Dis/Integrating Animals: Ethical Dimensions of the Genetic Engineering of Animals for Human Consumption

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Abstract Research at the intersections of feminism, biology and philosophy provides dynamic starting grounds for this discussion of genetic technologies and animals. With a focus on animal bodies, I examine moral implications of the genetic engineering of "domesticated" animals—primarily pigs and chickens—for the purposes of human consumption. Concepts of natural and artificial, contamination and purity, integrity and fragmentation and mind and body feature in the discussion. In this respect, Margaret Atwood's novel, *Oryx and Crake*, serves as a cogent medium for exploring these highly contentious practices and ideas as it provides hypothetical narratives of possibility. Moreover, it is used to highlight contemporary hegemonic assumptions and values in ways that make them visible. Particular attention is paid to issues of growing human organs in pigs for xenotransplantation (resulting, for Atwood, in "pigoons") and the ultimate end of the intensive factory farming of chickens through the genetic engineering of "mindless" chicken tumours (or, as Atwood calls them, "ChickieNobs"). Integral to these philosophical considerations is the provocative question of the genetic modification of animal bodies as a means to end the suffering of domestic food animals. The ultimate implications of this question include an ongoing sensory and moral deprivation of human experience, potentially resulting in a future mechanomorphosis, the extreme manifestation of an existing mechanomorphism.

Keywords Animal ethics · Genetic engineering · Mechanomorphosis · Oryx and Crake · Speculative/science fiction · Transgenic organisms

> Like The Handmaid's Tale, Oryx and Crake is a speculative fiction, not a science fiction proper. It contains no intergalactic space travel, no teleportation, no Martians. As with The Handmaid's Tale, it invents nothing that we haven't already invented or started to invent. Every novel begins with a what if, and then sets forth its axioms. The what if of Oryx and Crake is simply, What if we continue down the road we're already on? How slippery is the slope? What are our saving graces? Who's got the will to stop us?—Margaret Atwood[1]

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A biotechnological age is here and contemporary Western society is steeped in its controversies of possibilities and problems. Debates on its potential for inspiring hope, as a tool for environmental salvation, and for rousing fear, as in opening Pandora's Box and creating Frankensteins, have raged for long enough now to even become clichè. News of a new medical finding or agricultural epidemic makes headlines daily. Indeed, as I write, this week's leading headline on the ScientificAmerican.com website reads: "Mouse Research Bolsters Controversial Theory of Aging," and is accompanied by an all-too-familiar image of a white mouse, an icon of laboratory research.

The first paragraph reads,

> Aging is a process we humans tend to fight every step of the way. The results of a mouse study underscore the potential of antioxidants as a tool in that battle: animals genetically modified to produce more antioxidant enzymes lived longer than control animals did. (Graham, 2005)

While this news article may seem commonplace now, it is headlines such as this one that inspired Margaret Atwood to write a book of speculative fiction on how genetic engineering may continue to shape life on Earth in the future. Her novel, *Oryx and Crake*, published in 2003, opens with a description of an ominous and barren landscape and it becomes immediately apparent that Atwood's vision of the biotechnological future is dystopian to say the least. The take-home messages are deeply humbling as Atwood presents her readers with provocative and disturbing possibilities. As such, *Oryx and Crake* provides a transitional narrative space for the discussion of current biotechnological philosophies and practices in Western society and where they might lead to in the not-so-distant future. While the book covers many aspects of society and technology worthy of discussion, this chapter focuses on issues of genetically modified organisms (GMOs), particularly "transgenic organisms."[2] A transgenic organism is one that has been microgenetically engineered so that its genome contains genetic material derived from a different species (Wheale and McNally, 1990, p. 285). For example, a "geep" is a sheep and goat hybrid, containing genetic material from both species (Wheale and McNally, 1990, p. 276).

Focussing on transgenic animals, I explore the complex concepts and assumptions of value embedded within such practices of genetically engineering animal bodies. For instance, Leesa Fawcett[3] calls the use of animals as medical models of human disease, the ultimate practical expression of anthropomorphism (personal communication, 5 April 2005). The mouse model in the aging study quite literally becomes a metaphor for human physiology. This is particularly important in terms of challenging dominant Western understanding of humans and animals, of nature and culture, and related patriarchal dualisms,[4] which tend to define who and what we are. Thus, as Lynda Birke asserts, these Western scientific ideas and practices have integral connections with social and political, not to mention economic, issues and deserve attention from an ecofeminist perspective (1994, pp. 10–11). This treatment of animal bodies as biofactories is a clear expression of the strong reductionist trend in Western sciences in general, and biotechnologies in particular, which has

resulted in a predominant view of organisms as machines. The body-as-machine metaphor is prolific and powerful, and further exemplified in an application—which enjoys the most attention in this chapter—in which the bodies of animals are modified to grow in ways that result in commercially valuable and consumable "parts" and processes for medicinal or agricultural purposes. The production of these biofactories, of commodified transgenic flesh and viscera, is now a chilling reality, and may have even more startling implications with regard to both animal welfare and human moral sensibilities in its future development.

As such, research at the intersections of feminism, biology and philosophy (like Lynda Birke's and Leesa Fawcett's) provides dynamic starting grounds for this discussion of genetic technologies and animals. With a focus on animal bodies, I examine moral implications of the genetic engineering of "domesticated" animals—primarily pigs and chickens—for purposes of human consumption. Concepts of natural and artificial, contamination and purity, integrity and fragmentation and mind and body feature in the discussion. In this respect, Atwood's *Oryx and Crake* serves as a cogent medium for exploring these highly contentious practices and ideas as it provides hypothetical narratives of possibility. Moreover, it is used to highlight contemporary hegemonic assumptions and values in ways that make them visible, for example, by taking a current biotechnological process/practice to a seemingly absurd end. Particular attention is paid to issues of growing human organs in pigs for xenotransplantation (resulting, for Atwood, in "pigoons") and the ultimate end of the intensive factory farming of chickens through the genetic engineering of "mindless" chicken tumours (or, as Atwood calls them, "ChickieNobs"). Integral to these philosophical considerations is the provocative question of employing the genetic engineering of animal bodies as a means to end the suffering of domestic food animals. This discussion ultimately leads to its implications for the future of human experience and morality.

Dis/Integrity Is a Virtue?

