Introduction

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In the early 1980s, little more than two decades ago, the term 'genetic engineering' was hardly known outside research laboratories. By now it has gained common currency and both those in favour of genetic engineering and those against it tell us that it has the potential to change our lives more than perhaps any other scientific or technological advance.

In this work, we examine the major implications of genetic engineering. We try to explain the underlying science in a way that can be understood by the non-biologist, and we discuss the moral and ethical considerations that arise. Our main hope is to clarify the biological and philosophical issues involved. Mostly we prefer to elucidate the implications of particular views or courses of action to enable us to make up our own mind.

In this section, we provide a brief introduction both to genetic engineering itself and to the role of moral and ethical considerations.

What is genetic engineering?

Every organism carries inside itself what are known as genes. This is as true of bacteria and fungi as it is of plants and animas, including ourselves. These genes are codes or messages. They carry information. The information they carry is used to tell the organism what chemicals it needs to make in order to survive, grow and reproduce. Genetic engineering typically involves moving genes from one organism to another. For example, moving a gene from one type of plant to another type. The result of this procedure, if all goes as intended, is that the chemical normally made by the gene in the first type of plant is now made by the second type of plant. Suppose that the gene concerned promotes frost tolerance, in other words, it reduces the susceptibility of a plant to damage by frost. Then moving it into an important crop plant that is all too often damaged by frosts might have considerable benefits. Various terms in addition to genetic engineering have been used to describe such activities. These include 'genetic manipulation', 'genetic modification', 'genetic technology'' 'recombinant DNA technology' and even 'modern biotechnology'. We have tended to stick with 'genetic engineering'. This is partly because it is the mostly widely used term, and also because, along with genetic modification, it seems to us to be the phrase most exactly to include the two central elements of the new technology, namely the creation (i.e. engineering) of organisms with novel genetic constitutions.

It is easy to see that the potential advantages of genetic engineering are very great indeed. However, the suddenness with which genetic engineering has arrived makes it difficult to assess its validity, and its dangers, as well as its usefulness.

Genetic engineering and traditional biotechnology

Biotechnology is the application of biology for human purposes. It involves using organisms to provide us with food, clothes, medicines and other products. The phrase 'traditional biotechnology' is used to include all of biotechnology except for those procedures that have only become possible since the mid-1970s or so through advances in genetic engineering and other novel disciplines, such as embryo transfer, molecular biology and tissue culture. Traditional biotechnology is based on activities like the farming of animals and plants and the use of microorganisms in the manufacture of beer, wine, bread, yoghurt and cheese.

Traditional biotechnology has a long history. The domestication of animals and plants seems to have happened independently about 10000 to 8000 BCE in the Middle East, the Orient and the Americas

In considering the significance of these and other more recent examples of traditional biotechnology, it helps to appreciate that the following four processes are involved in the farming of domesticated animals or plants:

- Breeding of animals, or sowing of seeds
- Caring for the animals or plants
- Collecting produce (e.g. harvesting, milking, slaughtering)
- Selecting and keeping back some of the produce for the next generation.

For more than 10000 years, therefore, farmers have selected animals and plants. Much of this selection will have been conscious, with farmers often choosing, for example, to breed from larger and healthier individuals. Indeed, genetics is probably a much older science that is generally realized.

However, much of the selection by farmers was unconscious, as farmers unwittingly chose, for example, animals that were tractable or tolerant of overcrowding.

The fact that traditional biotechnology has such a long history might lead one to conclude that perhaps too much fuss is being made about genetic engineering. After all, traditional biotechnology often involves the transfer of genes in a way that would not happen in nature. That happens every time a farmer selects a bull to mate with cows, and every time a plant breeder dusts the pollen from one plant onto the female sex organ of another plant. Indeed, such traditional selective breeding has achieved dramatic results.

Traditional biotechnology has changed certain plants very greatly too. The modem wheat used in bread making is so different from native wheat that scientists are still uncertain as to its precise ancestry. What is clear, though, is that it results from at least two interspecific crosses. In other words, on at least two separate occasions, thousands of years ago, people succeeded in breeding one species of wheat with another species. The net result is that today's bread wheat contains approximately three times the number of genes as wild wheat found in the Middle East.

However, although traditional biotechnology can result in major alterations in the genetic make-up of organisms, it differs from genetic engineering in at least three important respects.

First although traditional biotechnology sometimes involves crossing one species with another these species are always closely related To the non-expert, the plant species crossed to make modern bread wheat all look much the same. Indeed, botanists classify them as being very closely related. This is markedly different from genetic engineering where, already, to give just two examples, human genes have been put into pigs and genes from bacteria into plants.

Secondly, the pace of change in traditional biotechnology is much slower than in genetic engineering. We are already at the point where a gene from one organism can permanently be inserted into the genetic material of another organism within a period of weeks. Traditional biotechnology, by comparison, works on a time scale of years.

