

Xilogravura do livro *Les songes drolatiques de Pantagruel* (1565), de autoria presumida de François Desprez. Obra em domínio público. Composição visual remixada.

DOSSIÊ ESPECIAL

PUTTING ANIMAL PARTS INTO HUMANS: A POLITICAL ANALYSIS

PONER PARTES ANIMALES EN HUMANOS: UN ANÁLISIS POLÍTICO

COLOCANDO PARTES DE ANIMAIS EM HUMANOS: UMA ANÁLISE POLÍTICA

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Submetido em: 12/08/2025
Aceito em: 15/09/2025
Publicado em: 17/11/2025

Como citar: KÖGEL, Johannes . Putting animal parts into humans: a political analysis. *(Des)troços: revista de pensamento radical*, Belo Horizonte, v. 6, n. 2, p. e61076, jul./dez. 2025.

DOI: 10.53981/destrocos.v6i2.61076

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Abstract
The roles of animals—particularly pigs and nonhuman primates—in xenotransplantation reveal complex ethical and symbolic dynamics. Nonhuman primates, due to their cognitive proximity to humans, were increasingly positioned as recipients rather than organ sources, reflecting an ethical "hierarchical upgrade." Pigs, genetically engineered to provide organs, embody an ambiguous status: highly alienated through biotechnological manipulation and sterile confinement, as "biocapital" commodified and embedded in market logics. Their "humanization", besides a change of their genetic-make, also features as standing in for humans, even though in a different role than their primate counterparts. The ethical connotation of this may benefit those animals in the long run. Recognizing animal alterity—not merely as biological bodies but as intentional subjects—as, for example, suggested by Amerindian metaphysics, reshapes the understanding of identity and medical practice amid molecular and semiotic conceptions of life. These considerations call for nuanced reflection on the boundaries between nature, culture, and species in contemporary biomedicine.

Keywords
Biopolitics; xenotransplantation; animals; humanization.

Resumen
Los roles de los animales—en particular, los cerdos y los primates no humanos—en la xenotrasplantación revelan dinámicas éticas y simbólicas complejas. Los primates no humanos, debido a su proximidad cognitiva con los seres humanos, fueron progresivamente situados como receptores y no como fuentes de órganos, reflejando una "mejora jerárquica" ética. Los cerdos, modificados genéticamente para proveer órganos, encarnan un estatus ambiguo: altamente alienados mediante la manipulación biotecnológica y el confinamiento estéril, como "biocapital" mercantilizado e insertado en lógicas de mercado. Su "humanización", más allá de una alteración genética, también implica ocupar el lugar de los humanos, aunque en un rol diferente al de sus contrapartes primates. La connotación ética de esto puede beneficiar a esos animales a largo plazo. Reconocer la alteridad animal—no simplemente como cuerpos biológicos, sino como sujetos intencionales—como, por ejemplo, lo sugiere la metafísica amerindia, reformula la comprensión de la identidad y de la práctica médica en medio de concepciones moleculares y semióticas de la vida. Estas consideraciones exigen una reflexión matizada sobre los límites entre naturaleza, cultura y especie en la biomedicina contemporánea.

Palavras clave
Biopolítica; xenotrasplante; animales; humanización.

Resumo
Os papéis dos animais—particularmente porcos e primatas não humanos—na xenotransplantação revelam dinâmicas éticas e simbólicas complexas. Os primatas não humanos, devido à sua proximidade cognitiva com os seres humanos, passaram progressivamente a ser posicionados como receptores e não como fontes de órgãos, refletindo um "upgrade hierárquico" ético. Os porcos, geneticamente modificados para fornecer órgãos, encarnam um status ambíguo: altamente alienados pela manipulação biotecnológica e pelo confinamento estéril, como "biocapital" mercantilizado e inserido em lógicas de mercado. A sua "humanização", além de uma alteração genética, também implica ocupar o lugar de humanos, embora em um papel diferente do desempenhado pelos primatas. A conotação ética disso pode beneficiar esses animais a longo prazo. Reconhecer a alteridade animal—não apenas como corpos biológicos, mas como sujeitos intencionais—como, por exemplo, sugerido pela metafísica ameríndia, reformula a compreensão da identidade e da prática médica em meio a concepções moleculares e semióticas da vida. Essas considerações demandam uma reflexão mais nuançada sobre as fronteiras entre natureza, cultura e espécie na biomedicina contemporânea.

Palavras-chave
Biopolítica; xenotransplante; animais; humanização.