In a brief survey of literature that discusses genetic engineering and animals, two prevailing concerns emerge, those that focus on issues of animal welfare and those that focus on issues of animal rights. Advocates of animal rights claim that animals, particularly vertebrates, should not be used at all,[5] while those taking up animal welfare accept the uses of animals to varying extents and direct their concerns to how animals are treated and whether harm can be justified by the benefits to humankind (Becker and Buchanan, 1996, p. 8). The moral equation of utilitarianism is commonly employed to calculate the overall "greater good" by subtracting the costs from the benefits, which is always done from an anthropocentric, or human-centred, perspective. That is to say that the benefits always relate to human needs and desires because only humans are morally responsible to other human beings. This is the ethical position that typically forms the basis of policy (Bowring, 2003, p. 127).[6]

However, the idea that there is indeed something inherently wrong with the genetic manipulation of animals is taken up in a different, yet equally popular,

philosophical approach known as deontological ethics. This ethical approach, most commonly developed from the philosophy of Immanuel Kant and applied to animals rather than just human beings, is drawn upon to argue that living beings should never be treated as merely a means to an end (Bowring, 2003, p. 134; Holland, 1990, p. 170). In a similar line of argument, others claim that it is wrong to treat animals as instruments solely for human purposes because they have value unto themselves, an intrinsic value, regardless of any instrumental value they may hold for human beings. But, it is not just that animals are considered instruments, the bigger problem is that they are viewed as mechanical instruments (Holland, 1990, p. 170). Stressing the full implications of this view, Val Plumwood states that "a nature represented in mechanistic terms as inferior, passive and mindless, whose only value and meaning is derived from the imposition of human ends is simply replaceable by anything else which can serve those ends equally well" (2002, p. 49).

This is an important contention because it exposes the extremely reductionist, value-laden nature of Western technoscience, with its fundamental ideology and language of mechanism which essentially makes genetic engineering possible. As Bowring succinctly sums up,

> the idea that the functioning of organisms can be distilled to discreet and transferable units of information is the dominant fiction which underpins and legitimizes the practice of genetic engineering. (2003, p. 1)

Rather than attributing or recognizing human characteristics in animals, known as "anthropomorphism," technoscience favours "mechanomorphism," labelling animal bodies, and describing behaviour, in mechanical terms (Cenami Spada, 1997, pp. 43–44). This mechanistic way of thinking and talking about organic life results ultimately in a dramatic reduction of actual bodies in biotechnological practices. Bowring further adds,

> the disturbing image engendered by these developments is thus of a scientific community indifferent to the natural patterns, features and divisions of organic life, and which is content to address the alter instead as an assemblage of inherently disposable artefacts to be manipulated and reconstructed according to human whim. (2003, p. 118)

It may be that what makes this mechanical reduction so disturbing is that it represents a deliberate corruption of an integrity of being, or telos.[7] This notion of integrity makes the fragmentation, the mutilation of bodies into machine-like components, unsettling in subtle and sometimes dramatic ways.[8] It appears to be an organic quality arising in an organism through its own bio-physical processes of development and through interaction with the environment within which it is immersed. It is also aligned with a notion of intrinsic value, which, as opposed to instrumental value, is independent of any human judgment of utility. Of course, the word "integrity" itself is loaded with meaning and particular moral value in English language and in Western culture, which likely heightens the discomfort felt by many when confronted with the threats to organic integrity that biotechnology is said to pose. This way of thinking is grounded in the pervasive Western assumption of a radical discontinuity between human beings and nature. By this logic, anything that human beings do is unnatural, and anything "manmade" [sic]—such as a transgenic

animal—is therefore also unnatural or artificial. The assumption that "natural is good" is remarkably prevalent in the literature on transgenics even though it is contested and problematized across cultures, ethnicities and religions. While many stick to this designation in their arguments, some make a distinction between the process and the animal itself. So, where the process of genetic engineering, the way in which a being is modified, is understood as unnatural because it is biologically impossible outside of a laboratory, the organism itself still possesses integrity of its own, and is neither natural nor unnatural in definitive terms (Holland, 1990, p. 169).[9]

Taking this understanding further, in her essay "The Promises of Monsters: A Regenerative Politics for Inappropriate/d Others," Donna Haraway disrupts any and all divisions between natural and artificial when she states that "if organisms are natural objects, it is crucial to remember that organisms are not born; they are made in world-changing technoscientific practices by particular collective actors in particular times and places" (2004, p. 65).

Moreover, Haraway insists that although life may seem to be overwhelmingly "denatured" by these human practices, "it is not a denaturing so much as a particular production of nature" (2004, p. 66). Haraway proposes that nature is continually co-constructed by various organic and technological actors, some human and some non-human (2004, p. 66). In spite of this, notions of natural goodness maintain a tenacious hold on Western imaginations and the debate often turns to the integrity of species, rather than the individual.

Pigoons, Purity and Perversions of Boundaries

Interestingly, the possibilities of actually transgressing the "natural" boundaries between species via genetic engineering effectively call into question the very definition and concept of species (Becker and Buchanan, 1996, p. 7). It points to a certain cultural arbitrariness both in scientific definitions of species as well as in the moral stances that species boundaries support. As Gerhold Becker puts it,

> to bridge the species barrier brings to the fore not only the very concept of species itself but also its significance and function in the natural order of beings. It is noteworthy that in most cultures the crossing of species lines used to be the subject of taboos for humans. (1996, p. 7)

If I may be allowed some cultural and historical generalizations, in the West there has been an acceptance of the idea that all organisms can be categorized into different species based upon biological characteristics, particularly in terms of mating. So defined, species have become relatively fixed and bounded phenomena and there is a long history regarding the ideological and practical maintenance of such boundaries in Western society.[10] Much has been written on this history of ideas already, of great chains of being and of cultural taboos, too much to summarize here; rather, I take up the underlying notions of purity and contamination in the discussion as they relate to attitudes and values regarding transgenic animals and xenotransplantation.

Fig. 1 Pig used for organ xenotransplantation (credit: Courtesy ITV/Carlton)

Both involve the deliberate crossing of the so-called species barriers and both result in the actual combination of genetic material from two or more different species.

In the fictional world created by Atwood in *Oryx and Crake*, such transgenic animals, called "pigoons" (or by their Latin title "*sus multiorganifer*"), play a pivotal role in human medical and commercial enterprise. At first they are used to provide various means of human physical enhancement and prolonging life, yet, ironically, in the end they become a tangible threat to human survival. For Jimmy, the principle character in the story, pigoons represent his family's livelihood.

