biotechnology and biological sciences research council

ETHICS, MORALITY AND ANIMAL BIOTECHNOLOGY

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Ethics, Morality and Animal Biotechnology

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1 Current developments in animal biotechnology

In general, the phrase **"animal biotechnology"** covers many well established procedures of conventional livestock breeding such as performance testing and the use of artificial insemination, as well as major developments in reproductive physiology over recent decades such as *in vitro* fertilisation (test tube babies) and embryo transfer (surrogacy). Some people would argue that the domestication of wild animals, which began several thousands of years ago, and the selective breeding practices of recent centuries are also examples of biotechnology.

However, in this booklet we focus mainly on ethical, moral and social issues surrounding relatively recent developments that involve genetic modification, i.e. the direct manipulation of an animal's genetic make-up. Genetic modification of animals was first achieved with mice in 1980, and of cattle, sheep and pigs by about 1985.

We will also consider issues raised by the new technology called nuclear transfer. Here, whole nuclei, and the genes which they carry, are transferred. This is the process that was used to produce the sheep Dolly, and subsequent cloned animals. It does not involve altering the genes, rather copying them. In this respect it resembles what gardeners do when they "take cuttings" of a plant to propagate it.

An outline of how genetic modification and nuclear transfer can be achieved is given on pages 23-25.

GENETIC MODIFICATION

Some people imagine that genetic modification invariably means moving genes from one species to another, or "adding" genes to an organism's normal complement. When it comes to considering ethical and other issues, it can be helpful, however, to remember that genetic modification covers two types of activities:

- Altering the genes normally present in an individual in such a way that the alteration is passed on to (at least some of) its descendants.
- Transferring a gene or genes from one individual to another of the same species, or of a different species.

A tale of two sheep

The ewe on the left is genetically modified: she carries a copy of a human gene for an enzyme inhibitor called alpha-1-antitrypsin which can be used to treat some lung disorders. Because the sheep carries a copy of a human gene she may be said to be "transgenic". The ewe on the right is Dolly – the world's first mammal cloned from an adult cell. She is neither genetically modified nor transgenic. Dolly has the same genes as the ewe from which an udder cell was taken and fused with an "empty" egg to produce her.

Why are genetically modified animals produced?

There are five reasons why genetically modified animals are produced:

1. **To help scientists to identify, isolate and characterise genes in order to understand more about their function and regulation.**

   Genetic modification can be used to knock out the activity of a particular gene. By correlating loss of function with this "knock out" it is possible to gain information about the role of the gene and the product for which it codes.

"Nude" mouse: A particular strain of mouse that is hairless and has a very small number, if any, of a particular type of cell of the immune system. The mice are frequently used to maintain human tumours which can then be studied more easily. Due to their genetic make up, the mice do not reject the tumours.

2. **To provide research models of human diseases, to help develop new drugs and new strategies for repairing defective genes ("gene therapy").**

   Animal models of diseases have been used for many years by exploiting naturally occurring mutations in genes, and in-breeding laboratory strains of animals carrying the mutation. An example is a mouse model of Duchenne Muscular Dystrophy. Genetic modification has been used to produce animal models of many diseases including mice with predisposition to cancers, and mice with cystic fibrosis. These models may be made by "knocking out" the activity of genes, as described above, or by inserting defective genes.

   By inserting additional copies of a gene into laboratory mice and observing the effects, scientists have recently confirmed the role of this gene in a disorder of human babies that is associated with increased susceptibility to childhood cancers. This will aid the design of new medical treatments.

When considering applications of genetic modification it may be helpful to distinguish between:

- Theoretical ideas about what might be possible with genetic modification
- The use of the technology as a tool in laboratory experiments, for example, to find out what a particular gene does
- The commercial production of genetically modified animals for use in medical, agricultural or other applications.

Many people who are opposed to genetic modification of animals tend to oppose all research using animals. How do we tease out any key moral and ethical issues **specifically** associated with genetic modification?

3. **To provide organs and tissues for use in human transplant surgery.**

   There is a shortage of human donors of hearts, kidneys and other organs for transplantation. Animals can be genetically modified so that they carry copies of the human genes that code for proteins that inhibit the immune response to foreign tissue. This means that organs from such animals might escape rejection and so could possibly be used for transplantation into human patients.

4. **To produce milk which contains therapeutic proteins; or to alter the composition of the milk to improve its nutritional value for human infants.**

   Sheep, goats and cattle have been produced that make medically important proteins only in their milk. This has been achieved by inserting copies of human genes for these proteins and attaching to them regulatory genes that make sure that the inserted gene works only in the mammary gland. Two products from transgenic animals are already in phase two clinical trials. The UK's PPL Therapeutics is testing alpha-1-antitrypsin purified from the milk of transgenic sheep for the treatment of children with cystic fibrosis, and the US company Genzyme Transgenics is testing the effectiveness of antithrombin III from goats in preventing blood clotting after surgery.

   Genetic modification of some cows could enable replacement of one or two "cow" proteins by "human-identical" proteins, so that milk from these cows could be used for premature human infants who cannot tolerate ordinary cows' milk.

5. **To enhance livestock improvement programmes.**

   In future genetic modification might enable breeders both to accelerate the rate of improvement in livestock performance, and to take advantage of genes not accessible through conventional selective breeding. Targets for improvement include enhanced disease resistance, for example, to develop chickens that resist infection by *Salmonella*.

This transgenic ewe makes large quantities of the human protein alpha-1-antitrypsin in her milk. One of her lambs is also transgenic for this protein, which has potential for treating and relieving symptoms in lung disorders including cystic fibrosis. Producing human proteins in this way gets around the problem of costly procedures for separating the components of blood and the risk of contamination with pathogens such as HIV.

Why are animals used instead of genetically modified microbes or plants?

Scientists' ability to move genes from, say, a plant into a microbe, or from an animal into a microbe, arises from the fact that all living things share the same genetic code. This means that a gene generally codes for the same sequence of amino acids (the building blocks of proteins) whether it is working in an animal, a plant or a microbe. It might be argued, therefore, that for some applications, transgenic plants or microbes might replace transgenic animals, so why are animals preferred? There are two main reasons.

First, animals may be preferred because of their closer biochemical similarity to humans. This is important for making therapeutic molecules. Many animal proteins need to be modified before they can carry out their function. Usually, the enzymes that are needed to do this only exist in animal cells. For example, a gene that produces the protein alpha-1-antitrypsin can be inserted into a plant, but plants lack the mechanism to attach carbohydrate groups to this protein. Without such groups the protein is removed from the human body 50 times faster than the natural product. So to make a useful therapeutic form of the protein, production must be in animal cells.

Another reason why animals are sometimes preferred for some genetic modification is because they can make large amounts of product. For example, extracting large quantities of a therapeutic protein from animal milk is technically more straightforward than purifying it from the fermentation broth of large scale fermentation chambers of cultured plant or microbial cells. For some therapeutic proteins which are required in large quantities, because patients need to take large doses, transgenic animals may be the only economically feasible way of making the proteins. Production in plants is relatively inexpensive and is an appropriate route for some products but not for others.

UK regulations regarding transgenic animals

In the UK research using transgenic animals is covered by the same controls as those for other animal research, i.e. the Animals (Scientific Procedures) Act 1986.

The production of transgenic animals is covered by requirements of the Advisory Committee on Genetic Modification (ACGM) and the Health and Safety Executive. They require notification of the work. These controls derive from the Genetic Manipulation Regulations (1989) made under the power of the Health and Safety at Work Act 1974.

If transgenic animals were to be released into the wild, prior approval would be required from the Advisory Committee on Releases to the Environment and the ACGM.

The experimental use of animals in the UK is covered by Home Office regulations. Under the 1986 Act, a project licence is required for each piece of research work, and a personal licence is required by individuals who carry out regulated procedures on animals. To obtain a licence, an applicant must attend and successfully complete an accredited training course.

The Animal Procedures Committee advises the Home Office on animal experiments under the 1986 Act.

Applications of nuclear transfer

In nuclear transfer, whole nuclei containing a full set of chromosomes are introduced into specially prepared recipient cells whose own chromosomes have been removed previously. The result is a copy, or clone, of the donor cell that contains the same genetic material (barring a minute amount of DNA inherited maternally via some other cell organelles called mitochondria).

The main application of nuclear transfer will probably be in allowing more precise genetic modification of, for example, cattle, sheep and pigs for medical uses. But several applications are envisaged. These include:

- *In providing founder animals leading to large numbers of genetically identical laboratory animals.*
- *In providing a more reliable way of producing transgenic animals, and for reducing the number of animals needed to establish each transgenic line.*
- *In enabling gene targeting in livestock and therefore the ability to conduct more sophisticated genetic modification than in the past.*
- *In helping scientists to identify the genetic contribution to different diseases, and so to distinguish between nature/nurture effects.*
- *In facilitating the study of age-related changes in cells, and their contribution to increased incidence of conditions such as cancer with age.*
- *In providing cells as a source of replacement grafting, for example, to treat conditions such as leukaemia and Parkinson's disease.*
- *In animal breeding, producing multiple copies of the very best performing animals will mean that the genetic progress achieved in elite herds will be more effectively transferred to the wider farming community.*
- *In genetic conservation. Current methods of conserving genetic diversity by storing frozen semen and embryos is expensive and time consuming. Using nuclear transfer, skin biopsies and even hair follicles might be used as sources of cells which could then be frozen in liquid nitrogen for long term storage.*

2 Moral and ethical concerns

"Only when ethics becomes a legitimate – and rational – part of the scientific attitude will concerns about particular aspects of animal biotechnology be taken seriously, or taken at all." (1)

We have now summarised the scientific practicalities of animal biotechnology, but the issues raised by this technology are not only scientific ones. Modern biotechnology has the potential to throw up a wide range of what are often referred to as "moral and ethical concerns" about which it seems difficult if not impossible to reach any substantial degree of consensus. This is certainly true of animal biotechnology, probably because of fundamental disagreements about what our attitudes and behaviour towards animals should be. (For convenience, the term "animals" rather than the cumbersome "non-human animals" will be used in this booklet, while acknowledging the fact that human beings can be seen as part of the animal kingdom and that the implied division between human and non-human animals can be unduly exaggerated).