Thirdly, genetic change as a result of traditional biotechnology happened to only a relatively small number of species, namely those that provide us with food and drink, such as crop plants, farm animals and yeasts. Genetic engineering is far more ambitious. It seeks to change not only the species that provide us with food and drink but also those involved in sewage disposal, pollution control and drug production. It also seeks to create microorganisms, plants and animals that can make human products, such as insulin, and even, possibly, to change the genetic make-up of humans.

Moral and ethical considerations

Having outlined the nature of genetic engineering and its relationship to traditional biotechnology, one further question in this introductory chapter needs to be tackled: why is it necessary to investigate *moral* and *ethical* concerns about genetic engineering? Some people argue that the key questions and problems here are scientific and commercial ones, best left to those with expertise in science and commerce. Ethical debate may provide a stimulating pastime for moral philosophers, but does it have any practical importance in the real world?

Two responses can be made to such queries. First, no new scientific or technological development can claim immunity from ethical scrutiny. The fact that new technologies exist does not mean that they necessarily *ought* to be employed. The pursuit of new knowledge and techniques can never be given a total ethical *carte blanche*, as a hypothetical example can readily demonstrate: 'No matter how interested a researcher may be in investigating the effects of massive doses of bomb-grade plutonium on preschool children, it is hard to imagine that anyone thinks he should be allowed to do so'.

This of course raises difficult questions about restrictions on scientific research, which we will explore more deeply later. At this point, however, we only need to note that science cannot be pursued in a moral and ethical vacuum in any society that claims to be healthy or civilised; the universal condemnation of so-called 'medical research' as pursued in various countries, including Nazi Germany, during times of war supports this view.

Moreover, it is not the case that scientists, technologists and industrialists generally *want* to operate in such a vacuum. As rational human beings, the great majority of such people appreciate the moral dimension to life as well as anyone else does. Moral and ethical questions, then, cannot be by-passed or ignored in genetic engineering, any more than they can elsewhere.

The second response to the query as to whether ethical debate has any practical importance in the real world is to acknowledge that moral and ethical concerns are of considerable practical importance in informing and influencing public attitudes towards modern biotechnology. Our attitudes are not, of course, wholly determined by our moral views alone, for other more pragmatic or self-interested factors will also play a part. Nevertheless, our moral views about any subject will clearly exert a powerful effect upon our perceptions of that subject and upon our attitudes towards it, for our moral beliefs play an integral part in how we see and interpret the world, which in turn helps to shape our choices and behaviour.

However, there remains the question: what is so special about genetic engineering? In other words, why we are so much bothered about the ethical concerns of this particular subject? One possible answer is to suggest that perhaps there is nothing that is special about genetic engineering. Rather, every significant scientific advance throws up attendant problems and possibilities that need ethical reflection. This is as true of genetic engineering as it is of nuclear power, *in vitro* fertilisation, the genetics of race, pollution, conservation and the many other subjects of public concern that science has brought into prominence.

However, it can also be argued that perhaps there *is* something distinctive about genetic engineering. For one thing, its scope seems near endless. We are promised that genetic engineering will revolutionise agriculture, medicine, the food industry and much else besides. For another, we are told by some that its potential for harm is immense. Then there is the pace of change: progress in genetic engineering seems to be happening so fast that perhaps ethical reflection is needed now before it is too late. Indeed, some claim that our scientific understanding has already outstripped our powers of moral comprehension. Finally, many aspects of genetic engineering strike at the very heart of our lives. Genetic engineering raises issues about the nature of life itself, about what it is to be human, about the future of the human race and about our rights to knowledge and privacy.

If moral concerns are so influential in this area, there must be a strong practical argument in favour not of trying paternalistically to persuade the public that genetic engineering is really a good thing but of encouraging moral judgments about it to be made on a rational and considered basis.

Usually books on ethical issues on genetic engineering use the terms 'moral' and 'ethical' interchangeably and without explanation or definition, implying perhaps that their meanings are self-evident and synonymous. This is certainly a common assumption, but such assumptions do not always lead to clear thinking and rational argument. If genetic engineering is indeed a source of moral and ethical concern, as is frequently claimed, then we need to clarify what exactly constitutes 'moral and ethical concern' before the debate can proceed any further.

The terms 'moral' and 'ethical' are often used interchangeably in everyday language and, indeed, by some philosophers. Nevertheless, distinctions can be drawn between them, and one of these will help in providing a structure for this investigation. There is certainly no consensus that 'moral' and 'ethical' should be used in the following way, and what matters in linguistic questions of this kind is not the particular labels themselves but the realisation that two different things with distinctive features can be distinguished and that greater clarity will be achieved if they are not confused. Given these provisoes, a possible distinction bctween 'moral' and 'ethical' will now be outlined.

