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Animal biotechnology and animal welfare[1]

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Introduction

During the past 30 years biotechnology has been used to develop a range of useful types of animal. These animals have made huge contributions to basic research and biomedicine and are beginning to enter the agricultural production system. This development raises a number of ethical questions. The central issue, as is so often the case, is about the boundaries of ethical acceptability.

Most people would readily agree that there is a difference between what humans *can* do and what they *ought* to do. Equally, most people would happily acknowledge that it is good to do the morally right thing. However, the harmony usually ends there, because although it is easy to agree that a good thing should be promoted, it is often hard to reach consensus on what that good thing is, how it can be promoted, and where to draw the line between *what is acceptable and what is not*. As soon as we begin discussing these questions, whether in private or in public, we are engaging in ethical discussion – discussion in which we seek to establish a substantial understanding of the concepts of good and right that can guide our choices when we are faced with opportunities whose acceptability appears uncertain.

The issue of ethical acceptability has closely shadowed developments within biotechnology over the past 30 years, not least when it comes to animal biotechnology. A range of possibilities including reproductive technologies, genetic modification and cloning has prompted concern about the ethical limits of our use of animals. It is probably an understatement to say that discussion has so far led to no consensus in the public sphere, but it would also be an overstatement to say that the debate has been futile. What *has* emerged, among other things, is a clearer understanding of the basic ethical assumptions behind the different viewpoints, together with greater attention to our ethical duties to animals.

What is animal biotechnology?

Animal biotechnology has developed rapidly over the past 20-25 years. The production of genetically modified animals began in the early 1980s, and cloning took off with the experiments by Steen Willadsen in the mid-1980s in which cloned sheep were produced by embryonic cell transfer

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(Willadsen, 1986). However, cloning technology only came to public prominence through work, lead by Ian Wilmut, in which somatic cell nuclear transfer was used to produce the cloned sheep, Dolly, in 1996 (Wilmut et al., 1997). Most work within animal biotechnology has been carried out on laboratory mice, sheep and cattle, but more recently the technologies have been adapted to other species such as pigs, goats, horses and cats. It should be noted that methodologies and success rates vary from species to species.

Animal biotechnology is used primarily for two purposes: to produce animals that can be employed in basic biological research into biological development and function, and to produce disease models that mimic human diseases and can therefore be utilised both in the study of disease (such as Parkinson's, cancer, cystic fibrosis, etc.) and to test new drugs. Increasingly, since the early 1990s, researchers have sought to develop animals with special traits making them useful within pharmaceutical production (bioreactors) and to create production animals with traits offering improved production, better animal health and/or reduced environmental impact. None of these applications has reached the market yet, but reports indicate that the first pharmaceuticals based on human proteins produced in animals are to be released in 2006 (CeBRA, 2005*a*). Similarly, some observers expect the first cloned animals to reach the agricultural production system in a few years; others anticipate that genetically modified animals will also enter the system within the foreseeable future (NAS, 2002).

Animal biotechnology can be defined in a number of ways. Which definition is used is of some importance, because the definition determines what should be considered a biotechnological novelty and what should be considered an established practice. Thus some people believe that only the new possibilities with genetic engineering and cloning should be categorised as animal biotechnology, while others wish to include well-established breeding technologies such as artificial insemination and even some older breeding practices (AICE, 1996; NAS, 2002). From an argumentative viewpoint, there are various reasons for including as much, or as little, as possible under the heading *animal biotechnology*, but we shall not discuss the merits of the contrasting definitions here. The more the new technologies can be seen as a natural extension of well-established practices the more it can be argued that there is nothing new under the sun and that, for example, regulation can be based on existing regulation and that the ethical concerns are no different from those arising from already established technologies – and vice versa (Lane 1996). In this article we will arrive at a fairly broad view, but our starting point will be modern biotechnological applications such as genetic engineering and cloning. We are proceeding in this way in order to demonstrate how the ethical debate about these novel possibilities might shed light on established practices within animal breeding. These established practices can be traced back to the rediscovery of Mendelian theories at the beginning of the twentieth century and the development of modern selective breeding practices from the 1920s onwards.