But what exactly is meant by saying that "moral and ethical concerns" are evident here? The terms "moral" and "ethical" are often used interchangeably in everyday language but it may be useful to try to distinguish between them. We need to clarify what exactly constitute "moral" and "ethical" concerns before we can proceed any further, though this is not to suggest that there is one and only one "correct" way of using the terms.

MORAL CONCERNS

Everybody (except perhaps the psychopath) 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. What issues arouse most moral concern will of course vary enormously between different individuals, cultures and periods of history. Moral views may refer to virtually any subject; a person may feel that it is wrong to hunt foxes, to make jokes about the Royal Family, or to smack children. 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 principles, or they may not. We all probably hold some moral views 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 CONCERNS

Ethics is a narrower concept than morality, and 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.'" (2)

More technically, ethics can also refer to a particular branch of philosophy which 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 puts our moral beliefs under the spotlight for scrutiny.

To call something a **moral** concern, then, does not necessarily mean that it is of much **ethical** significance. A number of surveys have shown that, if asked, people will express moral concern about modern biotechnology, but this does not tell us whether they have done any **ethical** thinking about the issues. According to this suggested distinction, then, moral concerns are felt about what it is right or wrong to do, while ethical concerns are about the reasons and justifications for judging those things to be right or wrong.

How can moral and ethical concerns be evaluated?

The approach to be adopted in this booklet is based upon the above distinction between "moral" and "ethical". Those aspects of animal biotechnology which appear to give rise to most moral concern will be described, and the various ways in which that moral concern is expressed will be examined and subjected to ethical scrutiny, which will analyse some of the concepts used and the principles implied.

No conclusive, prescriptive **answers** will be offered about the rightness or wrongness of animal biotechnology, for ethics cannot provide final "proof" of this kind derived from factual data. One cannot prove that animals ought or ought not to be used in cancer research in the same way that one can prove that cancer kills animals. Ethical judgements may be argued for or against, and shown to be more or less rational and informed, but their rightness or wrongness can never be comprehensively established. The purpose of this booklet, then, is more to pose questions than to answer them, in order that you, the reader, instead of being presented with ready-made conclusions, will be encouraged to ponder the questions for yourself and form your own assessment of the arguments.

People's moral concerns about animals differ in different cultures, and may change over time.

New technologies tend to provoke a hostile or suspicious response, which may or may not turn out to be justified by subsequent events. For example, there was extensive media coverage of the first test-tube baby Louise Brown. Since then, several hundred thousand test tube babies have been born, providing fulfilment to otherwise infertile couples.

Why do moral and ethical concerns matter?

One further question needs tackling in this section: why is it necessary to investigate moral and ethical concerns about animal biotechnology at all? Some may feel that the key questions and problems here are scientific or agricultural or medical or commercial ones, best left to expert practitioners. Does ethical debate have any practical importance in the real world?

Two responses can be made to such queries:

i. 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. Science cannot be pursued in a complete moral and ethical vacuum in any society that claims to be healthy and civilised, and in practice the legal and regulatory systems of such societies can be seen to rest upon an ethical basis.

ii. More specifically, surveys have shown that moral and ethical concerns are of considerable practical importance in influencing **public attitudes** towards modern biotechnology. Worries are being increasingly expressed that the potential benefits of modern biotechnology may be lost if the new processes and products fail to gain "consumer acceptance" because of moral concerns, which surveys in many countries show to be widespread. There must, then, be a strong practical argument in favour of examining the ethical basis of such concerns, not in order to try paternalistically to persuade people to accept the technology, but to raise the level of debate and to encourage judgements to be made on a rational and considered basis.

3 Animal ethics

> "The right not to be tortured is shared by all animals that suffer pain; it is not a distinctively human right at all." (3)

Before focusing on the moral and ethical issues concerning animal biotechnology, we need to consider briefly how animals and their treatment can raise any such issues at all. Why, in other words, might animals be thought to matter ethically? We use plants, minerals and all kinds of other natural materials for our own benefit and pleasure. Animals also can be extremely useful to us in many ways. So what, if anything, is wrong with using a pig or a monkey or a rat for our own ends, as we might use a tree or a rock?

Many people in the past have seen nothing at all wrong in doing this. The philosopher, Spinoza, for example, claimed that there was nothing wrong in human beings consulting their own advantage and using animals as they pleased, treating them in the way which best suits ourselves. Bernard, a famous French physiologist, asserted that the proper attitude for scientists was to disregard totally the pain suffered by unanaesthetised animals in experiments, and went so far as to practise what he preached upon the family dog, whose fate was shared by numerous animals used for experimental and teaching purposes.

This "instrumental" view of animals is also evident today, despite the gradual change which seems to have taken place this century in our attitudes towards animals, particularly in western countries. Most people are not averse to using animals as a major source of food; large numbers of animals are still used in medical and other forms of scientific research and testing; and cases are regularly reported of domestic animals being used as children's toys or for their owners' temporary amusement, and then being abandoned when their period of usefulness has expired.

However, it is difficult and dangerous to generalise about "instrumental" attitudes towards animals. Probably much depends upon the context and the particular set of values which individuals hold. Some meat-eaters, for example, while accepting animal slaughter for food purposes, may be opposed to fox hunting or to zoos; some vegetarians may not object to the killing of rats and mice for public health reasons or for medical research. The vast majority of human beings seems happy to benefit from the use of animals, directly or indirectly, and has always done so. The mere use of animals by human beings, then, has not in itself normally been seen as a matter for moral concern; indeed, some types or species of animal might well cease to exist if we did not use them. It is particular **kinds** of use which have come more and more under the ethical spotlight.

"Most people are not averse to using animals as a major source of food..."

Animal welfare and the moral community

The issue which has increasingly come to be seen as ethically significant is not the use of animals but their **welfare**. According to this view, the crucial distinction between animals and other natural materials which we may use is that animals can be said to fare well or badly; they can be treated in ways which either enhance or diminish their well-being; they can have experiences which are pleasant or unpleasant.

This concern for animal welfare is sometimes portrayed and dismissed purely as a matter of emotional response, particularly if the animals in question happen to have furry coats and soulful eyes. Philosophers, however, have long debated the possible ethical status of animals and explored the rational basis of arguments and claims about how human beings ought to behave towards them.

The fundamental issue at stake here concerns the extent of what has been labelled the "moral community". Being a member of such a community would mean, among other things, that one is considered worthy of moral respect and entitled to have one's interests taken into account. But do only human beings belong to this community? Membership must presumably depend upon certain qualifications, but philosophers have often disagreed over what those qualifications might be. Some, for example, have suggested characteristics such as rationality or the use of language in order to exclude animals from membership. A number of problems arise, however, over attempts to rule out animals in this way as members of the moral community. What is meant by rationality, and might not many animals be said to exhibit forms of it (e.g. in devising ways of overcoming obstacles)? Do not animals appear to use various forms of (non-human) language and communication? And most importantly, do not many humans also lack these qualities (e.g. infants and severely brain-damaged individuals), and do they thereby lose all moral and ethical status?

Sentiency

Arguments like these have led many to agree with the philosopher, Jeremy Bentham:

> "A full-grown horse or dog is beyond comparison a more rational as well as a more conversable animal than an infant of a day or a week, or even of a month old. But suppose they were otherwise, what would it avail? The question is not, can they reason? Nor can they talk? But can they suffer?" (4)

Sentiency, or the capacity to experience pain and pleasure, has increasingly come to be seen as an overriding qualification for membership of the moral community, and thereby for the possession of certain rights. The capacity of sentient beings to experience pleasure and pain, satisfaction and dissatisfaction, comfort and discomfort, means that they may be said to have such things as wants, needs, interests and quality of life, though the sentiency of many animals probably differs from that of human beings in certain respects - for example, in terms of self-conscious awareness and the ability to imagine and anticipate painful or pleasurable experiences. Although some philosophers and scientists have at times tried to argue that animals are mere automata, incapable of any mental or physical experience, commonsense suggests that we should reject what the American philosopher, Tom Regan, calls the "astonishing view (that) gorillas and cats are just as psychologically impoverished as BMWs and holly bushes" (5) - a view which in practice is probably held by very few people today who have any experience of animals.

