The Ethics of Xenotransplantation

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ABSTRACT
Xenotransplantation - moving organs from one species to another - is currently being actively researched as a possible contribution to the problem of a global shortage of human organs for transplants. Should xenotransplantation be encouraged, permitted, frowned upon or forbidden? I attempt to outline the main areas of debate that would need to be addressed before this question could confidently be answered. At present, though, we are some way from answering it. This is partly because of the lack of agreement among bioethicists about almost anything and partly because xenotransplantation raises a particularly wide range of ethical issues.

Xenotransplantation entails moving (i.e. transplanting) one or more organs (e.g. a heart or a kidney) from an individual of one species into an individual of another species. Since the 1980s a number of research groups have been attempting to genetically engineer domestic pigs so that their organs may be given to humans. From the perspective of applied philosophy, xenotransplantation is interesting because of the wide range of issues it raises. Is it necessary? Would it be safe? What are the animal welfare implications? Does it entail being disrespectful to non-human animals or involve violation of their telos or integrity? This paper cannot hope to provide definitive answers to all of these questions. However, it does aim to provide a map of the bioethical territory that needs to be traversed before such a set of answers can be arrived at.

I believe that such a map is now needed. There are several research groups actively been working in this field in a number of countries. Thousands of pigs genetically engineered with human genes have already been brought into existence and tens of millions of pounds have been spent in research. Since the research began, tens of thousands of people have died as a result of shortages of human organs for transplants. By the time this article appears, clinical trials of xenotransplants may have begun.[1] In any event, the first decade of the twenty first century of the Common Era is likely to see whether this technology becomes a regular feature of Western medicine or not.

One way of trying to decide whether any practice (e.g. xenotransplantation, prostitution, insider dealing, capital punishment) is acceptable is to examine all possible arguments for and against the practice within a single ethical framework. An obvious difficulty, though, is to decide which framework to adopt. There is little to be gained in applied philosophy in plumping for one ethical framework - e.g. consequentialism - when there still exists no widespread agreement as to what such an ethical framework should be or even whether one overarching one exists. The approach that is therefore taken here is to put forward, and briefly examine, appropriate arguments within a variety of possible frameworks.[2] As will become apparent, there are a considerable number of frameworks within which xenotransplantation can be examined. But first, some relevant factual information is needed about the biology of xenotransplantation, about its safety and about whether there is a need for it.

The biology of xenotransplantation

Immunology is a complicated subject. The long and short of it, though, is that each of us, in common with certain other animal species, has the physiological ability to recognise that our body and the organs therein are ours in a physical sense. The net result is that while our immune system (white blood cells, etc.) attacks foreign biological objects inside us, it does not attack

[1] Unsurprisingly, companies, such as Imutran Ltd. (a Novartis Pharma Company) and Genzyme, involved in the production and breeding of pigs for xenotransplantation, are keen for clinical trials to be allowed without a delay of many years.

[2] Most people who write on animal biotechnology, with the exception of certain philosophers, agree that the most fruitful way forward is to examine each issue within a variety of ethical frameworks. See, for example, Alan Holland and Andrew Johnson (eds.) (1998) *Animal Biotechnology and Ethics* (London, Chapman & Hall); Peter Sandoe and Nils Holtung (1998) 'Ethical aspects of biotechnology in farm animal production', *Acta Agriculturae Scandinavica*, Section A, Animal Science, Supplementum, 29, 51; and Mike Appleby (1999) *What Should We Do about Animal Welfare?* (Oxford, Blackwell Science). See also Anne Maclean (1993) *The Elimination of Morality: Reflections on Utilitarianism and Bioethics* (London, Routledge).

ourself. The advantage of this is obvious. Disease-causing organisms (e.g. viruses, harmful bacteria) can be attacked and destroyed without the body turning against itself.

The immune system can misfunction in various ways. For example, it may over-react to foreign bodies. This is what happens with allergies. In the worst case, such over-reaction can cause death (e.g. the fatal shock experienced by some people on eating nut products or being stung by a bee/wasp). The other main way the immune system can misfunction is by starting to attack parts of its own body. This seems to be what happens in a number of chronic diseases including rheumatoid arthritis.

