The genetic manipulation of plants, animals and microbes : the social and ethical issues for consumers : a discussion paper / by Roger Straughan.

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Straughan, Roger.
National Consumer Council.

Publication/Creation

London : National Consumer Council, 1989.

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The genetic manipulation of plants, animals and microbes

The social and ethical issues for consumers: a discussion paper

by Dr Roger Straughan

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24 AUG 1992 1642
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August 1989 PD 20/89

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Foreword

The issues raised by genetic manipulation are clearly of great importance to consumers. Here at the National Consumer Council, we felt that it would be helpful to commission advice before we took any views on the subject ourselves. Our food policy committee therefore commissioned this paper from Roger Straughan of Reading University. We believe that it is an interesting and helpful analysis of the issues involved and that it will be helpful to others besides ourselves as a basis for promoting an informed public debate on the subject. We have therefore decided to circulate it as a discussion paper.

We should very much appreciate any comments you want to make on Dr Straughan's paper. We should like to have views from the widest possible range of interested people before coming to any conclusion on the subject ourselves.

Jill Moore OBE
Chairman of the NCC's food policy committee
August 1989

If you would like to comment on this paper, please write to Ann Foster, National Consumer Council, 20 Grosvenor Gardens, London SW1W ODH, by 9 October 1989.

Contents

The genetic manipulation of plants, animals and microbes

A discussion paper on the social and ethical issues for consumers

by Dr Roger Straughan

Introduction

Genetic manipulation is a vast, complex and potentially emotive subject, and strict limits must be set to the scope of any report on the subject if it is to be useful and coherent. Therefore:

- this paper is restricted to issues concerning the genetic manipulation of plants, animals and microbes. (Microbes are the smallest form of life and include bacteria, viruses, moulds and single-celled plants and animals.) The paper does not deal with the genetic manipulation of human beings;
- genetic manipulation is considered largely in the context of food production. Medical and other applications are not discussed in any detail;
- the issues raised are related to consumer interests, whenever possible and appropriate;
- this paper is not written from a specifically scientific, economic, sociological or political viewpoint, though it is of course necessary to refer to such viewpoints when appropriate.

Given these limitations, precisely what sort of issues will the paper then focus upon, and from what perspective?

The "social/ethical issues" referred to in the title are intended to cover a wide variety of issues which raise questions about moral values, principles, obligations and rights. Scientific and technological questions tend to ask *can X be done?* while moral questions ask *should it be done?* As is seen in sections 3 to 5 these questions in the context of genetic manipulation can be crudely sub-divided into three further questions: *is it safe? is it fair? is it natural?* Anybody, of course, is entitled to ask and try to answer these questions, but one helpful perspective from which to tackle them is the philosophical one. It is becoming increasingly realised that philosophical methods can be usefully applied to a wide range of practical and often controversial topics, of which genetic manipulation is an excellent example. These methods involve, among other things, asking two key questions: *what do we mean?* and *how do we know?* Not only do these basic questions lie at the heart of all philosophy; they also lie at the heart of this paper. The *what do you mean?* question draws attention to the confusing (and perhaps confused) terminology of biotechnology and the emotive language that is often used in debates about it; the *how do you know?* question highlights the need for evidence and logical argument in these debates. To persist in asking these questions until we are clearer in our minds about what exactly is at stake here is the most practical and rational approach we can adopt in exploring this potential minefield.

Section 1 tries to clear the ground by looking at what is meant by genetic manipulation and how it relates to the wider area of biotechnology. Section 2 summarises some of the main benefits which are likely to result from the genetic manipulation of plants, animals and microbes. Section 3 examines issues concerning safety and risk. Section 4 discusses some of the socio-economic problems which genetic manipulation may create. Section 5 explores some of the religious/metaphysical objections to genetic manipulation. Section 6 summarises the conclusions reached and suggests some of the implications for consumers.

Section 1. What are we talking about?

Biotechnology, genetic engineering and manipulation, gene-splicing, and even recombinant DNA techniques are terms which are no longer used only within the scientific community, and are increasingly impinging upon the awareness of the general public. Newspaper and magazine articles together with radio and TV features are devoting an ever-growing coverage to these subjects and the issues which they raise. For example, during a period of about three months in the early part of 1989 considerable publicity was given on radio (*Face the Facts*, two programmes; *Today*, four reports) and on TV (*Country File*, *Panorama, Split Screen* and *The Life Revolution*, six programmes). During the same period a series of public lectures was given on "Biotechnology: the ethical issues" at the Centre for Social Ethics and Policy at the University of Manchester.

Despite such activity, however, it is doubtful whether many non-scientists could give a clear account of what techniques are involved in genetic manipulation. This is hardly surprising, as even the experts seem inconsistent and imprecise at times in their use of the above terms. All that can be offered here, then, are some rough and ready definitions which seem to command a reasonable level of agreement and which should help us sort out precisely what this report is dealing with.

It is generally accepted that "biotechnology" is a label which is both broad and elastic. It has been variously defined as:

(a) "any technique that uses living organisms or parts of organisms to make or modify products to improve plants or animals or to develop micro-organisms for specific uses" (1);

(b) "the application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services" (2);

(c) "the application of biological organisms, systems and processes to manufacturing and service industries" (3), and;

(d) "the use of plant and animal cells, microbes and their products to produce substances that are useful to mankind" (4).

Biotechnology has in fact been practised for thousands of years - ever since men and women started to make such products as cheese, bread, wine and beer - though the use of traditional fermentation processes has not tended to generate much in the way of ethical controversy. Such controversy has arisen directly from one branch of modern biotechnology - genetic manipulation, which is likely to be used increasingly to produce food from plants, animals and microbes. Again there is nothing new about the aims of this enterprise, for the selective breeding of plants and animals to improve yield is a practice probably as old as farming itself. The novelty and consequent controversy involves the development and application of revolutionary new means of achieving this long established end.

Genetic manipulation or engineering (the two terms are used interchangeably) refers to techniques of transferring genetic material from one species to another; these are known more technically as recombinant DNA techniques. Since Crick and Watson's pioneering work in the early 1950s, there have been rapid developments in scientists' understanding of how genetic information is passed from one cell to another and from one generation to another. DNA (deoxyribonucleic acid) is in effect the molecular basis of heredity, each molecule containing two complementary strands assembled in the pattern of a spiral staircase - the double helix.

Genetic manipulation allows pieces of DNA from a plant, animal or micro-organism to be transferred to a host organism in which they do not naturally occur, but in which they are capable of continued propagation (5). By this means the gene for a particular trait can be incorporated in a different species. Genetic manipulation is thus just one technique of modern biotechnology - embryo transfer, for example, is another.

Genetic manipulation has already in its short life been shown to have many possible revolutionary applications. Many of these relate to agricultural methods and to the production of food and drink; this area provides the focus of the report and is summarised in the next section. However, there are other important areas of application, actual or potential, some examples of which are briefly mentioned here to indicate the scope of this new technology.

