Biocentrism and Genetic Engineering[1]

ANDREW DOBSON

Politics Department
Keele University
Keele
Staffordshire ST5 5BG, UK

ABSTRACT: I consider the contribution that a biocentric perspective might make to the ethical debate concerning the practice of genetic engineering. I claim that genetic engineering itself raises novel ethical questions, and particularly so when confronted with biocentric sensibilities. I outline the nature of these questions and describe the biocentric basis for them. I suggest that fundamentalist opposition to projects of genetic engineering is unhelpful, but that biocentric claims should now be a feature of ethical consideration. I conclude, though, that while environmental ethicists can contribute powerfully to debates concerning the future of genetic engineering, the ultimate direction it takes is likely to be beyond their control.

KEY WORDS: Environmental ethics, biocentrism, genetic engineering, species.

To talk about genetic engineering in ethical terms is not new. At the outset, campaigners such as Jeremy Rifkin in the United States of America worked tirelessly to alert the public to the potential dangers of the release of recombinant organisms from laboratories.[2] The debates revolved mainly around the dynamics of risk assessment, and the ethical dimension concerned potential dangers to human health – was it proper to set limits on experimentation given that human health might be adversely affected? These campaigns resulted in strict guidelines regarding laboratory safety, and so far as we know legislation in this regard has been generally successful (in countries where legislation has actually been passed).

More recently, attention has focused on the human genome project. This project involves mapping the human gene sequence so that it can be read and understood much like a book. While this could in principle lead to a better understanding and treatment of genetically-based diseases, the whole question of what a disease *is* can be – in certain political circumstances – a fraught and extremely dangerous one. In this context genetic engineering raises the spectre of eugenics, and guidelines for experimentation and research are both continually developing and urgently required.

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What is common to the ethical debate surrounding genetic engineering up to now is that the human being has generally been taken as the sole object of ethical concern. The exception to this has been where animals are the subjects of genetically engineered experimentation, and animal rights activists and philosophers have sought to bring policy makers' attention to the welfare of animals involved in such experiments. In so far as this has involved considering the rights of animals in new areas of scientific endeavour it has not contributed anything new to the ethical debate itself. Put differently, the extent of the rights of animals is disputed, but that they might actually have rights is no longer a surprising thought: policy makers will expect to be confronted with claims of this sort and will take account of them in legislation. To this extent the ethical position of (some) animals in the context of genetic engineering is covered by existing legislation concerning the use of animals in scientific research.[3]

Biocentric holism extends the ethical debate in a different direction – a direction which has a direct bearing on the nature and practices of genetic engineering. I plan, briefly, to describe the nature of this holism and then, at greater length, to explore and assess its implications for genetic engineering. Biocentric holism I take to be a position that holds that value resides in 'wholes' of living entities besides human beings – for instance, in species.[4] I do not plan to argue for this holism, but rather to accept that some environmental philosophers do argue for it, and to assess its status in the particular context of genetic engineering.[5]

While my focus is therefore clearly holistic, it is only right to point out that the distinction between individual objects of moral concern and groups of objects of such concern is rarely drawn as starkly as I have drawn it here. More typically it will be said that individual objects draw at least a part of their moral relevance from their membership of a wider community – whether it be a species or an ecosystem. To this extent individuals are morally important in that they are members of a wider community, and so interference with individuals amounts to interference with the community that (partly) constitutes them. This point (which I pursue further on p.232) is relevant to the practice of genetic engineering in quite particular ways, as I shall shortly show.

What, though, of genetic engineering? Readers of this journal are unlikely to be familiar with its practices and this, precisely, is one of the major obstacles to informed debate. Philosophers seem continually to be trying to catch up with scientific advances, and just as they appear to do so another jump is made that demands an ethical response. The possibility of philosophers actually anticipating new techniques and therefore having a response ready and waiting seems remote, and so the best (and the least) we can do is to try to understand the scientific background as fully as possible.