Moral: Everybody can be said to have moral views, beliefs and concerns, to the effect that certain things are right or wrong and that certain actions ought or ought not to be performed. These views may refer to virtually any subject. Such 'moral concerns' may result from a lot of deliberation and reflection, or from very little; they may be firmly grounded in a consistent set of carefully considered rational principles, or they may not; their justification may have been consciously analysed, or it may not. Many of our moral views are probably held almost unthinkingly, perhaps as a result of our upbringing. We may just 'feel' that certain things are right or wrong; we have a 'gut reaction' about them; and that may be the sum total of some people's 'morality'.

Ethical: Ethics is normally thought of as a narrower concept than morality. It can be used in several different, though related, senses. The most general of these suggests a set of standards by which a particular group or community decides to regulate its behaviour — to distinguish what is legitimate or acceptable in pursuit of their aims from what is not. Hence we talk of "business ethics" or "medical ethics".

More technically, ethics can also refer to a particular branch of philosophy — 'moral philosophy'. There is disagreement among philosophers about the precise scope, function and methodology of ethics. For our present purposes, we should note that one central task of ethics is usually taken to be a critical investigation of the fundamental principles and concepts that are used in moral debate. Ethics tries to analyse and clarify the arguments that are used when moral questions are discussed and to probe the justifications that are offered for moral claims. So ethics in this sense is a critical 'second-order' activity which puts our 'first-order' moral beliefs under the spotlight for scrutiny. but this is not an activity reserved solely for professional philosophers. 'In so far as the man in the street thinks critically about his own moral views or those of others, or ponders on their justification, or compares them with rival attitudes, to that extent he is a moral philosopher'.

This way of distinguishing between 'moral' and 'ethical', therefore, shows how essential it is to 'unpack' the apparently straight-forward statement that genetic engineering is a source of moral and ethical concern; for to call something a *moral* concern does not necessarily mean that it is of much *ethical* significance. Genetic engineering may be a source of moral concern to some people today. However, people who express general *moral* concern and unease about genetic engineering, does not necessarily imply that they have done any *ethical* thinking about the issues.

Our intention in the present venture is to identify those issues of most ethical significance and to distinguish them from those of less substance. This analysis may also help to defuse some of the controversy surrounding genetic engineering, which often generates more heat than light. As one writer puts it: 'A significant part of the current debate can be traced to differences over moral principles. Also, unfortunately, there has been much unnecessary debate generated by careless moral reasoning and a failure to attend to the logical structure of some of the moral arguments that have been advanced.'[i]

Differences over moral principles, however, cannot be resolved by a simple appeal to 'the facts', for sets of facts whether about genetic engineering or anything else can never prove something to be morally right or wrong. Yet this does not mean that facts are unimportant or irrelevant when considering ethical questions: one cannot make informed ethical judgments about *x* without knowing the relevant facts about *x*. That is why we need to know some facts also about genetic engineering.

Ethics cannot, then, offer conclusive *answers* about the rightness or wrongness of genetic engineering for ethics cannot provide final 'proof' of this kind. One cannot prove that the hungry ought to be fed in the same way that one can prove that lack of food causes death. Moral judgments may be argued for or against, criticised or defended, and shown to be more or less rational and informed, but their rightness or wrongness can never be comprehensively established.

What ethical methods can be used to evaluate moral concerns? We know in principle how to set about evaluating a scientific claim that a particular genetic combination produces particular attributes in pigs, but how do we evaluate moral claims that it is wrong to apply genetic engineering to pigs? This raises vast and complex questions about the nature of ethics and the logic of moral judgments, and, as mentioned above, this has long been an arena for philosophical disagreement and competing theories. All that can usefully be said in general terms about the ethical methods that will be used is that they will emphasize two objectives:

- The analysis and clarification of the key concepts that tend to be used when these concerns are expressed (e.g. that genetic engineering is 'unnatural')
- The uncovering and probing of the underlying principles upon which the concerns appear to be based (e.g. that it is wrong for scientific research to take risks).

Extrinsic and intrinsic concerns

The moral concerns expressed about genetic engineering may, for convenience, be divided into two basic categories, to be labelled 'extrinsic' and 'intrinsic'. Genetic engineering may for a variety of reasons be thought to be either intrinsically wrong *in itself* or extrinsically wrong *because of its consequences*. This important distinction can be applied to a large number of moral issues and can often help in identifying the precise grounds of any moral concern. Confusion can quickly arise if the distinction is not drawn. A debate about the justifiability of abortion, for example, will not get very far if the participants fail to realise that one (intrinsic) set of arguments— that abortion is murder and, therefore, always wrong in itself — is of a different logical form from and so cannot be countered by another (extrinsic) set of arguments — that the consequences of allowing certain pregnancies to continue are sometimes morally unjustifiable.

