Target Article

Crossing Species Boundaries

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This paper critically examines the biology of species identity and the morality of crossing species boundaries in the context of emerging research that involves combining human and nonhuman animals at the genetic or cellular level. We begin with the notion of species identity, particularly focusing on the ostensible fixity of species boundaries, and we explore the general biological and philosophical problem of defining *species.* Against this backdrop, we survey and criticize earlier attempts to forbid crossing species boundaries in the creation of novel beings. We do not attempt to establish the immorality of crossing species boundaries, but we conclude with some thoughts about such crossings, alluding to the notion of moral confusion regarding social and ethical obligations to novel interspecies beings.

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Introduction

Crossing species boundaries in weird and wondrous ways has long interested the scientific community but has only recently captured the popular imagination beyond the realm of science fiction. Consider, for instance, the print and pictorial publicity surrounding the growth of a human ear on the back of a mouse;[1] the plight of Alba, artist Eduardo Kac's green-fluorescent-protein bunny stranded in Paris;[2] the birth announcement in *Nature* of ANDi, the first transgenic primate;[3] and, most recently, the growth of pigs' teeth in rat intestines[4] and miniature human kidneys in mice.[5]

But, bizarrely, these innovations that focus on discrete functions and organs are almost passé. As part of the project of harnessing the therapeutic potential of human stem cell research, researchers are now involved in creating novel interspecies whole organisms that are unique cellular and genetic admixtures (DeWitt 2002). A human-to-animal embryonic chimera is a being produced through the addition of human cellular material (such as pluripotent or restricted stem cells) to a nonhuman blastocyst or embryo. To give but four examples of relevant works in progress, Snyder and colleagues at Harvard have transplanted human neural stem cells into the forebrain of a developing bonnet monkey in order to assess stem cell function in development (Ourednik et al. 2001); human embryonic stem cells have been inserted into young chick embryos by Benvenisty and colleagues at the Hebrew University of Jerusalem (Goldstein et al. 2002); and most recently it has been reported that human genetic material has been transferred into rabbit eggs by Sheng (Dennis 2002), while Weissman and colleagues at Stanford University and StemCells, Inc., have created a mouse with a significant proportion of human stem cells in its brain (Krieger 2002).

Human-to-animal embryonic chimeras are only one sort of novel creature currently being produced or contemplated. Others include: *human-to-animal fetal or adult chimeras* created by grafting human cellular material to late-stage nonhuman fetuses or to postnatal nonhuman creatures; *human-to-human embryonic, fetal, or adult chimeras* created by inserting or grafting exogenous human cellular material to human embryos, fetuses, or adults (e.g., the human recipient of a human organ transplant, or human stem cell therapy); *animal-to-human embryonic, fetal, or adult chimeras* created by inserting or grafting nonhuman cellular material to human embryos, fetuses, or adults (e.g., the recipient of a xenotransplant); *animal-to-animal embryonic, fetal, or adult chimeras* generated from nonhuman cellular material whether within or between species (excepting hu-

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[1] See, e.g., Mooney and Mikos (1999); and the *Scientific American Frontiers* coverage of "The Bionic Body," available from: http://www.pbs.org/saf/1107/features/body.htm. See also Bianco and Robey (2001).

[2] See the bibliography of media coverage at http://www.ekac.org/transartbiblio.html.

[3] A sample headline from *The Independent* (London): "How a Glowing Monkey Will Help Cure Disease" (12 January 2001; available from: http://www.independent.co.uk/story.jsp?story=49841). See also Chan et al. (2001); and Harris (2001).

[4] "Scientists Grow Pig Teeth in Rat Intestines" is available from: http://www.laurushealth.com/HealthNews/reuters/NewsStory0926200224.htm. See also Young et al. (2002).

[5] "Human Kidneys Grown in Mice" is available from: http://news.bbc.co.uk/2/hi/health/2595397.stm. See also Dekel et al. (2003).

man beings); *nuclear-cytoplasmic hybrids,* the offspring of two animals of different species, created by inserting a nucleus into an enucleated ovum (these might be intraspecies, such as sheep-sheep; or interspecies, such as sheep-goat; and, if interspecies, might be created with human or nonhuman material); *interspecies hybrids* created by fertilizing an ovum from an animal of one species with a sperm from an animal of another (e.g., a mule, the offspring of a he-ass and a mare); and *transgenic organisms* created by otherwise combining genetic material across species boundaries.

For this paper, in which we elucidate and explore the concept of species identity and the ethics of crossing species boundaries, we focus narrowly on the creation of interspecies chimeras involving human cellular material—the most recent of the transgressive interspecies creations. Our primary focus is on human-to-animal *embryonic* chimeras, about which there is scant ethical literature, though the scientific literature is burgeoning.