In the spirit of instruction, then, and however basic it might seem, I want to begin by distinguishing three terms which are worth keeping apart: biotechnology, genetic selection, and genetic engineering. This is important because people often jump all to readily to the conclusion that genetic engineering is simply an advance on techniques of which we already have ethical experience, and that therefore no new ethical thinking needs to be done. My contention has two aspects: first, that genetic engineering is so sufficiently different from other techniques as to demand new thinking; and second, that biocentric and ecocentric holism introduce a new ethical dimension anyway.

Biotechnology could be taken to be the general term of reference for all three of these practices, but it is best to reserve it for the exploitation of the catalytic power of enzymes in, for instance, the preparation of food and drink. This technology has been used for thousands of years, and there is good evidence that the Sumerians and Babylonians used yeasts to make beer 8000 years ago, and that the Egyptians learned to make leavened bread with brewers' yeast about 6000 years ago. This is the kind of thing that tempts people to say – wrongly I believe – that genetic engineering is nothing new, and that therefore we need think no harder about endorsing its practice than we need think about the ethical implications for yeast of beer-making.

Slightly closer to the terrain of genetic engineering proper lies genetic selection. Again, genetic selection of plants and animals has been going on for longer than most people realise. Corn, for example, is quite unlike its nearest wild relatives teosinte and *Tripsacum*, and is a 10,000 year-old invention brought about by selecting seed for propagation and then interbreeding plants. Corn is entirely dependent on human beings for its survival because it cannot propagate itself, and it is an early example of genetic selection in the plant world.[6] Similarly, animals became the subjects of genetic selection as soon as their domestication became a fact of human social life – probably in the Neolithic period.

The selective breeding of plants and animals does not amount to genetic engineering however, and while there may be ethical issues at stake in genetic selection, I suggest that genetic engineering throws up new ones and it is these that will be the subject of what follows. While it is clear that biotechnology (as I have described it above) and genetic selection both have long histories, genetic engineering (sometimes referred to as recombinant technology) has a relatively short one, beginning around the 1970s. I want to refer to two definitions of genetic engineering, and to show why the differences are instructive in ethical terms.

First, Stephanie Yanchinski writes that, 'Simply put, genetic engineering means isolating the gene of one organism and inserting it into another'.[7] This definition stresses the *techniques* involved in genetic engineering and suggests that the gulf between it and genetic selection is a large one in that neither 'isolation' nor 'insertion' can be said to be taking place when breeding new strains of pea (for example). It is also important to note that there is also a difference of degree, if not wholly of kind, between the gene transfer (whether confined to the present generation or handed down to subsequent ones) of which Yanchinski writes and that which takes place when genes are transferred 'in nature' – either by 'gene jumping', by speciation, or by the introgression of genes between species caused by infertile hybrids breeding successfully with either or both of the parent species. The difference in degree is a result both of the accuracy of the isolation and transfer, and of the element of human premeditation that informs it.

Second, a draft definition prepared by the European Commission describes a genetically modified organism as one 'in which the genetic material is altered in a way that passes the natural barriers of mating and recombination'.[8] In contrast to Yanchinski's definition this one underscores the *nature* of the changes that take place. There are, of course, those who will argue that no such 'natural barriers' exist, in that while fertile breeding between hybrids may not be possible, breeding between hybrids and one or other of the parental species is possible. This objection in fact concedes the point that there is a 'natural barrier' (hybrids cannot breed), but makes the useful observation that drawing rigid biological distinctions is unwise. I think, in any case and for the moment, that these two definitions are sufficiently accurate and suggestive to sustain the following point: that the *techniques* to which Yanchinski refers make the *nature* of the changes to which the European Commission refers new to our general – and therefore to our ethical – experience. We are able to do things we have never done before in ways which are themselves new.

I am aware of standing out on something of a limb here. Alan Holland, for example, has written that, 'In truth, a genetic engineer with a lawyer's nose for precedent can find precedent enough in our present practices'.[9] I do not think this is right. In my view genetic engineering and genetic selection are only similar in the same sense that walking and space travel are both forms of locomotion. As Bill McKibben has written, 'Mendel could cross two peas, but he couldn't cross a pea with a pine, much less with a pig, much less with a person'.[10] I agree, therefore, with Michael Fox when he writes that, 'A common assertion by animal production technologists is that genetic engineering is simply an extension of the age-old practices of selective breeding and cross-breeding (or hybridization). [But] whatever analogy exists between the old practices and the new is shattered by the fact that in traditional breeding practices genes cannot be exchanged between unrelated species, whereas, in many transgenic manipulations, they can'.[11] On this reading, interference with old species and the ability to create new ones is what creates new ethical dilemmas.