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Introduction

"[A]n Indian", the legend has it, "found the secret for eternal life, but the price he paid was that he was transformed into a large grotesque and putrid smelling beast, with a craving for eating people. This giant creature stands 4-6 meters in height, is covered in coarse black hair with white patches and [...] has either a second large mouth on his chest or stomach, or has three mouths, with two being under each armpit".[1] This character from Amerindian and Amazonian mythology is called the Mapinguari, sometimes referred to today as the "Brazilian Bigfoot." It remains contested whether the Mapinguari—thought by some to be an incarnation of a giant, presumably prehistoric sloth—might correspond to a real animal.[2] As that may be, the moral of the story is not to tinker with natural boundaries, whether those limits concern one's lifetime or one's body.

At the same time, Amerindian cultures have long known ways of acquiring animal powers, in what we might now call "self-enhancement." A prime example is the jaguar, revered for its strength and associated with divinity. Yet, Amerindian mythology also includes cautionary tales of humans transformed into half-man, half-animal beings considered malevolent—such as the Yaguareté-abá.[3] Various traditions involve incorporating animals, whether through wearing animal forms or attire, or through ritual metamorphoses. These practices accompany notions of "becoming-jaguar"[4] or "becoming-puma", understood as a "kind of maturity of self" and a "form of worldly empowerment".[5]

In the following paper, I will discuss a different kind of human–animal mixing as it has emerged in the Western world through experimental transplantation medicine. On a molecular level, genetically modified animals—specifically pigs "humanized" through genetic engineering—serve as organ sources transplanted into human patients, creating human–animal chimeras. To date, there have been transplantations of hearts, livers, and kidneys; in one case, a patient lived with such a kidney for 130 days before it had to be removed.[6] Until systematic studies are conducted, it remains uncertain how such patients are perceived and how they perceive themselves—whether with awe, bewilderment, empowerment, estrangement, or some combination thereof. Here, however, I will not speculate on the subjective experience of transplantation patients, but will instead focus on the animals—namely pigs and simians—involved in this process.

I will begin by explaining why the discussion of these animals has a political dimension, before outlining the technoscientific imaginary of xenotransplantation and its historical trajectory in selecting the source animal. Examining the role of animals in xenotransplantation research—where they stand in for humans—reveals a task imbued with ethical implications and fragile boundaries. Pigs in particular will be assessed in their dual role as humanized entities, as commodified "biocapital" and honourable "donors". Standing on the verge of clinical trials, I will speculate on

[1] Charters, *The importance of storytelling in shaping attitudes towards jaguars*, p. 49.
[2] Dario, *Fantastic entities of the Amazonian indigenous culture*.
[3] Vidal de Battini, *Cuentos y leyendas populares de la Argentina*, p. 517.
[4] Viveiros de Castro, *Cannibal metaphysics*.
[5] Kohn, *How forests think*, pp. 201-202.
[6] Mou; Pu; Cooper, *Clinical xenotransplantation of gene-edited pig organs*.

what the future may hold for pigs used as source animals in such transplantations. In conclusion, I will draw out insights from Amerindian metaphysics, as touched on above.

1. Animals in politics

Why is this a political analysis? The political addresses the question of how we want to live together. This includes not only our relations with other humans, but also our relations with other animals, living beings, and nature as a whole. Within this, the biopolitical refers to the sphere concerned with the regulation and governance of individuals—not only as legal subjects, but, crucially, as living beings. Its object is life in aggregate form: the population.[7]

The fostering of life often manifests in the suppression or elimination of lifeforms deemed detrimental to it. For Michel Foucault, racism emerged as such a form of exclusion, in which certain population groups were fought against for the supposed vital well-being of others.[8] Another significant dividing line is that between humans and nonhuman animals—a line which, as we will see, is increasingly subject to contestation and change. Cary Wolfe has argued that this human–animal distinction functions more as a "discursive resource" than an objective reality.[9] Yet, in the cases we will examine, we see the merging of genetic material across species in strictly biological terms. Dinesh Wadiwel, moreover, regards animal domestication as the paradigmatic form of biopolitical governance.[10]

With the rise of novel biotechnologies—capable of determining, at the biological level, which life forms are brought into existence—biopolitics has increasingly focused on the production and management of malleable life. In this context, genetically engineered animals, such as pigs bred for xenotransplantation, become high-value commodities. They reveal the deep entanglement between the life sciences and the economy, and the way this nexus shapes fields of social inequality on a global scale.