Intrinsic arguments cut deeper than extrinsic ones. If abortion, genetic engineering or anything else is thought to be intrinsically wrong, no further considerations are morally relevant, for nothing can reverse that intrinsic wrongness; consequences do not have to be taken into account. Intrinsic arguments about the wrongness of something also focus attention upon its precise nature and its distinguishing characteristics. What distinguishes abortion from other medical procedures that may result in death? What distinguishes genetic engineering from traditional selective breeding? Wherein exactly does the alleged intrinsic wrongness lie?

Intrinsic arguments also have a more specific, clear-cut target than extrinsic ones. If I feel that abortion is intrinsically wrong, then it is clearly the act of abortion *per se* that I see as a moral concern; but if I feel moral concern about driving fast cars, it is not normally that activity in itself that I am objecting to, but their possible extrinsic effects and consequences, which could also result from all sorts of *other* activities.

This feature of extrinsic concerns raises a major problem. To claim that any activity or process will have undesirable consequences is to make *predictions* about future events. But predictions may be accurate or inaccurate, and no conclusive proof can ever be provided that a particular set of events will inevitably occur in the future. Extrinsic concerns must, therefore, always be in this sense provisional: they carry weight only in proportion to the likelihood of the predicted consequences actually occurring. So to appraise the validity of these concerns becomes in part a technical matter of trying to establish what really is most likely to happen, requiring in this case the specialist expertise and judgment of the biologist.

However, it is not essential to be a professional biologist in order to reach a reasonably informed ethical judgment about the consequences of genetic engineering. Professional scientists are not the only people capable of assessing the moral implications of scientific developments. We do not need to be highly qualified nuclear physicists in order to form considered ethical judgments about the standards of care and responsibility required in the handling of nuclear materials; the common-sense understanding of the intelligent layperson is quite adequate to appreciate the moral irresponsibility of running avoidable risks with dangerous products and processes.

Ethical questions, then, can still be directed at these extrinsic concerns despite their technical nature. Indeed it is essential that they should, for the following reasons:

- Even if agreement is reached about likely consequences (which, as we shall see, is rare) this does not automatically answer the moral and ethical questions. We still have to ask what is good or bad, right or wrong, *about* those consequences and examine the moral claims and assumptions surrounding them.

- There is never just *one* consequence to any activity but a whole set of consequences, often occurring at different times. Building a new motorway, for example, could produce an infinite number of consequences, which might include improving the traffic flow from point A to point B, increasing air pollution at point C and reducing it at point D, destroying the habitat of species E and providing a new one for species F. The consequences of any activity, therefore, cannot simply be morally approved or condemned *en bloc,* for they will often produce conflicting advantages and disadvantages.

- Consequences, then, have to be *weighed* and *compared* against each other, and this cannot be a matter of purely factual assessment. Attempts to estimate the likely costs and benefits of an activity can, of course, be made on a straightforward financial basis, but this does nothing to address the moral issues. (A financial assessment of this kind could have been made in deciding the method of extinction to be used in Nazi concentration camps.) Ethical judgments have still to be made about the *value* or *priority* to be placed upon different possible costs and benefits produced by different possible consequences. This can be a highly complex matter; how, in the above example, are the various costs and benefits of building a motorway to be valued and prioritised?

Having distinguished between extrinsic and intrinsic concerns and noted some general problems involved in evaluating the former, we can now proceed to examine the most obvious example of an extrinsic concern — that genetic engineering is risky

Extrinsic concerns about risk and safety

The most commonly expressed general concern about the possible consequences of genetic engineering is that these might be risky or even catastrophic. Eloquent critics of genetic engineering, such as Jeremy Rifkin in the USA, have concentrated much of their fire upon this concern, as the following two extracts from Rifkin's work illustrate:

> Now please just imagine introducing thousands of genetically engineered organisms: bacteria, viruses, plant strains and animal breeds in massive volumes for commercial purposes.

> Sheer statistical probability, my friends, suggests that they are not all going to be safe.[ii]
>
> 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 synchronised 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.[iii]

Concern about particular types of risk will clearly vary depending upon the particular application of genetic engineering that is under discussion, and Rifkin is here referring mainly to agricultural applications involving plants and animals. We shall consider the possibility of specific risks in more detail in later chapters, but some more general points about risk and safety and their ethical significance need to be made at this point.

One possible maneuver is to by-pass the issue completely by arguing that risk and safety are not in themselves moral or ethical matters. There is indeed something to be said for this viewpoint, which challenges the widely held (and often unexamined) assumption that any discussion of the morality and ethics of genetic engineering must immediately focus upon questions of risk and safety. A little reflection, however, shows that the connection is less obvious. 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 is not an ethical question. It is more risky to drive on motorways on wet road, but this is a statistical fact rather than a moral issue. Some activities are inevitably more risky than others, though none can be totally risk-free, and it does not follow that low-risk activities are morally superior to high-risk ones.