This introduces a different variation on the theme that genetic engineering is really nothing new. Its opponents often object to it in the vague sense that it is 'unnatural'. When articulated, this turns out to mean that transgeneticism effectively amounts to the creation of animals and plants that are not to be found in nature. Others will refer, though, to the phenomenon of natural speciation whose mechanics are explained by the Darwinian theory of evolution. Both are, of course, right. On the one hand, speciation clearly does take place – if it didn't, it is hard to see how evolution could take place at all. On the other, the *kind* of creation brought about by genetic engineering is of a sort that nature is hardly likely to come up with – the 'shoat' (sheep/goat), for example.[12] The question is: does the kind of change that results from genetic engineering matter ethically? I shall suggest that from a biocentric point of view, it does.

Before making any specific remarks about the environmental-ethical implications of genetic engineering, it is worth making one general one. Environmental ethics itself is part of the response to what is widely regarded as an environmental crisis. The dimensions of that crisis are well-known: globally, we are confronted by ozone depletion and global warming; more locally, communities suffer from deforestation, desertification, acid rain, eutrophication of rivers and lakes and so on. The reasons given for environmental degradation of this sort sometimes seem as numerous as the commentators who give them. Some environmental ethicists, though, have made a specific pitch for the problems associated with the way we *regard* the non-human natural world. Deep-ecological thinking has become an extremely complex and often arcane affair, but the general idea advanced is that we misunderstand our place in the scheme of things. On this view, our unwarranted adoption of a position of mastery with respect to the non-human natural world leads to practices that threaten its integrity as a sustainer of human and non-human life.

The general point, then, is that deep ecologists are likely to take up a *prima facie* position against genetic engineering precisely because it is a technology that expresses the very world view that they consider causes all the trouble: one of human mastery of the non-human natural world. The point, they say, is to develop practices and habits of mind that are an expression of membership, rather than domination, of the non-human natural world. From this point of view the ethical argument over genetic engineering is nothing less than an argument about what our relationship with the rest of the biotic (and abiotic) community should be. Peter Bunyard and Fern Morgan-Grenville express this in the following way: 'Biotechnology [by which they mean genetic engineering] is the most extreme instance of the modern, anthropocentric desire that we become "masters and possessors of nature". The biotechnology debate has to do with the kind of beings we wish to be and the kind of world in which we wish to live.' [13]

In similar vein Bill McKibben opposes genetic engineering pretty much wholesale because of the counter-productive effects it has on our relationship with the non-human natural world. In his view we need to retain a sense of the 'natural' in order to counteract our potentially lethal Promethean tendencies. He believes that the (increasingly vestigial) sense of wonder we experience when confronted by natural processes, and which he feels acts like the amber colour in a traffic light, giving us pause for thought before pressing on (or stopping altogether), is in danger of being wiped out by genetic engineering. He asks: 'What will it mean to come across a rabbit in the woods after genetically engineered "rabbits" are widespread? Why would we have any more reverence, or even affection, for such a rabbit than we would for a Coke bottle?'.[14] On this reading, genetic engineering is just one more example of a progressive humanisation of the environment signalling the eventual 'end of nature' as a check against which to mark our hubristic aspirations. For people like McKibben, the casual language of appropriation used by genetic engineers is a betrayal of insensitivity rather than an expression of success. So when Mike Fromm, a plant geneticist from Missouri, reports that 'the native gene [inserted in maize to make it toxic to the European corn borer pest] performs poorly, and we've engineered it so that it produces 1000 times more toxin',[15] the paradigm of manipulation is a cause for concern rather than celebration.