The possible applications of the new technologies can be divided up on the basis of the reason for using the technology. The applications that are mentioned in this and the following section are the ones usually mentioned in scientific articles on animal biotechnology. This does not mean that they have come to fruition, but only that researchers believe that they will be achievable in the light of anticipated scientific and technological expertise (CeBRA 2005). Thus some animals are used within basic research and as disease models (research animals). Here genetically modified animals are produced to investigate the function of genes and gene products and to create animals that mimic human diseases such as cancer or Parkinson's disease. The aim is to facilitate research into the diseases and test possible treatments (Khanna and Hunter, 2005; Emborg, 2004; Swanson et al., 2004). In this area, cloning is mainly used as a tool to produce the GM animals and to study abnormalities in reproduction (Olsson and Sandøe, 2005). Other animals are used as bioreactors that produce biological compounds not naturally occurring in them (so-called "pharm animals"). Typically a gene of human origin is introduced in the animal genome. This might be done to cause the animal to produce a specific protein in its milk that can be used in producing medicine to cure or alleviate human disease. For example, a sheep produced by the company PPL Therapeutics has been genetically modified to express a human protein in its milk called alpha-1-antitrypsin. Alpha-1-antitrypsin can be used in the treatment of lung disorders (NAS, 2002).

A third application involves animals used within the agricultural sector (farm animals). In principle animals with desirable traits could be cloned to speed up the dissemination of the desired genotypes; and animals could perhaps be genetically modified to increase productivity (growth rates, feedstuff utilisation, disease resistance, etc.), to develop new products (leaner meat, functional foods, etc.) or to reduce negative impact on the environment (Kues and Niemann, 2004). Finally, there is a range of more or less "exotic" applications of biotechnologies. The first genetically modified pet hit the market in 2003. It is a luminescent fish for aquariums called GloFish™ (Caplan, 2004, see also www.glofish.com). An American company – Genetic Savings and Clone, Inc. – offers to save genetic material from pets and clone them later. The company has so far only produced cloned cats, but it hopes to begin cloning dogs soon (CGS, 2005). There is also speculation that cloning may be used to save endangered species or recreate extinct species (Holt et al., 2004). Serious attempts to clone *Bos gaurus*, an endangered large wild ox, have been made but so far no successful results, in the form of viable animals, have been reported (Lanza et al., 2000). Other, more fanciful, projects in cloning, for example, Tasmanian tigers and mammoths are frequently reported in the media but no results of this kind have as yet been confirmed.

It should be noted that a prerequisite of ethical thinking on a specific human practice, such as animal biotechnology, is sound understanding of the technologies involved, the science behind them and the objectives of the applications. Although it has been questioned to what extent this kind of factual information is necessary to be able to pass ethical judgment, there is no doubt that more than superficial understanding is needed (Thompson, 1997). This, however, should not point to the erroneous conclusion that *all* that is needed to convert sceptics about biotechnology is information. Although widely assumed within the scientific community (CeBRA, 2005*d*), the so-called "knowledge deficit" of lay people does not explain the discrepancy between the often very positive conception of biotechnology that scientists bring to the debate and the far more sceptical attitude of the public. Studies have shown that the more information people have, the more likely they are to make up their minds and form an opinion; but they have also shown that this opinion will not necessarily be positive. Thus the Danish population proved to be one of the most informed about biotechnology in the 1999 Eurobarometer survey, but at the same time came out as one of the most sceptical (INRA, 2000; Lassen et al., 2006a).

Potential effects on animal welfare

The use of biotechnology on animals may cause welfare problems, and the present section provides a short list of examples. GM animals have so far mainly been used within biological research and as disease models. Usually the goal of modification is to produce animals that either under- or over-express certain genes, or that express a mutated, disease-causing human gene. In all these cases body function in the organism is in some way disrupted. In principle, modifications can involve any part of the animal genome, and the effects on the animal's phenotype range from those that are lethal to those that have no detectable effect on the health of the animal. It is therefore impossible to generalise about the welfare effects of genetic modification (Olsson and Sandøe, 2004).