It would, however, be difficult and somewhat short-sighted to maintain that questions about risk and safety can have no moral dimension. Risk and safety become matters of moral concern when they raise further questions about *responsibility, accountability* and *justifiability*. Moral concern is appropriate when irresponsible and unjustifiable risks are thought to be taken, which may result in harm to innocent parties: joyriding at high speed in a stolen car arouses moral concern to a far greater extent than driving a racing car in a Grand Prix. Furthermore, the *assessment* of risks may also be shown to have an ethical component, a point emphasised in a report on genetic engineering by a Swedish Government Committee, which is one of the few such documents to discuss explicitly the relationship between risk and ethics

> The Committee takes the view that the assessment of risks should be part of the ethical analysis, since it is ethically false to base a decision on poor foundations if the decision can be postponed until the foundations have improved. It is also ethically unacceptable to assert that the foundations for a decision are better than they are. Thus the open presentation of facts and viewpoints is important.[iv]

The question of risk cannot, therefore, be ignored in any ethical investigation of genetic engineering, and we need to look a little more closely now at some of the general concerns about risk that have been generated by the development of this technology.

The early history of the development of genetic engineering techniques was dominated by disputes about safety. 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'.

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 were gradually relaxed as confidence increased in the view that modified microbes are unlikely to pose significant ecological threats.

The complex issue of regulation can be considered in more detail, as it is clearly of central importance in trying to determine whether irresponsible and unjustifiable risks are being taken in genetic engineering. But if the possibility of catastrophic consequences may exist, as envisaged by Rifkin and others, is it perhaps irresponsible and unjustifiable to proceed with this technology at all?

It has been suggested that these consequences might include uncontrollable diseases, as already mentioned, global drought or the spread of indestructible weeds made resistant to pests and herbicides. Further fears have been voiced that a loss in genetic diversity among plants and animals could result, making them less resilient and so more vulnerable to various forms of attack in the future. More generally, some have claimed that genetic engineering could represent the first step on a slippery slope that will lead inexorably to a nightmare programme of 'universal eugenics: 'By continuing along this road, we could end up reducing the human species to a technologically designed product'.

The risks envisaged here are clearly of such a catastrophic nature that no one would feel justified in turning a blind eye to them. So can we cut short our ethical investigation at this point by accepting that such risk-taking is irresponsible and unjustifiable on the basis of a principle to the effect that any activity, which could lead to catastrophic consequences, ought not to be undertaken? Unfortunately, this simple and apparently responsible conclusion becomes less convincing when we look more closely at the principle on which it depends. The simple logical truth, which is of some ethical relevance here, is that it is impossible to *prove* that a particular event will or will not happen in the future. No activity or process can ever be guaranteed to present no risk whatever and to be 100% 'safe'; genetic engineering is no exception to this logical rule, as Godown emphasizes in a paper on the science of biotechnology:

> 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 . . . One cannot prove a universal negative and it

is silly to try.[v]

The claim that genetic engineering is potentially hazardous, therefore, carries less weight than it at first appears to do, once it is realised that *everything* is potentially hazardous. Further confusion can be caused by the fact that the term itself, 'potentially hazardous', is highly ambiguous, as Krimsky's analysis shows. 'X is potentially hazardous to P' may be interpreted as:

1. X can harm P under conditions C1 . . . Cn.
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. There is a finite probability that X can harm P.
4. There is a posited scenario of events such that X harms P, where the scenario has neither been confirmed nor disproved.

But is it perhaps mere sophistry to place too much weight on such logical and linguistic points? Critics like Rifkin argue that the risks involved here are of such a *level* as to make the further development and application of genetic engineering irresponsible; it is the particular and peculiar risks associated with these techniques that make them morally unjustifiable.

More general and fundamental questions, however, can be raised at this point about 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'; and, on the other hand, that 'it is morally wrong as well as politically dangerous to place restrictions on intellectual activities'.

The main problem here is that it is difficult if not impossible to determine what the 'safe' option really is. What constitutes 'risk-avoidance' in this case? Excessive caution does not necessarily remove the risk of future catastrophes. By banning research and development in any new technology that is thought to involve risks, we may run the risk of failing to produce an innovation that will be desperately needed in some future, unforeseen crisis. The history of science has proved to be highly unpredictable, and there can be no guarantee that 'playing safe' by abandoning research and development in genetic engineering will not deny us a technique or product that may *prevent* an environmental disaster in 50 years time.

In deciding whether unjustifiable risks are being taken in genetic engineering, therefore a balance has to be struck between the paralysis of extreme caution and the irresponsibility of uncontrolled experimentation. Since safety can never be totally 'proved', judgments have to be made about the likelihood of possible consequences and the relative value, desirability and priority to be assigned to these. This is an area where it is essential that science and ethics proceed hand in hand.