One of the earliest achievements of genetic manipulation was the production in 1979 of human insulin. Hitherto, insulin for diabetics had to be extracted from the pancreas of pigs or cows, but by transferring DNA to certain bacteria it was found possible to modify them in such a way as to produce human insulin, thereby reducing the problems of supply and of allergic response by some diabetics. Other uses of genetic manipulation in human health care include the production of the drug interferon, blood-clotting protein, various vaccines and human growth hormones to treat dwarfism, in addition to the development of new diagnostic tests for diseases such as AIDS. Genetic manipulation is likely to provide powerful weapons in the future treatment of cancer and cardio-vascular illness. By the 1990s it is expected that a major part of the health care industry will have been affected by genetic manipulation, and the potential for major advances in this area is clearly enormous (6).

Another highly topical area of application is pollution control and waste management. Specialised micro-organisms can be used to degrade dioxin and other pollutants in chemicals. Oil spills and sewage can also be "eaten up" by certain organisms and there is the possibility of developing a biodegradable plastic (7). Other possible applications of massive significance are in the field of energy resources. Fuel alcohol and methane gas can already be produced by biotechnological techniques, and there are prospects of adding hydrogen gas to this list. The development of specialised strains of yeast by genetic manipulation could in time increase the yield of fuel alcohol by fermentation processes, and so decrease our dependence on fossil fuels such as coal and oil.

These areas of development are worth mentioning briefly here, as they share common general features with agriculture and food production. On the one hand they indicate huge potential benefits for mankind; on the other they are open to many of the same objections which are examined in sections 3 to 5. We now turn to the main subject of this report - the effects of genetic manipulation on agriculture and food production.

Section 2. How can genetic manipulation affect agriculture and food production?

Applications of genetic manipulation to agriculture and food production are basically intended to enhance the useful and desirable characteristics of plants, animals and microbes and to eliminate the undesirable ones. The overall aim is, therefore, to improve the quality and to increase the quantity and profitability of food products. Farmers have of course for centuries aimed to improve their crops and their livestock by rule-of-thumb selection and breeding methods, but genetic manipulation has added a new dimension to this practice. A variety of techniques and approaches has already been developed, and the pace of research and development in this area is likely to increase rapidly. The following are some examples of significant innovations, but this is far from an exhaustive list.

(a) Disease and pest resistance

Genetic manipulation can be used to produce strains of plants which are resistant to common, troublesome diseases and pests. Genes have been identified in a number of species which provide resistance to various insect pests and viruses. Genetically engineered plants have been produced, for example, which are resistant to cucumber mosaic virus, which is a problem for growers of lettuce, tomatoes, cucumber, peppers and other horticultural crops (1). A bacterial gene has also been inserted into tobacco and tomato plants to protect them from leaf-eating insects.

(b) Weed control

Crops have to compete with weeds, but some weedkillers can create as many problems as the weeds they are intended to destroy. Some new classes of herbicide, however, such as glycophosphate, are considered to be environmentally benign, and plants have now been developed which will tolerate this herbicide, thus reducing the need for more harmful chemicals (2).

(c) Frost resistance

Frost damage can ruin a number of crops. This can be prevented to some extent, it is claimed, by removing a gene from certain bacteria which provide a nucleus for ice crystal formation. Spraying this bacteria on vulnerable crops can stop frost forming on the plants at temperatures several degrees below freezing (3). This, however, is one of the more controversial applications of genetic manipulation, as is shown in section 3.

(d) Pest control

The need for chemical pesticides can be reduced by genetic manipulation A genetically engineered bacterium has been produced which acts as a poison to caterpillars feeding on the roots of corn, but appears to be harmless to humans, animals, plants and beneficial insects (4).

(e) Nitrogen fixation

The nitrogen which plants need can be applied to the soil in the form of fertiliser, but this is both expensive and environmentally hazardous. Certain bacteria can take nitrogen from the air, and convert or "fix" it into a form which can be used for plant growth. Genetic manipulation is now being used to alter these bacteria in such a way that they can live in the roots of cereal crops and so provide a ready-made source of fertiliser.

(f) High protein food

Lack of protein is a major cause of malnutrition in many countries of the world. It is possible that palatable high protein food for humans could be produced from industrial waste products, using biotechnological techniques (5).

(g) BST (bovine somatotropin) and milk production

As far as animal food products are concerned, one of the most publicised genetic manipulation techniques to be developed has been in dairying. Bacteria can be genetically engineered to provide Bovine somatotropin (BST, a bovine growth hormone). When administered to cows it can increase milk production by almost a quarter, and it is claimed that no difference can be detected between this milk and milk from untreated cows. The issues raised by BST are discussed fully in sections 3 and 6. Porcine somatotropin has been similarly used to promote rapid growth in pigs and to lower the fat content of pork (6).

(h) Animal health

Genetically engineered vaccines are being developed to protect cattle and pigs against a variety of serious diseases, some of which it is believed may have been spread in the past by defective vaccines (7). It is also hoped that poultry diseases may be tackled by inserting resistant genetic material into chicken chromosomes (8).

(i) Food storage

Genetic manipulation can help to overcome the problem of goods losing nutritional value during storage. Nutritional value can be retained and improved (9) and food quality may be monitored more easily in the future (10).

The above list is merely a brief indication of some of the ways in which genetic manipulation is capable of affecting agriculture and food production. Many other techniques and applications have already been developed, while many more are still at the research stage (11). These examples, however, are sufficient to give an idea of the impact which genetic manipulation is likely to have in the near future and of the potential benefits which could result. These benefits are of obvious interest to consumers because it is claimed that they will lead to the "development of food products with improved nutritional value, better quality, and improved safety, taste and convenience" (12). The same writers make the following points about consumer interests:

The consumer is more concerned about these issues [quoted above] today than ever. Consumer surveys show the public willing to pay more for what it perceives to be a better and more convenient product; it will reject products that do not meet its expectations. Biotechnology research offers a major opportunity to tailor food products to public demands. Existing crop and animal products can be modified through genetic engineering; new crops and new products can be developed (13).

These writers are commenting on the North American consumer scene, but their judgments can be applied equally to the UK. Clearly genetic manipulation offers enormous potential benefits to consumers in the area of food production, as well as the even more exciting possibilities which it opens up for the whole of mankind in the areas of health, pollution control and energy resources.

However, just because possibilities exist, it does not necessarily follow that it is right to pursue them. If it is believed that X *can* be done, further arguments and value judgments are always needed to justify the claim that X *ought* to be done. How does this apply to the subject of this paper?