Animals have been identified as biopolitical subjects[11] or even as their archetypal form.[12] Matthew Chrulew, for example, outlines the parallels between the governance of human populations and that of zoo animals:

> Having once been objectified as merely "bare life", anonymous and replaceable bodies subjected to violence and neglect, animals in zoological gardens progressively became subjectified as the scientifically known and individually nurtured subjects of biopolitical care. They came to be governed as subjects of their own experience, with modes of perception distinctive to their species and individual life history; to be governed as subjects who act, who perform distinctive behaviours that could be evaluated in detail by their keepers and thus modified and optimised towards various goals (reproduction, natural expression, health and vitality).[13]

[7] Foucault, *Society must be defended*.
[8] Foucault, *Society must be defended*.
[9] Wolfe, *Before the Law*.
[10] Wadiwel, *The war against animals*.
[11] Chrulew, *Animals as biopolitical subjects*.
[12] Wolfe, *Before the Law*.
[13] Chrulew, *Animals as biopolitical subjects*, pp. 229-230.

In xenotransplantation, however, we encounter a bio/thanatopolitics nexus,[14] in which the life and survival of the human is predicated on the death of the animal. The welfare of the animals used in laboratory experiments—so far as it is maintained at all—is generally preserved for purely instrumental purposes, i.e., there is no nurturing directed toward the animals "as subjects of their own experience," but only insofar as it serves experimental ends. Consequently, Robert Kirk is right to characterise the history of laboratory animals as one in which they are objects, not subjects, of biopolitics. As such, it is "sought not only to make them live but to make them live biologically productive lives".[15] This continues, of course, only until their purpose has been served, they fall ill, or their suffering becomes intolerable. If there is truth in Bruno Latour's claim that "it is inside the laboratories where the future reservoirs of political power are in the making,"[16] then we can trace its consequences in industrial livestock farming or in mass euthanasia events, such as those triggered by epidemics or by overpopulation in zoos and similar facilities.

Finally, taking up the challenge posed by Felice Cimatti and Carlo Salzani in their anthology—to move beyond a biopolitics enacted at the expense of nonhuman animals[17]—I will close this paper's discussion with a speculative, yet in my view realistic, future scenario that could benefit animals over the medium to long term in the years ahead.

2. Xenotransplantation's imaginary

Xenotransplantation refers to the transplantation of cells, tissues, or organs between members of different species. Current research focuses on using grafts from pigs for transplantation into humans. The "sociotechnical imaginary"[18] of xenotransplantation envisions a world without organ shortages: for every patient in need of a replacement organ—kidney, heart, liver, lung, or, in principle, any body part—a suitable transplant would be available. Since the supply of human donor organs is limited, animals, particularly pigs, are used as organ sources. Biological science has developed ways, through biotechnologies such as cloning and genetic engineering, to produce pigs whose organs are fit and safe for human use. Biotechnological companies operate specialized sterile and hygienic facilities in which large populations of transgenic pigs are kept. Medical science, for its part, has refined methods to preserve organs during transport and transplantation, and to maintain them in recipients through appropriate immunosuppression regimes.

This imaginary is already approaching realization, and research is extending its horizon toward the next step: exogenesis.[19] In laboratory settings, this involves producing human–pig chimeras by knocking out animal genes responsible for the development of specific organs and inserting human stem cells that grow into human organs within the animal host. In this way, not only can human organs be grown inside animals, but—if the human stem cells are taken from the eventual

[14] Carr, *Species of contagion*.
[15] Kirk, *The birth of the laboratory animal*, p. 202.
[16] Latour, *Give me a laboratory and I will raise the world*, p. 157.
[17] Cimatti; Salzani, *The biopolitical animal*.
[18] Jasanoff; Kim, *Containing the Atom*.
[19] Wolf *et al.*, *Designer pigs for xenogeneic heart transplantation and beyond*.

transplant recipient—the resulting organ carries the person's DNA, potentially eliminating the need for immunosuppression altogether. This would take personalized transplantation medicine to a radically new level. One could imagine a future in which every newborn—at least, every one whose family can afford it—would be accompanied by a personalized pig host containing organs and body parts genetically matched to that individual, ready for use if needed. Moreover, the very notion of "need" is expanding beyond cases of organ failure or degeneration toward the idea of pre-emptive replacement before deterioration occurs.[20]