Is there anything ethically wrong with research that involves the creation of human-to-animal embryonic chimeras? A number of scientists answer this question with a resounding “no.” They argue, plausibly, that human stem cell proliferation, (trans)differentiation, and tumorigenicity must be studied in early embryonic environments. For obvious ethical reasons, such research cannot be carried out in human embryos. Thus, assuming the research must be done, it must be done in nonhuman embryos—thereby creating human-to-animal embryonic chimeras. Other scientists are less sanguine about the merits of such research. Along with numerous commentators, they are quite sensitive to the ethical conundrum posed by the creation of certain novel beings from human cellular material, and their reaction to such research tends to be ethically and emotionally charged. But what grounds this response to the creation of certain kinds of part-human beings? In this paper we make a first pass at answering this question. We critically examine what we take to be the underlying worries about crossing species boundaries by referring to the creation of certain kinds of novel beings involving human cellular or genetic material. In turn, we highlight the limitations of each of these arguments. We then briefly hint at an alternative objection to the creation of certain novel beings that presumes a strong desire to avoid introducing moral confusion as regards the moral status of the novel being. In particular we explore the strong interest in avoiding any practice that would lead us to doubt the claim that humanness is a necessary (if not sufficient) condition for full moral standing.

Species Identity

Despite significant scientific unease with the notion of *species identity,* commonplace among biologists and commentators are the assumption that species have particular identities and the belief that the boundaries between species are fixed rather than fluid, established by nature rather than by social negotiation. Witness the ease with which biologists claim that a genome sequence of some organism—yeast, worm, human—represents the identity of that species, its blueprint or, alternatively, instruction set. As we argue below, such claims mask deep conceptual difficulties regarding the relationship between these putatively representative species-specific genomes and the individual members of a species.

The ideas that natural barriers exist between divergent species and that scientists might someday be able to cross such boundaries experimentally fuelled debates in the 1960s and 1970s about the use of recombinant DNA technology (e.g., Krimsky 1982). There were those who anticipated the possibility of research involving the crossing of species boundaries and who considered this a laudable scientific goal. They tried to show that fixed species identities and fixed boundaries between species are illusory. In contrast, those most critical of crossing species boundaries argued that there were fixed natural boundaries between species that should not be breached.

At present the prevailing view appears to be that species identity is fixed and that species boundaries are inappropriate objects of human transgression. The idea of fixed species identities and boundaries is an odd one, though, inasmuch as the creation of plant-to-plant[6] and animal-to-animal hybrids, either artificially or in nature, does not foster such a vehement response as the prospective creation of interspecies combinations involving human beings—no one sees rhododendrons or mules (or for that matter goat-sheep, or geep) as particularly monstrous (Dixon 1984). This suggests that the only species whose identity is gener-

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[6] A possible exception is the creation of genetically modified crops. But here the arguments are based on human health and safety concerns, as well as on political opposition to monopolistic business practices, rather than on concern for the essential identity of plant species.

ally deemed genuinely "fixed" is the human species. But, what is a *species* such that protecting its identity should be perceived by some to be a scientific, political, or moral imperative? This and similar questions about the nature of species and of species identities are important to address in the context of genetics and genomics research (Ereshefsky 1992; Claridge, Dawah, and Wilson 1997; Wilson 1999b).

Human beings (and perhaps other creatures) intuitively recognize species in the world, and cross-cultural comparative research suggests that people around the globe tend to carve up the natural world in significantly similar ways (Atran 1999). There is, however, no one authoritative definition of species. Biologists typically make do with a plurality of species concepts, invoking one or the other depending on the particular explanatory or investigative context.

One stock conception, propounded by Dobzhansky (1950) and Mayr (1940), among others, is the *biological species concept* according to which species are defined in terms of reproductive isolation, or lack of genetic exchange. On this view, if two populations of creatures do not successfully interbreed, then they belong to different species. But the apparent elegance and simplicity of this definition masks some important constraints: for instance, it applies only to those species that reproduce sexually (a tiny fraction of all species); moreover, its exclusive emphasis on interbreeding generates counterintuitive results, such as the suggestion that morphologically indistinguishable individuals who happen to live in neighboring regions but also happen never to interbreed should be deemed members of different species. (Imagine viewing populations of human beings "reproductively isolated" by religious intolerance as members of different species, and the biological species concept fails to pick out *Homo sapiens* as a discrete species comprising all human beings.)

Such results can be avoided by invoking other definitions of species, such as the *evolutionary species concept* advanced by G. G. Simpson and E. O. Wiley, which emphasizes continuity of populations over geological time: "a species is a single lineage of ancestral descendant populations of organisms which maintains its identity from other such lineages and which has its own evolutionary tendencies and historical fate" (Wiley 1978, 18; see also Simpson 1961). Unlike the biological species concept, this definition of species applies to both sexually and asexually reproducing creatures and also underscores shared ancestry and historical fate—and not merely capacity to interbreed—as what unifies a group of creatures as a species. The evolutionary species concept is by no means unproblematic, however, mainly because it is considerably more vague than the biological species concept, and so also considerably more difficult to operationalize.