His father is employed as a genetic engineer at OrganInc Farms, a huge biotechno-industrial compound, which also serves as a gated-community for all of its employees and their families. As Atwood explains in the narrative,

> The goal of the pigoon project was to grow an assortment of foolproof human-tissue organs in a transgenic knockout pig host—organs that would transplant smoothly and avoid rejection, but would also be able to fend off attacks by opportunistic microbes and viruses, of which there were new strains every year. A rapid maturity gene was spliced in so the pigoon kidneys and livers and hearts would be ready sooner, and now they were perfecting a pigoon that could grow five or six kidneys at a time. Such a host animal could be reaped of its extra kidneys; then, rather than being destroyed, it could keep on living and grow more organs, much as a lobster could grow another claw to replace a missing one. (2003, pp. 22–33)

It is interesting to note that in naming them "pigoons," Atwood hints at the idea that since they have undergone dramatic genetic modifications they are no longer "pigs," that they have become a new animal altogether. This is contrary to

the language currently employed in biotech rhetoric, where genetically modified pigs are still called pigs, and yet it also points to another controversial aspect in biotechnology: the patenting of GMOs. A patent is only granted if an organism is considered to be completely novel and artefactual, which is what the renaming actually represents.[11] To be sure, the boundary between reality and fiction is porous. As Atwood stated in the passage at the beginning of this chapter, this is not merely the stuff of speculation, or science, or fiction and there are presently many examples in which human genetic material is being inserted into the genomes of other animals. For example, transgenic pigs, known as "Beltsville"[12] pigs, "were produced from single-cell embryos that had been injected with a human growth hormone gene" (Bowring, 2003, p. 124). The corporeal results of this experiment failed dramatically in terms of animal welfare, as Bowring explains:

> The pigs showed improved weight gain, greater feed efficiency, and reduced subcutaneous fat, but at the cost of a wide range of pathological side-effects, including 'gastric ulceration, severe synovitis [joint inflammation], degenerative joint disease, pericarditis and endocarditis [inflammation of the outer and inner lining of the heart], cardiomegaly [enlargement of the heart], parakeratosis [cracking of the skin], nephritis [inflammation of the kidney] and pneumonia. 'In addition,' the researchers disclose, 'gilts were anoestrus [infertility due to quiescence or involution of the reproductive tract] and boars lacked libido'. (Bowring, 2003, p. 125)

Clearly, there is no moral consideration for the individual pigs involved, only the potential human benefits of increased agricultural efficiency are of value. Strangely enough, however, these transgenic pigs present a challenge to such blatant anthropocentrism, and may serve to undermine species-based morality (Ryder, 1990, p. 190). It comes back to ideas of purity and species boundaries and we are forced to ask at what point does a pig with human genes stop being a pig and become something more human, or a porcine–human hybrid? Richard Ryder (1990) raises this provocative idea in his essay, "Pigs Will Fly," when he poses questions like

> How many human genes make a sufficiently human creature to have human rights in the eyes of the law? How many human genes can you give a humanized pig before you feel obliged to send it to school rather than to the slaughterhouse? (p. 190)

Ryder is hopeful that the perforation of species boundaries "spotlights the absurdity of our species-based morality", particularly by drawing attention to practices in which human growth hormone genes

> have already been injected into the embryos of pigs. The aim was to produce bigger and juicier pork chops. But wait a minute. This would mean eating human genetic material! It might only be a minute proportion of the chop, but all the same, would it not be a partial cannibalism? (Ryder, 1990, p. 190)

Playing up the revulsion of this very real possibility in her fiction, Atwood has Jimmy reflect on the same questions while dining at the OrganInc Farms cafeteria where, "to set the queasy at ease, it was claimed that none of the defunct pigoons ended up as bacon or sausages: no one would want to eat an animal whose cells might be identical with at least some of their own" (2003, pp. 23–44). Beyond their role as living pork factories, and like the pigoons, present day pigs are also

being genetically modified to provide a "source of replacement organs (the so-called "spare parts factories") for humans" (Bowring, 2003, p. 121). To this end, the use of biotechnology is vital. Bowring explains that

> Though pig heart valves have been used in human cardiac surgery for some years, the future prospects for xenotransplantation using living organs like hearts and kidneys are naturally limited by the aggressive rejection and often destruction of foreign matter by the human immune system (even in successful cases the recipients must take immunosuppressant drugs for the rest of their lives). For this reason progress is being made in adding human DNA sequences to pig embryos in order to produce animals which express human proteins that prevent or reduce hyperacute rejection of the organ by the recipient. (2003, p. 121)

The purpose of this process is to make a pig's body less pig-like[13] so that it can become more compatible with human bodies, and in essence then, more human (at least on a physiological level). The impetus for ridding the pig's organ of all traces of its "pigness" perhaps also arises in part out of sentiments of a general distaste, a "feeling that there is something undignified for the recipient in receiving a pig's heart" (Aldridge, 1996, p. 132). Atwood mirrors this attitude of aversion through a sardonically humorous exchange between Jimmy's parents, in which his father enthusiastically announces a recent breakthrough at work to his mother:

> 'We've done it,' said Jimmy's father's voice. 'I think a little celebration is in order.' A scuffle: maybe he'd tried to kiss her.
> 'Done what?'
> Pop of the champagne cork. 'Come on, it won't bite you.' A pause: he must be pouring it out. Yes: the clink of glasses. 'Here's to us.'
> 'Done what? I need to know what I'm drinking to.'
> Another pause: Jimmy pictured his father swallowing, his Adam's apple going up and down, bobbity-bobble. 'It's the neuro-regeneration project. We now have genuine human neocortex tissue growing in a pigoon. Finally, after all those duds! Think of the possibilities, for stroke victims, and. . .'
> 'That's all we need,' said Jimmy's mother. 'More people with the brains of pigs. Don't we have enough of those already?' (p 56)

While fears of contamination appear justified[14] and provide reason for caution, general concepts of blood purity and contamination may be more dangerous in terms of racism and classism. Notions of pedigree have been around for centuries, revered in royal family lineage and designations of "pure blood" and "blue blood", and have extended to breeding practices of "domesticated" animals, such as dogs, cats and horses.[15] This is not an unfamiliar idea, and so does not require elucidation. A more novel and complex implication of "blood purity" however, is its exposure of how certain beliefs arise out of bodily experiences which may not be reconcilable with what are considered to be rational truths and facts (Kirmayer, 1992, p. 329). Such beliefs and fears can play out even when the species barrier is not transgressed, for instance, in cases of human-to-human blood transfusion. For example, Laurence Kirmayer illustrates what he calls "the body's insistence on meaning" through a challenging case study of a man, called "Mr. Y", who refuses to undergo a life-saving blood transfusion because of his belief that the