But how exactly can ethical judgments be made about such issues as risk and safety? Dangerous outcomes are but one of the possible consequences of genetic engineering, others might include the alleviation of world hunger or the exploitation of economically vulnerable individuals and countries. Any ethical assessment of the technology in terms of its possible consequences, then, will have to attempt to weigh the potential costs and benefits in some way. These costs and benefits cannot, however, be purely or even predominantly economic or financial, for ethics cannot be equated with accountancy. The costs and benefits must relate to a wider range of considerations, and while there is no philosophical consensus over the precise nature and extent of these, they are usually thought to include such things as the welfare, interests, rights and needs of human beings (and perhaps also of other animals).

Ethical theories that focus upon consequences in this way are usually labeled 'consequentialist', and the best known of these is utilitarianism, which in its original and simplest form maintained that actions are right or wrong in proportion to the total amount of pleasure or pain that they produce, thus making the greatest happiness of the greatest number the ultimate ethical criterion. There are, however, some obvious objections to this approach, including:

- How in practice is this ethical arithmetic to be carried out?
- How is unfair treatment of innocent individuals to be avoided?

These problems are well illustrated in the case of genetic engineering. In the first place, even if the likely consequences can be accurately predicted, how exactly are the predicted costs and benefits to be weighed in terms of overall welfare and happiness? How, for example, is the possibility of increased food supplies to be weighed against the possibility of an invasion by indestructible weeds? A *further* ethical principle seems to be needed to resolve such issues and how is *that* in turn to be justified? And in the second place, how are the interests of particular individuals (e.g. small farmers) or perhaps of animals to be protected if the ethical arithmetic indicates a course of action that is likely to benefit the majority but cause serious harm to members of such minority groups?

Clearly there are no easy answers to such questions. Most philosophers would now agree that the original formulation of utilitarianism is too crude to cope with the complexity of moral concerns, and a number of attempts have been made to produce more refined versions of the theory.

But for some people the possible consequences of genetic engineering will be seen as irrelevant. The technology itself can be thought to be intrinsically wrong, regardless of its results. Having reviewed some of the issues raised by a common extrinsic concern about risk and safety, we can now turn to the more sweeping claim that genetic engineering is wrong in itself. Two examples of this claim will be examined, namely that genetic engineering is unnatural and that it shows a lack of respect for nature.

Intrinsic concerns about unnaturalness

Many people feel that genetic engineering is in some way unnatural. For some, this may not be an intrinsic concern but rather another way of expressing fears about possibly risky consequences. The argument here would be that 'Nature knows best' and that the natural world as we know it is the result of a long evolutionary process with a well established track record, whereas genetic engineers are gambling with their unproven introductions. The general issue of risk and safety has already been considered. The more distinctive and fundamental concerns about the unnaturalness of genetic engineering are, however, of an intrinsic kind.

In many cases, there may well be a religious foundation for such feelings: Nature, representing the perfect work and will of God, is being interfered with by this new technology. Religious views about genetic engineering, however, can cover a very wide spectrum, and the complexity of the issues raised deserves separate treatment. The following chapter will accordingly be devoted to specifically religious and theological questions, including those concerned with the issue of 'natural law'.

So what is the basis of this concern and what ethical principles do it implies? Reduced to its simplest form, the argument seems to be as follows. 'Nature and all that is natural is valuable and good in itself; all forms of genetic engineering are unnatural in that they go against and interfere with Nature, particularly in the crossing of natural species boundaries; all forms of genetic engineering are, therefore, intrinsically wrong'.

The various elements in this argument need to be separated and examined in the light of two basic questions: what is meant by 'natural' and 'unnatural', and what is good about being 'natural' and bad about being 'unnatural'?

What is meant by 'natural' and 'unnatural'?

Before the above argument can even get off the ground, we have to be able to identify and agree about what is to count as 'natural' and 'unnatural'. Depending on the context in which it is used, the word 'natural' may mean 'usual', 'normal', 'right', 'fitting', 'appropriate', 'uncultivated', 'innate', 'spontaneous', and no doubt many other things as well. Perhaps most commonly, 'natural' is contrasted with 'artificial' or 'man-made'. But if we accept the above distinction practically every element of our modern life-style is 'unnatural'. Nor can more traditional products and processes avoid such a charge of 'unnaturalness', for the progress of civilisation has been largely dependent upon our 'interference with Nature'. Yet if every domestic or farm animal, every garden plant or agricultural crop, every item of food or clothing is thought of as unnatural because it interferes with Nature, as logically it must, then the concept of 'unnaturalness' surely becomes so broad as to be meaningless.