A third approach to defining species has lately received considerable attention among philosophers of biology. This approach is known as the *homeostatic property cluster* view of species, advocated in different ways by Boyd (1999), Griffiths (1999), and Wilson (1999a). Following Wilson (1999a, 197–99) in particular, the homeostatic property cluster view of species is properly understood as a thesis about natural kinds, of which a species is an instance. The basic idea is that a species is characterized by a cluster of properties (traits, say) no one of which, and no specific set of which, must be exhibited by any individual member of that species, but some set of which must be possessed by all individual members of that species. To say that these property clusters are "homeostatic" is to say that their clustering together is a systematic function of some causal mechanism or process; that an individual possesses any one of the properties in the property cluster significantly increases the probability that this individual will also possess other properties in the cluster. So the list of distinguishing traits is a property cluster, wherein the properties cluster as a function of the causal structure of the biological world. Of course, an outstanding problem remains, namely that of establishing the list of traits that differentiate species one from the other. Presumably this would be achieved by focusing on reproductive, morphological, genealogical, genetic, behavioral, and ecological features, no one of which is necessarily a universal property of the species and no set of which constitutes a species essence. We return below to the homeostatic property cluster view of species when we consider how best to characterize *Homo sapiens.*

To these definitions of species many more can be added: at present, there are somewhere between nine and twenty-two definitions of species in the biological literature.[7] Of these, there is no one species concept that is universally compelling. Accordingly, rather than asking the generic question, "How is 'species' defined?" it might be useful to fo-

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[7] Kitcher (1984) and Hull (1999) each discuss nine concepts. Mayden (1997) discusses twenty-two.

cus instead on the narrower question "How is a species defined?" In response to the latter question Williams (1992) proposes that a species be characterized by a description comprising a set of traits differentiating that species from all others. It is no small task, however, to devise a satisfactory species description for any particular group of beings. Take, for example, *Homo sapiens.* Significantly, not even a complete sequence of *the* human genome can tell us what particular set of traits of *Homo sapiens* distinguishes human beings from all other species.

When molecular biologists first talked about mapping and sequencing the human genome, their goal was to construct the sequence of nucleotides in all the genes in all the chromosomes in the normal human body. The sequence was meant to serve as a reference point to which individual genomes could be compared in efforts to locate deviant genes implicated in phenotypic variation. As well, the sequence was meant to facilitate the study of gene function in development (often in comparison with the consensus genomes of organisms belonging to other species) and to establish historical relationships among organisms.

Two draft sequences of a "standard" or "typical" human genome were published in 2001, one produced under the auspices of the publicly-funded Human Genome Project (HGP), the other by Celera Genomics. The HGP's official genome is a composite of genetic information from tens or hundreds of human individuals, while Celera Genomics' official genome is a composite of genetic information from five individuals (but principally Craig Venter, Celera's former president; Wade 2002). The sequences are nonetheless supposed to be 99.9% identical to individual human genomes, and that 0.1% variation, in concert with environmental variations, is supposed to explain the immense diversity among human beings (for a recent statement of this position, see Plomin et al. 2002). But, excepting identical twins, every human genome is different from every other. Further, while one's maternal DNA may differ by 0.1% from one's paternal DNA, and one's own DNA may differ from that of any other individual by 0.1%, it is not the case that there is a certain part of an individual's genome that is 99.9% identical with every other human's genome. Although human beings might share 99.9% commonality at the genetic level, there is nothing as yet identifiable as *absolutely* common to all human beings. According to current biology, there is no genetic lowest common denominator, no genetic essence, "no single, standard, "normal" DNA sequence that we all share" (Lewontin 1992, 36). The only way to determine how common the standard sequences are is to compare them with the actual sequences of a large number of individuals in an effort to detect conserved portions and polymorphisms; no one, though, is proposing such an endeavor. Even so, there is no way in which a single genome—not even Craig Venter's—can *represent* the immense genetic variability characteristic of *Homo sapiens* (Tauber and Sarkar 1992; Lloyd 1994; Robert 1998).

Moreover, comparative genomic research has thus far been of no help in establishing the boundary of human species identity. Much of "our" DNA is shared with a huge variety of apparently distantly related creatures (e.g., yeast, worms, mice). Indeed, given the evidence that all living things share a common ancestor, there is little (if any) uniquely human DNA.[8] More strikingly perhaps, though human beings are morphologically and behaviorally vastly different from chimpanzees, we differ genomically from chimps by no more than 1.2–1.6% (Allen 1997; Marks 2002; Enard et al. 2002; Olson and Varki 2003). Further, the surprisingly small number of genes in the sequenced human genome, as compared to original estimates, offers a serious blow to the idea of human uniqueness at the genomic level (Claverie 2001). Finally, there is no comfort to be found in the assessment that a tiny number of physical, chemical, genetic, and developmental accidents made human history possible. In sum, even though biologists are able to identify a particular string of nucleotides as human (as distinct from, say, yeast or even chimpanzee), the unique identity of the human species cannot be established through genetic or genomic means.

What Is Homo sapiens?

