acceptance for such technology to be used. In this context the broad range of concerns and issues relating to all kinds of 'new biotechnologies' arise, e.g. use of genetically-engineered crops, medicines and other products, and consumption of genetically-engineered food ingredients. In this project, fertility controls for possums will be the focus, as an example of such technologies.

Previous recent work in New Zealand on public attitudes to biological control of animal pests sets some context for the proposed investigation. Since that earlier work was undertaken, the release of the RCD virus release in New Zealand may have altered some perceptions of biocontrols. The current public controversy about genetically modified food may also influence public attitudes to other forms of biotechnology.

The project will also explore issues relating to the provision of information about fertility controls: how much is known by the public, who should provide further information, how should this information be communicated, and which sources of information are trusted?

The project is being undertaken by the Parliamentary Commissioner for the Environment under s 16(f) of the Environment Act. The Commissioner is being supported in this project by a Reference Group (see below) and by the two Crown Research Institutes involved in possum control research, Landcare Research New Zealand Ltd and New Zealand Pastoral Agriculture Research Ltd (Agresearch).

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Ethical Issues of New and Emerging Technologies

Research approach

The project will require a brief 'plain-English' description of the types of fertility control techniques currently being investigated in New Zealand. A survey or series of focus groups will then be arranged to explore perceptions of these techniques, and the results obtained from these surveys/focus groups will be explored and reported.

Reference Group

To assist the Commissioner in planning, executing and reporting on the project, a Reference Group is being set up. Proposed roles for the Reference Group are:

1. Approve proposed methodology and survey design
2. Suggestion for groups to be surveyed
3. Review report and other project outputs
4. Public education role.

The composition of the Reference Group represents a wide range of interested parties.

Outcomes

Essential components of information expected from the project:

1. Levels of acceptability of different biocontrol approaches to various participant groups.
2. Reasons for different levels of acceptability. What are the key factors making different approaches acceptable or not acceptable?
3. What information do different public groups need and from whom would they accept it?

Results will be reported and distributed widely in written, electronic and oral forms. Collaboration with the Talking Technology Trust, which is hoping to convene a Talking Technology consensus conference on the same topic in late 1999 or early 2000, is being investigated.

Preliminary timetable

April - July 1999	Complete scoping and background work, convene Reference Group, confirm methodology
August - September 1999	Information gathering and analysis
October - December 1999	Report writing and editing

Further information

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