Online Ethics Center
FOR ENGINEERING AND SCIENCE

Background

Description

Part of unit 4 of the Course on Genomics, Ethics and, Society, this section provides background to this unit on genomics, ethics, and domesticated animals.

Body

Cloning and Transgenic Animals: Key Technologies

Two types of animals are created with genomics technologies: those that are cloned, where the genome of the clone is identical to that of the “parent,” and those whose genome has been deliberately altered (what are generally called transgenic animals). Clones have, historically, been produced by "embryo splitting" to produce multiple, identical sibling animals; more recently, clones have been produced from adult somatic cells. In this case, clones are developed largely in order to preserve the traits of the “parent” (e.g., to obtain an exact genetic copy of a prize-winning racehorse). Transgenic animals are developed to produce substances, organs, or disease models useful for human beings. For instance, animals can be genetically modified to produce milk or blood with components that that can be used in pharmaceuticals. Others are modified to allow their tissues or organs to be transplanted into humans (called xenotransplantation). Still others are created to develop or to be resistant to various diseases, such as cancers, which can then be used in drug tests. Animals may also be modified to have other properties, such as to grow more quickly and/or to grow larger—capabilities that may improve their food potential for humans (for instance the AquaAdvantage salmon in the case study in this module).

Here are some key terms, and techniques, used to produce clones and transgenic animals:

- Pronuclear injection: DNA is injected into the pronucleus of a fertilized egg (zygote). This was the method used to produce the first transgenic mice in 1981.
- Sperm-mediated gene transfer: Sperm cells are incubated with DNA and then used for artificial insemination.
- Retrovirus-mediated gene transfer: A virus is used as a vector to transmit the DNA.
- Embryonic stem cell transfer: DNA is integrated into embryonic stem cells. These cells are then inserted into a developing embryo.

With many of these procedures above, the DNA integrates randomly into the "host" genome. This generally means that the rate of transgenesis will be unpredictable. However, as methods improve, more precise genetic modifications will become possible. Newer methods of genome engineering (e.g. genome targeting by the CRISPR/CAS system) allow much more precise insertion of gene sequences into the genome.

- Somatic cell nuclear transfer (SCNT): The nucleus of an oocyte is removed (enucleation) and replaced by the nucleus of a transgenic somatic cell. The developing embryo is then implanted into a host. SCNT is the method of cloning that is most commonly discussed today.

For more general information on the development of GM animals, see http://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/GeneticEngineering/Gene

Cloning and Transgenic Animals: Concerns, Values, and Consequences

1. Concern for Animals: Welfare

One of the major concerns about processes both of cloning and genetic modification is that these practices may cause or contribute to animal welfare problems. Such concerns may take different forms, depending on how one conceives of animal welfare – or what makes for a ‘good life’ for animals.

One prominent view of animal welfare is based around animals’ subjective experiences. These include animals’ negative experiences of suffering (including pain, fear and frustration) and positive, pleasurable experiences, including fulfillment and comfort. This is sometimes called a *hedonist* approach to welfare. A good life for an animal is understood here as one that has as many stimulating and comfortable experiences, and as few frustrating, unpleasant or painful experiences as possible.

However, alternative views of animal welfare – particularly relevant when thinking about cloning and genetic modification – argue that other things matter for animal welfare, either in addition to, or instead of, an animal’s subjective experience. On these views, animal welfare depends on animals being able to live natural lives, and to carry out natural behaviors. Of course, one reason why this might matter would be if not being able to do so caused animals unpleasant experiences - this would be problematic for a hedonist too. But other versions of this view of welfare object to ‘unnaturalness’ even if it does not cause negative subjective experiences. The argument here is that to live a good life, animals must be able to realise natural, or species-specific potentials. So, for instance, on such a view, it might be argued that an indoor cat has lost something crucial if it can’t go out to hunt, even if the cat itself is not aware of missing anything.

Applying these conceptions of animal welfare to cloning and genetic modification raises some important issues. The practices required to carry out animal cloning do cause animals some discomfort and suffering. For instance, cloning technologies as currently practiced cause a high number of spontaneous late-term abortions (which if late-term foetuses feel pain may be problematic) and create offspring with deformities and health problems. Modified animals used as human models in medical research are created to develop diseases, many of which will be painful (such as cancers and neurological complaints). These potentially painful practices raise ethical questions for those with a hedonistic account of welfare. And aside from the technologies themselves, broader ethical issues about welfare and animal husbandry are raised: are these animals being kept in conditions that allow them opportunities for positive experiences, where they don’t suffer from frustration, deprivation (or over supply) of social contact, the right amount of food, water, light and heat?

Those who are concerned about naturalness and species-specific potential may have further welfare concerns: that some of these procedures are ‘unnatural’ and therefore problematic, independently of how the individual animals themselves experience them. For instance, on this view, breeding GM hairless mice might be problematic, even if being hairless doesn’t cause the mice negative experiences. However, alternative conclusions could be drawn, even on a ‘naturalness’ view of welfare. It could be argued that a GM mouse has a ‘new natural’ – what is ‘in the nature’ of that mouse is what it has been bred to be like. So, something different is ‘natural’ to a GM mouse than a normal mouse. What one thinks about this may depend on whether ‘naturalness’ is being taken to mean something like “excessive human intervention” or “what’s in the nature of an organism”. GM animals may look more problematic on the first view than the second, where what’s in the ‘nature’ of an organism has been changed.