It is because the immune system normally works so effectively that people receiving human-to-human transplants generally have to be given large doses of immunosuppressive drugs. As their name implies, these drugs suppress the immune system and so prevent it from rejecting the transplanted organ. Unfortunately, patients with suppressed immune systems are less able to fight off germs though with the latest generation of immunosuppressive drugs this is now less of a problem.

When it comes to transplanting non-human organs into humans, an extra difficulty arises. Within hours of the transplant, even if immunosuppressive drugs are used, so called hyperacute rejection sets in and the transplant fails. It is to try and overcome this problem that pigs are being genetically engineered to carry a single human gene. This gene results in the pigs producing a human protein on the surface of their internal organs. As a result, it is hoped that when these organs are used in transplants, hyperacute rejection will be avoided.

Would xenotransplantation be safe?

A number of national and international ethical committees as well as individual scientists have looked at the question of xenotransplantation.[3] . One of the particular foci of concern has been the issue of safety. We know that pigs carry what are called porcine endogenous retroviruses (engagingly abbreviated as 'PERVS'). In the light of BSE and AIDS it is unsurprising, and encouraging, that there is tremendous hesitancy in allowing any scientific/technological procedure to go ahead that might lead to new human infections.

[3] See Nuffield Council on Bioethics (1996) *Animal-to-Human Transplants: The Ethics of Xenotransplantation* (London, Nuffield Council on Bioethics); The Advisory Group on the Ethics of Xenotransplantation (1996) *Animal Tissue into Humans* (London, Department of Health); Mae-Wan Ho (1998) *Genetic Engineering - Dream or Nightmare? The Brave New World of Bad Science and Big Business* (Bath, Gateway Books); Robert A. Weiss (1998) 'Transgenic pigs and virus adaptation', *Nature*, 391, 327; and Eve-Marie Engels (1999) 'Xenotransplantation: a doubtful prospect', *Biologist*, 46, 73. The World Health Organisation has an active electronic discussion group on xenotransplantation to which a number of philosophers, amongst others, contribute. To subscribe to it - there is no fee - send an e-mail with the subject line blank and with 'subscribe xenodiscussion' in the body of the message to <majordomo@who.int>. An archive website is supported by the OECD at www.oecd.org./dsti/sti/s_t/biotech/xenosite/country.htm which also provides links to policy and consultation documents produced by individual countries. In 1999 the Council of Europe Parliamentary Assembly voted for an international moratorium on xenotransplantation but for further research to be undertaken.

The current (November 1999) position in the UK is that if (and it is a big 'if') xenotransplants are allowed, the safety requirements will be stringent. In particular, there is a great deal of work going on to reduce to near-zero levels the chance of any infectious agents, such as viruses, passing as a result of transplants from pigs to humans. The United Kingdom Xenotransplantation Interim Regulatory Authority is proposing that anyone receiving a xenotransplant must agree to provide lifelong post-operative compliance with a whole set of conditions including: (a) use of barrier contraception; (b) refraining from pregnancy / fathering a child; (c) allowing the relevant Health Authorities to be notified when moving abroad. In addition, all household members and sexual partners will need to be seen pre-xenotransplantation to ensure they are informed about possible risks, how to minimise them, and to have baseline blood samples taken for indefinite archiving.[4]

Some recent research suggests that the chances of porcine endogenous retroviruses passing from pigs to humans may be low. Perhaps surprisingly, world-wide there are several hundred people who have already been treated with various living pig tissues. Most commonly this has been done when a patient's blood is passed through a pig liver or spleen to 'clean' it - the pig organ remaining outside the patient's body. A careful study has shown that in none of the 160 patients who had been treated with a living pig tissue and from whom samples could be obtained was there any evidence of pig-to-human transmission of porcine endogenous retroviruses. This was the case despite the fact that 23 of the patients had living pig cells inside themselves, in some cases for over eight years.[5]

Of course, this study does not prove that pig viruses won't infect humans but it does suggest that the likelihood is lower than many experts had feared. What is still unclear is how serious the consequences would be if such infection(s) did occur.

Is there a need for xenotransplantation?