What, then, is *Homo sapiens?* Though clearly there is no one authoritative definition of species, notions of "species essences" and "universal properties of species" persist, always in spirit if not always in name, in discussions about breaching species boundaries. For this reason, on occasion, attempts to define *Homo sapiens* are reduced to attempts to define *human nature.* This is a problem, however, insofar as the literature exhibits a wide range of

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[8] In fact, through studies in comparative genomics biologists have demonstrated horizontal transfer of genes between lineages, suggesting a remarkable fluidity of species "boundaries" at the genomic level. Some of this literature is reviewed in Doolittle (1999).

opinion on the nature of *human nature;* indeed, many of the competing conceptions of *human nature* are incommensurable (for a historical sampling of views, see Trigg 1988). On one view the claim that there is such a thing as human nature is meant to be interpreted as the claim that all members of *Homo sapiens* are essentially the same. But since everything about evolution points toward variability and not essential sameness, this would appear to be an inherently problematic claim about human nature (Hull 1986). One way of avoiding this result is to insist that talk of human nature is not about essential sameness but rather about universality and then to explain universality in terms of distinct biological attributes—a functional human nervous system, a human anatomical structure and physiological function, or a human genome (Campbell, Glass, and Charland 1998). A classic example of the latter strategy, explaining universality genetically, appears in an article on human nature by Eisenberg (1972), who writes that "one trait common to man everywhere is language; in the sense that only the human species displays it, the capacity to acquire language must be genetic" (126).[9] In this brief passage Eisenberg moves from the claim that language is a human universal, to the claim that the ability to have a language is unique and species specific, to the claim that this capacity is genetic (Hull 1986). But, of course, language is not a human universal—some human beings neither speak nor write a language, and some are born with no capacity whatsoever for language acquisition. Yet, in a contemporary context, no one would argue that these people, simply by virtue of being nonverbal and/or illiterate, are not members of the same species as the rest of us.[10]

And therein lies the rub. We all know a human when we see one, but, really, that is all that is known about our identity as a species. Of course we all know that human beings are intelligent, sentient, emotionally-complex creatures. We all know the same of dolphins, though. And, of course, not all human beings are intelligent, sentient, or emotionally complex (for instance, those who are comatose); nevertheless, most among us would still consider them human.

The homeostatic property cluster approach to species avoids the problem of universality but at the possible expense of retaining an element of essentialism. Recall that, according to the homeostatic property cluster view, membership in a species is not determined by possession of *any particular* individual homeostatically clustered property (or *any particular sets* of them) but rather by possession of *some* set of homeostatically clustered properties. Nevertheless, although possession of property *x* (or of property set *x*-*y*-*z*) is not *necessary* for species membership, possession of *all* the identified homeostatically clustered properties is *sufficient* for membership, which suggests that a hint of essentialism persists (Wilson 1999a).

This is an ironic result, inasmuch as essentialism in biology is vanishingly rare. This is because essentialism—or at least stock conceptions of essentialism according to which a species is identified by essential intrinsic properties—is at odds with evolutionary biology.[11] Significantly, commentators of all stripes tend to revert to essentialist thinking when pondering the locus of humanity. This might be because of a persistent folk essentialism, reflecting "a way of thinking about living systems whose continuing grip on us is explained by the fact that it develops long before we are exposed to scientific biology" (Griffiths 2002, 77). It might also be because the very idea of a "locus of humanity" is always already an essentialist idea.

Moral Unrest with Crossing Species Boundaries[12]

As the above discussion of species identity makes clear, there is no consensus on what exactly is being

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[9] Other examples are everywhere to be found in commentaries on the human genome project.

[10] And even were language a human universal *par excellence,* there is simply no basis for the assumption that invariability (universality) and genetics must be connected. See Hull (1986); and Oyama (2000).

[11] This case is usually made in terms of Mayr's distinction between (non-Darwinian) typological thinking and (Darwinian) population thinking (Mayr 1959). For a useful account of Mayr's distinction, see Sober (1980). Griffiths (1999) attempts to resurrect an alternative account of essentialism compatible with Darwinism, wherein he deals not with intrinsic essential properties but rather extrinsic (relational) ones. We will not discuss this effort here, nor will we address the view that typological thinking has an important role to play in contemporary evolutionary biology in approaching the evolution of form (Love 2003).

[12] Given our suggestion that the notion of species boundaries is problematic, at least biologically speaking, it might seem odd for us to continue using the language of "crossing species boundaries." We offer two defenses: first, the language is commonly used, especially to capture some sort of moral demarcation line (see below); second, we intend the notion, biologically, in a limited sense. Consider any individual human. That individual human contains a genome, a specifically human genome; call this genome H. Next, con-

breached with the creation of interspecies beings. As against what was once commonly presumed, there would appear to be no such thing as fixed species identities. This fact of biology, however, in no way undermines the reality that fixed species exist independently as moral constructs. That is, notwithstanding the claim that biologically species are fluid, people believe that species identities and boundaries are indeed fixed and in fact make everyday moral decisions on the basis of this belief. (There is here an analogy to the recent debate around the concept of race. It is argued that race is a biologically meaningless category, and yet this in no way undermines the reality that fixed races exist independently as social constructs and they continue to function, for good or, more likely, ill, as a moral category.) This gap between science and morality requires critical attention.