"foreign" blood will contaminate him with the donor's, "genetic material that carries personality traits" (1992, p. 325). Exasperated by the patient's irrationality, his doctor explains that it is impossible and refuses to investigate the experiential basis of the patient's belief which, upon psychiatric consultation, is found to stem from traumatic childhood experiences in hospitals with the doctors treating his kidney disease (Kirmayer, 1992, p. 326). During the interview, the psychiatrist notices that Mr. Y makes repeated references to feeling vulnerable in terms of his body boundaries and to his impressions of the physicians' insensitivity and repeated transgressions of those boundaries (Kirmayer, 1992, p. 326). It was also apparent that Mr. Y is "fastidious" about caring for his body, and he admits to eating only organic foods and drinking purified water (Kirmayer, 1992, p. 327). But, as Kirmayer surmises, his body issues go much deeper and have wider social dimensions:

> Mr. Y is a foreigner, a businessman who has come from Europe to Canada. He views the locals as less cultured and sophisticated than himself. He feels their coarseness is intrinsic, part of their bodily constitution, and fears receiving blood from them since this would taint his body and with it his mind. This incipiently racist theme of "blood purity," although it may receive impetus from Mr. Y's childhood traumas, finds support in collective representations and discriminatory practices. (1992, p. 329)

Promises of Failure and Risks of Success (or, It's All About Perspective!)

With this kind of visceral discrimination, I can only imagine the horror of Mr. Y's reaction to the idea of receiving blood or organs from an animal of another species. Nevertheless, biotechnological research in this area gallops on with great fervour and promise for medical progress. Meanwhile, there is a greater uncertainty to this work that I have yet to see specifically addressed in the literature on transgenics. While there is much written about the fears of failure in which the GMO is unable to survive out in the world due to unforeseen problems (such as increased susceptibility to disease that was coded for on a gene that was removed for other reasons (Rollin, 1995, p. 110), and about welfare arguments concerned with failure (as in the Beltsville pigs' case) there is very little about the risks of success. Admittedly, concerns of ecological risk have received some attention, but they all tend to focus on microscopic organisms, invertebrates (mainly insects) and transgenic plants, that have been modified for agricultural purposes. The conventional warning is that, "unlike chemical substances, genetically engineered organisms have the capacity to mutate, migrate and multiply" (Holland, 1990, p. 173) and that "a genetically engineered organism once free in the environment is impossible to recall" (Bereano, 1996, p. 30).

As with the fear of blood contamination due to xenotransplantation, this fear of "polluting" an ecological system with a "foreign" organism has an experiential basis; experiments in biological pest control have provided all too many lessons learned, the hard way, of what can happen. So the logic follows that any novel

(i.e. transgenic) organism has no natural habitat, no place of origin in this world, and therefore always presents an ecological risk if released from the laboratory. But, what of those transgenic animals never intended for release? Although human beings are capable of altering the genetic makeup and phenotypic expression of that modified genotype, we are not actually in control of evolution, and even transgenic animals kept in a laboratory or otherwise confined may change and adapt over time, through mutation and reproductive processes. What, indeed, might be the potential long-term implications of splicing human genetic material into pig embryos? Has the scientific mind become so accustomed to a severely reductionist view of the world that it can only "see" animals as passive machine-like objects, an assemblage of inert parts to be tinkered with? Some humility and wonder is in order; a respect for all that is still not known or understood about bodies and whole biological systems, and the findings of biological sciences which suggest their dynamic complexity and chaotic nature.[16] For all of its sophistication, the science of genetic engineering is founded upon an overzealous faith in the technology itself, and upon an over-simplified idea of living processes and bodies. The former, known as technological determinism, creates a hold upon scientific thought and effectively eliminates worries of risk. The latter, known as biological determinism, defines animals as only the physical products of their DNA.[17]

In this regard, Atwood's pigoon becomes not only a kind of allegory for the ecological risks of transgenic organisms, but also a warning for what may come to pass, quite literally. In Jimmy's own lifetime and as a result of deliberate human action, a microorganism wipes out all human life on Earth. In this post-apocalyptic world, pigoons have escaped from the laboratories and now roam freely. Possibly emphasizing the agency of all transgenic animals, Atwood writes, "They were always escape artists, the pigoons: if they'd had fingers they'd have ruled the world" (p. 267). In this scenario, from the pigoon's perspective of course, they are very successful in terms of ecological adaptation and ability to thrive. On the other hand, from a human perspective, pigoons become an experimental failure, or monstrous mistake, as they now express both the desire and talents to hunt and eat human flesh. Apparently, the practice of mixing human and pig genetic material for numerous generations has endowed pigoons with a certain amount of human similarity. Jimmy contemplates this phenomenon when he finds himself in a vulnerable position. He ruefully reflects

> There are too many pigoon tracks around here. Those beasts are clever enough to fake a retreat, then lurk around the next corner. They'd bowl him over, trample him, then rip him open, munch up the organs first. He knows their tastes. A brainy and omnivorous animal, the pigoon. Some of them may even have human neocortex tissue growing in their crafty, wicked heads. (Atwood, 2003, p. 235)

The pigoons have clearly evolved human-like traits as a result of their genetic alteration, and Atwood illustrates the irony through their apparent enjoyment of the tables being turned. For instance, at one point Jimmy narrowly escapes his predators by fleeing up a steep flight of stairs, knowing that pigoons are not physically built

to climb a staircase. In his panicked haste, he drops his plastic bag carrying what amounts to his worldly belongings:

> He starts cautiously downward. As he's stretching out his hand, something lunges. He jumps up out of reach, watches while the pigoon slithers back down, then launches itself again. Its eyes gleam in the half-light; he has the impression it's grinning. They were waiting for him, using the garbage bag as bait. They must have been able to tell there was something in it he'd want, that he'd come down to get. Cunning, so cunning. (Atwood, 2003, 271)