However, effects may be divided into two main categories: the intended and the unintended. Welfare problems stemming from intended genetic change are hard to avoid, since the very point of inducing the change is to affect the animal. Thus, the mouse carrying the human Huntington's disease gene will inevitably suffer welfare problems in developing the disease, including rapid progressive loss of neural control leading to premature death (Naver et al., 2003). Unintended effects are connected with the present inaccuracy of the technology and our insufficient understanding of the function of different genes in different organisms. Both of these kinds of factor operate to create the rather unpredictable nature of genetic modification at the phenotypic level. However, it is likely that at least some of the unintended welfare problems can be avoided as the technology and our scientific understanding develop. Where the intended consequences of genetic modification (for example, in creating a disease model) are concerned, it may be possible to predict welfare consequences using information about the effects of similar mutations in other species, including the human disease symptoms. Thus some studies try to evaluate welfare consequences beforehand. This potentially enables the producers of the animal to consider these consequences before the animal is actually produced (Dahl et al., 2003).

Animals are cloned either to produce genetically identical copies of desired individuals or as a tool to produce GM animals. Owing to the fact that some of the genetic material is located in the mitochondria and thus is provided by the egg cell that is used in cloning, and to certain epigenetic factors that are not yet well understood, the cloned animal will not be 100 % identical to the donor animal, either in genotype or phenotype (CeBRA,, 2005*c* and 2005*d*). The importance of this for the different applications is still unclear. No matter what the purpose, the success rates of animal cloning are low (3-5%), and of the few individuals born, many suffer from impaired health and welfare. Problems include placental abnormalities, foetal overgrowth, prolonged gestation, stillbirth, hypoxia, respiratory failure and circulatory problems, malformations in the urogenital tract, malformations in liver and brain, immune dysfunction, lymphoid hypoplasia, anaemia and bacterial and viral infections (van Reenen et al., 2001). Some of these conditions are gathered under the term Large Offspring Syndrome (LOS). LOS is often seen in cloned animals, but it also occurs when other reproductive technologies are employed. It is not yet clear whether the welfare problems experienced by cloned animals can be avoided through technological or methodological improvements or whether there are deeper epigenetic factors behind them (CeBRA, 2005*c*).

Two perspectives on animal welfare

There are two conceptions of the ethical concerns about animal welfare engendered by biotechnology: a narrow one and a broader one. We will describe these in more detail below. For the moment let us simply note that the first focuses on avoiding pain and other kinds of suffering in the animals, and on promoting positive experiences: in general this conception focuses on the subjective experiences of the animal. Besides these considerations the broader perspective also includes the animal's opportunity to engage in essential species-specific kinds of behaviour (Fraser et al., 1997; Duncan and Fraser, 1997; Appleby and Sandøe, 2002; Rollins, 1993). The broad perspective partly overlaps with a third category of concern in which animal biotechnology is questioned not because it poses any risks to animal welfare but because it is seen as violating animal integrity and basic concepts of naturalness. There is thus no consensus as to what should be counted as a welfare problem and what should not. Here we will simply describe in more detail some of the welfare problems that animal biotechnology might generate from the two main perspectives within the debate: the narrow perspective that looks at the subjective experiences of the animal and the broader perspective that also looks at the animal's ability to act according to its species-specific needs.

From a narrow perspective only the subjective experience of the animal has ethical importance. If the animal has negative experiences (for example, pain, suffering and anxiety), their cause (in this case biotechnology) is deemed ethically problematic. If the animal does not have any negative experiences, as for instance would a mouse with cancer in the early stages, it may have an incurable illness but it does not have a welfare problem (yet).

From the broader perspective the question of animal welfare is also about the extent to which the animal is allowed to fulfil what can be called its species-specific potential, regardless of its subjective experience. Very often the broader perspective will point to an additional group of considerations that has to be taken into account when we reflect on animal welfare. Being concerned with the opportunity of the animal to engage in certain kinds of behaviour does not prevent one from caring about the subjective experiences of the animal. Nevertheless, occasionally these two kinds of consideration are difficult to reconcile in practice; in that situation it becomes important to clarify what kind of perspective is in play. Considerations within the narrow perspective regarding the subjective experiences of the animal might be outweighed by the other considerations included in the broader perspective as we will illustrate in the following.