Scientifically, there might be no such thing as fixed species identities or boundaries. Morally, however, we rely on the notion of fixed species identities and boundaries in the way we live our lives and treat other creatures, whether in decisions about what we eat or what we patent. Interestingly, there is dramatically little appreciation of this tension in the literature, leading us to suspect that (secular) concern over breaching species boundaries is in fact concern about something else, something that has been mistakenly characterized in the essentialist terms surveyed above. But, in a sense, this is to be expected. While a major impact of the human genome project has been to show us quite clearly how similar we human beings are to each other and to other species, the fact remains that human beings are much more than DNA and moreover, as we have witnessed throughout the ages, membership within the human community depends on more than DNA. Consider, for example, the not-so-distant past in which individual human beings of a certain race, creed, gender, or sexual orientation were denied moral standing as members of the human community. By appealing to our common humanity, ethical analysis and social activism helped to identify and redress what are now widely seen as past wrongs.

Although in our recent history we have been able to broaden our understanding of what counts as human, it would appear that the possible permeability of species boundaries is not open to public debate insofar as novel part-human beings are concerned. Indeed, the standard public-policy response to any possible breach of human species boundaries is to reflexively introduce moratoriums and prohibitions.[13]

But why should this be so? Indeed, why should there be *any* ethical debate about the prospect of crossing species boundaries between human and nonhuman animals? After all, hybrids occur naturally, and there is a significant amount of gene flow between species in nature.[14] Moreover, there is as yet no adequate biological (or moral) account of the distinctiveness of the species *Homo sapiens* serving to capture all and only those creatures of human beings born. As we have seen, neither essentialism (essential sameness, genetic or otherwise) nor universality can function as appropriate guides in establishing the unique identity of *Homo sapiens.* Consequently, no extant species concept justifies the erection of the fixed boundaries between human beings and nonhumans that are required to make breaching those boundaries morally problematic.[15] Despite this, belief in a fixed, unique,

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sider some nonhuman animal, or even a plant; call this genome not-H. Next, consider the application of standard genetic manipulation techniques to isolate a particular functional stretch of DNA from this specific not-H genome. Finally, consider the application of standard gene transfer techniques to insert (across "species boundaries," as we here understand the term) the gene from not-H into H, via the germ line. Some of the offspring of the bearer of genome H would thereafter contain genomes in which the gene from not-H appears. The bearer of H and her/his offspring would thus be interspecies beings (in the limited biological sense intended).

[13] See, for example, s6(2)(b) Infertility (Medical Procedures) Act 1984 (Victoria, Australia); s3(2)(a)–(b) and s3(3)(b) Human Fertilisation and Embryology Act 1990 (United Kingdom); and Article 25 Bill containing rules relating to the use of gametes and embryos (Embryo Bill), September 2000 (the Netherlands). See also Annas, Andrews, and Isasi (2002).

[14] A particularly well-documented example of gene flow between species is Darwin's finches in the Galapagos Islands. For a recent account, see Grant and Grant (2002).

[15] A possible objection is that the biological species concept could in fact do the required work: human beings do not successfully interbreed with mice or moose, and so the boundary is established. We do not find the objection compelling. Whether human beings can in fact successfully interbreed with mice or moose is an open empirical question; while it does not happen in nature, it might happen artificially in the ways noted at the outset of this paper. The artificiality of such reproduction does not render it of a different kind, though. Human beings requiring reproductive technologies in order to breed are nonetheless human, they nonetheless reproduce, and they nonetheless generate offspring who are unquestionably human. So, the biological species concept cannot be used to discount the potential artificial creation of hybrids or of chimeras as a matter of breaching fixed species boundaries.

human species identity persists, as do moral objections to any attempt to cross the human species boundary—whatever that might be.

According to some, crossing species boundaries is about human beings playing God and in so doing challenging the very existence of God as infallible, all-powerful, and all-knowing. There are, for instance, those who believe that God is perfect and so too are all His creations. This view, coupled with the religious doctrine that the world is complete, suggests that our world is perfect. In turn, perfection requires that our world already contains all possible creatures. The creation of new creatures—hybrids or chimeras—would confirm that there are possible creatures that are not currently found in the world, in which case "the world cannot be perfect; therefore God, who made the world, cannot be perfect; but God, by definition is perfect; therefore God could not exist" (Morriss 1997, 279).[16] This view of the world, as perfect and complete, grounds one sort of opposition to the creation of human-to-animal chimeras.

As it happens, however, many do not believe in such a God and so do not believe it is wrong to "play God." Indeed, some would argue further that not only is it *not* wrong to play God, but rather this is exactly what God enjoins us to do. Proponents of this view maintain that God "left the world in a state of imperfection so that we become His partners"—his co-creators (Breitowitz 2002, 327).

