Ethical Issues in Genetic Engineering and Transgenics

in

• Ethics Debate

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By Linda MacDonald Glenn

Genetic engineering involves manipulating genes. Genetic engineering is the collection of techniques used to

* isolate genes
* modify genes so they function better
* prepare genes to be inserted into a new species
* develop transgenes

Transgenic organisms contain altered genes from other organisms. The process of creating a transgene includes isolating the gene of interest from the tens of thousands of other genes in the genome of a gene-donor species. Once that gene is isolated, it is usually altered so it can function effectively in a host organism. That gene is then combined with other genes to prepare it to be introduced into another organism, at which point it's known as a transgene. A transgenic organism, sometimes called a chimera, is one that contains a transgene introduced by technological methods rather than through selective breeding.

Transgenics have traits not normally found in the species.

Current Developments

Transgenics allow scientists to develop organisms that express a novel trait not normally found in the species; for example, a type of rice known as golden rice has elevated levels of vitamin A. Scientists have also developed sunflowers that are resistant to mildew and cotton that resists insect damage. Possible transgenic combinations can be broken down generally into three categories (here "animal" refers to nonhumans):

* plant animal human combinations
* animal animal combinations
* animal human combinations

Transgenic plants can contain human proteins to produce edible vaccines. An example of a plant animal human transgenic combination would be one in which the DNA of mouse and human tumor fragments is inserted into tobacco DNA. The harvested plants contain a potential vaccine against non-Hodgkin's lymphoma.1 Other transgenic plants have been used to create edible vaccines. By incorporating a human protein into bananas, potatoes, and tomatoes, researchers have been able to create prototypes of edible vaccines against hepatitis B, cholera, and diarrhea.2 The vaccines are proving to be successful in tests on agricultural animals and humans.

Goats with spider genes produce spider silk proteins in their milk. BioSteel® is a product created from an animal animal transgenic combination. Scientists at Nexia Biotechnologies, a company based in Montreal, isolated the gene for silk protein from a spider capable of spinning silk fibers—one of the strongest yet most resilient substances known—and inserted it in the genome of a goat's egg prior to fertilization. When the transgenic female goats matured, they produced milk containing the protein from which spider silk is made. The fiber artificially created from this silk protein has several
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potentially valuable uses, such as making lightweight, strong, yet supple bulletproof vests. Other industrial and medical applications include stronger automotive and aerospace components and stronger, more biodegradable sutures for closing wounds.3

Pig organs can be used for human transplants.

Other transgenic animals have medical uses, too. Animal human transgenic combinations represent a booming aspect of biotechnology. Here are several examples:

* Pigs are often chosen as transgenic animals because their physiology and organ size are so similar to humans. The hope is that pig organs can be used for organ transplantation, known as xenotransplantation, alleviating the shortage of human hearts and kidneys, which are in scarce supply. Researchers are also exploring the use of cell transplantation therapy for patients with spinal cord injury or Parkinson's disease.4 There are several drawbacks to xenotransplantation (discussed below).
* Other uses of this transgenic combination include growing tissue on a scaffolding, or supporting framework. This then can be used as a temporary skin substitute for healing wounds5 or burns6 or as replacement cartilage, heart valves,7 cerebrospinal shunts, or even collagen tubes to guide re-growth of nerves that have been injured.8
* Additionally, commercial companies seek to derive therapeutic proteins, such as monoclonal antibodies, from the milk of transgenic cows, goats, rabbits, and mice and use them to administer drugs in treatment of rheumatoid arthritis, cancer, and other autoimmune disorders.9

Ethical Issues

Transgenic biotechnology presents an exciting range of possibilities, from feeding the hungry to preventing and treating diseases; however, these promises are not without potential peril. Some of the issues that need to be considered are the following:

Transgenic biotechnology presents challenges, such as health risks.

* Are we blurring the lines between species by creating transgenic combinations?
* What are the known health risks associated with transgenics?
* What are the long-term effects on the environment when transgenics are released in the field?
* What ethical, social, and legal controls or reviews should be placed on such research?
* Are we inflicting pain and suffering on sentient creatures when we create certain types of chimeras?
* Will transgenic interventions in humans create physical or behavioral traits that may or may not be readily distinguished from what is usually perceived to be "human"?
* If the blending of nonhuman animal and human DNA results, intentionally or not, in chimeric entities possessing degrees of intelligence or sentience never before seen in nonhuman animals, should these entities be given rights and special protections?
* What unintended personal, social, and cultural consequences could result?
* Will these interventions redefine what it means to be "normal"?
* Who will have access to these technologies, and how will scarce resources be allocated?

Are we crossing species boundaries?

Some individuals have argued that crossing species boundaries is unnatural, immoral, and in violation of God's laws. This argument presumes that species boundaries are fixed and readily delineated. However, a recent issue of the American Journal of Bioethics reflects that the notion of species boundaries is a hotly debated topic.10 Some bioethicists have pointed out there are a variety of species concepts: biological, morphological, ecological, typological, evolutionary, phylogenetic, to name a few.11 All of these definitions of what a species is reflect changing theories and the varying purposes for which different species are used by individuals.