An illustrative dilemma – one not involving biotechnology but which highlights the difference between the narrow and the broad perspective – concerns the evaluation of the welfare of battery hens and free-range hens. From a narrow perspective, there is no ethical objection to denying the animal the opportunity to follow its instincts (as battery cage egg production does) as long as this does not affect the subjective welfare of the animal, that is, lead to negative experiences (Appleby and Sandøe, 2002). One can rarely prevent an animal from following its instincts without causing it suffering, but through breeding (either of the conventional sort or involving cloning and/or genetic engineering) changes could theoretically be induced in the animal that will make it more fit for the conditions under which it will have to live. And since this would have no negative subjective consequences for the individual hens, such a use of biotechnology would be seen as ethically unproblematic. This means that for instance the welfare problems caused by battery cage egg production could theoretically be solved through breeding chickens that did not suffer because of these conditions rather than changing the conditions (Rollin, 1995). In practice though, it is difficult to see how this can become a reality in the foreseeable future. Firstly, the trait to breed for would have a complex genetic background, since the objective must be an animal in which one has eradicated all motivations other than those that can be satisfied in a battery cage. Secondly, it will be a difficult challenge to ensure that one is indeed breeding for an animal with a restricted set of motivations rather than an animal that reacts passively, or even with apathy, to adverse conditions. This is not to say that breeding for behavioural traits cannot be used to improve animal welfare (problem behaviours such as feather pecking in hens have indeed been shown to be under genetic control), only that the objective of producing what Ben Mepham calls an "animal vegetable" does not seem to be easily obtainable.

From the broader perspective the very idea that we should breed hens to cope with battery cages raises serious worries and questions about what the natural life of a chicken is, and what experiences constitute such a life. Instead of changing the chicken, one would look for ways of allowing the chicken to fulfil its natural potential as far as possible through changes in the production system. Life as a free-range chicken is obviously less protected than life as a battery hen. Disease, feather pecking and cannibalism occur frequently within flocks of chickens (Kjær and Sørensen, 2002). Nevertheless, from a broader perspective this may be an acceptable situation, since it is counterbalanced by the fact that the chickens are living more naturally.

From a broad perspective the new animal biotechnologies raise concerns in two areas. First of all, they extend technological control over procreation – a control that is already widespread within animal breeding through the use of semen collection, artificial insemination, superovulation, embryo transfer, transvaginal ovum pick up, etc. This affects both the process (the sexual life of the animals) and the result (the offspring). In both cases it can be questioned whether this interference is ethically acceptable, since all the technologies mentioned can, in very general terms, be described as unnatural when compared to the "normal" life of animals. Secondly however, the idea of naturalness as something valuable in itself raises questions about how naturalness should be understood. From animals used in basic research to farm animals bred for production, one can question if anything in their life is natural – at any rate, if "natural" means wild. The question should perhaps rather be about the extent to which the domesticated animal has an opportunity to fulfil its species-specific behaviour within the framework that the domestication process has built. Thus a laboratory mouse will live its life in a cage, but it might nonetheless fulfil certain species-specific behaviour (for example, digging or nest building) if given the chance.

Another case illustrating the difference between the narrow and the broad perspective is that of blind hens. Since genetically modified and/or cloned animals have not been introduced into the agricultural production system yet, we cannot draw on concrete examples but will highlight the envisioned ethical considerations by using realistic analogical examples. A Canadian scientist involved in poultry breeding has bred a blind egg-laying hen (Ali and Cheng, 1985). This variety of hen, according to the researcher, would help to reduce the welfare problems of free-range chickens. These birds harm one another by pecking, and sometimes even cannibalising, weaker members of the flock. Blindness apparently reduced these kinds of behaviour. It should be noted that the blindness was not inflicted on living chickens, but something they were born with. From a narrow welfare perspective the blind hens seem to be better off than their sighted peers.