There appear to be strong prima facie reasons for developing further the techniques of genetically manipulating plants and animals for the purpose of food production; these reasons rest upon the likely significant benefits, outlined above, in terms of increased human welfare. But good prima facie reasons are not necessarily conclusive, particularly where complex issues of the kind raised by genetic manipulation are involved. Various kinds of objection have been and will no doubt continue to be levelled against genetic manipulation, and these objections highlight the social and ethical issues which provide the focus of this report. Let us turn to the first objection, which is probably of most direct concern to most consumers – the question of safety.

Section 3 Is it safe?

In one sense, safety does not appear to be a moral or ethical question. The safety of a product, process or activity is, at least on the face of it, an empirical matter to be determined by experiment and experience. Whether or not a toadstool is safe to eat, for instance, is not an ethical question. Yet questions about safety can be closely related to and can indeed raise ethical questions. To develop the example just given, if it is known that poisonous toadstools grow in profusion in a particular public area, what steps if any should be taken and by whom to prevent people from eating them? Questions about safety, then, raise further ethical questions about responsibility and accountability and about acceptable or justifiable levels of risk.

These general considerations of responsibility, accountability, acceptability and justifiability are all highly relevant to the genetic manipulation of plants, animals and microbes for the purposes of food production; but before we can explore them further, a distinction needs to be drawn between the safety of a *process* and the safety of a *product*. It is in theory quite possible for a safe process to result in an unsafe product, or for an unsafe process to result in a safe product. Controversy over the safety of genetic manipulation has at times confused or conflated these two aspects, but it has been the processes and procedures involved (and their possible consequences) which have created most concern about safety.

Does this make safety in this case a less pressing issue for consumers, whose interests are normally seen as centred on the quality and value of the products they are offered? To some extent this is true; much of the debate about the possible risks of various research techniques is not directly relevant to consumers as such. Nevertheless, consumers are also the public, and public safety must in a broader sense constitute a "consumer interest". Moreover, if some of the more dramatic "doomsday scenarios" which critics of genetic manipulation have proposed ever transpire, there could be either no consumers left to consume anything or nothing consumable left for consumers to consume. This report cannot, therefore, ignore the question of process safety.

Is the process safe?

The early history of the development of genetic manipulation techniques was dominated by disputes about safety, particularly in the USA. These disputes have been graphically documented in great detail in a book by Krimsky which describes the "social history of the recombinant DNA controversy" (1). Basically the fear in the 1970s was, and to some extent still is, that genetically engineered organisms could escape or be deliberately released from the laboratory into the environment with unpredictable and possibly catastrophic consequences. A particular concern was that the bacterium Escherichia coli was being used in experimental work, and that as this bacterium resides naturally in the human gut, genetically engineered variants of it might cause an uncontrollable spread of disease outside the laboratory. Other ecological disasters were hypothesised in the event of modified microbes escaping and "upsetting the balance of nature". An American report justifying new regulatory legislation in 1977 summed up the possible dangers as follows:

Foreign DNA in a micro-organism may alter it in unpredictable and undesirable ways. Should the altered micro-organism escape from containment, it might infect human beings, animals or plants causing disease or modifying the environment. Or the altered bacteria might have a competitive advantage, enhancing their survival in some niche within the ecosystem (2).

During the 1970s increasingly stringent regulations were introduced, and in Japan and Holland genetic manipulation research was totally banned. During the 1980s, however, these regulations have been gradually relaxed as confidence has increased in the view that modified microbes are unlikely to be able to survive outside the laboratory. In the UK the safety of genetic manipulation work is regulated by the Advisory Committee on Genetic Manipulation, which is part of the Health and Safety Executive; this committee also has a Planned Release subcommittee and a Transgenic Animals working party.

Scientists generally seem happy with the present situation and tend to congratulate themselves on their responsible attitude and initial caution. G.H. Fairtlough of Celtech Ltd., for example, comments:

These initial guidelines have in the event proved to be too stringent and most countries have now relaxed some of them in the light of increasing scientific knowledge. This pattern, starting with tough rules which are relaxed as knowledge allows us to be more discriminating, seems to be an excellent one, not least from industry's point of view as the reverse process of loose guidelines, followed by public concern, is likely to lead to permanent over-regulation. It will of course be necessary to keep a careful watch on scientific developments to make sure that radical advances in molecular genetics do not lead to potentially hazardous research being undertaken. On this issue the scientific community has shown itself capable of a *self critical attitude and the response of many governments has been well informed and rapid. We must hope this will continue (3).*

This confidence, however, is not universally shared, and W. Klassen of the United States Department of Agriculture describes two major safety concerns of the general public.

(a). That the release into the environment of genetically engineered micro-organisms may result in some unintended, grievous and perhaps permanent damage or loss, eg., fear that release of bacteria capable of serving as nuclei in the formation of raindrops and ice crystals, might inadvertently cause a global drought. Thus, there is a need for more knowledge of the factors that affect the ability of species to survive, proliferate, and to disperse in nature. Also, greater understanding is needed of the potential for genetic exchange in nature between genetically engineered micro-organisms and other species. Methodology for following the fate in the environment of sparse populations (eg. less than 1000 microbial propagules per gram of soil) need to be developed.

(b). That genetically engineered crop plants may themselves become intractable weeds because resistance to all major herbicides has been spliced into their genetic blueprints. Moreover, some fear that such herbicide resistant crops may cross with wild weedy relatives and, thereby, spread herbicide resistance into sectors of the weed flora (4).

Other writers are less restrained in their portrayal of the potential hazards. Jeremy Rifkin, for example, who has headed the opposition to genetic manipulation in the USA argues that genetically engineered products differ from chemical products in at least three important respects (though it is really the process and not any particular product that he is objecting to here):

- they are alive and thus inherently more unpredictable when introduced into the environment;
- they can reproduce, grow, migrate and mutate;
- they cannot be recalled to the laboratory once released (5).

He also draws an analogy with the introduction of certain "exotic", non-native organisms to North America, claiming that a small percentage of these has "run wild, wreaking havoc on the flora and fauna of the continent", giving the examples of gypsy moths, kudzu vines, Dutch elm disease, chestnut blight, starlings and Mediterranean fruit flies (6). His conclusion is typically dramatic:

Whenever a genetically engineered organism is released there is always a small chance that it too will run amok because, like exotic organisms, it is not a naturally occurring life form. It has been artificially introduced into a complex environment that has developed a web of highly synchronized relationships over millions of years. Each new synthetic introduction is tantamount to playing ecological roulette. That is, while there is only a small chance of it triggering an environmental explosion, if it does, the consequences can be thunderous and irreversible (7).

Rifkin is also not alone in his concern about the effects of genetic manipulation in the overall reduction of "genetic diversity" in the future:

Genetic diversity ensures that each species will have enough variety to effectively adapt to changing environments. By eliminating all of the so-called unprofitable strains and breeds, we undermine the adaptive capacity of each species (8).