World-wide there are approximately 150 000 people waiting for an organ transplant.[6] Each year many thousands of people have their lives saved as a result of human-to-human transplants. However, each year many thousands of people die who would have lived had they received a transplant. Indeed, the majority of people waiting for a transplant never receive one. The purchase of human organs - a market-led 'solution' to the shortage - is, by-and-large, illegal. The qualification 'by-and-large' is necessary as some countries permit the sale of human eggs, sperm and blood. None, though, to my knowledge, allows the purchase of organs for transplants. Nevertheless, there are not infrequent reports in the media of organs being offered for sale and/or

[4] United Kingdom Xenotranplantation Interim Regulatory Authority (1999) *Draft Report of the Infection Surveillance Steering Group of the UKXIA* (London, Department of Health). Similar stipulations are being proposed in some other countries.

[5] Khazal Paradis, Gillian Langford, Zhifeng Long, Walid Heneine, Paul Sandstrom, William M Switzer, Louisa E Chapman, Chris Lockey, David Onions, The Zen 111 Study Group and Edward Otto, (1999), 'Search for cross-species transmission of porcine endogenous retrovirus in patients treated with living pig tissue', *Science*, 285, 1236.

[6] Novartis Imutran (1999) Animal *Welfare: Xenotransplantation - Helping to Solve the Global Organ Shortage* (Cambridge, Imutran Ltd.).

bought for transplants. In one case, US$5.7 million was apparently bid during an online auction of a human kidney before the auction was halted.[7] The original advertisement read:

> 'You can choose either kidney ... Buyer pays all transplant and medical costs. Of course only one for sale, as I need the other one to live. Serious bids only.'

The reason that most people waiting for an organ transplant never receive one is simply that there aren't enough human organs to go around. There are three main reasons for this. First, the number of people who would benefit from a transplant continues to rise. In part this is because of advances in transplant surgery which mean that more organs (e.g. lungs) can now be transplanted than used to be the case. In part, too, this is because a greater range of medical conditions can now be treated by transplantation than used to be the case.

A second reason why there aren't enough human organs to go around is that only a very small proportion of deaths result in organs that are suitable for transplants. Deaths from motor vehicle accidents provide a high proportion of suitable organs, yet, thanks to improvements in road safety (seat belts, improved car design, better road layouts, greater use of motor cycle helmets), the number of people killed in such accidents is reducing in those countries - i.e. the West - where transplant surgery is numerically significant.

A final reason for the shortage of human organs is that many countries have some sort of 'opt in' rather than 'opt out' system for organ donation. This can mean that for a transplant organ to become available (a) the dead person needs previously to have expressed a wish for their organs to be used for transplantation; (b) a doctor must ask relatives to consent to this; (c) no close relative must object to the transplant.

Of course, the question 'Is there a need for X?' cannot be answered simply by demonstrating a use to which X could be put. The use must be deemed appropriate and many people (i.e. non-consequentialists) would also argue that the means required to effect X must also be acceptable in themselves. Most people are likely to accept that human-to-human transplants fulfil a need in that such transplants manifestly lead to many people each living for several to many more years of life, typically with a significantly enhanced quality of life too. It is difficult for anyone who has even watched a television programme about transplantation, let alone known someone who has benefited from one, to argue that human-to-human transplants aren't needed.

Nevertheless, it would, in principle, be possible for someone to argue that it would be a better world if (a) more people accepted that their lives should not be prolonged by human-to-human transplants; (b) the money spent on the procedures was put to better use elsewhere - whether within the medical services or, for instance, by employing more academics with a specialism in philosophy. However, even someone arguing thus would, I suspect, be hard pushed to maintain that human-to-human transplants should be forbidden by law. Even most vegetarians, in my experience, don't argue for all meat-eating to be outlawed. It should, though, be noted that there are some strong cultural differences between countries with regard to the acceptability of human-to-human transplants. In Japan, for example, heart transplants are virtually unheard of because

[7] Anon (1999) 'Online bidders' stake in kidney', *Monash Bioethics Review*, 18, 39.

death is only understood to have occurred once the heart stops beating. Such hearts cannot be used in transplants.