Speciesism

If we admit that animals can suffer and that that capacity is ethically significant, how might this affect our attitudes towards animals? Peter Singer, an Australian philosopher whose work on animal ethics has been highly influential, claims that equal consideration should be given to all beings capable of suffering: "if a being suffers, there can be no moral justification for refusing to take that suffering into account." (6) Such a refusal, involving preferential consideration for human beings over animals, has been labelled "speciesism." Just as racism or sexism involve preferring the interests of a particular race or sex simply because one is a member of that race or sex, so speciesism implies that the mere fact of belonging to a particular species (e.g. *Homo sapiens*) is ethically significant in determining one's membership of the moral community and the non-membership of other species. Critics of speciesism, then, claim that membership of a particular species is as irrelevant as membership of a particular sex or a particular race in deciding who deserves moral respect and considerate treatment.

The force of the objections to speciesism is perhaps best appreciated by considering a science fiction example. Suppose that a race of bug-eyed aliens, of infinitely greater intelligence and power than our own, were to take over the earth and to set about using human beings for food and experimental research. Would we readily accept their claim that they were the more powerful species and **therefore** entitled to do anything they liked to other species, including our own? We would probably feel that their superior powers did not give them, **on ethical grounds**, the right to use us in any way they pleased, just because we were members of a different species; our feelings, interests and capacity for pain and pleasure should be taken into account by this alien species. Being a member of a more powerful species, then, does not in itself confer moral superiority, any more than being a member of a more powerful race, country or social group does.

Parents of children suffering from cystic fibrosis may well have different perceptions about the use of genetically modified animals in the search for a cure, than will those with no personal experience of the condition. But how ethically relevant is this?

To change the example, if we have to choose between trying to save a child or a dog from drowning in a river, we would normally feel a moral obligation to favour the child, but the justification for this could not (morally) be that human beings are more powerful than dogs as a species, and that therefore this dog's interests do not matter. A dog's sentiency and capacity for suffering are ethically relevant factors, to be taken into account whenever it is appropriate and possible to do so, but this does not mean that its interests are necessarily to be treated as being on a par with those of a human being, whatever the circumstances. By no means all philosophers would accept that all species are of **equal** moral standing. Are not chimpanzees, for example, worthy of greater moral respect than mosquitoes? Some would argue that, while it may be arbitrary and wrong to show moral respect (or disrespect) for members of a particular species **purely** because they **are** members of that species, it does not necessarily follow that all species are deserving of equal moral respect. However, it is generally agreed that the sentiency of any species requires some kind of moral respect.

But how exactly should one species take account of the sentiency of another? There is not space here to delve deeply into the philosophical complexities of this question, but two main approaches need to be briefly mentioned at this point.

a) Utilitarianism

The utilitarian approach which represents an important philosophical tradition, argues that here, as in other ethical decisions, a calculation has to be made of what is likely to maximise pleasure and minimise pain. The best course of action, ethically speaking, is that which produces the most overall satisfaction.

The main problems with this approach are concerned with how exactly to do this calculation, particularly when we are talking about **animal** experiences of pleasure and pain, which are likely to be different from our own. Also, if we are aiming at the maximum **overall** satisfaction, how are animal pains and pleasures to be weighed against human ones? Are human interests to be given a heavier weighting than animal ones and, if so, how is this to be ethically justified in view of the objections to speciesism noted above?

Cystic fibrosis is the most common "single gene" genetic disease in Caucasians. One in 25 of us carries the recessive gene responsible and 1 in 2,500 babies suffer from the disease. For sufferers, life expectancy is only in the twenties or thirties, and constant treatment is needed to maintain a reasonable quality of life.

Cystic fibrosis (CF) mice and wild type and heterozygote littermates. The cystic fibrosis mice were created by using embryonic stem cells (see page 24). The mutant mice cannot be distinguished from their littermates visually but their cells display electrophysiological properties characteristic of CF. These mice have been successfully used to validate gene therapy approaches to disease treatment.

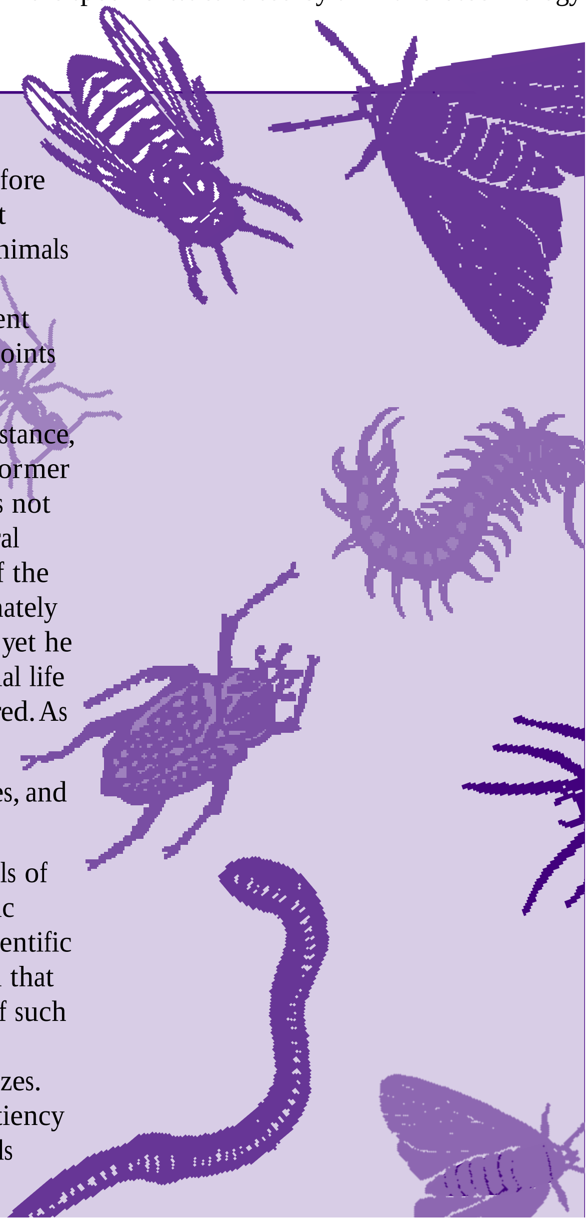
Discussions about how justifiable it is to use animals for food production or for medical research will need to weigh different levels of human benefit against different levels of animal suffering. Peter Singer, for example, argues that the pleasures and benefits human beings derive from eating meat are unlikely to outweigh the discomfort and pain of farm animals reared under modern intensive conditions.

The utilitarian calculation suggests that the justification for some degree of animal suffering is much stronger if the objective is a cure for life-threatening diseases rather than a leaner pork chop, because the corresponding human benefit is much greater. This utilitarian conclusion may conflict with many people's assumption that it is laboratory research which raises the most serious moral concerns about animal suffering. Such an assumption may result from a failure to think the issues through, but it may also be based upon an alternative way of making ethical judgments about the sentiency of animals.

b) Inherent value
A second possible approach to the treatment of sentient creatures focuses not upon calculations of their pain and pleasure, but upon their inherent value as individuals, which gives them the right to be treated with respect. To use a sentient individual, human or animal, purely as a means to achieve one's own ends, without any respect for that individual's ends, is ethically unjustifiable according to this account. (This approach is sometimes identified as an "animal rights" view, but as rights can become an emotive term which is not necessarily helpful in debates about how animals ought to be treated, it will not be emphasised in this booklet).

This approach also raises further questions. How exactly, for example, does one show respect for an animal's "ends", and how does one decide what those "ends" are? This question will be examined in more detail in a later section when the issue of animals' "telos" or nature is explored. Also, to what extent is it possible to respect an animal's "ends" while pursuing one's own? If animals, for example, are produced to be killed for our food, can the way in which they are allowed to live their lives still demonstrate respect for them as individual sentient beings?

This section has deliberately raised questions rather than tried to answer them, but it should have demonstrated that "animal ethics" is not just about our emotional reactions to animals. These questions are difficult and complex; they need careful consideration and rigorous analysis, and some of them will come under closer scrutiny in the following sections. Having briefly surveyed the general questions which are prompted by animal ethics, we can now start to examine how they relate to the more specific issues raised by animal biotechnology.



The extent of the animal kingdom

One final, even more fundamental, question needs to be posed before proceeding to the specific sections on animal biotechnology: what **counts** as an animal, when we are considering animal ethics? If animals are to be included as members of the moral community and consideration given to their sentiency, welfare, interests and inherent value, a decision still has to be made about which, if any, cut-off points should be established within the animal kingdom.

What are the boundaries of this kingdom? Do they extend, for instance, to insects and micro-organisms? Biologists normally include the former and exclude the latter, but this kind of scientific classification does not answer the ethical question about what forms of life demand moral respect. As an illustration of this problem, we can take the work of the theologian, doctor and missionary, Albert Schweitzer, who passionately advocated respect for all life, on the grounds of its inherent value; yet he presumably felt little respect for those forms of insect and microbial life which brought death and disease to the Africans for whom he cared. As the philosopher, Mary Midgley, puts it,

"speciesism is hard to apply to locusts, hookworms and spirochetes, and was invented without much attention to them." (7)

Part of the difficulty here stems from uncertainty about what levels of sentiency, if any, are experienced by "lower" forms of life. Scientific opinion here is divided, though it is perhaps doubtful whether scientific data could ever conclusively resolve the issue. Many have assumed that invertebrates lack sentiency, but others claim that the behaviour of such creatures as the octopus suggests otherwise. Darwin believed that earthworms showed intelligence in making their way through mazes. As far as insects are concerned, some biologists consider their sentiency an open question, and have argued for a respectful attitude towards their nervous systems, which are far from fully understood.