This has been seen as an important moral issue by other, more restrained commentators. For example, in Yoxen's sober report on *The Impact of Biotechnology on Living and Working Conditions*, he states:

... the massive loss of genetic resources that is occurring today will have consequences for many generations to come. This then is both a moral issue and a practical question which will have to be dealt with politically (9).

So how safe are the processes involved in genetic manipulation? Unfortunately this crucial, simple-sounding question does not have a simple answer. This is not just because we do not yet have enough factual evidence – though the need to "generate relevant data" is a point repeatedly emphasised in Yoxen's report (10). It will always remain, however, a matter of judgment to decide when sufficient data has been "generated" to allow experiments involving the deliberate release of genetically engineered organisms to go ahead (11).

But why cannot the apparently straightforward question *is it safe?* be given a straightforward yes or no answer? This is because the question in fact conceals considerable complexities, which arise from the following factors.

(a) The whole concept of risk or hazard is a difficult one, and risk assessment is now an established academic field of study. As one example of the difficulties, Krimsky shows how the key term "potentially hazardous", which features prominently in many debates about genetic manipulation, is in fact highly ambiguous.

X is potentially hazardous to P *may be interpreted*

1. X can harm P under conditions $C_1 ... C_n$.
2. It is not known that X cannot harm P under some set of conditions or another.
3. There is some evidence that X may be harmful to P.
4. There is a finite probability that X can harm P.
5. There is a posited scenario of events such that X harms P, where the scenario has neither been confirmed nor disproved (12).

Statements or claims about the "safety" of X will therefore be equally ambiguous.

(b) Scientists cannot "prove" by empirical investigations that one experiment or class of experiments is more hazardous than another without undertaking experiments that are in fact hazardous.

(c) Scientists cannot "prove" by tests and experiments that a particular event will never happen in the future. We can talk only in terms of apparent probabilities. Godown illustrates this point forcefully:

Can science tell us for instance what will be the result of creating and releasing a novel organism from which a single gene has been deleted? Could it ever be flatly stated on the basis of scientifically established facts that there is no possibility of anything going wrong when a genetically engineered organism is deliberately released? The answer is obviously no, and I am willing to be quoted. One cannot prove a universal negative and it is silly to try (13).

(d) Factual evidence provided by experts cannot, therefore, conclusively answer the question, *is it safe?* Decisions about risk and safety will inevitably also involve value judgments, and if these are to be rationally based they will need to take into account:

(i) the balance of potential risk versus potential benefit. The possible risks which the general public (and more specifically, research workers) may run have somehow to be weighed against the likely benefits which may accrue from genetic manipulation. It could be argued here that ethically, in terms of fairness and accountability, those who are likely to benefit most should be those who run the greatest risks (eg. the research scientist, whose livelihood and reputation depends upon his or her experimental work). Giving the general public suitable information about the balance of risk and benefit raises further complex issues which will be considered in more detail later.

(ii) the comparative risks of genetic manipulation techniques. As there can be no activity or procedure which can be guaranteed as totally "risk-free", we can only try to assess risks comparatively. It has been suggested, for example, that the degree of risk involved in genetic manipulation techniques is less than that run in keeping a household pet, and that the risk of an altered E. coli bacterium causing widespread disease is less than the risk incurred in eating a washed radish, raw carrot or piece of lettuce from one's own garden (14). The problem with such comparisons is that they must still be "unproven" for the reasons given above, but they do at least encourage us in our value judgments to acknowledge that "safety" must always be a comparative notion.

(iii) wider issues concerning the responsibilities and obligations of scientists, and the relative value to be placed on scientific progress and the pursuit of new knowledge. For example, it can be argued on the one hand that "the fundamental ethical posture of science should be to do no harm, which implies reducing the risks to a negligible factor regardless of the anticipated benefits" (15); and on the other hand that "it is morally wrong as well as politically dangerous to place restrictions on intellectual activities" (16). Risk avoidance can incur as many social and moral costs as risk-running.

Making decisions about the safety of genetic manipulation processes, therefore, requires that somewhere the balance has to be struck between the paralysis of extreme caution and the irresponsibility of uncontrolled experimentation. The striking of this balance means making value judgments about complex social/ethical issues for which there are no simple answers. Equally complex are questions about how policy decisions are to be made in this area and by whom. At the very least, the public must be made aware of what the main issues are. "The British public is very docile and very ignorant about genetic engineering," stated Professor Peter Campbell of University College London, at a recent symposium (17).

Is the product safe?

This is to some extent a less wide-ranging question, though many of the general points made above concerning risk, and the implications drawn from them, apply here also. Any consumer product in which genetic manipulation plays a part will of course have to satisfy exactly the same standards and regulations as those produced by conventional means; in addition, they are examined by an Advisory Committee on Novel Foods and Processes, which reports to the Ministers of Health and Agriculture.

The clearest and most economical way to demonstrate the relevant issues in this area is to focus on one particular product which has generated considerable publicity and controversy, as it has been the first to impinge upon the awareness of the public and of the consumer. As was mentioned in section 2 (page 9) genetically engineered bovine somatotropin (BST) can be used to boost milk production by up to twenty five per cent. BST is a naturally occurring substance and all milk contains minute traces of it. It is claimed that milk produced from cows injected with genetically engineered BST is indistinguishable from other milk. It should be noted that the use of BST does not involve any genetic manipulation of the cows – "transgenic" animals are not involved here; the genetically engineered BST is used simply as a means of increasing milk production (18).

Genetically engineered BST milk became the subject of controversy in 1987/88, when trials were extended from research institutions to commercial farms. The Ministry of Agriculture, Fisheries and Food (MAFF), after reviewing all available data on the human safety of such milk, authorised the sale of milk from the trials into the pool of normal milk distribution, as they saw no reason to keep the milk off the market or to separate it from other supplies. The identity of the trial farms was not revealed. Consumers, therefore, had no way of knowing whether they were drinking genetically engineered BST milk or not.

A number of objections have been raised against genetically engineered BST milk in the UK and in other countries. These include the following claims:-

- no research has been done on the possible effects of genetically engineered BST milk on the consumer, especially on babies and pregnant mothers. (19) Also, nothing is known about the long-term effects;
- the treatment may reduce the lactation cycle of the cows, leading to production-related disease, or to cows "burning themselves out" (20);
- independent tests of quality and effects on consumers cannot be carried out if genetically engineered BST milk is pooled and not kept separate (21).

Concern has been further fuelled by:

a requirement in the Netherlands that genetically engineered BST milk from trial farms must be discarded;

requests from retailers such as Co-op, Marks & Spencer, Sainsbury, Tesco and Waitrose that genetically engineered BST milk should be kept separate and labelled distinctively;

environmental pressure groups which have in the USA produced television commercials claiming of genetically engineered BST milk: "it could be a health hazard to cows - and the milk you drink will contain that hormone. What are they doing to our milk?" (22). A consumer boycott has been called for by Rifkin: "We're going to ask people all over the United States, 'Do you want milk that came from cows that were injected with growth hormone?' ... BGH is going to be a frontline issue for American consumers ... I don't think it will be accepted by consumers here and in Europe" (23). (BGH – bovine growth hormone – is an alternative term for BST; it raises linguistic issues which will be mentioned in section 6).