Perhaps the most famous expression of the kind of environmental ethics that has spawned deep ecology is Aldo Leopold's so-called 'land ethic'. In his *A Sand County Almanac* (1949) he wrote that, 'All ethics so far evolved rest upon a single premise: that the individual is a member of a community of interdependent parts ... The land ethic simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: the land'.[16] The move is a simple but far-reaching one. It is simple in that it appeals directly to normal and accepted ethical experience: when taking an action we need to consider its consequences for other members of the community and the community itself. It is far-reaching in that it includes hitherto unlikely beings and objects (and groups of beings and objects) in that community. Alan Holland has made fruitful use of this perspective in the context of genetic engineering. He observes that we standardly view a community as 'a situation giving rise to responsibilities'.[17] From this, and taking the community to be the community at (its) large(st), he derives the injunction that genetic engineering should be conducted, '*in a manner compatible with the continuing existence of the biosphere viewed as a community*'.[18]

The problem with this is that it is radically underspecified, but as a general rule of stewardship it will give rise to constraints on the practice of genetic engineering that are unthinkable from anything other than an environmental-ethical perspective. As has often been pointed out, the communitarian focus of some environmental ethics appears to subordinate the interests of the individual to the interests of the community. Leopold's land ethic led him to write that: 'A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise',[19] and Holmes Rolston III's 'The individual is subordinate to the species, not the other way round'[20] is a more recent expression in similar vein. Holland's injunction, though, leaves room for the view that *parts* of the community contribute to the community's integrity and are therefore deserving of moral attention. Under normal circumstances the parts in question are considered to be individuals (such as individual human beings in a human community), but the novel contribution of some types of environmental ethics is to suggest that parts can also be construed as species. This has a considerable bearing on genetic engineering, for if species are morally considerable then the special ways in which genetic engineering affect their integrity need to come under scrutiny.

I shall focus on species shortly, but it needs to be pointed out that individuals are also important to biocentrics holists, primarily for their characteristic as instantiations of species. This view is often couched in terms of the *telos* of the organism in question, which is held to be its 'nature or "beingness"'.[21] In this sense a being's *telos* is akin to its 'species being', and if the former is a morally relevant characteristic then genetic engineering is ethically problematic because '[T]ransgenic manipulations alter the *telos* of an animal'.[22] Such a viewpoint also undercuts a standard defence of genetic engineering – that its practice could make the lives of intensively-reared farm animals more bearable by engineering them to cope with their new conditions. This would be unethical in its systematic collaboration in the deviation of an animal's *telos.*

One radical environmental ethicist has drawn a direct link between an animal's *telos* and its genetic makeup, thereby making genetic engineering problematic in a very obvious way. Holmes Rolston III writes that we should regard what *is* as a standard for what we *ought* to do, and in terms of organisms, 'what is' is given in the genetic code. He suggests that '[T]his information is a modern equivalent of what Aristotle called formal and final causes; it gives the organism a *telos*, or end, a kind of (nonfelt) goal. Organisms have ends, although not always ends in view'.[23] He further argues that the genetic set that gives an organism its *telos* is also a normative set: what genetically is is what genetically ought to be. Evidently genetic engineering turns out to be, on this reading, a problematic form of meddling in what is at the heart of what is morally considerable in organisms. It needs to be pointed out that Rolston's position, taken at face value, leads to some uncomfortable conclusions, not the least of which is that 'damaged' genetic codes (such as that of the human sufferer of cystic fibrosis) should be left alone. It would seem prudent to add an 'in principle' clause to anything fundamentalist Rolston might have to say so as to preserve his general intention yet make way for reasonable judgements in specific cases.

Rolston also gives us a lead into the fundamental biocentric and holistic theme concerning the relationship between environmental ethics and genetic engineering: the role of species. Rolston says bluntly that 'A species exists; a species ought to exist',[24] and that this means that, 'The species too has its integrity, its individuality, its right to life'.[25] Taken at face value again this implies that transgenetic experiments are morally indefensible in that they interfere, by definition, with the integrity of species. It might be objected – against Rolston – that interference with individual members of a species cannot amount to interference with the species itself because there will always be examples of the unengineered species in existence. If the identities of Species A1 (unengineered) and Species A2 (engineered) are seen as discrete then the objection probably holds, but if their identities are defined (at least partly) in a relational sense, then the 'creation' of Species A2 affects the identity of Species A1. In this sense, the interference with individual members of A1 that led to the creation of A2 amounts to interference with the Species A1.