4 Intrinsic concerns about animal biotechnology

> "There can be no manipulation more profound than that of another being's genetic structure." (8)

Animal biotechnology is a morally sensitive issue because many people have concerns not only about the treatment of animals but also about the nature of modern biotechnology itself. Some feel that all forms of genetic modification may be wrong in themselves, regardless of what they are being applied to and what consequences may result.

Animal biotechnology, then, 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 rights and wrongs 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 thus always wrong in itself - is radically different 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 any practice is thought to be intrinsically wrong, no further considerations are morally relevant, for nothing can reverse that intrinsic wrongness; consequences and intentions do not have to be taken into account.

As intrinsic concerns are in many respects more fundamental than extrinsic ones they are best explored first. In this section, then, the strategy will be firstly to consider some intrinsic objections to modern biotechnology in general, and then see how these may apply to animal biotechnology in particular.

Religious concerns

It is possible to hold religious views to the effect that modern biotechnology is blasphemous. These views may rest upon the belief that God has created a perfect, natural order; for people to attempt to "improve" that order by manipulating DNA, the basic ingredient of all life, and in some cases crossing species boundaries instituted by God, is not merely presumptuous but sinful. Some religions place great importance on the "integrity" of species, and object to any attempts to change them by genetic modification.

The essence of this concern, then, is that modern biotechnology is trying to "displace the first Creator", or to "play God", but in assessing such claims, the following points need to be noted.

i. By no means **all** religious believers would make these claims. Different religions have different perspectives upon the nature of God and his creation. Even among Christians, for example, there is no unanimous condemnation of modern biotechnology *per se*. There is, for example, scriptural support for the view that humanity has been given by God an approved, privileged position of "dominion" over Nature. Some modern theologians even see biotechnology as a challenging, positive opportunity for us to work with God as "co-creators".

ii. Animal biotechnology may move genes from one species to another, but religious believers do not necessarily hold that the boundaries between species are sacred and immutable, nor indeed that they are so regarded by God. For many religious believers evolutionary theory may suggest a view of species as provisional and fluid collections of individuals, each species playing its part in a developing process, initiated by God, of which we ourselves are a fairly recent product.

Problems with Nature and naturalness

A belief that modern biotechnology is intrinsically wrong need not rest upon a religious basis. Agnostics and atheists would be unmoved by arguments about blasphemy, but might still share what seems to be a widely felt concern that biotechnology is in some sense "unnatural" and therefore wrong.

Reduced to its simplest form, the argument seems to be as follows: "Nature and all that is natural is valuable and good in itself; modern biotechnology is unnatural in that it goes against and interferes with Nature, in some cases crossing natural species boundaries; modern biotechnology is therefore intrinsically wrong".

To examine this argument, we need to ask two fundamental questions: first, what are meant by "natural" and "unnatural"?; second, what is good about being "natural"?

i. What are 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." This is no easy task in a world where we are offered natural beef, natural toothpaste, natural margarine and a host of other allegedly "natural" products.

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 on the basis of that distinction practically every element of our modern Western 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 humanity's "interference with Nature". Yet if every domestic or farm animal, every garden plant or agricultural crop, is thought of as the result of "unnatural interference", then the concept of "unnaturalness" surely becomes so broad as to be meaningless.

The more specific and serious charge of "unnaturalness" that has been levelled against genetic modification, however, is that it may breach natural species boundaries and violate the natural integrity of species. One problem with this argument is that biologists are unsure about the extent and even the definition of "natural species boundaries". Indeed the meaning of the term "species" is itself far from clearcut, depending very much on the context in which it occurs. Furthermore, some crossing of species boundaries does occur "naturally" without any help from modern biotechnologists, though some examples of genetic modification (such as transferring genetic material from a fish to a fruit or vegetable) could certainly never occur in the "natural" course of events.

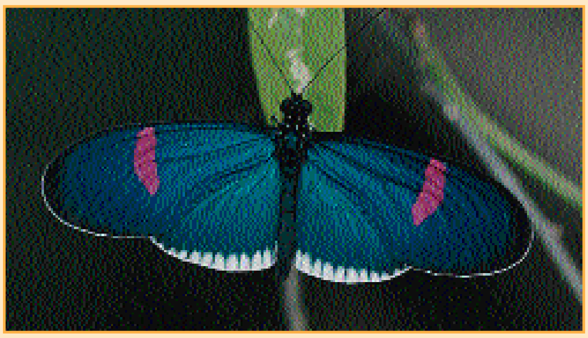
The definition of "natural" and "natural species boundaries", therefore, creates serious problems which suggest that we are not likely to find much help here in sorting out the ethical issues. But even if these difficulties of definition could be overcome, the argument about "unnaturalness" faces further ethical objections.

Species boundaries

The so-called "species boundary" may not be as much of a barrier as some people have imagined. It might be more helpfully regarded as a point on a continuous scale.

It is estimated that about 10% of wild bird species cross with some regularity and in some cases higher rates of over 30% are observed, for example, in the birds of paradise and among Darwin's finches. As scientists become able to track the fate of more and more individual genes, even higher rates of hybridisation may become apparent.

These two butterflies are different species of the passion butterfly Heliconius *but they hybridise in the wild. Top:* Heliconius himera *and bottom* H. erato.



ii. What is good about being "natural"?

Why should we assume that whatever is "natural" is good and whatever is "unnatural" is bad? A "natural" event, product, process or tendency (however defined) is not automatically good or desirable. Many "natural" substances are harmful; 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 modern theologian Don Cupitt points out, Nature can be seen as a "kindly mother, lovely in every aspect" but also as "wild, chaotic and pitiless".(9)

We cannot then simply deduce what is morally right and wrong from certain facts about the world and about Nature. Simply because something happens in Nature does not mean that we can have no ethical justification for interfering with it. So even if natural species boundaries can be identified (which may be difficult), their mere existence does not tell us what **ought** to be done about them. The Alps, for example, are a "natural" boundary between Italy and Switzerland, but that geographical fact tells us nothing about whether it is morally right or wrong to cross from Italy to Switzerland.

Dogs evolved from a common wolf-like ancestor. The enormous differences between breeds have been introduced by selective breeding over long periods of time for different physical and behavioural traits. Breeds have been developed for use in hunting, different types of work, and to be "companion animals" for humans. Is this more "natural" or more acceptable than genetic modification? Is the speed of change an important issue?

Problems with animals

The moral concerns so far described in this section could apply to all applications of modern bio-technology, whether the genetic material involved be that of animals, plants, human beings or even micro-organisms. If we now focus upon animals, however, we find that further, more specific issues may be raised.

INSULIN

- a case history that touches on many aspects of the current debate about the use of animals in research, and genetic modification technology.

In 1921, Frederick Banting and Charles Best in Canada showed that an animal pancreatic extract could control blood sugar levels in a diabetic dog. After purification processes and further animal tests, it became possible to test the extract on humans. The first use of insulin to treat a critically ill diabetic boy occurred in the following year. Subsequently, people with diabetes around the world were treated with insulin which was derived from the pancreatic cells of cattle or pigs.

Within the last 20 years, advances in molecular biology and gene technology have enabled scientists to make "human insulins" which are less likely to cause allergic reactions and which have other potential clinical advantages. Such insulins can be made either by converting the pig insulin into the human form, or by using genetic modification to insert a synthetic copy of the human gene for insulin into bacteria or yeast cells. In the latter case, the yeast and bacteria cells are cloned and used as "mini-factories" to produce large amounts of the human insulin.

There are an estimated 60 million people with diabetes world-wide. As well as treating human diabetes, insulin is also used to treat the condition in cats and dogs.

i. Transgenic animals can create particular problems for some religious groups. For Muslims, Sikhs and Hindus it would be forbidden to eat foods containing genetic material from animals whose flesh is forbidden. Such religious requirements raise fundamental questions about the identity of animals and its genetic basis. If, for example, a small amount of genetic material from a fish is introduced into a melon (in order to allow it to grow in lower temperatures), does that melon become "fishy" in any meaningful sense? Some would argue that as all living beings share a great deal of common genetic material, transferring a gene from an animal to another organism does not involve any incorporation of the animal's identity into that organism, though others would maintain that the transferred genes are precisely those which are distinctive of the animal.

ii. Many appear to be uneasy about the transfer of genetic material from and into animals, though there seems little concern that insulin for treating diabetics is now produced by inserting copies of human genes into micro-organisms. This suggests that it is the involvement of animals rather than the crossing of species (or even kingdom) boundaries which is felt to be morally problematic.

iii. The cloning of animals has recently become the focus of great public interest and media attention. As explained in Section 1, cloning is a biotechnological procedure which does not involve genetic modification, though the distinction is probably not widely appreciated by non-scientists. Cloning techniques have, however, raised some moral concerns of an intrinsic kind, because of the genetic identity of the resulting animals. Some critics have objected that the deliberate production of genetically identical animals is wrong, because it fails to respect the uniqueness and individuality of all animals, particularly if the aim is a production-line uniformity.

iv. Does modern animal biotechnology pose any distinctively new ethical problems which were not already raised by traditional selective breeding? Some would claim that we have for centuries practised a form of "genetic modification" which has altered species and "interfered with Nature" on a massive scale, the results of which are evident in every domesticated animal today. Belgian Blue cattle, for example, have been bred to have massive hindquarters, and the ethical issues raised by such creatures would seem to be the same whether these animals are produced by selective breeding or by genetic modification. On the other hand, it can be argued that the speed and precision of modern animal biotechnology and the fact that we can now **directly** modify animals' DNA present us with possibilities and responsibilities which do introduce a new ethical dimension in terms of the increased power and control we can now exercise over the shape of animals' lives. This issue leads directly to another, which philosophers have recently debated at some length.

v. Even if it is accepted that some examples of animal biotechnology are not intrinsically wrong and could be seen as extensions of traditional breeding practices, the question still arises as to **how far** this technology can legitimately go. Are **some** alterations to animals' genetic structure intrinsically wrong, and if so, why? Of course, similar questions can again be asked about selective breeding, which some would argue has gone too far in some cases - e.g. in designing breeds of dogs and cats as fashion accessories and for other frivolous purposes, with little regard for the origins of these species.