On the other side of the fence, those who have developed the product and the technique are equally adamant that genetically engineered BST milk is entirely safe and indistinguishable from other milk. A discussion dossier from Elanco Products Ltd, who produce and test BST, states:

The first thing that must be said is that there is no threat to consumers' health. BST is a protein, it occurs naturally in all cows and an infinitesimal quantity of BST is in all fresh milk. Because BST is a protein, it is digested if taken orally and broken down to inactive component amino acids. The amount that is in milk is not changed by supplementation of the cow herself, nor is any component of the milk significantly changed. Finally, somatotropins are species limited; BST is not active in humans.

BST is safe. There are no dissenters to that fact. Speaking on the UK radio programme Farming Today on October 17, 1988, Rachel Waterhouse of the respected Consumers' Association stated, "We accept that BST is safe. Certainly in the short term, we see no problems about it". Other consumer representatives in other venues have reiterated this statement which is supported by massive amounts of scientific evidence and no contrary data whatsoever (24).

So what is the consumer to make of all this, and what ethical issues, if any, are raised in this example? There appears to be no evidence that genetically engineered BST milk constitutes any threat to human health; but just as there can be no totally risk-free process, so there can be no totally risk-free product, and clearly we can have no evidence of the long-term effects of a product which has been available only since 1987. As in the case of process-safety, a judgment has to be made, weighing the possible risks to the consumer against the possible benefits. (There are also socio-economic arguments against genetically engineered BST milk production, which are considered separately in section 4, while the general issue of animal welfare is examined in section 5.)

As genetically engineered BST milk, like any other product, cannot be "proved" to be a hundred per cent safe, the question of consumer choice arises, and with it the problem of labelling. This crucial issue is reviewed in more general terms in section 6, but it is particularly relevant to the case of genetically engineered BST milk. If it is possible, as we have seen, to object to this product (even on what many would claim are illogical grounds) should the consumer have the right to refuse to buy it? This right was certainly denied when the unidentified genetically engineered BST milk from unidentified trial farms was fed into the pool of the milk distribution system. Judith Eversley of the Consumers in the European Community Group argues: "we think consumers should be given a choice about the milk they buy. They don't have to buy food produced by methods they dislike, and shouldn't have to buy milk from BST-treated cows" (25). This is a compelling argument, though there are practical problems about how genetically engineered BST milk could be distinctively labelled, seeing that all milk contains BST, and none could thus be described as "BST-free". We return to labelling and alternative ways of conveying information to consumers in section 6.

Summary

Some risk must attach to the introduction of any radically new process or product. In the case of the applications of genetic manipulation, the risks have been described as having a low probability but a potentially high consequence: "probably nothing will go wrong, but if it does the results could be widespread" (26). In these circumstances there is clearly an ethical obligation upon those who are developing and implementing these new techniques (and who stand to benefit considerably from them) to generate and make public the maximum relevant data and to base their decisions and procedures upon this, while accepting that no amount of such data can ever conclusively "prove" the total safety of a process or product. Decisions about applications of genetic manipulation ultimately involve complex value judgments about priorities in areas where conflicting views can be and in practice are held. Consumers and the general public, therefore, need to be given authoritative, impartial information about the available data, and also to be made aware of, and encouraged to participate in, debates concerning the broader social and ethical implications of the safety issue.

Section 4
Is it fair?

It may seem odd at first sight to query the genetic manipulation of plants and animals in terms of "fairness". Nevertheless, there are important social, economic, legal and political issues at stake here, which in many respects raise even more obvious and direct ethical considerations than does the safety issue. These are basically concerned with the principles of equity, justice, and respect for the welfare and rights of other persons. (The welfare and rights of animals will be dealt with in the next section.)

Clearly many of the developments already described have great potential for increasing human welfare. In particular, in that problem area which many see as generating the most urgent moral imperatives of this generation – the equitable provision of food supplies throughout the world – many genetic manipulation techniques are specifically designed to increase dramatically the quantity and availability of food supplies by overcoming various geographical and climatic obstacles. If genetic manipulation can indeed help to alleviate or even in the longer term to solve the problems of world food supplies and eradicate hunger and starvation, this gives it an enormous potential "moral plus."

As with the safety issue, however, the situation is less clear-cut than it at first appears, and on closer inspection genetic manipulation may be seen as a double-edged tool when applied in the pursuit of fairness and equity. A major cause for concern is the growing control exercised by large multi-national agrochemical companies over the farming methods and products of small farmers in the developing world. Such farmers, it is claimed, are being persuaded that they must buy new genetically engineered strains of seed for their crops together with the proprietary chemicals which are sold to complement them. The cost of this new style of farming is high and by abandoning their traditional crops and methods, subsistence farmers in Africa, Asia and South America are apparently becoming increasingly dependent on credit and high interest loans (1).

The suitability of some of the new strains of seed for subsistence farming has been questioned, and concern expressed over the "genetic erosion" which results when a few "super-strains" are concentrated upon and the overall diversity of genetic material is reduced, a point already referred to in section 3. Jack Doyle of the Environmental Policy Institute, Washington, DC, summarises the main issues clearly:

The genes of high-technology agriculture lodged in every new crop variety or livestock breed can carry with them high capital and extensive infrastructure costs. There may be more economically appropriate strategies for less developed countries - strategies that use a low-technology approach to agriculture, or employ "common sense" biology - such as the use of native crops, or crop and livestock breeding for disease and insect resistance - rather than strategies whose genes have a "predilection" toward the use of irrigation, pesticides, or fertilizer for "high yield (2).

Ironically, the increasing monopoly and influence of the multi-national companies have often depended upon their acquisition of original genetic plant material from those areas of the world where the above problems are most evident. Ethiopia and Mexico, for example, enjoy a particularly rich genetic diversity of plant material, despite their economic poverty, and it is claimed that farmers there are now having to pay high prices for "new" strains of seed which originated from their own native plant material (3). Not surprisingly, this has led to charges of "a new form of international imperialism over the genetic pool of the planet" (4):

In various United Nations forums over the past decade, third world countries have argued that the biotechnical powers are robbing them of their national heritage and, in so doing, forcing them into a new form of servitude. With control over genetic resources, genetic technologies and world- wide marketing and distribution of genetic products, the trans-national corporations and their host nations will be able to successfully exploit the southern hemisphere countries during the coming Biotechnical Age just as they did during the Industrial Age, when they controlled much of the world's non-renewable resources, industrial technologies and distribution of petro-chemical products (5).