At this point it is necessary to distinguish between two different viewpoints within the broad animal welfare perspective. To people taking the first viewpoint, both the notion of deliberately breeding chickens that have such limited potential as to be content with life as a battery cage hen and the aim of breeding blind hens to solve production problems in the agricultural sector are seen as ethically problematic in ways that might outweigh the advantages of these ideas as perceived from the narrow perspective. Something just seems to be amiss when you deliberately create an animal with less potential than normal (Lassen et al., 2006a), whether or not the animal has negative experiences as a result. Implicit in this version of the broader perspective is a certain respect for the natural state of the animal. Although it is intuitively compelling, it should be pointed out that this perspective suffers from an inherent ambiguity when domesticated animals are discussed, since it is almost impossible to point to a stage in the development of such animals that would constitute their natural state and thus be the developmental point that should be respected (Appleby and Sandøe, 2002).

This is a leading reason why other thinkers have suggested a different way of considering animal welfare problems within the broader perspective. They believe that the natural behaviour of the animal is to be respected, but the natural behaviour of the animal is not seen as something static. And just as domesticated animals have been bred to be better adapted to housing in confinement in the past, animals today can be bred, either conventionally or through genetic modification, to be better adapted for modern day production systems. Thus the fact that one can alter the nature of an animal by genetic modification does not constitute an ethical problem as long as one respects the nature that the animal ends up with (Rollin, 1995).

Whether we choose to look at animal welfare from a narrow perspective or one of the broader perspectives, two additional important issues must be borne in mind when evaluating the ethical dimensions of animal biotechnology. First of all, it is important to note that, from an animal welfare perspective, the difference between traditional breeding technologies and the new biotechnological tools seems to be more of a quantitative difference in the potential of applications than a qualitative difference that creates entirely new welfare issues.

The second issue is that the range of ethical concerns raised by animal biotechnology goes beyond questions of risks to animal welfare. An obvious group of considerations that we have only briefly mentioned concerns risks to human health. These considerations are usually treated within risk assessment frameworks. Then there is the familiar concern that one or other proposed uses of animal biotechnology might be the beginning of a "slippery slope" culminating in genetic modification and cloning of humans. The broadly social impact of animal biotechnology on agricultural structure, the economy and so on, is also an important ethical aspect to be considered in relation to animal biotechnology, as is the possible change that greater control of nature as such could induce in the overall relationship between humans and nature. We mention this only to emphasise that issues other than animal welfare – and issues of an equally complex kind – arise in connection with animal biotechnology. These are not covered in this article.

The challenges of animal biotechnology

Questions about the real difference between genetic engineering and animal cloning, on the one hand, and more conventional ways of "improving" animals by selective breeding and the creation of disease models through, for example, exposure to chemical compounds or radiation, on the other, are important – not least because the interconnectedness of the new technologies with the old is often used as an argument for the new biotechnologies. The argument runs roughly as follows. There is nothing new under the sun. We continue to change animals to suit our own needs. Only the precision and effectiveness of the methods has changed (Kues and Niemann, 2004). Hence animal biotechnology raises no unique ethical problems. As we have shown above, and as it has been argued in a number of publications in recent years (for example, Olsson and Sandøe, 2004; Buehr et al., 2004; NAS, 2002), the premises of this argument do seem to be true. At least, it is true that most of the welfare problems associated with cloning and genetic engineering can be found in more conventional technologies too. Large Offspring Syndrome is not only a problem within the cloning technology, but also when other kinds of biotechnology procedures are used (CeBRA, 2005*c*). The welfare problems that may arise from depriving animals of their natural procreative activity are also linked to other technologies. And welfare problems arising from the genetic engineering of animals can be found in selective breeding programmes as well, as for instance when an excessively narrow focus on productivity leads to leg disorders in broiler chickens, or to increased levels of mastitis in cows (Olsson and Sandøe, 2004). Ironically enough, the most eye-catching difference between the old and the new technologies may be uncertainty about the unintended side effects in the latter, and especially with genetic engineering, since this contradicts the biotechnologist's claim to work with greater precision.