In considering this question, some philosophers have made use of the notion of an animal's **telos**, a term first introduced by the Greek philosopher Aristotle. Telos has proved to be a slippery concept which can be given different interpretations by different writers, but it is generally understood to refer to the nature and interests of an animal, arising from its membership of a particular species. Bernard Rollin, an American philosopher who has written extensively about animals' telos, illustrates it by speaking of the "pigness" of the pig and the "dogness" of the dog - "fish gotta swim, birds gotta fly". Telos, according to Rollin, defines:

"the way of living exhibited by that animal, and whose fulfilment or thwarting matter to the animal. The fulfilment of telos matters in a positive way and leads to well-being or happiness; the thwarting matters in a negative way and leads to suffering". (10)

Happiness and suffering here have a wider meaning than mere pleasure and pain. To isolate a naturally social animal, for example, does not cause it physical pain, but can cause psychological suffering because its telos is being ignored or violated.

It is easy to see how the notion of telos is relevant to animal biotechnology, for some current examples of genetic modification could certainly be said to involve altering animals' telos, while many more can be envisaged as lines of possible future research. Genetic modification can be used, for instance, to prevent broody behaviour in turkeys, thereby boosting productivity by up to 20%. Many other forms of genetic modification have been suggested which might alter farm animals in ways which made them better adapted to methods of intensive production.

Belgian Blue

It is debatable whether proposals to produce "double muscled" cattle such as the Belgian Blue by genetic modification would obtain ethical approval by UK regulatory bodies. Yet such cattle have been developed commercially by selective breeding processes that exploit a natural mutation which gives rise to the double muscling effect.

What issues does this raise? Do any moral concerns arise principally from the nature of the animal produced or the method of production? What are the implications for the regulatory processes?

Some of these possibilities raise difficult ethical questions. Would it be wrong to modify animals in ways which altered their telos, but which thereby also reduced their experience of suffering or frustration? Keeping chicken in battery cages, for example, frustrates many natural aspects of their behaviour, and could be said to ignore their telos. If chicken could be engineered so as not to suffer the frustration of having their desires thwarted, they might be said to have benefited from having their telos altered in this way. A more extreme example might be the production of "decerebrated" animals, unable to experience pain or suffering of any kind – though it is perhaps doubtful whether such creatures could strictly be called "animals" at all.

Philosophers disagree over the ethical issues raised here. Rollin, for example, argues that while we should always **respect** animals' telos, this does not mean that we should never **change** a telos if happier animals result; if a telos is changed by genetic engineering, the animals must be no worse off than they would have been without the change. Others would claim, however, that to create animals with reduced capacities is to restrict their freedom and to show a lack of respect.

We cannot delve further here into the complex issues surrounding animals' telos. However, it should be noted that genetic engineering is not the only means by which a telos may be changed. All domesticated animals today show characteristics which have been produced by selective breeding and which represent changes to their telos – for example, reduced aggression. Those who would oppose on intrinsic grounds any changes to a telos which animal biotechnology might effect must consider whether they would also raise ethical objections to the methods which have produced all domestic pets and farm animals. Is it the type of animal produced or the process by which it is produced that is the real source of moral concern?

vi. A final, specific concern which needs a brief mention is that of patenting, which some feel highlights the failure of animal biotechnology to respect the individuality and intrinsic value of animals. Some genetically engineered animals have already been patented for their usefulness as models of human disease, and this will be discussed further in the following section.

Patenting in this context is a highly controversial and complex issue which leads some to feel it morally wrong to see animals (or other living organisms) as objects which can be invented and owned. However, it can be argued that the emotive charge of "patenting and owning life" loses much of its force when it is realised that the "ownership" involved is of the invention itself and not of living "matter". In the case of animal biotechnology, a patent would imply ownership not of an actual animal but of the invention of the "genetic kit" which produces a particular attribute. In any case, the logic behind moral objections about "owning life-forms" seems far from clear in view of the fact that we happily talk about owning cats and dogs without arousing moral indignation.

Although the above concerns are best described as intrinsic (i.e. they raise queries about whether animal biotechnology is wrong **in itself**), we have seen that some of them also touch upon issues of animal welfare which relate to the possible extrinsic **consequences** of the technology. The next section, therefore, will focus directly upon ethical problems arising from these and other possible consequences.

Would you be prepared to eat

(i) free range turkey,

(ii) intensively reared turkey,

(iii) genetically modified turkey?

What different ethical issues are raised in each case?

5 Extrinsic concerns about animal biotechnology

> "When one is genetically engineering animals, what we can do far exceeds what we can know and predict, and it is thus good policy to prepare for the worst case" (11)

The possible consequences of animal biotechnology are many and varied. A number of the developments outlined in Section 1 could produce substantial benefits, notably in the area of medical research. Other less desirable consequences, however, can also be envisaged, relating particularly to various kinds of risk and to increased animal suffering, both of which can give rise to serious moral concerns. Any technology can, of course, be used for good or ill, but the possibility of abuse and potential for harm cannot rule out its legitimate use and potential for benefit.

The moral concerns here are difficult to assess because they must involve predictions about future states of affairs. 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.

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

i. Even if agreement is reached about likely consequences (which 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. (e.g. of what ethical significance is animal welfare?)

ii. There is never just one consequence to any activity but a whole set of consequences, often occurring at different times. The consequences of any activity, therefore, cannot simply be morally approved or condemned *en bloc*, for they will often produce conflicting advantages and disadvantages. (e.g. human beings may benefit from animal suffering)

iii. 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. (Presumably a financial assessment of this kind was made in deciding the method of extinction to be used in Nazi concentration camps). Ethical judgements 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 section will not, therefore, concentrate upon trying to establish "the facts" about the possible effects of animal biotechnology, although some tentative assumptions will have to be made about likely and unlikely consequences. The aim will rather be to identify the range of moral concerns felt about the possible consequences of animal biotechnology, to analyse the logic of these concerns and to illustrate how the weighing of costs and benefits necessarily depends upon more fundamental value judgements.

Is animal biotechnology risky?

Riskiness is not in itself a moral or ethical matter. 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.

Risk and safety become matters of moral concern only when they raise further questions about **responsibility** and **justifiability**. Moral concern is appropriate when irresponsible and unjustifiable risks are thought to be taken, which may result in harm to innocent parties. Determining precisely what constitutes "irresponsible" risk-taking and when a possible benefit justifies a possible risk is highly problematic, however.

What kinds of risk are claimed to attach to animal biotechnology, and are they sufficiently "irresponsible" and "unjustifiable" to merit moral concern? Any new technology is unpredictable, and it is this unpredictability which produces concerns about various risks. Although genetic technology is often claimed to be precise in targeting specific genes, it remains unpredictable in terms of its possible wider effects and unforeseeable consequences. One particular line of research is especially open to this charge, where genes whose function is unknown are "knocked out" in order that the results may be observed - e.g. on the immune system of mice. If this random approach were to lead to harmful consequences, it might be difficult to avoid the accusation of irresponsible experimentation.

A number of other concerns has been expressed and debated, (12) and these include:

i. Concerns about the speed with which animal biotechnology can effect changes in animals, compared with traditional selective breeding which allows changes to be observed and assessed over many generations.

ii. Concerns that this "fast-lane" method of breeding food animals might produce unexpected and harmful results for those who eat foods derived from such animals (e.g. cattle and pigs engineered to grow at a faster rate).

iii. Concerns that animal biotechnology might narrow the gene pool and reduce genetic diversity, so producing monocultures which could be vulnerable to new diseases or other environmental threats.

iv. Concerns that animals engineered in biomedical research to be models of human diseases might escape and infect the human (and animal) population, or might generate new and more resistant strains of the disease.

v. Concerns that organs from genetically modified animals might transmit viral diesases if used in human transplant surgery.

vi. Concerns that genetically modified animals might be accidentally or deliberately released into the environment, causing various forms of ecological disaster as the introduction of alien species is wont to do. Transgenic fish, particularly salmon designed to grow at a faster rate, are often used as an example here, though of course it is not only genetically modified animals which are capable of creating ecological problems.