However, even if it is accepted that there is a need for human-to-human transplants, this is not to imply that there is necessarily a need for xenotransplantation. For one thing, it is very possible that, at least in the early stages of 'treatments' with xenotransplants, patient survival will be significantly lower when compared with human-to-human transplants. A cost-benefit analysis (for those who accept that cost-benefit analyses are the appropriate way to decide such ethical problems) might weigh against these xenotransplants. A separate point is that perhaps societies are wrong to ban the sale of human organs for transplants. Indeed, don't I have a duty to provide one of my two healthy kidneys for someone who has none?[8]

More prosaically, better health education might lead to less of a demand for hearts and other organs. Further, if only more of us carried donor cards and gave permission for our dead relatives' organs to be used in transplants the need for xenotransplants to meet the shortfall would be reduced. In addition, though it is still too early to be sure that they will ever have a widespread practical utility, significant advances are being made in artificial (metal and plastic) organs. Finally, advances in tissue culture, cloning and stem cell research hold out the hope that at least some human organs may be grown from a patient's own tissues. One advantage, should this ever become possible, is that there should be few or no rejection problems.

Welfare considerations

Practically everyone agrees that welfare considerations need to be taken into account when deciding whether, and if so how, sentient animals such as pigs should be used for human ends. Suffering involves susceptibility to pain and an awareness of being, having been or being about to be in pain.[9] Pain here is used in its widest sense and includes stress, discomfort, distress, anxiety and fear. As every biologist knows, it is difficult to argue against the contention that vertebrates, and probably certain invertebrates such as octopuses, can experience pain.[10]

The extent to which animals are aware of their pain is more open to question. but there is increasing acceptance that certain of our closest evolutionary relatives have the requisite degree of self-consciousness. A growing number of biologists and philosophers accept that, at the very least, most mammals can suffer.[11]

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[8] For discussion of the ethical issues raised by the sale of human organs see Andrew Kimbrell (1993) *The Human Body Shop: The Engineering and Marketing of Life* (London: HarperCollinsReligious); and Nicole Gerrand (1999) 'The misuse of Kant in the debate about a market for human body parts', *Journal of Applied Philosophy*, 16, 59.

[9] Michael J Reiss and Roger Straughan (1996) *Improving Nature? The Science and Ethics of Genetic Engineering* (Cambridge, Cambridge University Press).

[10] Jane A. Smith and Kenneth M. Boyd (eds.) (1991) *Lives in the Balance: The Ethics of Using Animals in Biomedical Research - The Report of a Working Party of the Institute of Medical Ethics* (Oxford, Oxford University Press).

[11] Marian Stamp Dawkins (1980) *Animal Suffering: The Science of Animal Welfare* (London, Chapman and Hall); and Peter Singer (1993) *Practical Ethics*, 2nd edn. (Cambridge, Cambridge University Press). For a review of attempts to determine the suffering of animals, including transgenic animals, used in experimental procedures see E. S. Jenkins and R. D. Combes (1999) 'The welfare problems associated with using transgenic mice to bioassay for bovine spongiform encephalopathy', *Animal Welfare*, 8, 421.

So would xenotransplantation lead to significant amounts of non-human animal suffering? Consider, first of all, the pigs that would be used. Companies involved in research on xenotransplantation maintain that their pigs are extremely well looked after. Indeed, in the UK, the pigs (both those which have been genetically engineered and those which have not) used in the research are, in my view, looked after better than are pigs on many pig farms. Imutran, for example, uses what is widely agreed to be a high quality animal welfare system (the Nurtinger system) to house its pigs.[12] This comprises a warm, insulated bed and a cooler area for loafing, feeding and drinking. It gives pigs a choice of environment and temperature and provides for social contact.