These problems could be further exacerbated by the hotly debated issue of patenting. The development of "plant breeders' rights" in recent years has enabled royalties to be paid for the use of new strains of seed, and full-scale patenting of plant and even animal material is now a reality. (Animal patenting is discussed in section 5.) A proposed EEC directive, for example, aimed at constructing a common framework for plant breeders' rights by 1992, is likely to provide for the patenting of genetic manipulation products and processes. If such regulations are extended and accepted worldwide, one effect could be to prevent farmers from following the traditional practice of saving seed from one year's harvest to sow for the next; in France where such legislation already exists, a group of farmers from Burgundy has recently been prosecuted for doing this. The implications of extending such regulations to the Third World are considerable. Plant breeders argue, not without justification, that the new technological developments incur high costs and that some protection is needed to encourage further research and innovation. Nevertheless, where monopolies exist or are likely to develop, the danger of exploitation for the sake of excessive profit must be recognised (6).

The possible exploitation of peasant farmers is by no means the only socio-economic problem of ethical significance created by the new genetic technology. Two inter-related results of genetic manipulation applications are likely to be increased substitutability and increased productivity.

(a) **Substitutability,** which is itself a powerful factor in increased productivity, involves the use by means of genetic manipulation of an alternative raw material in order to produce the same end product (7). One example is provided by the sugar sector, where novel sweeteners are reducing the traditional market for sugar beet and sugar cane. Other commodities such as potato starch, vegetable oil and some dairy products are facing a similar challenge as a result of developments in substitutability (8). Substitutability, it is claimed, will lead to less employment, and "developing countries will suffer from this much more severely, at least in the short term, than the industrialised nations" (9).

(b) **Increased productivity** will lead to greater competition. The dairy industry again provides a good example: "fewer cattle would be needed to meet the demand, which is likely to mean that many farmers would have to leave farming. Those farms and regions which already have technological and economic advantages will benefit preferentially... Smaller, less adaptive producers will find it harder and harder to compete" (10). Particular concern has been expressed in the USA, and a study conducted by Cornell University has been cited in the BST debate, which suggests that "within 3 years of the time BGH (BST) reaches the market place, upwards of twenty to thirty per cent of all American dairy farmers may be out of business" (11).

The likely effects of increased substitutability and productivity as a result of genetic manipulation developments are summarised by Yoxen as follows:

In the developing world the number of jobs in agricultural production threatened by technical change runs into many millions. How greatly the producers in individual countries will be affected also depends on political and economic factors. There will certainly be many new opportunities for some, even if many will be powerless to respond (12).

These considerations suggest a further set of possible objections to genetic manipulation which are sometimes voiced not so much in terms of *is it fair?* as *is it needed?* Assuming that genetic manipulation is a safe and efficient means of increasing production, do we need that increase? Do we, for instance, need a method of increasing milk production which may, as we have seen claimed, put twenty-five to thirty per cent of American dairy farmers out of business in three years? According to Rifkin the answer is clear:

Do we need more milk? The United States Department of Agriculture ... is using our tax money for the whole herd buy-out, because we are over-producing milk and American consumers are spending billions of dollars to house all the surplus .... I can't find anyone that is too favourably disposed to BGH. *It appears that the only ones that want this product are four chemical companies .... Should they be the institutions to define progress? (13).*

Such arguments about "need" always call for careful analysis. This is because statements or claims about needs are never as simple or straightforward as they may at first appear, whether the alleged needs are personal, social, economic or whatever. The statement "we need x" cannot be a plain statement of fact in the way that "we want x" or "we lack x" is. To say "we need x" is both to describe our situation in lacking x (or being likely to lack x) and to prescribe that we ought to have x in order to achieve some further end that is thought desirable. So any questions about needs inevitably involve values and value judgments, and cannot be answered conclusively just by pointing to sets of facts.

Thus, *do we need genetically engineered* BST *milk?* (or any other application of genetic manipulation to food production) is not a factual question, but rather another way of presenting the problem of weighing one set of values or priorities against another. If the resulting increase in productivity and in understanding of new techniques is judged to be more desirable than the possibly damaging social effects of those increases, then the "answer" will be, *yes, we do need it.* If the balance of desirability is judged to be otherwise, the "answer" will be, *no, we do not.* Formulating the problem in terms of "need", therefore, cannot bypass the difficult value judgments which have to be made.

Summary

The social, economic and political implications of genetic manipulation raise fundamental moral questions about individual choice, freedom and rights. If the livelihood of millions of farmers and agricultural workers, who are "powerless to respond", is indeed threatened, this does not in itself demonstrate that the new techniques are "wrong" or "unfair", but equally it would be morally short-sighted to dismiss the problem as representing merely "the price of progress".

Those responsible for making the relevant commercial, legal and political decisions in this area need to show sensitivity to a wide range of interests, particularly if those most directly affected are likely to be the poorest, least influential and most vulnerable individuals.

Consumers also must be made aware of the social costs which the products of genetic manipulation may incur. As with the safety issue, difficult value judgments have to be made, balancing the potential benefits in terms of more equitable food supplies against the potential hardship in terms of unemployment and loss of livelihood and independence.

Section 5
Is it natural?

The previous two sections have dealt with misgivings which might be entertained about the possible effects of genetic manipulation. In neither section, however, have there appeared objections directed against genetic manipulation as being in itself, or intrinsically, wrong. Criticisms that these techniques are "unsafe" or "unfair" could, in principle at least, be met by taking steps to eliminate or, more realistically, to reduce the "unsafeness" or the "unfairness". This final set of objections, however, is of a different kind, for they strike at a more fundamental level by claiming that genetic manipulation is intrinsically wrong, regardless of the good or bad effects it may produce.

Most of these arguments maintain that genetic manipulation is in some way "unnatural" and therefore wrong. They are in the main "metaphysical" arguments in the sense that they incorporate a view of the world, mankind and nature which cannot be proved or disproved by pointing to sets of physical facts. Many, but by no means all, are also religious in that they depend upon beliefs about God and his relationship to the natural world. Many of the arguments are inter-related, though it is quite possible to support some while rejecting others. None are specifically "consumer" arguments, though no doubt many consumers could be identified as holding the range of beliefs on which they are based.

The main strands of these arguments and the beliefs that underlie them can be briefly listed as follows:

1. Genetic manipulation involves "playing God", by tinkering with the stuff of life. God not man is the owner and director of Nature (often personified in such arguments with a capital N). We are attempting a second Genesis, and "before we displace the first Creator we should reflect whether we are qualified to do as well" (1). Scientists should "stop playing God and listen to what God has to say in preserving his creation and its evolution into the distant future" (2).