Many scientists would not share these concerns, and it must be emphasised that the magnitude of such risks (of which the above are only a brief sample) is highly controversial, but this is not the place for a detailed technical assessment of each case. Regulatory bodies have in fact been established to undertake such assessments. However, some of the risks envisaged here could be of such a catastrophic nature that no one would feel justified in turning a blind eye to them. So does it follow that any activity which could lead to catastrophic consequences ought not to be undertaken? Unfortunately, this simple and apparently responsible conclusion overlooks the fact 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", and animal biotechnology is no exception to this logical rule. **Any** activity could conceivably lead to catastrophic consequences.

But how much weight should we place on this logical truth? Critics argue that the risks involved here are of such a level as to make the further development and application of animal biotechnology irresponsible; it is the particular and peculiar risks associated with these techniques that make them ethically unjustifiable. Clearly the issue here is partly one of technical assessment, and this will of course vary from case to case, making generalisations about the "safety" of animal biotechnology virtually impossible. One obvious ethical requirement here is a stringent system of risk assessment and regulation which ensures that no irresponsible risks are taken in the light of current knowledge, though it must be recognised that no such system can ever be foolproof. However, excessive caution does not necessarily remove the risk of future catastrophes. It is possible that "playing safe" by abandoning research and development in all forms of animal biotechnology might deny us a technique or product which could prevent an environmental disaster in fifty years time, or could prove invaluable in the treatment of serious diseases.

Trying to decide in any area what level of risk-taking is ethically justifiable, by weighing possible

REPORTS

In recent years there have been several reports that cover many of the issues considered in this booklet. These include:

Report of the Committee on the Ethics of Genetic Modification and Food Use (1993). A Report to MAFF. Committee chaired by Revd Dr J C Polkinghorne.

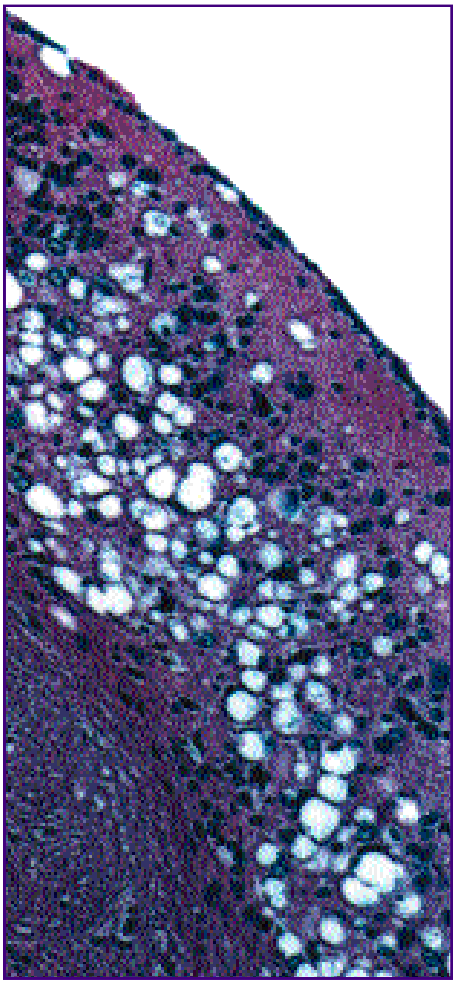
Report of the Committee to consider the Ethical Implications of Emerging Technologies in the Breeding of Farm Animals (1994). A Report to MAFF. Committee chaired by Revd Professor Michael Banner.

Animal Tissue into Humans (1996). Department of Health. A Report by the Advisory Group on the Ethics of Xenotransplantation, chaired by Professor Ian Kennedy.

Animal-to-Human Transplants – the ethics of xenotransplantation (1996). Nuffield Council on Bioethics.

costs against possible benefits, is a difficult task, usually requiring detailed analysis on a case-by-case basis. With animal biotechnology, however, the issue becomes even more complex and controversial, because the costs and benefits will be experienced by two different groups with different interests - human beings and animals. While some of the possible human benefits could be dramatic, particularly in terms of medical research, and consequently significant enough to outweigh a certain level of risk, the situation is much less clear in the case of animals. This has led some commentators to conclude that it is likely to be human beings who reap the benefits and animals who incur the costs.

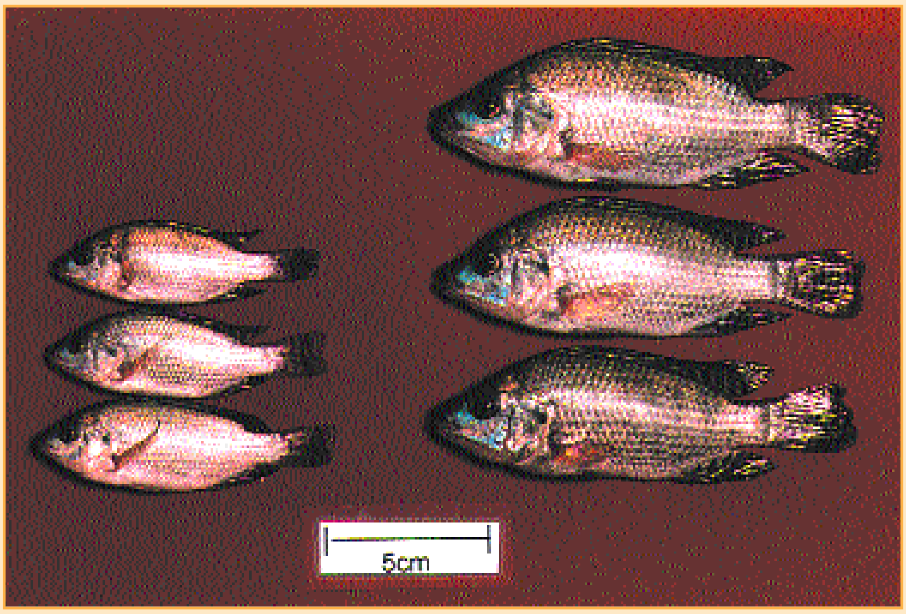
In order to examine these possible costs more closely, we now need to return to the subject of animal welfare and ask whether the possible consequences of animal biotechnology might involve levels of pain and suffering which are ethically unacceptable.



A section of mouse brain infected with the agent of the sheep disease scrapie. This shows the vacuolation that is a feature of the spongiform encephalopathy diseases that include scrapie, BSE and CJD. Transgenic mice have been important in understanding the nature of these diseases and in assessing the transmissibility of BSE to humans.

GENETIC MODIFICATION AND SPECIES CONSERVATION

If a species that is threatened with extinction could be saved by introducing a gene that gave disease resistance into the germ line of breeding animals, would this be acclaimed as a triumph for genetic modification technology? How might our views about this differ from those on the use of modern reproductive technologies used in many zoos to save endangered species? How would we evaluate the risk of using genetic modification in this way? Would it ever be justifiable to use GM to “resurrect” extinct species?



Three 9 months old transgenic tilapia (right) and 3 non-transgenic full siblings. (Reproduced with permission, from Rahman et al *1998, Transgenic Research, 7: 357-369).*
These transgenic fish were produced by introducing a gene that codes for a salmon growth hormone. The aim of producing such transgenic fish containing a novel growth hormone gene is to provide faster growth, thus reducing the farming period, and better food conversion rates, which would reduce the production cost.

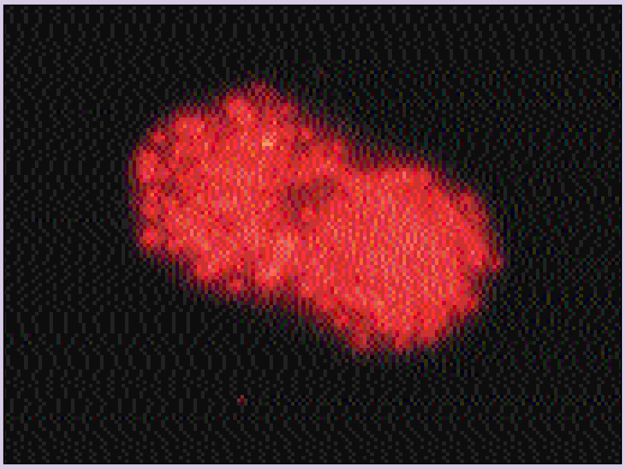
Animal welfare

Critics of animal biotechnology claim that no benefits have resulted yet for the animals themselves from the new technologies and that there is evidence of actual harm being caused. An early example of such harm which is often quoted was provided by the "Beltsville" pigs (named after the US Department of Agriculture research station where they were born). Growth genes were inserted into these animals to produce faster growth and leaner meat, but the animals also suffered from a number of serious and disabling disabilities, as have sheep treated in a similar way. The unpredictable nature of such experiments clearly has considerable potential to cause animal suffering, particularly in the early stages of a new technology, though more recent work in this particular area is claimed to have overcome the problems.

Other grounds for claiming that animal biotechnology may be detrimental to considerations of animal welfare include: (13,14)

i. Disease resistance is aimed mainly at diseases which are endemic to intensive farming methods, where animals and birds are highly vulnerable to infection. Increasing the productivity of food animals by genetic modification might also increase stress and performance-related diseases.

ii. The production of pharmaceutical proteins in animal milk might increase pressure to extend the length of lactation or the frequency of milking.