Others maintain that combining human genes or cells with those of nonhuman animals is not so much about challenging God's existence, knowledge, or power, as it is about recognizing this activity as inherently unnatural, perverse, and so offensive. Here the underlying philosophy is one of repugnance. To quote Kass (1998), repugnance

> revolts against the excesses of human wilfulness, warning us not to transgress what is unspeakably profound. Indeed in this age in which . . . our given human nature no longer commands respect . . . repugnance may be the only voice left that speaks up to defend the central core of humanity. (19)

For many, the mainstay of the argument against transgressing species "boundaries" is a widely felt reaction of "instinctive hostility" (Harris 1998, 177) commonly known as the "yuck factor." But in important respects repugnance is an inchoate emotive objection to the creation of novel beings that requires considerable defense. If claims about repugnance are to have any moral force, the intuitions captured by the "yuck" response must be clarified. In the debate about the ethics of creating novel beings that are part human, it is not enough to register one's intuitions. Rather, we need to be able to clearly identify and critically examine these intuitions, recognizing all the while that they derive "from antecedent commitment to categories that are themselves subject to dispute" (Stout 2001, 158).

A plausible "thin" explanation for the intuitive "yuck" response is that the creation of interspecies creatures from human materials evokes the idea of bestiality—an act widely regarded as a moral abomination because of its degrading character. Sexual intimacy between human and nonhuman animals typically is prohibited in law and custom, and some, no doubt, reason from the prohibition on the erotic mixing of human and nonhuman animals to a prohibition on the biotechnological mixing of human and nonhuman cellular or genetic material. There are important differences, however. In the first instance the revulsion is directed toward the shepherd who lusts after his flock and acts in a way that makes him seem (or actually be) less human (Stout 2001, 152). In the second instance the revulsion is with the purposeful creation of a being that is neither uncontroversially human nor uncontroversially nonhuman.

A more robust explanation for the instinctive and intense revulsion at the creation of human-to-animal beings (and perhaps some animal-to-human beings) can be drawn from Douglas's work on taboos (1966). Douglas suggests that taboos stem from conceptual boundaries. Human beings attach considerable symbolic importance to classificatory systems and actively shun anomalous practices that threaten cherished conceptual boundaries. This explains the existence of well-entrenched taboos, in a number of domains, against mixing things from distinct categories or having objects/actions fall outside any established classification system. Classic examples include the Western response to bisexuality (you can't be both heterosexual and homosexual) and intersexuality. Intersexuality falls outside the "legitimate" (and exclusive) categories of male and female, and for this reason intersex persons have been carved to fit into the existing categories (Dreger 2000). Human-to-animal chimeras, for instance, are neither clearly animal nor clearly human. They obscure the classification system (and concomitant social structure) in such a way as to constitute an unacceptable threat to valu-

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[16] Note that Morriss does not subscribe to such a position.

able and valued conceptual, social, and moral boundaries that set human beings apart from all other creatures. Following Stout, who follows Douglas, we might thus consider human-to-animal chimeras to be an abomination. They are anomalous in that they "combine characteristics uniquely identified with separate kinds of things, or at least fail to fall unambiguously into any recognized class." Moreover, the anomaly is loaded with social significance in that interspecies hybrids and chimeras made with human materials "straddle the line between *us* and *them*" (Stout 2001, 148). As such, these beings threaten our social identity, our unambiguous status as human beings.

But what makes for unambiguous humanness? Where is the sharp line that makes for the transgression, the abomination? According to Stout, the line must be both sharp and socially significant if trespassing across it is to generate a sense of abomination: "An abomination, then, is anomalous or ambiguous with respect to some system of concepts. And the repugnance it causes depends on such factors as the presence, sharpness, and social significance of conceptual distinctions" (Stout 2001, 148). As we have seen, though, there is no biological sharp line: we have no biological account of unambiguous humanness, whether in terms of necessary and sufficient conditions or of homeostatic property clusters. Thus it would appear that in this instance abomination is a social and moral construct.

Transformative technologies, such as those involved in creating interspecies beings from human material, threaten to break down the social dividing line between human beings and nonhumans. Any offspring generated through the pairing of two human beings is by natural necessity—reproductive, genetic, and developmental necessity—a human. But biology now offers the prospect of generating offspring through less usual means; for instance, by transferring nuclear DNA from one cell into an enucleated egg. Where the nuclear DNA and the enucleated egg (with its mitochondrial DNA) derive from organisms of different species, the potential emerges to create an interspecies nuclear-cytoplasmic hybrid.