Will the technology facilitate transmission of disease? While the issue of the morality of crossing species boundaries reflects differing world views and may be conceptually unclear, there are known risks associated with xenotransplantation of transgenic cells or organs from animals to humans. For
example, there is a small but significant risk of the transmission of usually fatal zoonotic diseases, such as bovine spongiform encephalopathy (also known as "mad cow disease"), porcine endogenous retroviruses (PERVs), and Nipah encephalitis.\textsuperscript{12} The introduction of these diseases to the human population could have devastating consequences. The U.S. Food and Drug Administration has banned xenotransplantation trials using nonhuman primates until the procedure has been adequately demonstrated to be safe and ethical issues have been sufficiently publicly discussed.

Is it ethical to create altered animals that may suffer? The risks and benefits of the experimental use of animals need to be discussed as well. Similarly, by combining animal DNA and human DNA with plant DNA, do we run the risk of creating new diseases for which there is no treatment? The long-term risks to the environment are unknown. Various bioethicists, environmentalists, and animal rights activists have argued that it is wrong to create "monsters" or animals that would suffer as a result of genetic alternation (for example, a pig with no legs), and that such experimentation should be banned.\textsuperscript{13}

Is it possible the technology may be used to create slaves?

Altering Humans

Several bioethicists have called for a ban on species-altering technology that would be enforced by an international tribunal.\textsuperscript{14} Part of the rationale for a ban is the concern that such technology could be used to create a slave race, that is, a race of subhumans that would be exploited. In April 1998, scientists Jeremy Rifkin and Stuart Newman, who are both opposed to genetically modified organisms (GMOS), applied for a patent for a "humanzee" part human and part chimpanzee, to fuel debate and to draw attention to potential abuses on this issue. The United States Patent and Trademark Office (USPTO) denied the patent on the grounds that it violated the Thirteenth Amendment to the United States Constitution, which prohibits slavery. The decision has been appealed, but the appeal has not yet reached a court, and it may never do so. The appeal may be dismissed on other technical grounds.

Can the definition of "human" be applied to altered species containing human genes? Although the USPTO has permitted the extensive patenting of bioengineered life forms and human DNA, the question that has been raised by Newman and Rifkin's application is one that will not be resolved easily: What constitutes a human being? A genetic definition is not very helpful, given the variability of gene sequences between individuals. A species definition is controversial, as mentioned earlier. If we look to characteristics for a definition, there are many characteristics that humans share with primates and other animals.\textsuperscript{15} If we create a being that has the ability to speak and perhaps even reason but looks like a dog or a chimp, should that being be given all the rights and protection of a human being? Some bioethicists argue that the definition of "human being" should be more expansive and protective, rather than more restrictive. Others argue that definitions that are more expansive could be denigrating to humanity's status and create a financial disincentive to patenting creations that could be of use to humanity. The question of whether or not the definition should be more expansive or more restrictive will have to be considered as courts, legislatures, and institutions address laws regarding genetic discrimination.

Will society manipulate the genetic traits of children? In a similar vein, the International Olympic Committee has expressed concern that athletes will soon employ genetic engineering to get an edge.\textsuperscript{16} If individuals are willing to genetically manipulate their children to make them better athletes, then it's likely individuals will be willing to manipulate their children to be brighter, better looking, more musically inclined, or whatever the parents think would give them an advantage. Opponents of genetic manipulation argue that by allowing this we run the risk of creating a race of superhumans, changing what it means to be normal and increasing the ever-widening gap between the have's and the have-nots. Proponents of genetic manipulation argue that currently parents can and do give their children advantages by sending them to better schools or giving them growth hormone and that banning genetic manipulation is a denial of individual liberties. These arguments also reflect the opposing philosophies regarding how scarce resources should be allocated.

Society must address the ethical and legal issues of altered organisms.

Conclusion
Transgenics and genetic engineering present intriguing and difficult challenges for 21st century scientists and ethicists. Until we as a society or, perhaps, as a global entity can agree on what beings, human or otherwise, are worthy of moral and legal status and respect, we can expect intense cross-disciplinary debate and discussion as new intelligent life is created through science and medicine.

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About the author: Linda MacDonald Glenn, J.D., L.L.M. (in Biomedical Ethics, from McGill University) is a healthcare ethics educator and consultant. She recently completed a fellowship at the Institute of Ethics with the American Medical Association, where her research encompassed the legal, ethical, and social impact of emerging technologies and evolving notions of personhood. Prior to returning to an academic setting, she consulted and practiced as a trial attorney with an emphasis in patient advocacy, bioethical and biotechnology issues, end of life decision-making, reproductive rights, genetics, parental and biological "nature vs. nurture," and animal rights issues; she was the lead attorney in several cutting edge bioethics legal cases. She has advised governmental leaders and agencies and published numerous articles in professional journals and books. Her most recent articles include "A Legal Perspective on Humanity, Personhood and Species Boundaries". in the American Journal of Bioethics, September 2003 (vol. 3, pp. 27-28), and "Biotechnology at the Margins of Personhood: An Evolving Legal Paradigm". in the Journal of Evolution and Technology, March 2003 (vol. 13, pp. 35 37). Glenn has taught at the University of Vermont School of Nursing, the Medical College of Wisconsin, and the University of Illinois at Chicago College of Medicine, and she has addressed public and professional groups internationally. More about her background can be seen at www.biomedlaw.com [2].

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