Disease resistance genes

Scientists have mapped novel genes involved in determining chickens' resistance to infection by Salmonella*, and the virus that causes Marek's disease. These are among the first economically important traits for which genes have been mapped in poultry. This picture shows a gene (highlighted in yellow) on one of the chromosomes, located using a specific marker sequence.*

iii. Providing organs for transplants to humans will involve similar confinement and isolation in a clinical environment. The Government Advisory Report on the Ethics of Xenotransplantation (1997) accepted that pigs used for this purpose may be exposed to harm and suffering. (15)

iv. Changes to the growth rate of the embryo may cause reproductive stress for the mother.

On the other hand it can be argued that animals may benefit from biotechnology. A wide range of diseases and disorders could be tackled in this way, and while some of these may be exacerbated by ethically questionable farming practices, animal welfare might still be said to have improved if the overall level of disease is reduced. Other undesirable practices might be reduced, such as the destruction of day-old male chicks, castration and tail-docking. Many genetic disorders (for example, in dogs) might also be prevented. Those who do not object to changing animals' telos if they are thereby caused less suffering or discomfort would also argue that it could benefit animals to be genetically modified so as to fit them for living conditions for which they are not "naturally" suited. Finally, there is the possibility of using genetic technology to save endangered species from extinction.

Disagreement exists then, over the possible impact of genetic technology on animal welfare, but concerns about the potential for animal suffering are by no means the sole province of philosophers and animal welfare groups. In 1995, for example, the Banner Committee in the UK produced a report for Government Ministers on the ethical implications of emerging technologies in the breeding of farm animals, (16) which recognised that genetic modification might result in welfare problems, some of which might not be immediately apparent. This Committee produced three general principles for future practice:

i. Harms of a certain degree and kind ought under no circumstances to be inflicted on an animal.

ii. Any harm to an animal, even if not absolutely impermissible, nonetheless requires justification and must be outweighed by the good which is realistically sought in so treating it.

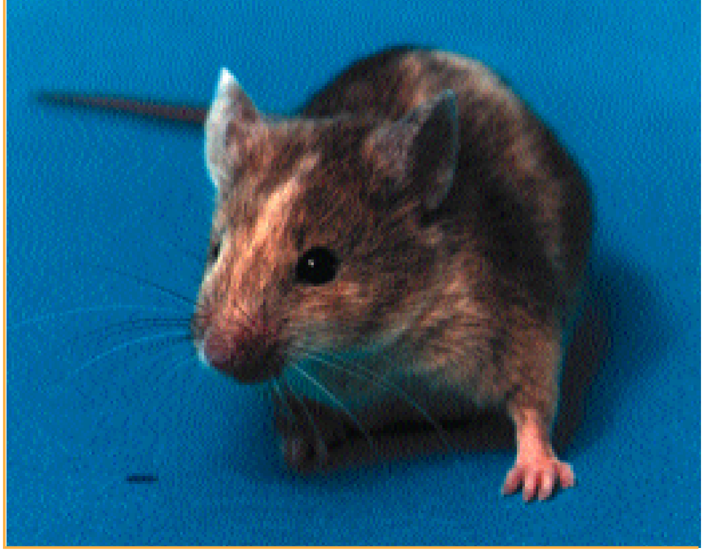
iii. Any harm which is not absolutely prohibited by the first principle, and is considered justified in the light of the second, ought, however, to be minimized as far as is reasonably possible.

In applying these principles to the issue of altering animals' telos, the Committee concluded that it would be unacceptable to use genetic modification to increase the efficiency of food conversion in pigs by reducing their sentience and responsiveness, thereby decreasing their level of activity, on the grounds that this would be morally objectionable in treating the animals as raw materials upon which our ends and purposes can be imposed regardless of the ends and purposes which are natural to them. Such recommendations reflect legislation introduced in Sweden, requiring that farm animals be allowed to live their lives in accordance with their telos - e.g. that cattle have the right to graze and that chicken and pigs have the right to freedom of motion – though it must be remembered that the telos of farm animals could be said to have been already reshaped in many ways by selective breeding, as mentioned earlier.

Most animal biotechnology at present, however, is practised not on the farm for food purposes, but in the laboratory for research purposes, and genetically modified laboratory animals raise particular and difficult problems in terms of animal welfare. Such animals may be used in various ways, and these are controlled by regulations intended to minimise suffering, but it is as models of human diseases that they create especially thorny ethical dilemmas. Animals have in fact been used as disease models for many years, but the production of genetically modified animals for this purpose has recently attracted particular attention and debate.

The best-known example of such an animal is the so-called oncomouse, the first creature ever to be (controversially) patented, which is genetically designed to develop cancer. The creation of this animal poses the question of whether an ethical distinction can and should be drawn between **inducing** cancer in a laboratory animal and genetically **engineering** an animal to develop cancer. While there seems little difference in terms of the animal's welfare (or lack of it), some have argued that it is ethically objectionable to alter an animal's genetic structure with the clear purpose of causing it to be defective and to develop a painful, lethal condition.

Even more problematic than the oncomouse, however, is the use of animals to model other human diseases. At least in the case of cancer research, regulations require procedures to minimise the suffering of laboratory animals by employing euthanasia at a certain stage of the tumour's development. However, it has been suggested that research into a number of devastating human genetic diseases (e.g. Lesch-Nyhan disease and HPRT deficiency), where animals are likely to be increasingly used as models, will need to keep those animals alive for as long as possible in order to study the full course of the disease. As Bernard Rollin points out, there is no way to study many of these diseases in acute, terminal or short-term



The use of genetic modification in animal experimentation is increasing. Of all the animals used in research procedures in Great Britain, over 85% are specially-bred rodents.

experiments, and as anaesthesia cannot be maintained for long periods there appears to be the potential here for a considerable amount of animal suffering. (17)

The issue of animal welfare and the distinction between genetically modified food animals and laboratory animals throws into sharp relief the ethical problems which have been the focus of this booklet. If there are, as the Banner Committee's first principle claims, harms of a certain degree and kind which ought under no circumstances to be inflicted on an animal, it seems that some such harms might well be involved in the areas of medical research mentioned above. Yet although critics claim that the differences between laboratory animals and human beings makes most of the research based upon animal studies of dubious value, it is arguable that by not using animals in such research, human beings may suffer. If such dilemmas exist even in the area of medical research, where the aim is to improve dramatically the quality of human life for many, the ratio of animal costs to human benefits looks even more ethically questionable in the case of the possible suffering of food animals.

Extrinsic concerns about risk and welfare have been shown to raise basic questions about the ethical assessment of costs and benefits, such as when (if ever) do the possibly dramatic benefits of a new technology outweigh its possibly catastrophic risks, and how are possible human benefits to be set against probable animal suffering. The task of ethics here is to examine the justifiability of the alternative courses of action and the general principles on which they might be based. Ultimately, however, these principles are likely to reflect fundamental beliefs and value judgments, which cannot simply be "proved" right or wrong, about what is to count as human development and progress and what our relationships and obligations should be towards other species.

6 Conclusions

As this booklet has not attempted to offer simple answers to moral and ethical questions about animal biotechnology, a convenient list of such answers cannot be provided in this concluding section. Nevertheless, a number of underlying themes has emerged, explicitly or implicitly, which are worth drawing together briefly at this point.

i. Animal biotechnology can generate a number of **different** moral concerns. Distinctions of various kinds need constantly to be drawn in order to pinpoint precisely the grounds of the moral concern and the target at which it is directed. Intrinsic and extrinsic concerns, for example, have to be carefully distinguished as they rely upon radically different forms of argument. Generalisations about the rights and wrongs of animal biotechnology as a whole are not likely to be very helpful.

ii. For moral concerns to carry weight, they should specify what is **distinctively** objectionable about their target or demonstrate that the objectionable feature is equally objectionable in other contexts. It is illogical, for example, to object to animal biotechnology simply on the grounds that it "interferes with Nature," without at the same time objecting to countless other examples of such "interference" occurring in agriculture, horticulture, medicine and many other activities which most of us accept without question.

iii. A major reason why animals raise ethical issues is that they are sentient beings. Belonging to a particular species does not in itself automatically confer moral superiority or inferiority in relation to members of other species. Taking account of the sentiency of other species may suggest an approach which attempts to calculate animal and human pleasures and pains, or one which respects animals as individuals possessing inherent value. In either case, difficult judgments have to be made about the precise boundaries of the animal kingdom and the qualifications for membership of the moral community.

iv. Moral concerns that animal biotechnology is intrinsically wrong depend largely upon beliefs about its "unnaturalness", but these raise problems of definition and of ethical justification. The question of whether it can ever be right to alter an animal's nature or telos, and if so to what extent and for what purposes, has however provoked serious ethical debate.

v. Equally complex and controversial are utilitarian attempts to evaluate the consequences of animal biotechnology in terms of risks and benefits. Huge benefits are predicted by some, particularly in the area of medical research, but these have to be weighed against potentially serious risks. The ethical assessment is further complicated by the issue of animal welfare, and by the question of whether certain levels of harm ought under no circumstances to be inflicted on an animal.

The examples of moral and ethical issues examined in this booklet are not intended as an exhaustive list, though they probably encompass the main areas of current concern. One of the challenges presented by our ever-developing range of knowledge and skills, however, is that it continues to throw up novel and more complex questions about what it is right and wrong to do, and these questions cannot be answered by referring back to some previously agreed moral rule-book, partly because no such rule-book exists and partly because, even if it did, it would be inadequate to deal with fresh and often unforeseen developments. Science and ethics, then, need to proceed hand in hand in exploring new territories such as animal biotechnology, to ensure that the wide-ranging implications for human and animal welfare are kept under constant review.