In 1998 the American firm Advanced Cell Technology (ACT) disclosed that it had created a hybrid embryo by fusing human nuclei with enucleated cow oocytes. The goal of the research was to create and isolate human embryonic stem cells. But if the technology actually works (and there is some doubt about this) there would be the potential to create animal-human hybrids (ACT 1998; Marshall 1998; Wade 1998). Any being created in this way would have DNA 99% identical with that of the adult from whom the human nucleus was taken; the remaining 1% of DNA (i.e., mitochondrial DNA) would come from the enucleated animal oocyte. Is the hybrid thus created simply part-human and part-nonhuman animal? Or is it unequivocally human or unequivocally animal (see Loike and Tendler 2002)? These are neither spurious nor trivial questions. Consider, for example, the relatively recent practice in the United States of classifying octoroons (persons with one-eighth negro blood; the offspring of a quadroon and a white person) as black. By analogy, perhaps 1% animal DNA (i.e., mitochondrial DNA) makes for an animal.[17]

A more complicated creature to classify would be a human-to-animal chimera created by adding human stem cells to a nonhuman animal embryo. It has recently been suggested that human stem cells should be injected into mice embryos (blastocysts) to test their pluripotency (Dewitt 2002). If the cells were to survive and were indeed pluripotent, they could contribute to the formation of every tissue. Any animal born following this research would be a chimera—a being with a mixture of (at least) two kinds of cells. Or, according to others, it would be just a mouse with a few human cells. But what if those cells are in the brain, or the gonads (Weissman 2002)? What if the chimeric mouse has human sperm? And what if that mouse were to mate with a chimeric mouse with human eggs?

All of this to say that when faced with the prospect of not knowing whether a creature before us is human and therefore entitled to all of the rights typically conferred on human beings, we are, as a people, baffled.

One could argue further that we are not only baffled but indeed fearful. Hybrids and chimeras made from human beings represent a metaphysical threat to our self-image. This fear can be explained in both historical and contemporary terms. Until the end of the eighteenth century the dominant Western worldview rested on the idea of the Great Chain of Being. The world was believed to be an ordered and hierarchical place with God at the top, followed by angels, human beings, and various classes of animals on down through to plants and

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[17] Mitochondrial DNA is not insignificant DNA. Like nuclear DNA it codes for functions.

other lesser living matter (Lovejoy 1970; see also Morriss 1997). On this worldview human beings occupied a privileged place between the angels and all nonhuman animals. In more recent times, though the idea of the Great Chain of Being has crumbled, the reigning worldview is still that human beings are superior to animals by virtue of the human capacity for reason and language. Hybrids and chimeras made from human materials blur the fragile boundary between human beings and "unreasoning animals," particularly when one considers the possibility of creating "reasoning" nonhuman animals (Krieger 2002). But is protecting one's privileged place in the world solid grounds on which to claim that hybrid- or chimera-making is intrinsically or even instrumentally unethical?

Moral Confusion

Taking into consideration the conceptual morass of species-talk, the lack of consensus about the existence of God and His role in Creation, healthy skepticism about the "yuck" response, and confusion and fear about obscuring, blurring, or breaching boundaries, the question remains as to why there should be any ethical debate over crossing species boundaries. We offer the following musings as the beginnings of a plausible answer, the moral weight of which is yet to be assessed.

All things considered, the engineering of creatures that are part human and part nonhuman animal is objectionable because the existence of such beings would introduce inexorable moral confusion in our existing relationships with nonhuman animals and in our future relationships with part-human hybrids and chimeras. The moral status of nonhuman animals, unlike that of human beings, invariably depends in part on features other than species membership, such as the intention with which the animal came into being. With human beings the intention with which one is created is irrelevant to one's moral status. In principle it does not matter whether one is created as an heir, a future companion to an aging parent, a sibling for an only child, or a possible tissue donor for a family member. In the case of human beings, moral status is categorical insofar as humanness is generally considered a necessary condition for moral standing. In the case of nonhuman animals, though, moral status is contingent on the will of regnant human beings. There are different moral obligations, dependent on social convention, that govern our behavior toward individual nonhuman animals depending upon whether they are bred or captured for food (e.g., cattle), for labor (e.g., oxen for subsistence farming), for research (e.g., lab animals), for sport (e.g., hunting), for companionship (e.g., pets), for investment (e.g., breeding and racing), for education (e.g., zoo animals), or whether they are simply cohabitants of this planet. In addition, further moral distinctions are sometimes drawn between "higher" and "lower" animals, cute and ugly animals, useful animals and pests, all of which add to the complexity of human relationships with nonhuman animals.

These two frameworks for attributing moral status are clearly incommensurable. One framework relies almost exclusively on species membership in *Homo sapiens* as such, while the other relies primarily on the will and intention of powerful "others" who claim and exercise the right to confer moral status on themselves and other creatures. For example, though some (including ourselves) will argue that the biological term *human* should not be conflated with the moral term *person,* others will insist that all human beings have an inviolable moral right to life simply by virtue of being human. In sharp contrast, a nonhuman animal's "right to life" depends entirely upon the will of some or many human beings, and this determination typically will be informed by myriad considerations.