The idea of pig–human hybrids running rampant in the streets may be taking current GMOs to an absurdly extreme end of the range of possibility. However, experience does suggest that organisms can and will respond to biological and ecological changes in unpredictable ways. Atwood's pigoons remind us of this agency of animals, which tends to be ignored or denied all too often. Therefore, although "mechanical models express the denial to nature of any uniqueness, agency and power" (Plumwood, 2002, p. 49), warnings of ecological risk speak loudly and clearly of the agency and power of transgenic organisms. Such agency is expressed when genetically modified wheat suddenly appears in an organic farmer's field several kilometres away, and when the Beltsville pig's body develops severe arthritis. Unfortunately, the denial of animal agency is underpinned by a reification of the "gene" itself, the ultimate reduction of life into its smallest component part, which guides genetic engineering. Birke cautions that "reifying them allows us to see only the genes, devoid of their physiological context, the organism itself and its environment" (1994, p. 83). Once removed from their original context, how can scientists be sure of how the gene will function in an essentially alien one? Expressing this concern, Birke questions

> what happens to the inserted gene apart from its attributed role of molecule factory. How does it interact with the sheep's genes? Or with its cells? Or with its wider environment? And what are the consequences of those actions? (1994, p. 83)

Thinking of a gene as just interchangeable DNA matter brings the discussion back to the question of species hierarchy, presenting a challenge to the superiority dominantly attributed to the human species over all others. Success in genetic engineering depends upon similarity between and among different individuals and species, otherwise it could not work. As a result, "the boundaries start to dissolve", and Birke recognizes that "to avoid that worrying prospect, we can label the genes as embodying essence. Human genes must have something special about them, an essence of humanness, that gives them a territorial boundary" (1994, pp. 83–84). This presents us with an apparent paradox in which "genetics as a system of representation both challenges concepts of species as fixed (in the practice of, for example, transgenics) and reinforces them (by incorporating notions of essence)" (Birke, 1994, p. 84).

Rather than struggling with the contradiction, it appears that biotechnoscience is content to ignore it and to maintain one set of rules for defining human beings and another set for all other animals. To continue this hierarchy of species by defining

animals as only products of their biology poses perhaps the greatest threat to animal agency and welfare, resulting in the actualization of the "animal is machine" metaphor.

Designed for Deprivation

Factory farming is already based upon thinking of animals as machines to be tinkered with so they can be made more efficient. For instance, cows are thought of as milk machines and given genetically engineered bovine growth hormones, known as Bovine Somatotropin (BST), to increase their production of milk (Wenz, 2001, p. 222; Wheale and McNally, 1990).[18] As the conditions within industrial animal agriculture intensify, the occurrences of disease and disharmony among the animals themselves increase dramatically (Bowring, 2003, p. 131). Unfortunately, rather than changing the conditions of production, many look to genetic engineering for quick-fix solutions. As Caroline Murphy points out, "the 'Trojan horse' of disease resistance may provide a means whereby genetic engineers can design animals to cope with conditions that no animal, genetically engineered or not, should be expected to endure" (1990, p. 16). Modifications to animal bodies via genetic engineering thus effectively enable continued, and possibly even increased, deprivation as animals are treated as nothing more than meat factories, confined to "cramped and unsanitary conditions" (Bowring, 2003, p. 132). This in itself is cause enough for alarm in terms of animal welfare, yet becomes even more horrifying as proponents attempt to alleviate all causes of suffering through changing the very nature of the animals.

Those in favour of redesigning animals to be even better adapted to factory environments call it simply the "latest stage in the historical process of 'domesticating' animals" (Bowring, 2003, p. 132), insisting that it is no different, in theory, from pastoral practices of domestication through selective breeding. But the stakes are much higher, as Bowring explains, this means that now "one could, therefore, produce chickens which lack a desire to nest" (2003, p. 136). What's more, advocates insist that since transgenic animals could, in principle, be created without causing suffering, and for that matter engineered "... to suffer less, there is in the eyes of most scientists nothing inherent in genetic engineering which makes it an unethical tool" (Bowring, 2003, p. 132).

By contrast, opponents assert that this would be morally reprehensible, and turn again to the argument that the telos of beings should not be violated under any circumstances (Bowring, 2003, pp. 133–134; Holland, 1990, pp. 170–171; Fox, 1990, pp. 32–33). Expanding upon his earlier deontologic argument, Holland claims that

> there is a distinction between using another creature's ends as your own—which is acceptable—and disregarding that other creature's ends entirely—which is not. A problem, however, which Kant's notion does not seem to address... comes when the genetic engineer starts to redesign those ends. (1990, p. 170; emphasis added)

Fig. 2 An oncomouse—bred for cancer (credit: Brian Gunn/IAAPEA)

The End of Animal Suffering = The End of Animals?

Incidentally, this is precisely what Bernard Rollin advocates in his "new social ethic for animals" (1995). Rollin argues that if animals can be modified to be "happier" in the confinement conditions of factory farms, there should be no moral opposition to it. It is interesting that he does not argue that it should be a moral imperative, only that it should not be immoral to alleviate suffering using genetic modification to better fit animals to their conditions. In response to claims of the inviolability of telos, Rollin addresses his critics by emphasizing that he believes there is nothing wrong with changing the nature, or telos, of an animal as long as the animal's interests—which emerge from that telos—are not violated (1995, p. 171).[19] For example, he supports changing the nature of a chicken, when normally confined in a battery cage, which suffers frustration at not being able to nest to lay her eggs so that the "new kind of chicken" no longer expresses the urge to nest and instead experiences satisfaction at laying eggs in a cage (Rollin, 1995, p. 172). Rollin admits that public apprehension to his argument may emerge from "a queasiness that is at root aesthetic. The chicken sitting in a nest is a powerful aesthetic image. . .. A chicken without that urge jars us"(1995, p. 175).

However, he is quick to point out that this pastoral image is already forsaken to an immense degree in current practices of factory farming, which should cause as much if not more concern than hypothetical applications of genetic engineering. Indeed, his argument becomes harder to dispute as he recounts that Western culture has "a historical tradition as old as domestication for changing (primarily agricultural) animal telos (through artificial selection) to fit animals into human society to serve human needs. We selected for non-aggressive animals, animals disinclined or

unable to leave our protection and so on" (Rollin, 1995, p. 174). Here, Rollin's argument begins to appear very pragmatic in the face of the West's "current exploitative business context" (1995, p. 182) of intensive industrial animal agriculture.