At this point, of course, the question of whether discrete species actually exist becomes crucial. It has been argued that arguments from integrity have no basis in biological fact: 'If one accepts Darwin's theory on the origin of species it becomes very difficult to argue that natural kinds and individuals have an integrity which artificial kinds and individuals lack'.[26] At the same time (and assuming that something like a species can be said to exist) it will be objected that more is required for a species' integrity to be destroyed than the transference of one or two genes. And if no more *is* required than this, then surely species are continually destroyed in an entirely 'natural' way through the phenomenon of 'jumping genes'?

Is Rolston forced to concede, then, that species do not exist? In the discrete, Platonic, sense maybe he is – but then he might still refer to the European Commission's definition of a genetically engineered organism cited earlier (see p.230). From the point of view of this definition, natural barriers to mating and reproduction exist in that hybrids cannot breed successfully with one another. The attenuated and admittedly porous sense of 'species' to which this gives rise is strong enough at least to sustain the 'amber traffic light' notion to which I referred earlier (p.231). From this point of view barriers to mating – even if overcome by hybrids breeding with either one of both of the parental species – have moral significance in that we are invited to pause and wonder whether what is difficult 'in nature' should be made easy by technology. I think, in other words, that too much can be made by both sides of the question of the existence of species. Those like Rolston who say, uncompromisingly, that they do exist are likely to fall foul of biologists who argue that the biological evidence says otherwise. But these biologists, in uncompromising turn, are in danger of missing the very real ethical concerns that biocentrics have raised by attending only to the letter, and not to the spirit, of their message.

Where has this got us to? Biocentric views of genetic engineering derive from two main sources. First, genetic engineering is held to constitute a practice that expresses a human will to domination of the non-human natural world. This, they will say, is inappropriate in the context of a global environmental crisis part of whose cause, at least, is the very habits and practices of which genetic engineering is such a sophisticated example. Second, biocentrics find value in beings and collections of beings whom we do not normally regard as members of the moral community. From this point of view, and to the extent that genetic engineering interferes with the moral considerability of an individual's *telos*, or with a species, it is held in *prima facie* suspicion by biocentrics.[27]

There seem to be two principal ways to go from here. First, this *prima facie* suspicion can be turned into wholesale opposition to all forms of genetic engineering, on the grounds that its practice is immoral from the perspectives outlined above. Such a view, though, has two possible defects. The first is that the biological descriptions upon which the moral case are based are themselves questionable. There are biologists who will claim that the notion that species are morally considerable cannot be true because species do not, as such, exist.

The second is that such wholesale rejection pays too little mind to the potentially beneficial consequences of some forms of genetic engineering, and I would like to explore this objection in rather more detail. On this reading, a case-by-case examination is appropriate in which the guideline questions would be *what* is being done to *whom* (or to what), and *why*. Biocentrics might merely demand in this context that the moral considerability of species (to the extent that it is believed that there is such a thing) be taken into account as a further factor in the decision-making process. They would probably be happy, in this case, with a stewardship-type formulation such as that suggested by Alan Holland (p.232): that genetic engineering should be conducted ‘in a manner compatible with the continuing existence of the biosphere viewed as a community’.

This consequentialist dimension seems an appropriate one for biocentrics to take into account: the fields of application of genetic engineering are many and varied, and it is unhelpful to take an uncompromisingly prohibitive view of its practice. In the context of medicine, for example, the uses to which genetic engineering can be put are multiple, and the list can sometimes read as a succession of nails being banged into the coffin of those who would seek to restrict genetic engineering experimentation. How could anyone refuse to endorse something with such potential for improving human health? Applications range from the production of larger quantities of insulin than would be available without genetic engineering, through the manufacture of vaccines for (for example) malaria, dengue fever and leprosy, to the possible treatment of genetically-based human disorders.