7 Technical Annex

Three ways by which animals can be genetically modified

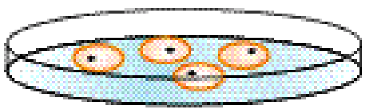
(a) Pro-nuclear injection

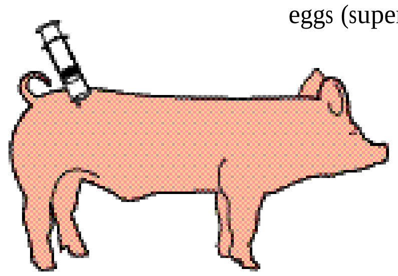
Microinjection of DNA (genes) into a one-celled embryo (single recently-fertilised egg).

1. Single celled embryos are produced

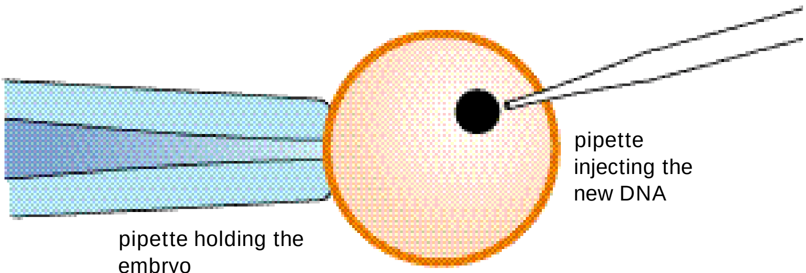
either by *in vitro* maturation and fertilisation of egg cells. This approach has been used with bovine egg cells.

or by mating a female animal that has been injected with a hormone to produce a larger than usual number of eggs (superovulation).

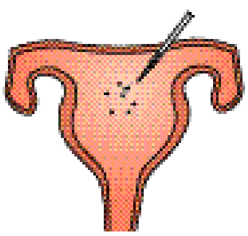




2. The single cell embryos are isolated and injected with typically 200-500 copies of the new gene. This process is called microinjection. The injected gene incorporates randomly into the host's DNA.



3. After a few cell divisions, microinjected embryos are transferred to the oviduct of female animals which have been induced by hormones to act as surrogate mothers.



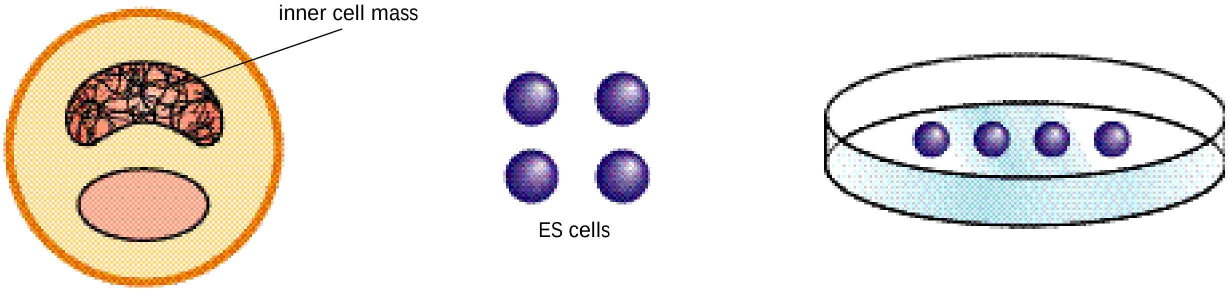
4. Embryos develop in the surrogate mother. Offspring are tested to see if they possess the new gene.

The overall efficiency of gene insertion is low, perhaps 2-5%, although this varies between species and may be up to 10% in mice. This low efficiency is compounded by the fact that the inserted genes may not work efficiently. However, in total, several genes have been successfully introduced into different livestock species using microinjection.

(b) Gene targeting in embryonic stem (ES) cells.

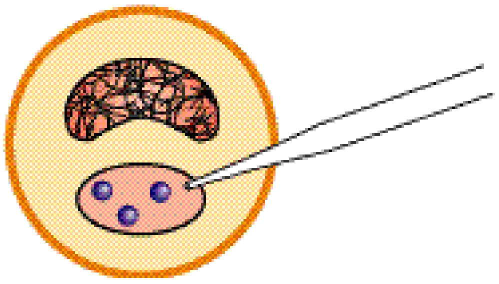
This method is usually used to target the insertion of the DNA by homologous recombination and so provides a method for specifically disrupting or replacing an endogenous gene, although it can be used for simply adding new genes.

1. Fertilised embryos are isolated and from these stem cells are dissected out and so-called embryonic stem (ES) cell lines are established.



2. DNA sequences are introduced into the ES cells and in a very small proportion of cases will be inserted at the targeted site in the genome.

3. The targeted cells are selected from the rest and injected into embryos at the blastocyst stage.



4. These embryos are implanted into surrogate mothers. The animals produced are chimeras with a proportion of the cells in each tissue derived from the normal embryo cells and a proportion from the injected modified ES cells.

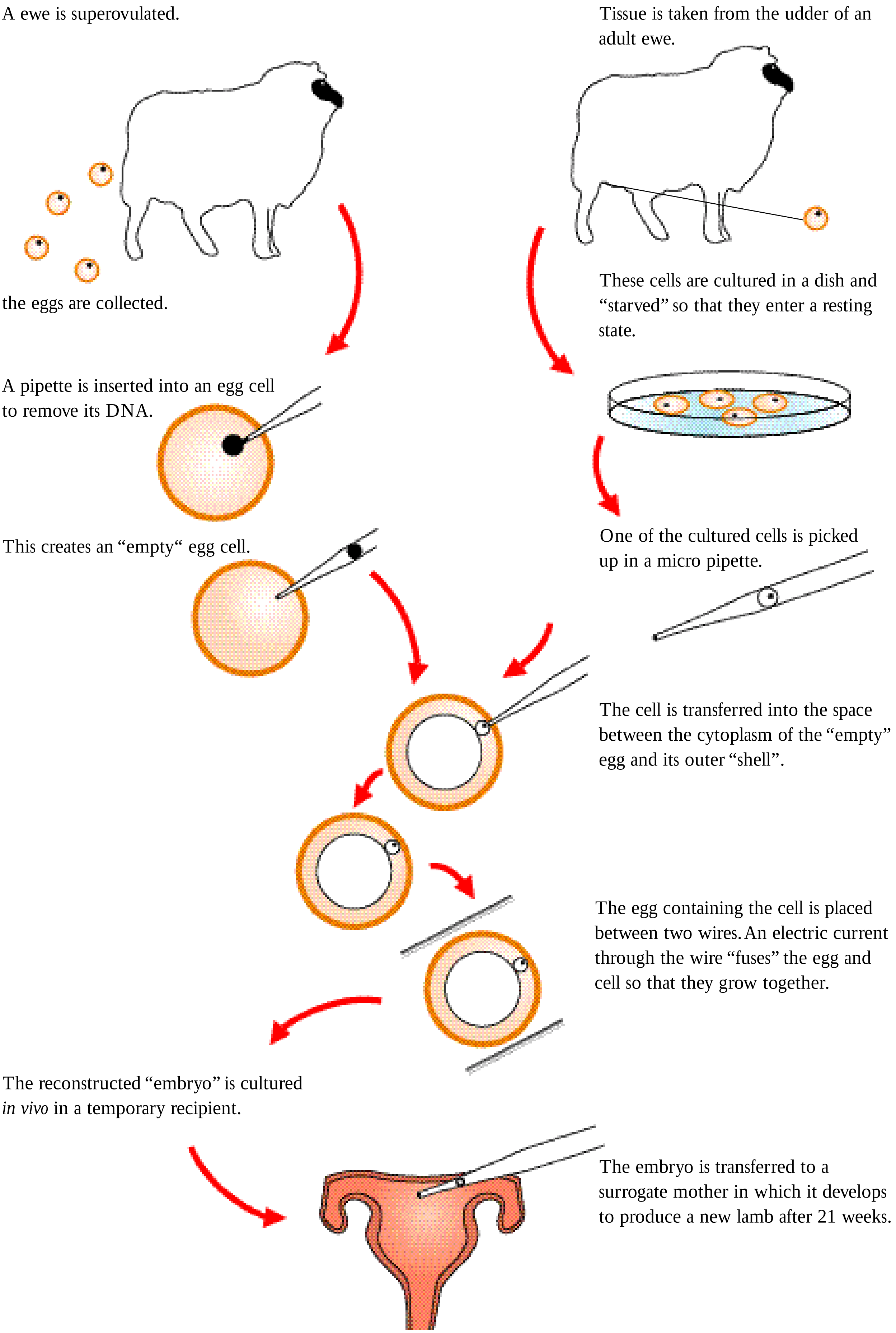
5. A proportion of the offspring of these animals will be genetically modified, i.e. they carry the targeted change introduced into the ES cells.

ES cells are only available in mice and, so far, this route is limited to this species.

ES cells have been widely used to knock out gene activity in mice but have not been isolated from livestock. Nuclear transfer has been developed as an alternative way of deriving genetically modified animals from genetically modified cells.

(c) ***Nuclear transfer***

This is the process that produced Dolly, the world's first mammal derived from the cell of an adult animal.



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12. See e.g. Rollin, B. (1995), pp.108-136

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