However, it is not possible to dismiss criticism of animal biotechnology merely by pointing to the similarities between earlier and new uses of animal technology. The problem with this argument is that people will not necessarily have accepted the older techniques. Members of the public are largely unaware of the consequences of selective breeding. In general they are critical of confined housing systems, but in reality they were consulted on neither of these matters. We would therefore like to reverse the argument: public worries about new biotechnologies, and the genuine ethical concerns into which they can be translated, should be seen as a reason to critically analyse not only new biotechnologies but also existing technologies, and as a trigger for serious discussion of the limits to what it is ethically acceptable to do to animals (Olsson and Sandøe, 2005). Animal biotechnology might not be something radically new, but it can be the straw that broke the camel's back (Cooper, 1998).

What *is* evident today is that ethical questions raised about the regulation of the new biotechnologies used on animals are not concerned only with the question of welfare understood as mental states or experience. Today, all parties in the debate agree that there are limits to the amount of physical pain or mental stress that it is ethically justifiable to impose on an animal. But it is also becoming more and more widely recognised that other factors should influence the way we treat animals. These factors include the preservation of the naturalness of the animal, and the importance of giving an animal the opportunity to fulfil its species-specific potential. Such factors are becoming increasingly prominent within the regulatory debate. Of course, they are especially conspicuous when no traditional welfare problems are at stake.

As we have argued, there are two different conceptions of animal welfare in the ethical debate about animal biotechnology: one that focuses on the mental states of the animals and one that takes broader considerations into view. It is very seldom that one encounters the view that animal welfare is irrelevant to the evaluation of the biotechnological possibilities. This situation, though, should be compared with the situation only 15 to 20 years ago. At that time, only a minority defended what is today considered the narrow perspective (Matheny, 2005). This shift in attitudes can also be detected in the regulatory framework. Consider Article 3 of the Protocol of Amendment to the European Convention for the Protection of Animals kept for Farming Purposes adopted by the Council of Europe in 1992:

Natural or artificial breeding or breeding procedures which cause or are likely to cause suffering or injury to any of the animals involved shall not be practised; no animal shall be kept for farming purposes unless it can *be reasonably expected, on the basis of its phenotype or genotype, that it can be kept without detrimental effects on its health or welfare.2*

It should be noted that even though this article of the amending protocol focuses "only" on the narrow conception of animal welfare, it has proved difficult to transpose the convention into European legislation. At any rate, this excerpt can be compared with recently passed legislation on cloned animals in Denmark. In this legislation it is explicitly stated that animals may be cloned only if an independent research approval committee deems the purpose of this procedure useful (Danish Ministry of Justice, 2005). What is most noteworthy here is that the law limits certain applications of animal cloning regardless of its effect on animal welfare. This means that even if no welfare problems are involved, it is still necessary to demonstrate the perceived usefulness of the technology to show that it is ethically acceptable. This justification involves balancing the perceived goal of the process (research, medicine, agriculture, etc.) and the ethically problematic features inherent in the technology. The underlying motive for this strict regulation of animal cloning is not stated in the Danish legislation, but it is evident from the report prepared as foundation for the legislative work that the concept of animal integrity is one of the major factors (Danish Ministry for Science, Technology and Development, 2003). In December 2002 the Folketinget [Danish parliament] decided to encourage the government to appoint a preparatory committee to follow up the Folketinget motion for adjournment of May 1997 with a view to establishing rules for research regarding animal cloning and accompanying technologies. The result of this work can be seen in The Danish Ministry for Science, Technology and Development 2003.

Animal integrity can perhaps best be understood as an inherent limit in the relationship between humans and nature governing what is ethically acceptable for humans to do to animals. In other words, integrity is a limit based on an understanding or experience of animals as beings surrounded by an impenetrable aura that may be violated only if the reasons are adequate from an ethical perspective (Gjerris, 2005). It should be noted here that this is only a rough outline for one interpretation of the concept of integrity. Nevertheless, it should be clear that the idea of animal integrity both broadens the concept of animal welfare beyond the narrow perspective and rejects the notion that the naturalness of an animal is something that should only be respected in the individual animal – thus permitting humans to change the nature of animals in general, as was the case in the second version of the broader perspective.