It follows that hybrids and chimeras made from human materials are threatening insofar as there is no clear way of understanding (or even imagining) our moral obligations to these beings—which is hardly surprising given that we are still debating our moral obligations to some among us who are undeniably biologically human, as well as our moral obligations to a range of nonhuman animals. If we breach the clear (but fragile) *moral* demarcation line between human and nonhuman animals, the ramifications are considerable, not only in terms of sorting out our obligations to these new beings but also in terms of having to revisit some of our current patterns of behavior toward certain human and nonhuman animals.[18] As others have observed (e.g., Thomas 1983), the separateness of humanity is precarious and easily lost; hence the need for tightly guarded boundaries.

[18] Animal-rights advocates might object to the creation of part-human hybrids on the grounds that this constitutes inappropriate treatment of animals solely to further human interests. Obviously, proponents of such a perspective will not typically have a prior commitment to the uniqueness and "dignity" of human beings. For this reason we do not pursue this narrative here.

Indeed, asking—let alone answering—a question about the moral status of part-human interspecies hybrids and chimeras threatens the social fabric in untold ways; countless social institutions, structures, and practices depend upon the moral distinction drawn between human and nonhuman animals. Therefore, to protect the privileged place of human animals in the hierarchy of being, it is of value to embrace (folk) essentialism about species identities and thus effectively trump scientific quibbles over species and over the species status of novel beings. The notion that species identity can be a fluid construct is rejected, and instead a belief in fixed species boundaries that ought not to be transgressed is advocated.

An obvious objection to this hypothesis is that, at least in the West, there is already considerable confusion and lack of consensus about the moral status of human embryos and fetuses, patients in a persistent vegetative state, sociopaths, nonhuman primates, intelligent computers, and cyborgs. Given the already considerable confusion that exists concerning the moral status of this range of beings, there is little at risk in adding to the confusion by creating novel beings across species boundaries. Arguably, the current situation is already so morally confused that an argument about the need to "avoid muddying the waters further" hardly holds sway.[19]

From another tack, others might object that confusion about the moral status of beings is not new. There was a time when many whom we in the West now recognize as undeniably human—for example, women and blacks—were not accorded this moral status. We were able to resolve this moral "confusion" (ongoing social discrimination notwithstanding) and can be trusted to do the same with the novel beings we create.

Both of these points are accurate but in important respects irrelevant. Our point is not that the creation of interspecies hybrids and chimeras adds a huge increment of moral confusion, nor that there has never been confusion about the moral status of particular kinds of beings, but rather that the creation of novel beings that are part human and part nonhuman animal is sufficiently threatening to the social order that for many this is sufficient reason to prohibit any crossing of species boundaries involving human beings. To do otherwise is to have to confront the possibility that humanness is neither necessary nor sufficient for personhood (the term typically used to denote a being with full moral standing, for which many—if not most—believe that humanness is at least a necessary condition).

In the debate about the ethics of crossing species boundaries the pivotal question is: Do we shore up or challenge our current social and moral categories? Moreover, do we entertain or preclude the possibility that humanness is not a necessary condition for being granted full moral rights? How we resolve these questions will be important not only in determining the moral status and social identity of those beings with whom we currently coexist (about whom there is still confusion and debate), but also for those beings we are on the cusp of creating. Given the social significance of the transgression we contemplate embracing, it behooves us to do this conceptual work now, not when the issue is even more complex—that is, once novel part-human beings walk among us.

Conclusion

To this point we have not argued that the creation of interspecies hybrids or chimeras from human materials should be forbidden or embraced. We have taken no stance at all on this particular issue. Rather, we have sketched the complexity and indeterminacy of the moral and scientific terrain, and we have highlighted the fact that despite scientists' and philosophers' inability to precisely define *species,* and thereby to demarcate species identities and boundaries, the putative fixity of putative species boundaries remains firmly lodged in popular consciousness and informs the view that there is an obligation to protect and preserve the integrity of human beings and *the* human genome. We have also shown that the arguments against crossing species boundaries and creating novel part-human beings (including interspecies hybrids or chimeras from human materials), though many and varied, are largely unsatisfactory. Our own hypothesis is that the issue at the heart of the matter is the threat of inexorable moral confusion.

With all this said and done, in closing we offer the following more general critique of the debate about transgressing species boundaries in creating part-human beings. The argument, insofar as there is one, runs something like this: species identities are fixed, not fluid; but just in case, prohibiting the transgression of species boundaries is a scientific, political, and moral imperative. The scientific imperative is prudential, in recognition of the inability to anticipate the possibly dire consequences for

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[19] This objection was raised for us by Vaughan Black.

the species *Homo sapiens* of building these novel beings. The political imperative is also prudential, but here the concern is to preserve and protect valued social institutions that presume pragmatically clear boundaries between human and nonhuman animals. The moral imperative stems from a prior obligation to better delineate moral commitments to both human beings and animals before undertaking the creation of new creatures for whom there is no apparent a priori moral status.

As we have attempted to show, this argument against transgressing species boundaries is flawed. The first premise is not categorically true—there is every reason to doubt the view that species identity is fixed. Further, the scientific, political, and moral objections sketched above require substantial elaboration. In our view the most plausible objection to the creation of novel interspecies creatures rests on the notion of moral confusion—about which considerably more remains to be said. ■

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