He is not without sympathy, nor ignorant of the full ramifications of what he suggests; rather, he presents himself as a realist—justifiably cynical of society's lack of will to change such strongly rooted economic, political and social practices—admitting that to change the nature of an animal to fit a poor environment rather than changing the environment itself is merely the "lesser of two evils" (Rollin, 1995, p. 192), but a necessary one when the likelihood of the system changing to fit animals' needs is slim.

Up to here, Rollin presents a fairly persuasive case. However, he takes it too far when he suggests

> . . .if we could genetically engineer essentially decerebrate food animals, animals that have merely a vegetative life but no experiences, I believe it would be better to do this than to put conscious beings into environments in which they are miserable. (1995, p. 193)

To suggest genetically modifying a chicken which lacks the urge to nest is provocative enough, but to suggest a chicken which lacks a brain is downright shocking. And it is here where we come to the most extreme manifestation of the mechanical metaphor, and the division of mind and body, with the proposed production of actual meat machines.

This prospect is celebrated among some scientists in the field and has apparently been around for quite some time. In fact, Rollin's comment on "decerebrate food animals" was inspired by a conversation with a genetic engineer who claims that

> . . .in the long run, biotechnology will make the whole debate about agricultural animal welfare moot. Eventually, he told [Rollin], we will be able to create the relevant animal proteins in fermentation vats produced by bacteria genetically coded to do so. Thus we will be able to have animal products without animals. (1995, p. 193)

Furthermore, Peter Roberts recalls that

> . . .those attending a cattle breeders conference in Cambridge England, in 1988 were somewhat stunned when they were told that within 15–20 years the production of meat need no longer involve the rearing and slaughter of animals (Ridley, 1988). In this case they were not being told about textured soya proteins, but about genetically engineered meat, not grown in the stockyard but cultivated in vitro (in glass dishes) in commercial laboratories, from cells selected from rump steak or chicken breasts. (1990, p. 201)[20]

Beyond Suffering: "ChickieNobs Bucket O'Nubbins"

Bringing this terrifying prospect to life in the world of Oryx and Crake, Atwood confronts her readers with an evocative image that they will surely find unforgettable. Jimmy is visiting his best friend, Crake, at his new high school called the Watson–Crick Institute. As its name implies, it's an institute of genetic technology, with students specializing in areas such as "Botanical Transgenics," "NeoGeologicals,"

and "Décor Botanicals." Crake takes Jimmy on a tour of these departments, winding up in "Neo Agriculturals" or "AgriCouture" as it is nicknamed. Here, Jimmy is presented with "a large bulblike object that seemed to be covered with stippled whitish-yellow skin. Out of it came twenty thick fleshy tubes, and at the end of each tube another bulb was growing" (Atwood, 2003, p. 202). He is told that they are essentially chicken parts, some just breasts, others just drumsticks. They have been modified to have no head, just a mouth into which nutrients are dumped:

> This is horrible,' said Jimmy. The thing was a nightmare. It was like an animal–protein tuber. 'Picture the sea-anemone body plan,' said Crake. 'That helps.' 'But what's it thinking?' said Jimmy. (Atwood, 2003, p. 202)

In response, Jimmy is told by one of the student scientists involved that it's not supposed to think that "they'd removed all the brain functions that had nothing to do with digestion, assimilation and growth" (Atwood, 2003, p. 203). "'No need for added growth hormones,' said the woman, 'the high growth rate's built in. . .. And the animal-welfare freaks won't be able to say a word, because this thing feels no pain'" (Atwood, 2003, p. 203).

Jimmy's immediate response of horror and his question of "what's it thinking" speak to an agency in chickens that has been dramatically violated and distorted. Atwood then makes allusions to the already tight relationship between present-day research in biotechnology and big business through its commercial applications:

> 'Those kids are going to clean up,' said Crake after they'd left. The students at Watson–Crick got half the royalties from anything they invented there. Crake said it was a fierce incentive. 'ChickieNobs, they're thinking of calling the stuff.' 'Are they on the market yet?' asked Jimmy weakly. He couldn't see eating a ChickieNob. It would be like eating a large wart. (Atwood, 2003, p. 203)

As unpalatable as they seem to Jimmy at first, eventually they become familiar, cheap and convenient enough for him to overcome his revulsion. With his acquiescence to ChickieNobs Bucket O'Nubbins, Atwood is definitely commenting upon the power of marketing and on contemporary society's cultural amnesia regarding many once controversial environmental issues. As warnings of global warming and species extinction become increasingly monotonous and commonplace in the news and everyday life, it seems that the public tends to either tire of them or finds them so completely overwhelming that it becomes preferable to ignore them and let the politicians work it out. Ironically, this seemingly pervasive apathy in dominant Western society is exactly what Rollin had been referring to for supporting the non-fictional production of ChickieNobs.

To get beyond these circular arguments of suffering, Holland stresses freedom as grounds for objection, which he defines as "the capacity to exercise options;" he abhors the idea that an animal might be modified to have a diminished capacity in this respect (1990, 171; also see Fox, 1990, p. 34). With sober wit he acknowledges that if capacity is to be modified, a kind of genetic lobotomy is the inevitable result since

> . . .the genetic engineer is unlikely to deal with the problem of the unhappy pig by increasing the animal's sophistication to the level where it is capable of being philosophical about its

> condition and learns not to mind. Rather, the capacities of the animal would be reduced to the state where it was, from a sentient point of view, more vegetable than animal. (Holland, 1990, p. 172)

Depriving Ourselves: Mechanomorphosis and Other Ethical Consequences

Alternatively, it may be more generative to argue that genetic engineering presents a violation of "being" in terms of living processes rather than seemingly static qualities such as capacities. To this end, Bowring cautions that the continued treatment of animals as malleable artefacts is as much a threat to "human's own vital sensibilities" as it is to animal welfare, and that it will "progressively erode the scope for and substance of human's moral existence" (Bowring, 2003, p. 3). In other words, through the philosophy and practices embedded within genetic engineering that ultimately reduce all animal life into biological machines, human beings are distorting their own experience of the world, and thus their values and belief systems along with them. In phenomenological terms, human beings are situated within our own unique bodies, which connect us with the world, enabling sensory experiences of it, while simultaneously limiting what and how we know to our own embodied experiences (Merleau-Ponty, 1962, p. 82). There can be no absolute objectivity, nor isolated subjectivity, as we are always in relation to other beings, materials and processes. To borrow Maurice Merleau-Ponty's fabric metaphor of existence, I imagine numerous threads stretching from my body out to everything and everyone around me (Gill, 1991, p. 4). And just as each thread stretches in both directions, so too is perception reciprocal, facilitating my experiences as both an observer and as one who is observed by others. Extending this reciprocity of perception to animals, David Abram provides an elegant example of an ant walking upon his arm. He senses the ant visually and through the touch of the ant's feet upon his skin, and realizes that the ant also senses him as he notices the ant respond to his arm movements (Abram, 1996, p. 67). Counter to a mechanical view of nature, a phenomenological perspective enables such experiences of intentionality and agency in others, particularly other animals. Emphasizing the importance of human–animal interaction through direct embodied experiences, Bowring stresses that