However, there is more to the welfare of the pigs than their housing.[13] For a start, the pigs are subjected to a number of surgical procedures. Laparatomies (to flush out eggs) are performed under general anaesthetic because of the convoluted nature of the uterine horns in the pig. In addition, if and when clinical trials begin, it seems likely that some so-called 'gnotobiotic' (germ-free) animals will be needed. Such animals would be obtained by what is sometimes euphemistically called 'surgical derivation'. This means that shortly before birth, the entire uterus with the piglets would be removed (surgical hysterectomy) from the mother. The piglets would then be raised in isolation and in sterile conditions. The current UK draft code of practice for the housing and care of pigs intended for use as xenotransplant source animals states:

Due to the high welfare costs to the animals, in terms of being raised in a barren environment with little or no social contact, source animals must not be reared beyond four weeks of age in an isolator.[14]

Further, it is not only pig welfare that needs to be considered. Current research aimed at improving the success of xenotransplants has meant that many hundreds, possibly thousands, of primates (captive-bred cynomolgus monkeys and wild-caught baboons) have already been used in surgical operations. While many of these operations are deemed a research 'success', this, of course, is to view the procedure from the perspective of the surgeons and scientists involved (and perhaps, ultimately, the patients and shareholders who may benefit). From the point of view of the non-human primates, every such operation leads to considerable pain and a dramatic shortening of lifespan.

It is difficult to be sure but, on balance, my prediction would be that while xenotransplantation raises significant animal welfare issues, these are unlikely to be perceived by regulators or, indeed, by most people, to be sufficient for xenotransplantation to be outlawed on these grounds. However, there are other issues to consider in addition to human safety and animal welfare.

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[12] Novartis Imutran op. cit.

[13] Gill Langley and Joyce D'Silva (1998) *Animal Organs in Humans: Uncalculated Risks & Unanswered Questions* (London, British Union for the Abolition of Vivisection & Petersfield, Compassion in World Farming); Tim O'Brien (1998) *Farm Animal Genetic Engineering*, 2nd edn (Petersfield, Compassion in World Farming); and Home Office (1999) *Draft Code of Practice for the Housing and Care of Pigs Intended for Use as Xenotransplant Source Animals* (London, Home Office).

[14] Home Office op. cit., p.18.

Changing the nature of animals

Let us assume that xenotransplantation will require genetically engineering pigs through the insertion into pig DNA of one or more human genes. Manifestly this involves changing the 'nature' of the pigs in at least some sense. Is this acceptable? Imutran has argued that 'This involves changing only 0.001% of the genetic make-up of the pig'.[15] To some, though, the actual percentage of change is not of prime importance. If I am unfaithful to my spouse on only 0.5% of nights, is this ten times better than if I am unfaithful on 5% of nights?

A frequent cry against genetic engineering of any sort is that 'It's unnatural'. However, this objection is difficult to defend. After all, what is 'natural'? In everyday language smallpox, earthquakes and death are natural whereas vaccines, laptops and foreign holidays aren't. In other words, there doesn't seem to be much of a relationship between what is 'natural' and what is good.

Nevertheless, the 'It's unnatural' argument can be defended in a number of ways. For a start, a number of religions argue that, at least to some extent and in some sense, nature is good. In the Jewish and Christian traditions, the understanding is that on the sixth day 'God saw everything that he had made, and behold, it was very good'.[16] Death and decay entered the world through sin, but even after the Fall sufficient of God's goodness is manifest in the creation for much that is natural to be good. Around this notion there has built up an entire theology of natural law.

Nor is it only within religions that nature has been seen as an indicator of goodness. Even Nietzsche at times suggested this while Heidegger criticised technology in that instead of allowing our purposes to find creative expression through the qualities of objects themselves we design things to suit our purposes.[17] To this day there is a considerable body of opinion holding that 'natural' practices are desirable in such separate activities as education (Rousseau onwards), child nutrition (e.g. 'breast is best'), agriculture (organic farming), food (artificial flavourings) and medicine (traditional medicines).

Aside from psychological reasons for the success of appeals to nature, one great advantage of nature is that it has been around for quite a while. Consciously or otherwise the thought may be 'Our ancestors successfully brought up their children, farmed and prepared their food in these ways so traditional approaches must be OK'. After all, and quite logically, one cannot be sure about the long-term consequences of any new technology (including genetic engineering), only of practices that have been around for a considerable time and so are now considered 'natural'.