2. Genetic manipulation assumes a "reductionist" view of life, encouraging us to adopt the chemist's perspective and look upon all forms of life as "just DNA":

> *...the important unit of life is no longer the organism, but rather the gene .... From this reductionist perspective, life is merely the aggregate representation of the chemicals that give rise to it and therefore they see no ethical problem whatsoever in transferring one, five or a hundred genes from one species into the hereditary blueprint of another species. For they truly believe that they are only transferring chemicals coded in the genes and not anything unique to a specific animal. By this kind of reasoning, all of life becomes desacralized. All of life becomes reduced to a chemical level and becomes available for manipulation (3).*

3. Genetic manipulation breaches barriers and boundaries between species which Nature has set up through the process of evolution to prevent genetic interactions between species, possibly for some overriding evolutionary reason (4). Alternatively, the "creationist" view is that all existing species were created once and for all by God, and attempting to modify this arrangement constitutes a form of blasphemy. Both perspectives see species as "sacred", either in evolutionary or creationist terms, and genetic manipulation as a violation of this "sacredness":

> *The entire notion of a species as a separate, recognizable entity with a unique nature or telos becomes arcane once we begin recombining genetic traits across mating walls (5).*

4. Genetic manipulation distorts mankind's relationship with the rest of nature. By engineering plants and animals for our own purposes, we come to assume that we own other life forms: "genetic engineering represents the concretisation of the absolute claim that animals belong to us and exist for us" (6). The possibility of patenting new life forms encourages this arrogance: "what hubris in the human species! We can claim to invent a pig because we put a human gene in genetic code - as our invention? We own a patent on it?" (7).

5. Genetic manipulation of animals involves "unnatural" experiments and can cause suffering. "Transgenic" animals - for example, a sheep/goat chimaera - can be

produced by genetic manipulation, while press and television publicity has recently been given to pigs injected with human growth hormone who were crippled by arthritis. Psychologically, what does the loss of "species integrity" do to the "psyche" of an animal? And if human genes are transferred to animals, what human attributes, potentialities and rights might go with them?

6. Genetic manipulation could represent the first step on a slippery slope that leads inexorably to a nightmare programme of universal "eugenics":

In laboratories all across the globe, molecular biologists are making daily decisions about what genes to alter, insert and delete from the hereditary code of an organism. These are eugenic decisions. Every time a genetic change of this kind is made, the scientist, the corporation or the state is tacitly, if not explicitly, making decisions about what are the good genes that should be inserted and preserved and what are the bad genes that should be altered or deleted. This is exactly what eugenics is all about (8).

By continuing along this road, we could end up reducing the human species to a technologically designed product (9).

To examine the above arguments and their underlying assumptions fully would require a full-scale thesis. All that is offered here is a brief list of comments and considerations, some general and some specific, which may help us in judging the relative validity of some of the above claims.

(a) There are obvious and notorious difficulties involved in trying to define what counts as "natural" and "unnatural". How do we decide whether or not it is "natural", for example, for women to prefer child-rearing to a career, for boys to play with dolls, for huskies to live as household pets, or for roses to be blue? How can we ever be sure what, if anything, "Nature" prescribes? Moreover, even if we could be sure about this, it would not have any direct ethical relevance - something is not made automatically good or right just because it is "natural". Some of the most likely examples of "natural" human characteristics would include such dispositions as jealousy, aggression, insecurity, possessiveness and self-centredness, but what is morally desirable about these? (10). A value judgment always has to be made about the so-called "facts of nature" - even when we think we can identify them. These logical points highlight the dangers of sweeping statements about the "unnatural" aspects of genetic manipulation and of assumptions that moral implications follow clearly from them.

(b) The concept of "natural species barriers" is particularly obscure. Much controversy among American scientists in the 1970s centred on whether or not such barriers existed, and it was found that clear cut answers were not available:-

... the issue whether there are genetic barriers separating species is a complicated affair. Partly, this is because most discussions have not clearly explicated the meaning of species barriers..... Inquiry into these matters must consider three questions: (1) What types of barriers divide species? (2) What forms of genetic exchange exist apart from what can be achieved through technology? (3) Which barriers, if any, can be uniquely breached by DNA technology? (11).

This is not the place for a detailed, technical discussion of the issue (12). We must merely again note the danger of simplistic assumptions.

(c) Genetic manipulation is incompatible only with some, and by no means all, sets of religious beliefs. It is, for example, quite possible to believe in a God who does not see species as particularly "sacred", but as provisional within the evolutionary process which he has initiated and of which innovative man is a product. Complementary to this view is the belief that man should "use his talents" (as recommended in the parable) by developing to the full all the knowledge and skill which is available to him. As for man's relationship with animals, there is a long established theological tradition that he has been given "dominion" over the animal kingdom. Genetic manipulation is thus not necessarily objectionable to religious believers.

(d) Man has always "played God" and practised "eugenics" in his attempts to "improve" breeds of animal and strains of plants for his own ends - every dog show or seed catalogue provides evidence of this. Genetic manipulation can be seen, therefore, as merely a more efficient and speedy method of doing what man has always tried to do. The emotive overtones of the word "eugenics" should not lead us to assume that applying this method to the production of plants and animals will inevitably lead to a "genetically controlled society".

(e) If genetic manipulation leads to instances of animals suffering, this can of course be questioned on ethical grounds in the same way as any other experiment or procedure. The Animals (Scientific Procedures) Act 1987, covers all aspects of experimentation relating to animal welfare and the avoidance of cruelty or unnecessary suffering. The use of transgenic animals is covered by this Act (though the process of actually incorporating the gene is not) (13). It can of course be debated whether the Act offers sufficient protection to animals generally, but this issue in which there is understandably much public interest is best discussed in a wider context than that of genetic manipulation, which does not appear to present any distinctively new problems in this area.

Summary

The above points are not intended to "answer" all the moral and religious arguments about genetic manipulation. They do suggest, however, that some of the arguments rest upon shaky foundations and obscure concepts, often presented in an emotive form. Nevertheless, although the cumulative force of these arguments is by no means irresistible, it is clearly possible to hold coherent religious or metaphysical beliefs which require the rejection of genetic manipulation on moral and/or theological grounds. Perhaps the most compelling of these concern the "reductionist" objection and the unease about patenting life forms - and it is interesting to note that these place less weight upon the intrinsic "wrongness" of genetic manipulation than upon the possible psychological effects it might produce on those who practise it.

The range of beliefs outlined in this section are not held only by members of "fringe" or "extreme" minority groups. A recent survey, for example, showed that more than two-thirds of the American public say that they are opposed to "the creation of new life forms" (14). If many people can sincerely object on fundamental grounds to genetic manipulation as "unnatural" and therefore wrong, the implications of this for the subject of this report must be acknowledged, and will form part of the concluding section.

Section 6 Conclusions

This paper has tried to summarise and assess some of the main arguments for and against the genetic manipulation of animals, plants and microbes with particular reference to food production and consumer interests.