> While there are… obvious dangers involved in romanticising traditional agricultural practices for being 'closer to nature', it may still be argued that the genetic approach to farming, and the reductionist science which underpins it, marks a watershed in the development of humans' relationship to nature in so far as it involves a decisive degradation in their subjective qualities of feeling and perception. (Bowring, 2003, p. 138)

In doing so, we are losing the capacity to relate to other animals, our own bodies and other human beings. Such an impoverishment of experience is, as evident in the discussion throughout this chapter, intimately connected with an inanimate language, reinforcing and reinforced by a dominant mechanical worldview. To speak of organisms as machines legitimizes our treatment of them as artefacts, as completely

knowable and transparent objects and of their lives as having no ethical significance. As such, Bowring warns that

> ". . .genetic engineers' favoured language of 'bioreactors,' 'spare-parts factories,' 'nutraceutical fruits,' 'live-stock pharming,' 'biofacture' and so on, are not just commercially sanitised descriptions of what remain stubbornly recalcitrant natural phenomena. . .: this mechanistic language and philosophy is also disturbing for the way they seem to express the degradation of scientists' own physical and moral sensibilities, and a diminishing care for the integrity of life which has troubling ramifications for human relations themselves. (2003, p. 142)

Behind commercial profits from the commodification of bodies and lingering enlightenment fantasies of revealing all the secrets of nature, there lurks the ominous promise of our own sensory and moral deprivation. Ultimately, by transforming nature into an insensate, decerebrate, wholly objectified product, devoid of independent well-being, the biotech programme may thus deliver its golden promise by relieving us of care. The mechanization of nature will lead to the mechanization of ourselves, our sentiments, judgments, fears and dreams (Bowring, 2003, p. 143).

In this respect, Bowring worries that "this process is already foreshadowed by the cultural fetishization of the cyborg, and of course in the assertion that human nature itself should now become the object of the biotech enterprise" (2003, p. 143). While I can appreciate Bowring's fear of the cyborg, I do not find it to be problematic in itself. Truth be told, I find the reality of the cyborg metaphor much more appealing than the current mechanical one, particularly in terms of Haraway's understanding of the cyborg's potential to expose and dissolve hierarchical divisions between mind and body, nature and culture and so on that are the direct result of a mechanical (and patriarchal) worldview (1991). For, as Haraway reminds us in her infamous "cyborg manifesto," a cyborg is a "hybrid of machine and organism, a creature of social reality as well as a creature of fiction" (1991, p. 149). If we are already cyborgs, as Haraway contends and Bowring fears, then we are least still partly human animals. As cyborgs, we retain some form of organic sensory perception while also enjoying technological augmentations. Thinking of ourselves in this way may enable the humility so desperately needed in our social relations with other animals, particularly as it encourages us to engage our imaginations, to recognize both the generative and destructive fictions in our worldviews, as we struggle to comprehend our ontological predicament (the meaning of life, the universe and everything).[21]

If we continue along the biotechnological path without questioning its ideological basis, we risk much more than becoming actual cyborgs, we risk manifesting our mechanomorphism via mechanomorphosis. That is, we gamble with becoming machines ourselves, in the most reductionist sense, inheriting only the mechanistic part of our cyborg heritage and leaving all traces of humanimality behind. With the loss of embodied sensibility, of our modes of social relatedness, we run the risk of eliminating our ability to ponder metaphysics, to question our own actions and fundamental beliefs, and with it the desire or need for ethics at all. In due course, we need to resist our conversion into insensate automatons and imagine what is at stake. Will the dis/integration of our corporeal-selves and other animals,

and re/integration through mechanomorphosis lead to amoral relationships? Do we really want to achieve a future without suffering by way of disembodiment?

Notes

1. Quoted from an essay by Margaret Atwood about the writing process of the book on the Oryx and Crake website at http://www.randomhouse.com/features/ atwood/essay.html
2. For an accessible scientific explanation of genetic engineering and the processes of producing transgenic organisms, please see Aldridge, S. (1996). *The Thread of Life: The Story of Genes and Genetic Engineering*. Cambridge: Cambridge University Press.
3. In her foundation course on Environment and Culture: Nature, Technology and Society, Leesa Fawcett, an associate professor in the Faculty of Environmental Studies at York University, has lectured extensively on complex social and biological issues raised by genetic technologies, including: the dangers of genetic discrimination and the oppression of differently abled people arising from "designer babies"; the diverse cultural and religious attitudes towards xenotransplantation; and, the implications of phenomena such as zoonoses (transfer of disease across species) which challenge "pure" boundaries assumed by hierarchical dualisms and their corresponding ethical perspectives, like anthropocentrism.
4. For cogent explanations of the patriarchal (male hierarchy) basis of modern, Western sciences, please see Plumwood, V. (1993). *Feminism and the Mastery of Nature.* London: Routledge and Plumwood, V. (2002). *Environmental Culture: The Ecological Crisis of Reason*, London: Routledge; also see Haraway, D. (1989). *Primate Visions*. London: Routledge.
5. For a thorough argument against the use of animals in experimentation and in favour of animal rights using dominant Western philosophical perspectives, such as utilitarianism and deontological ethics, see Wacks, R. (1996). Sacrificed for Science: Are Animal Experiments Morally Defensible? In J. K. Becker and J. P. Buchanan (Eds). *Changing Nature's Course: The Ethical Challenge of Biotechnology*. Hong Kong: Hong Kong University Press.
6. "Most advisory reports in the UK and the European Union on the 'ethical implications' of biotechnology have thus taken the utilitarian view that there is nothing inherently wrong with the genetic manipulation of animals, but scientists involved in such practices must demonstrate that there are tangible human benefits to be gained from their work" (Bowring, 2003, p. 127).
7. Michael Fox provides a dramatic view of this when he states: "Genetic engineering makes it possible to breach the genetic boundaries that normally separate the genetic material of totally unrelated species. This means that the telos, or inherent nature, of animals can be so drastically modified (for example by inserting elephant growth hormone genes into cattle) as to radically change the entire direction of evolution, and primarily towards human ends at that" (1990, p. 32).
8. In a paper she recently presented at the American Association of Geographers conference, Emma Roe, of Cardiff University, explores similar notions of integrity and cow flesh in the beef industry stating that: initially, the living cow has integrity, wholeness; then, it is disintegrated through the butchering process into fleshy parts; and, finally, the flesh is virtually re-integrated through the marketing of the meat product, through the product history information and common image of a cow on the package label (*Growing beef: The 'branded' non-human(s) and the retail distribution of the bovine body part(s)* presented at the American Association of Geographers (AAG) Annual Conference in Denver, Colorado, 5–9 April 2005).
9. In support of this claim, Holland cites Charles Darwin's work regarding "naturally occurring" animals and those that have been modified through selective breeding, stressing that "nearly all of the distinctions which Darwin observes between natural and artificial forms of life. . .reduce to a difference of degree rather than of kind" (1990, p. 169).