However, to what extent does the genetic engineering in question in this particular technology really change the nature of pigs? From the pigs' point(s) of view, it can be argued 'not at all'. As considered above, the practicalities of genetic engineering have significant welfare implications but it seems difficult to argue from a pig's perspective that the genetic engineering itself has changed its nature. The pig's behaviour is no different; its mental capacities and experiences are

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[15] Novartis Imutran op. cit.
[16] Genesis 1.31.
[17] Martin Heidegger (1977) *The Question Concerning Technology and Other Essays*. Translated and with an Introduction by William Lovitt (New York, Harper Colophon).

unchanged. The only difference is that it produces an extra internal protein. Traditional breeding, on the other hand, has resulted in very significant changes to the natures of farm animals (increased tolerance of high stocking densities, increased tractability, massive changes in milk, wool and meat production, etc.).

Religious considerations

Most religious writers are cautious about genetic engineering with some objecting to it outright on the grounds that it is tantamount to 'playing God'. Interestingly, though, some theologians have argued that part of what it is to be human is to accept our God-given creativity and use it wisely.[18] This would mean that genetic engineering, per se, is no more inadmissible than any other technology. Rather it should be judged by its fruits, by the way it is undertaken and by the intentions of those who undertake it.

At the same time, there have been significant movements within Judaism, Christianity and Islam in recent decades serving, as it were, to give greater voice to the perspectives of non-human animals.[19] After all, the Hebrew scriptures include a number of instructions relating to non-human animal welfare, with some of the Wisdom writings arguing that non-human animals have a purpose beyond that of human benefit.

Other religions have longer established or stronger teachings about the need for human duties towards non-human animals. In Buddhism, for example, there is a prohibition on the taking of animal life, while according to the Isa Upanishad, in the Hindu scriptures, the Earth does not belong to humanity. In Jainism, the concern for ahisma (non-injury) goes hand-in-hand with an insistence on a vegetarian diet. Lay members are encouraged to engage only in occupations that minimise the loss of life while it is the monastic practice to carry a small broom with which gently to remove any living creature before one sits or lies down.

Animal rights, respect, telos, genetic integrity and intrinsic value

As has been very widely discussed, moral philosophers disagree as to whether even humans have rights.[20] [20]. Even if we do, it has been maintained, by many philosophers from Kant onwards, that non-humans have no rights. On the other hand, it has been argued, on grounds that derive from Rawls' veil of ignorance, that even contractarianism can allow non-rational, but sentient, agents to possess moral status and have rights.[21] Obviously those who believe that non-human animals have rights are likely to argue that xenotransplantation is ethically wrong.

A different approach is to ask whether xenotransplantation and the attendant research is disrespectful to pigs and the primates used in the research. It seems difficult to answer 'no'. After all, the pigs and primates are being used instrumentally as means to ends with many of their

[18] Ted Peters (1997) *Playing God? Genetic Determinism and Human Freedom* (New York, Routledge).
[19] Reviewed by Reiss and Straughan op. cit. See also Andrew Linzey and Dorothy Yamamoto (eds.) (1998) *Animals on the Agenda: Questions about Animals for Theology and Ethics* (London, SCM).
[20] For a recent collection of essays on human rights situated within the field of genetics see Justine Burley (ed.) (1999) *The Genetic Revolution and Human Rights: The Oxford Amnesty Lectures 1998* (Oxford, Oxford University Press).
[21] Mark Rowlands (1997) 'Contractarianism and animal rights', *Journal of Applied Philosophy*, 14, 235.

normal behaviours and 'intentions' thwarted. However, it could be argued that their lives are still worth living and that most of them would not even have lives were the research not being undertaken (the 'eating bacon is good for pigs' argument).

Other ethical frameworks put at centre stage the telos of animals (their ends in an Aristotelian sense), their genetic integrity or their intrinsic value (the worth organisms have in themselves, irrespective of their usefulness for humans).[22]

To consider each of these frameworks adequately would require a paper in itself. Suffice it to say that as yet no agreement exists as to the validity of any of them. To some extent, it may be that it is precisely because of the plethora of non-consequentialist frameworks which have been proposed that utilitarianism remains the dominant framework within which many of the regulations concerned with our use of animals are framed.