The balancing of commercial and scientific interests against the "interests" of the animals raises a set of challenges. These challenges arise both for proponents of the broader approach (who will have to argue convincingly that a concept such as integrity should be respected) and in the political and regulatory process that follows in the wake of the different applications of biotechnology on animals. What is clear from a number of European surveys is that concepts such as integrity and naturalness play a significant and growing role in the general perception of legitimate use of biotechnology on animals (Lassen et al., 2005a).

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This situation could lead to a growing discrepancy between the very scientific and individualistic way of evaluating the ethical consequences of animal biotechnology that is implicit in risk-based studies of human health and animal welfare which have traditionally guided the regulatory process and a wider evaluation, involving notions of naturalness and integrity, for example. We do not mean to imply that there is something wrong with the scientific approach, but we do wish to point to the fact that the ethical concerns go deeper than that. As suggested, more general questions about the way in which animal biotechnology may contribute to change in the social world, about the possibility that animal cloning may facilitate reproductive cloning of humans, and about the perceived naturalness of the animals, are omitted in the scientific approach. This difference may also have a geographical and geopolitical dimension: where Europe and the EU are moving towards a broader understanding of animal welfare as the basis for regulation, the United States maintain a narrow understanding of animal welfare when they evaluate new biotechnology. This is evident in the emerging transatlantic discussion of the regulation of cloned animals and products derived from them or their offspring (CeBRA, 2005*b*).

Closer examination of what assumptions underlie the call for protection of the nature of animals could be a way of addressing some of these questions. These questions are usually dealt with rather superficially in the scientific literature, but they nonetheless play a significant role in forming public attitudes towards animal biotechnology (Lassen et al., 2006a, b). The fact that concepts such as naturalness or integrity are complex and not readily quantified does not mean that they are inappropriate subjects for rational discussion. It just means that they have to be discussed within a broader context than a narrow scientific one.

Any such discussion will reveal that there is more than one way to interpret such concepts. One way would be to claim that a concept such as naturalness tries to capture the distinction between the knowledge of the animal that is expressed through our understanding of its usefulness to humans and the knowledge that is expressed in our immediate experience of the animal. A cow is a producer of hide, milk and meat; it holds no surprises when experienced from a human perspective, where the fulfilment of human need is at the centre. But in another perspective, where the cow is understood as something independent of humans – as a life form with its own needs, history and importance – it becomes clear that we do not know all there is to know about cows just because we know how to use them. There is something more to cows: something that in a sense alienates them from us and that should prevent us from reducing them to merely a means to our ends.

Implicit in this distinction is a notion of the amount of control over the animal that we can exercise without violating its naturalness or integrity. In this sense, respect for naturalness can be understood as the polar opposite of total commodification of the animal as a natural resource. Although these notions are hardly of a scientific nature, they can be discussed meaningfully. They should not necessarily be dismissed offhand as either irrational or built upon elaborate religious or philosophical systems. They could also offer ways of describing very basic experiences of animals as something more than biological machines (Gjerris, 2005).

Whether considerations such as these should play a role in future regulation of animal biotechnology and more conventional ways of breeding animals is an open question. There can be no doubt, however, that failure to take them seriously will deepen the already existing gap concerning the ethical legitimacy of biotechnology, between science and industry, on the one hand, and the general public, on the other. We should seek socially robust solutions to the challenges that animal biotechnology raises. This may mean that we have to develop regulation that is based on something broader than empirical knowledge about physical risks to humans and animals. It may also mean not only that new possibilities will be rejected but also that existing practices within, say, animal breeding will need to be re-evaluated. But since the alternative scenario might very well be one in which growing public acceptance of the broader approach leads to even more negative public attitudes to new applications of animal biotechnology and conventional animal husbandry, this may be in the interests of all the stakeholders in the debate.

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