10. Employing cannibalism as a theme, Stuart Newman (1995) discusses the historical and particularly religious bases of boundaries between species in Carnal Boundaries: The Commingling of Flesh in Theory and Practice, in L. Birke. & R. Hubbard (Eds), *Reinventing Biology: Respect for Life and the Creation of Knowledge*. Bloomington and Indianapolis: Indiana University Press.
11. Take OncoMouse for example. Designed to develop various forms of cancer under the total control of the genetic technician, OncoMouse is the "first patented animal in the world" (Haraway, 1997, p. 79). According to an advertisement by Du Pont, the corporation which actually holds the patent, "Each OncoMouse carries the ras oncogene in all germ and somatic cells. This transgenic model, available commercially for the first time, predictably undergoes carcinogenesis" (Haraway, 1997, p. 81). So named, OncoMouse is an artefact, a trade-marked commodity, and no longer considered a mouse.
12. The pigs are named after the town of Beltsville in Maryland, USA, where they were "produced" in a US Department of Agriculture laboratory. The failure was very widely publicized and considered a "public relations disaster" for genetic engineering (Murphy, 1990, p. 15; for more information also see http://www.bbc.co.uk/science/genes/gene_safari/wild_west/bigger_and_better.shtml
13. It is worth noting here that genetic scientists are also developing a strategy for "deleting the porcine gene that codes for an enzyme (called *a*-1,3-galactosyltransferase) which makes the sugar that, recognized as a foreign antigen by the primate immune system, causes hyperacute rejection in humans" (Bowring, 2003, p. 121).
14. Beyond such aesthetic revulsion, there is a definite and well-grounded fear that disease and its vectors will also transgress the species barrier in dangerous and unpredictable ways. Bowring warns of the "widespread concerns amongst ecologists and medical researchers that xeno-transplantation will allow new and unknown microorganisms, harmless to their natural hosts, to cross the species barrier, causing infectious disease, spreading cancer-causing retroviruses, and potentially creating mutant viruses as deadly as HIV, Ebola, or BSE. Pigs are already known to harbour endogenous retroviruses which have been found to infect human cells in vitro" (2003, pp. 303–304). Bowring further notes that "the Ebola and Marburg monkey viruses have caused large disease outbreaks in humans, and HIV is widely believed to have derived from a monkey retrovirus, and millions of people in the 1950s were infected with the non-virulent monkey virus SV40 after vaccines were contaminated by the monkey kidney cells in which they were produced" (2003, pp. 303–304).
15. The practical extensions of such human ideals into animal breeding are cited by Lynda Birke: "Even the breeding of pet animals have moved from Victorian 'fancies' into the technological society of the twentieth century. At the time of writing, a doggie sperm bank had recently started in California. Reminiscent of the human sperm bank set up in the 1970s to provide sperm from men with high IQs, the canine version (the Canine Cryobank and Animal Fertility Clinic) offers sperm from 'blue blood dogs and cats' (such as particular sled dogs) and abortions offered (at $350 each) in the event of fertilization from 'substandard sperm'" (1994).
16. In this respect, Bernard Rollin points out the similar warning made by Michael Crichton in his speculative/science fiction novel *Jurassic Park*: "Crichton's fictional vehicle for making his point is the prospect of re-creating dinosaurs by genetic engineering for a dinosaur wildlife park. Although scientists build into both the animals and the park various clever mechanisms to prevent the animals from reproducing or ever leaving the confines of the preserve, things do not go as planned. The conceptual point underlying Crichton's story is drawn from the relatively new branch of mathematics known as chaos theory, which postulates that the sorts of intrinsically predictable systems beloved by Newtonians, determinists and introductory philosophy professors. . . are few and far between, and, in any case, are essentially irrelevant to complex new technologies like genetic engineering" (1995, p. 72). The bottom line is that biological systems are too complex and chaotic to make thorough predictions about, something unanticipated can and likely will occur.

17. Arguing against biological determinism, both Birke (1994, p. 84) and Haraway (2004, p. 65) refer to Simone de Beauvoir's well-known assertion that "women are made, not born," an assertion often repeated by feminists in opposition to the biological determinism of gender.
18. Wheale and McNally (1990) devote an entire section to the discussion of "Genetically Engineered Bovine Somatotropin (BST)," with essay contributions from four additional authors in their book *The Bio-Revolution: Cornucopia or Pandora's Box?* London: Pluto Press. The chapters by Bulfield and Webster are particularly relevant. Also see my discussion of the ethical and practical implications of the cow as milk machine metaphor in Warkentin (2002). It is not just what you say, but how you say it: an exploration of the moral dimensions of metaphor and the phenomenology of narrative, *Canadian Journal of Environmental Education* 7:241–255.
19. Also see Rollin (1998). On telos and genetic engineering. In A.Holland & A. Johnson (Eds.). *Animal Biotechnology and Ethics*. London: Chapman and Hall.
20. The reference to Ridley that Roberts makes in this quotation is curiously impossible to find. All of my attempts so far have been unsuccessful, but I encourage anyone interested to try (Ridley, 1988).
21. Unless, of course, we accept the answer of "42," given in Douglas Adams' very popular work of science fiction, *The Hitchhiker's Guide to the Galaxy*.

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