As far as agriculture is concerned, genetic engineering has sometimes been hailed as the cutting edge of the second ‘green revolution’: the application of scientific and industrial techniques to the problem of growing more food, more effectively in ever smaller spaces. In this case, genetic manipulation takes the place of artificial pesticides, herbicides, fungicides and fertilisers. There is, for example, the possibility of creating cereal crops with built-in herbicide or pesticide resistance, or of developing plants that are capable of ‘fixing’ air-borne nitrogen, thus doing away with the need to use ever greater quantities of nitrogen-rich artificial fertiliser which have uncertain but potentially environmentally damaging effects if used over long periods of time.[28]

Not only plants but animals, too, can ‘benefit’ from the snip of genetic scissors. Techniques of genetic selection can be improved so as to produce woolier sheep,[29] and genetic engineers can of course create new animals, such as pigs carrying a human growth hormone so as to make them leaner and heavier. Animals carrying new genes in this way are said to be ‘transgenic’,[30] and it is worthwhile observing that fattening pigs in this way amounts to a crossing of the natural barrier as defined by the European Commission, in that if we take this natural barrier to be the species then its crossing constitutes the creation of a new species.

Again, much of the opposition to genetic engineering comes from the environmental movement, while its supporters will point out the irony of this given that genetic engineering has the potential to deal with environmental problems. Most obviously, micro-organisms with the ability to degrade toxic waste can be cultured and then put to work on the dispersal of (for example) oil slicks. Similarly, environmentalists' concerns over water scarcity could be made redundant with the creation of drought-resistant plants. More generally, genetic engineering could be read as undermining many of the positions environmentalists adopt on environmental protection because whatever we do to the environment can be rectified or modified by genetic manipulation. In this respect genetic engineering turns out to be the ultimate 'technological fix': 'Environmentalists ... may lose important utilitarian or prudential arguments for protecting natural ecosystems [with advances in genetic engineering]. These arguments become harder and harder to defend as we find cheap technological substitutes for nature's gifts'.[31]

Determining the legitimacy of genetic engineering, then, becomes a question of weighing up the claims of moral agents and objects within these various fields of application. In these contexts most people will agree on the legitimacy of the genetic engineering of microbes with a view to dispersing oil slicks, on the grounds that the value of microbes and of the ecosystems into which they are delivered[32] are outweighed by the good that will be done. Likewise, we might reach the conclusion that genetic engineering can be carried out on an animal without altering its *telos* in unacceptable ways, and for sufficiently good reason. An example of this would be the work carried out by Ian Wilmut, John Clark and Paul Simons in Edinburgh with a view to producing proteins required for the treatment of haemophilia. The clotting factors are normally made in the liver, but the Edinburgh team sought to have them produced in sheep's milk so that they could be harvested from the mammary glands. If we take the team's report that the transgenic sheep are 'perfectly healthy'[33] at face value, then concern at the violation of species boundaries might be overridden by the knowledge that the animal's *telos* is more or less intact (female sheep are supposed to produce milk) and that the aim of treatment is a worthy one. On the other hand most people shudder when they learn that pigs made fatter and leaner by the introduction of a human growth hormone typically suffer from arthritis, lack of co-ordination in the back legs and high levels of stress.[34] Biocentrics (among others) may argue here that the suffering of individual pigs, the altering of their *telos* and interference with the integrity of a species are too high a price to pay for leaner meat.

The examples of genetic engineering are legion, and in my view any ethical committee formed with a view to recommending principles for legislation would be bound to look at a large number of them. The point of this article has been to show that a biocentric perspective should now be represented on any such committee so that the question of the value of species form a part of the moral equation. The point would be to argue that human interest is not the only interest of moral significance, and that adding in concern for (some) individual animals does not take fully enough into account the range of ethical positions now on offer. Despite the views of its detractors, biocentrism need not lead to unhelpful forms of irrationalism. It is perfectly possible to advance rational arguments both voicing concern for the general implications of genetic engineering in respect of human relations with the non-human natural world, and on behalf of the putative values of species.