The more specific and serious charge of 'unnaturalness' that has been leveled against genetic engineering, however, is that it 'breaches natural species boundaries and violates the natural integrity of species:

> Genetic engineering makes it possible to breach the genetic boundaries that normally separate the genetic material of totally unrelated species. This means that the *telos*, or inherent nature of animals can be so drastically modified (for example by inserting elephant growth hormone genes into cattle) as to radically change the entire direction of evolution, and primarily towards human ends at that. Is that aspect of the animal's *telos* we refer to as the genome and the gene pool of each species not to be respected and not worthy of moral consideration? [vi]

A biologist might try to refute the argument that it is unnatural to breach the genetic boundaries between species on a number of grounds. For a start, such a view fails to realise that the theory of evolution, on which all our understanding of the nature of species is based, *requires* that species change over time. Every species alive today is believed to be the direct descendant of the early single-celled species that existed over three billion years ago. Species that currently exist have passed through many, possibly hundreds, of separate speciation (formation of a new biological species) events. In other words, species are not static; their genetic composition naturally changes over time.

Further, a view of evolution that assumes that species remain genetically isolated from one another is out of date. We now realise that a number of distinct processes allow the movement of genetic material from one species to another. Certain viruses, for example, carry genetic material between species. Equally, many bacteria have mechanisms that allow them to take up genetic material from other species and then integrate it into their own. In other words, for many species, their *telos* includes the ability to cross species barriers.

Finally a biologist might point out that no single universally accepted criterion of the term 'species' exists. Different biologists use the word in a number of distinct ways. At one extreme the term is employed to refer to a group of individuals that are able to breed only amongst themselves and not with members of other 'species'. Given this definition, it is simply tautologous to assert that it is unnatural to cross species barriers. At the other extreme, and this is the way in which, in practice, most biologists use it, the term species refers to a group of individuals that look very similar to one another or, to be more formal, that share certain morphological criteria that render them distinct from other 'species'.

These arguments serve to caution us against accepting unquestioningly the objection that genetic engineering is unnatural because it involves the crossing of species boundaries. Nevertheless, such reasoning can appear more convincing than it really is. For a start, the argument that species are not naturally static with respect to their genetic composition fails to acknowledge the remarkable slowness with which evolution normally acts. It usually takes more than a million years for one species to evolve into another; only a handful of examples are known in which animal species have evolved into new ones within less than 5000 years. Genetic engineering operates on a timescale of months or a few years, not millennia.

Further, it is important not to exaggerate the incidence in nature of the exchange of genetic material between species. True, such exchange is important in soil bacteria and can be mediated, in some other organisms, by certain viruses. Nevertheless, the movement of genetic material between species is, for most species, almost certainly both rare and of limited significance. This is, of course, not the case with genetic engineering. The genetic engineer is able to manipulate conditions so that these transgressions of species boundaries are both frequent and of major importance.

Finally, the fact that a genuine academic debate exists as to the precise meaning of the term 'species', though worth noting, is of little significance in the context of a debate about the naturalness or otherwise of the movement of genetic material between species. Whatever biological definition of a species is accepted, most genetic engineering involves the movement of genetic material, between species. It is fair to conclude that in the above respects most genetic engineering is 'unnatural'. However, the argument about 'unnaturalness' faces other philosophical objections.

What is good about being 'natural'?

The argument under consideration assumes that whatever is 'natural' is good and whatever is 'unnatural' is bad, but is this assumption warranted? A 'natural' event, product, process or tendency (however defined) is not automatically good or desirable. Many 'natural' substances are harmful; many of our 'natural' tendencies and reactions, such as jealousy and aggression, are not normally thought morally praiseworthy; many 'natural' events, such as earthquakes and hurricanes, create destruction and suffering and are, indeed, usually labelled 'natural' disasters; many 'natural' organisms cause pain, disease and death. As the theologian Don Cupitt points out, Nature can be seen as a 'kindly mother, lovely in every aspect' but also as 'wild, chaotic and pitiless'.[vii] Darwin, the founder of modern evolutionary theory, shared the latter view, lamenting the 'clumsy, wasteful, blundering, low and horribly cruel works of nature'.

To assume that we can simply deduce what is morally right and wrong from certain facts about the world and about Nature is to commit what philosophers have called the 'naturalistic fallacy,' often translated as 'You can't get an ought from an is!' The logical point at issue here is really a very simple one: simply because something happens in nature does not mean that it is right or good, that it should be preserved or protected. A specific example of the naturalistic fallacy can be found in the argument about breaching natural species barriers. Even if these barriers unequivocally can be identified (which appears unlikely), their mere existence provides no clear ethical directives about what *ought* to be done about them.

Claims about the 'unnaturalness' of genetic engineering, therefore, do not appear to have much ethical significance, resting as they do upon unclear language and unsound reasoning. An argument to the effect that genetically engineering a drought-resistant strain of plant, for example, is 'unnatural' and, therefore, wrong would hardly stand up to much critical scrutiny. There are, however, more sophisticated versions of the 'unnatural' argument that some believe to carry greater ethical weight. These can take several forms but all focus in some way upon a lack of respect, which modern biotechnology is thought to embody.