Changing the nature of humans

A further argument against xenotransplantation would be to maintain that in some way the practice changes human nature, that it breaks down the barrier(s) between ourselves and other species. From a purely ethical perspective this objection is difficult to substantiate. After all, our status as moral subjects is not dependent, surely, on the origin of our hearts or other internal organs. To suppose otherwise would be to commit the genetic fallacy in both its classical and current senses. Further, many evolutionary biologists and certain philosophers would welcome the breaching of what is often felt as too rigid a barrier between ourselves and other animals.[23]

Nevertheless, the argument has psychological appeal and deserves serious consideration for this reason. To take an extreme instance, one could imagine - and the 1973 film O Lucky Man! did so imagine - a scenario in which a whole pig body (minus the head) is transplanted onto a human head.[24] Would we be in favour of such a practice? My supposition is that most people would find such a procedure abhorrent. Now such 'arguments from disgust', as we might term them, cannot simply be accepted at face value; after all many people in previous generations found the notion of female doctors disgusting while many people today recoil from the idea of same-sex sexual relationships. Nevertheless, such arguments deserve serious consideration, if only because they are widely held. Indeed, I am surprised that, to my knowledge, no-one has yet cited the New Testament verse 'For not all flesh is alike, but there is one kind for men, another for animals, another for birds, and another for fish' in support of the notion that xenotransplantation - indeed, genetic engineering more generally - is wrong on the grounds that it blurs the distinction between humans and non-humans.[25]

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[22] Henk Verhoog (1992), 'The concept of intrinsic value and transgenic animals', *Journal of Agricultural and Environmental Ethics*, 5, 147; Bernard E. Rollin (1995) *The Frankenstein Syndrome: Ethical and Social Issues in the Genetic Engineering of Animals* (Cambridge, Cambridge University Press); and Holland and Johnson op. cit.
[23] Peter Singer (1981) *The Expanding Circle: Ethics and Sociobiology* (Oxford, Clarendon Press); and James Rachels (1991) *Created from Animals: The Moral Implications of Darwinism* (Oxford, Oxford University Press).
[24] The script is available as Lindsay Anderson and David Sheerwin (1973) *O Lucky Man!* (Plexus, London). The original screenplay is © 1973 by Sam.
[25] 1 Corinthians 15.39.

Conclusion

Given this tremendous diversity of opinion, what are we to conclude? From the perspective of public policy and regulation - which cannot wait for agreement among moral philosophers - perhaps the only way forward is to try to reach decisions by consensus.[26] It is true that this does not solve everything. After all, what does one do when consensus cannot be arrived at? Nor can one be certain that consensus always arrives at the right answer - a consensus may once have existed that women should not have the vote. Nevertheless, there are highly desirable reasons both in principle and in practice in searching for consensus.

A consensus should be based on reason, take into account long established practices of ethical reasoning and be open to refutation and the possibility of change. Consensus should not be equated with majority voting. Special consideration needs to be given to minorities, particularly if they are especially affected by the outcomes, and to those - such as young children, the mentally infirm and non-humans - unable to participate in the decision-making process.

We cannot be certain that a consensus is absolutely valid. However, procedures can be put in place which increase the likelihood that a consensus is reliable and trustworthy. The issue is partly one of epistemology. For example, anyone arguing either for or against xenotransplantation from a utilitarian perspective would have their hand strengthened if they were able to produce rigorous conclusions based on the following three numbers:

- Some measure of the overall harm that would result from the research in terms of suffering to the animals used. (Strictly, this should include the upset caused to people who oppose the use of animals in this way.)
- Some measure of the overall benefit that is expected to result from the research if it succeeds. (Strictly, this should include the pleasure experienced by people as a result of the successful use of xenotransplants enabling their relatives and friends to live longer, more fulfilling lives.)
- An estimate of the chances of the research succeeding.

In the meantime, until widespread agreement as to the acceptability or otherwise of xenotransplantation is reached, a considerable amount of work remains to be done on its ethics.[27]

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[26] Jonathan D. Moreno (1995) *Deciding Together: Bioethics and Moral Consensus* (Oxford, Oxford University Press); and Michael Reiss (1998) 'Building animals to order', *Biologist*, 45, 161.

[27] This paper is based in part on talks given at the 3rd World Congress on Alternatives and Animal use in the Life Sciences (Bologna, 1999) and at the British Association Annual Festival of Science (Sheffield, 1999). I am very grateful to Roger Straughan who first instructed me in bioethics and who provided valuable comments on an earlier draft of this paper.