It would be naive, though, to expect such issues to be satisfactorily settled by philosophers alone. Even assuming that guidelines can be agreed upon and enacted as legislation, unscrupulous operators will take their business to places where there either is no legislation, or no means to enforce it. In the same way that the principles of free trade dictate that pollution can be exported to where it can be most cheaply disposed of, so genetic engineers will move their laboratories to countries with less restrictive practices.[35] They may even feel that that it is worth running criminal risks to garner the profits that can be made, as the Wistar Institute, a private research organisation in Philadelphia, is reported to have done by running rabies experiments – strictly regulated in the USA – in Argentina: 'The organisation did not tell the Argentine authorities about the field trial, still less seek their approval'.[36]

So research in genetic engineering is as likely to be driven and regulated by the demands of the capitalist market as it is by good intentions and philosophical principles. There is no guarantee that once it had been decided that the violation of the integrity of species caused by gene transfer between plants is overidden by the potential benefits to human beings, that a disease-resistant kiwi-fruit would not be engineered ahead of a disease-resistant staple crop for the Third World. It is a real worry that research will chase the interests of the rich and powerful rather than those of the poor and needy. The poor and needy are often poor and needy because they have no voice to express their demands. The environment is the most silent political subject of them all, and environmental ethicists choose to speak on its behalf. The question is whether anyone is listening – genetic engineers included.

NOTES

[1] Versions of this paper were read at Lancaster University in 1991 and at the International Bioethics Conference at Girton College, Cambridge in 1992. I would like to thank those who participated for their helpful comments. The same applies to two anonymous referees of an earlier version of this article whose sense of rigour was of great value to me. I am grateful, too, for the help that Dr John Woodley of the Department of Biological Sciences at Keele University gave me in respect of genetic engineering. He cannot, of course, be held responsible for my misunderstandings. Mike Dobson provided me with essential references from scientific journals, and I thank him too.

[2] See, for example, Rifkin 1983 and 1985
[3] Of course the protection afforded by such legislation is regarded as wholly inadequate by most animals rights activists and many animal rights philosophers.
[4] I shall discuss later whether species can be said to exist.
[5] Rolston (1992) is an example of a biocentric holist.
[6] Dixon, 1985, p.46
[7] Yanchinski, 1987, p.46
[8] The Royal Commission on Environmental Pollution, 1989, p.9
[9] Holland, 1990, p.169
[10] McKibben, 1990, p.134
[11] Fox, 1990, p.34
[12] The 'shoat' is called a 'geep' in the United States of America. Perhaps, as an anonymous referee of this article pointed out, it is just a different colour.
[13] Bunyard and Morgan-Grenville, 1987, p.286
[14] McKibben, 1990, pp.194-5
[15] in Coghlan, 1992, p.21
[16] Leopold, 1949, quoted in Dobson, 1991, p.239
[17] Holland, 1990, p.167
[18] Ibid, p.168 (emphasis in the original).
[19] Leopold, 1949, in Dobson, 1991, pp.240-1
[20] Rolston, 1992, p.84
[21] Fox, 1990, p.31
[22] Ibid.
[23] Rolston, 1992, p.79
[24] Ibid, p.83
[25] Ibid, p.85
[26] Holland, 1990, p.169
[27] It is worth pointing out that not only genetic engineering is potentially morally culpable in these terms. From the point of view I have been describing traditional breeding techniques could also come under scrutiny. The differences between the two are, though, considerable and a detailed comparison of them is beyond the remit of this paper. The most important distinction here, though, is that traditional breeding techniques are confined to potentially 'natural' combinations of the species' gene pool whereas engineering techniques are not.
[28] See, for example, Postgate, 1990, p.57
[29] 'In Australia, feeding sheep with a diet containing genetically engineered alfalfa which has an increased content of cysteine, has led to a 5% increase in production of wool, worth Australian $300 million in a single year', Chakrabarti and Bhargava, 1990, p.83
[30] Wilmut et al, p.56
[31] Sagoff, 1988, p.29
[32] Assuming that rigorous impact assessments have been carried out.
[33] Wilmut et. al., 1988, p.57
[34] MacKenzie, 1988, p.29 and Wilmut et. al., 1988, p.58
[35] This is already happening in respect of German companies, for instance, where the bureaucratic workload required to comply with laws regulating genetic engineering safety is encouraging companies to relocate in countries where laws are more lax. See Toro, 1992, p.6
[36] Connor, 1988, p.66

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