On some ethical views, both cloning and genetically modifying animals are regarded as unacceptable. One school of thought that generally endorses such a view argues that – on the grounds of the capacities animals have, in particular to feel pain and pleasure – many animals have basic rights not to be routinely seriously harmed, killed or confined, and more generally not to be treated as human ‘instruments’. Of course, on these views the use of any laboratory and agricultural animals is highly questionable. However, other views – such as broadly utilitarian ones – maintain that we need to weigh the overall welfare costs to animals against the benefits to humans. On this view, if creating animal disease models, for instance, really does make significant contributions to preventing, curing or alleviating serious human diseases, then the creation of these models can be ethically justified.

These are, of course, not the only considerations in a ‘weighing’ model. Even if it is true that the benefits of genetically modifying animals outweighs the costs, it may yet be the case that the same or greater benefits could be achieved through other means that cause less suffering to animals. Cloning animals in order to retain specific traits, for instance, is in many cases less successful than conventional breeding; although there maybe some cases of substantial benefits, in many cases, the costs (given current cloning technologies) to animals seem very high.

2. Concern for Genetic Diversity and the Environment

A separate set of concerns – raised about artificial selection more generally, but in particular about cloning and certain types of transgenic animals - is that there will be a negative impact either on genetic diversity of the domesticated animal breeds or species concerned, or that a release into the environment will impact on the genetic diversity of wild animals.

For instance, if most cattle were clones, and a new cattle disease emerged, the fear here is that the entire cattle population might be susceptible, since the cattle population would lack genetic diversity. This would likely cause a good deal of animal suffering (so raising welfare concerns) and presents significant difficulties for human food supply, and agricultural livelihoods, with corresponding impacts on human wellbeing. At present, however, this kind of worry seems unnecessary, as there's no likelihood of cloned or GM individuals dominating any particular species; it's difficult to maintain that for the foreseeable future, in this sense, GM and cloning technologies pose any special threat beyond those already identified in conventional breeding.

There's a more plausible risk that GM animals could pose a threat to the diversity of wild species, if, for instance, they were to escape from laboratories or farms and either interbreed with related wild populations, or introduce new parasites or diseases to them. Loss of wild diversity from deliberate releases of captive bred and hatchery animals has already been argued to be a problem, both in commercial fishery and among game birds. One example is the deliberate release of hatchery raised (but not GM) salmon into the environment, resulting in 90% of Baltic salmon being of hatchery origin (Latke et al 2010). The accidental (or deliberate) release of GM animals could present additional risks, though these risks don't seem to be on a different scale to the risks to diversity presented by domesticated and captive-bred animals.

It's also possible that GM animals could be created with the goal of being less environmentally damaging than existing agricultural animals. For instance, GM pigs, dubbed "Enviropigs", developed at the University of Guelph in Canada, were created to excrete significantly less phosphorus in their waste. (See http://www.uoguelph.ca/enviropig/) Since phosphorus run-off into water is an important environmental pollutant, it was thought that the use of Enviropigs would be environmentally beneficial in comparison with non-GM pigs. Although the funding was withdrawn from this particular project, the possibility remains of creating GM animals to be less environmentally damaging than existing agricultural animals –

although this would require public acceptance of such technologies, and face objections that the environmental problems caused by agricultural animals are not due to the animals' physiology, but due to the ways in which they are farmed.

3. Concerns for Humans/Society

The development of both cloning technologies and GM animals aim to produce a variety of benefits to humans, primarily medical benefits to reduce human suffering and to lengthen life, and benefits in terms of food quantity, quality, taste and affordability. There is some dispute as to how beneficial certain of these technologies actually are (for instance, cloning food animals) and concerns about the costs and risks to non-humans and the environment, as discussed above.

With the exception of concerns about animal welfare, the use of GM technologies in medicine, and in drugs derived from these technologies, is widely accepted. However, there's significant public concern about risks to health from eating cloned or GM animals, and their use for food is in many countries restricted or illegal. At present, cloned animals are rarely used for food; they are usually used for breeding; it's their offspring that generally enters the food chain. In the US, the FDA has concluded that "meat and milk from clones of cattle, swine (pigs) and goats, and the offspring of clones from any species traditionally consumed as food, are as safe to eat as food from conventionally bred animals" (FDA 2013) – and that meat from clones and the offspring of clones need not be labeled. However, there is still significant public opposition even in the US to meat and milk from cloned animals or their offspring entering the food chain. In Europe, cloning is significantly restricted: cloning is not permitted except for research, medical and conservation purposes; products of cloned animals are not currently permitted in the food chain (though the primary reason for such restrictions appears to be animal welfare). In general, public acceptance of GM animals in the food chain is very low (this was why funding for the Canadian Enviropig was withdrawn).

The use of GM and cloned animals in agriculture, unlike the use of GM crops, is currently very limited. So while fears of corporate domination and worries about small farmers and potential justice issues have been expressed, at present there is little reason to think that cloned or genetically modified animals will become agriculturally dominant. So while it's possible that ethical and political concerns about the social impacts of cloning or GM animals could, in principle, follow similar trajectories to debates about GM crops, there's little likelihood of this happening in the near future. However, increased attention is being directed at projections that the human population will reach 9-10 billion people by 2050 and will rapidly put great constraints on food resources, particularly animal-sourced foods, unless production systems can be increased. Improved and precise genome editing techniques may drastically change the perception and conversation about genetically engineered food animals in the coming years.

References

- FDA, 2013, “Animal cloning and food safety” http://www.fda.gov/forconsumers/consumerupdates/ucm148768.htm.
- Laikre, R., Schwartz, M., Waples, R. Ryman, N. and the GEM working group. 2010. Compromising genetic diversity in the wild: unmonitored large scale release of plants and animals. *Trends in Ecology and Evolution* 25/9 520-529.

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