Intrinsic concerns about disrespect

What kind of disrespect might genetic engineering be accused of exhibiting, and towards what? There are two main arguments we shall examine here, each concerned with aspects of our relationship with the natural world.

The reductionist argument

Jeremy Rifkin has eloquently propounded this view:

> Already researchers in the field of molecular biology are arguing that there is nothing particularly sacred about the concept of a species. As they see it, the important unit of life is no longer the organism, but rather the gene. They increasingly view life from the vantage point of the chemical composition at the genetic level. From the 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 even a hundred genes from one species into the heredity 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.

This kind of claim still depends heavily upon assumptions about species boundaries that have already been shown to be highly, debatable. When those assumptions are challenged, the reductionist argument as such loses much of its force. Of course, it is possible for any researcher to come to adopt a reductionist view of life as a result of his or her professional work, but that danger is just as great for the economist or social scientist (in terms of viewing human beings as mere statistics) as for the molecular biologist. In any case, the possible psychological effects of pursuing a particular subject cannot constitute a serious objection against the subject itself. Should historical research, for example, be banned on moral grounds because a few historians may become obsessed by the macabre details of public executions? If a genetic engineer finds that he is starting to see his wife, his children, his dog and his flower bed 'reduced to a chemical level', the answer is surely not to condemn or outlaw genetic engineering but for that unfortunate individual to seek psychiatric help.

There is, however, a broader dimension to the reductionist argument that deserves to be taken more seriously, namely a concern that genetic engineering shows a certain lack of respect for the environment. This leads us to the second argument to be examined.

The holistic argument

This set of views applies to a far wider range of issues than those raised by genetic engineering and embraces many ideas that are often loosely labelled 'holistic', 'ecological' or 'environmental'. Here is not the place to analyse these ideas in great depth, other than to note that they include claims and theories about the interdependence of all life-forms in a complex, self-regulating 'biotic community', and the consequent extension of moral rights and moral value to the non-human world. A new 'environmental ethic' is thus implied: 'People who really value wilderness and natural systems will not think it morally permissible for the last people on earth (who know they are the last people) to set about destroying the plant and animal species of their world . . .. People with the new values will disapprove of certain ways of using natural systems and living creatures'.

Would these 'ways of using natural systems' include genetic engineering? Do these techniques in some way lack respect for the 'biotic community'? The World Council of Churches' report *Integrity of Creation*, for example, asserts that they are not associated with, 'a world view that does not respect humanity's dependence on the earth as mother and as the source of life and nourishment'.

But what exactly is 'respect' and how do we display a lack of it? The importance of respect as an ethical principle was underlined by the German philosopher Kant, who argued that respect required treating others as *ends*, never only as *means*. So to use another being *instrumentally*, entirely for one's own purposes, without taking any account of the other's interests, involves a lack of respect and is morally wrong.

Can genetic engineering be accused of lacking this kind of respect? The following points need to be taken into consideration.

First, Kant's account of respect makes it clear that we should never treat another being 'as means *only*'. In other words, as a modern philosopher has put it: 'In Kant's view at least, treating another life-form as an instrument is not incompatible with showing it respect.

There is a distinction between using another creature's ends as your own — which is acceptable — and disregarding that other creature's ends entirely — which is not'.

This point is perhaps best illustrated by examples of our possible relationships with other animals. Some forms of so-called factory farming appear to use animals purely as a means to increased food production, considering the animals' 'ends' only in so far as that will result in a better 'product' or higher 'productivity'. Less intensive forms of farming, however, while still using animals for human ends, may also be able to show some respect for those animals' ends (i.e. their 'natural' wants and tendencies, and even perhaps their individuality). This distinction is also reflected in the recent trend towards 'welfare labelling' of animal food products, the rationale for which is that using animals for food need not be incompatible with respecting important aspects of their welfare and life-style.

On this view, it seems possible for the genetic engineer to avoid the charge of disrespect if the material with which he or she is working is not seen in a purely instrumental light, but there are complex questions to be tackled here about the 'ends of animals and plants.

Secondly' on a less abstract level why should it be assumed that any scientist is *likely* to exhibit a lack of respect in the area of his or her particular expertise? Specialist knowledge and skills commonly lead to *greater* rather than *less* sensitivity, awareness and awe. Astronomers do not despise the heavens because they know a lot, about them nor do veterinary surgeons lose their respect for animals because they are skilled in treating them and operating upon them. So why should genetic engineers be thought automatically to lack respect for the living material which they are working with?

Thirdly, genetic engineering seems no more or less open to the charge of disrespect than traditional techniques. Selective breeding has always aimed at modifying life-forms for commercial ends and has, therefore, treated plants and animals partly at least as 'means.

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