The application of genetic manipulation techniques in this area offers great potential benefits in terms of increased quantity and improved quality of food, which could yield obvious advantages for consumers and a possible long term solution to the problems of world food supplies. However, the main areas of social/ethical concern can be summed up in the questions, *is it safe?*, *is it fair?* and *is it natural?* The paper has not attempted to offer simple, direct answers to these questions; instead, it has shown why such answers are not possible. In each case, possible objections to genetic manipulation have been reviewed and the social/ethical issues outlined. These have been summarised at the end of each section.

Many of the issues discussed have implications for consumers and these have been noted at various points. They can now be drawn together and developed a little further. To this end the following four proposals are suggested, not as firm conclusions but as a stimulus for further debate.

1. As the most obvious and immediate area of possible consumer concern is probably safety, and as some risk, however small, must attach to the introduction of any radically new process or product, consumers have the right to be given all relevant information about such processes or products, and to expect that all reasonable safeguards have been taken. They should also be made aware of and encouraged to participate in debates about the broader social/ethical aspects of the safety issue, as outlined in section 3.

2. Consumers are also entitled to information about the likely socio-economic effects of genetic manipulation, as described in section 4, and about the possible social costs involved.

3. They are also entitled to information about what precisely is being done in genetic manipulation work, as they may be unaware that it could conflict with their religious or moral beliefs.

4. As it is possible to object to, or have serious reservations about, genetic manipulation either in itself or in terms of its possible effects, on prudential, social, moral or religious grounds, consumers should have the right to choose not to buy products which result from these techniques and processes.

These proposals are deliberately provocative and clearly create more problems then they solve. To conclude this report, two of these will be briefly elaborated: the specific problem of labelling and the general problem of language.

(a) Labelling

Should some of the information called for in the above proposals be provided on the labels of products? Is the consumer entitled only to information about the contents of the product itself, or also about the processes which helped to produce it? "Process information" is already provided in the case of some foods - eg. free-range eggs and freeze-dried instant coffee - but the information here is used as a positive selling-point, not as a possible warning.

Genetically engineered BST milk again provides a useful example here. If such milk is indistinguishable from other milk in terms of its content, should the consumer be able to distinguish it on the grounds of its means of production? A recent European Parliament resolution has called for all products from livestock intended for human consumption to indicate clearly all treatments used in their production with a view to safeguarding consumers and giving them a choice (1). The Dairy Trade Federation has also called for labelling to allay consumer fears, however ill-founded, while the National Farmers Union and the milk marketing boards are opposed to labelling, unless milk from treated herds is shown to be different (2). As was noted in section 3, the labelling of milk presents particular difficulties, as all milk contains BST and none could therefore be described as "BST-free".

This example underlines the broader problem of how the consumer should be given information about products which have in some way involved genetic manipulation. There is clearly a limit to the amount of information that can be squeezed on to a label, and it may be that the best way of offering detailed, technical information to those consumers who want it is not to resort to increasingly wordy labels. A possible alternative line of development is suggested by the recently established Food Safety Advisory Centre and its Foodline telephone service. Whatever method is used, however, the crucial question of language will have to be addressed.

(b) Language

The language used to describe and discuss genetic manipulation has been a recurring theme of this report, and it is fitting to return to it again finally in the context of consumer education. The four proposals suggested earlier in this section require that consumers be told a lot about genetic manipulation. But how is this to be done? Many of the terms used in current discussions of genetic manipulation, for example, have negative overtones. Genetic "manipulation" itself and genetic "engineering" have a sinister ring to them, and it is significant that the American pressure groups campaigning against BST always refer to it as "bovine growth hormone". A UK producer of BST comments ruefully:

... the word hormone, that class of 200 plus chemicals which are the biological messengers of all living creatures, has become misunderstood and mistrusted by the consuming public (3).

The language of genetic manipulation in fact tends to fall into one of two extreme categories - either the highly technical language of the scientist or the highly emotive language of the propagandist. There is an urgent need for the general public to be informed about genetic manipulation in language which avoids reference on the one hand to eukaryote-prokaryote genetic exchange, and on the other to scientists playing God and tinkering with the stuff of life. Information expressed in neutral, non-technical language is needed to enable consumers to appreciate and assess the potential benefits and drawbacks of genetic manipulation and to draw the basic distinctions necessary if they are to exercise an informed choice. For instance, some consumers might be happy to buy milk which has come from cows whose yield has been increased by injections of supplementary genetically engineered BST, but have strong moral or religious objections to buying products derived from transgenic animals.

A carefully planned education programme is therefore called for if food products involving genetic manipulation techniques are to be acceptable to the majority of consumers, and if irrationally polarised attitudes are to be avoided. This programme should not take the form of a propaganda exercise motivated by commercial interests; it should offer the public the basic facts about genetic manipulation and information about both its likely benefits and the possible areas of concern with which this report has dealt. In this way Genetic manipulation may avoid the pitfalls which food "irradiation" has suffered, and which could probably have been circumvented if much more attention had been paid initially to educating the public (4) and to recognising the powerful psychological effects that an unfortunate choice of word can have.

Acknowledgements

I am most grateful for the generous help that I have received in preparing this report from the following, who have provided me with valuable information and insights, either in discussion or in the form of written and other material.

BBC; Professor P. M. A. Broda, University of Manchester, Institute of Science and Technology; C.Davis, Manager of Research and Development, Elanco Products Ltd, Basingstoke; Ann Foster, Food Policy Adviser, National Consumer Council; Dr C.G. Gayford, Head of Department, Department of Science and Technology Education, Faculty of Education and Community Studies, University of Reading; Rt Rev Dr J.S. Habgood, Archbishop of York; Dr J. Harris, Research Director, Centre for Social Ethics and Policy, University of Manchester; Rev. Dr A. Linzey, Director of Studies, Centre for the Study of Theology, University of Essex; Professor B.E.B. Moseley, Head of Laboratory, AFRC Institute of Food Research, Reading; National Centre For School Biotechnology, University of Reading; Dr M. Parker, Ministry of Agriculture, Fisheries and Food; Professor R. Wilson, Faculty of Education and Community Studies, University of Reading; Dr E. Yoxen, Project Leader, Centre for Exploitation of Science and Technology, University of Manchester.

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4. RIFKIN J, (1985), *op. cit.*, p.55

5. *Ibid.*, p.56

6. Material taken from "Face the Facts," cited above

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8. *Ibid.*, Chapter 4

9. *Ibid.*, p.69

10. *Ibid.*, pp.58-9

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Section 5

1. Quoted in KRIMSKY S, *op. cit.*, p.266

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3. RIFKIN J, (1985), *op. cit.*, p.53

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Section 6

1. Resolution approved by European Parliament, July 5, 1988

2. Material provided by C Davis, Elanco Products Ltd.

3. *Ibid.*

4. Interview with Professor B E B Moseley, Agricultural Food Research Council, Institute of Food Research, Reading, 16/3/1989