3. Finding the right animal

The history of xenotransplantation is, for the most part, the story of two groups of nonhuman animals: nonhuman primates—in the form of apes and monkeys—and pigs. While in earlier centuries humans experimented with organs, tissues, cells, and blood from a wide range of species, including sheep, goats, pigs, calves, dogs, and rabbits, the second half of the 20th century concentrated on nonhuman primates, especially chimpanzees and baboons.[21] In the 21st century, however, pigs have become the exclusive source of xenogeneic material. Because of their physiological similarity to humans, nonhuman primates were long regarded as the ideal "donor," enabling so-called concordant xenotransplantation (in contrast to discordant xenotransplantation, as in the case of pigs). Various developments—rooted in strategic and practical considerations, shifting bioethical discourses, and safety concerns—eventually drove a transition away from primates and toward pigs as the preferred source animal.

Nik Brown examines the discourses surrounding this transition.[22] In natural-scientific contexts, the similarities between pigs and humans were increasingly emphasized, while the relationship between humans and nonhuman primates was reframed in terms of difference. In cultural and ethical discourse, the inverse logic prevailed: the similarities between humans and nonhuman primates, and the differences from pigs, were highlighted.

Peta Cook maps the ordering of species—humans, nonhuman primates, pigs—along physiological, phylogenetic, and ethical lines, showing how this hierarchy shaped their respective roles in the xenotransplantation complex: pigs as source animals, nonhuman primates as stand-in models for humans, and humans as the eventual recipients or beneficiaries.[23]

Kristofer Hansson points out a parallel development in which nonhuman primates are humanized in ethical terms, while pigs are dehumanized — that is, assigned a lower moral value that permits their deliberate use and alteration, paradoxically through their biological humanization.[24] This also achieved the goal of elevating pigs from their otherwise low status, making them worthy donors of organs for human use.[25]

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[20] Kögel *et al.*, *Engineering organs, hopes and hybridity*.
[21] Deschamps *et al.*, *History of xenotransplantation*.
[22] Brown, *Xenotransplantation*.
[23] Cook, *Science Stories*.
[24] Hansson, *The reconfigured body*.
[25] Cook, *Science Stories*.

Ray Carr identifies a predominance of utilitarian liberalism—rooted in Peter Singer's influential arguments about the basis of personhood[26]—in key ethical assessments of xenotransplantation during the 1990s, such as the Nuffield Council on Bioethics report and the so-called Kennedy Report, issued by an advisory group on the ethics of xenotransplantation and adopted into UK legislation in 1997.[27] Campaigns like The Great Ape Project, supported by primatological research and ethical reasoning,[28] stressed the humanness of primates, particularly apes, and advocated for their inclusion among the holders of basic rights—an entitlement previously reserved for humans. This elevation of primates on the ladder of animal hierarchy, however, came at the expense of pigs, who were increasingly positioned as providers of transplantable body parts. Yet, through what Roberto Esposito terms the "dispositive of the person"[29]—a regime of knowledge and power that disciplines and exposes excluded beings to violence—primates, particularly baboons and macaques, continue to be used in xenotransplantation research as human stand-ins in pig-to-primate transplantation experiments.

Both the Nuffield and Kennedy reports concluded that nonhuman primates should not be used as source animals because the harm caused to them was deemed unethical. Pigs, on the other hand, were declared suitable as sources. Nonhuman primates could be used as experimental recipients, provided their numbers were minimized. The Kennedy Report's reasoning effectively permits the killing of many pigs to benefit a single human, while prohibiting the death of a nonhuman primate for the benefit of only one person—unless more than one human stands to benefit. Hence, nonhuman primates were ruled out as source animals but allowed to serve in preclinical trials as recipients, where their role might benefit multiple humans.[30]

The fluidity of such reasoning is evident in the rationale offered in a position paper of the International Xenotransplantation Association (IXA):

> Non-human primates such as baboons have complex social behaviors, and there are many ethical concerns about their use, including the fact that those closest in size to humans are protected species. In addition to these ethical issues, financial and practical problems, relating to the breeding of large numbers of these animals in captivity for use as organ-source animals, and increased safety concerns about viral transmission, which is more likely to occur between closely related species, essentially rule out non-human primates as useable organ sources.[31]

Where primates were once considered a perfect fit—due to their evolutionary proximity to humans, which minimizes immunological barriers—they have now, not least because of the ability to genetically modify immunological mechanisms, come to be regarded as potentially dangerous source animals, owing to the heightened

[26] Singer, *Practical ethics*.
[27] Carr, *Species of contagion*; Nuffield Council on Bioethics report, *Animal-to-human Transplants*; Department of Health (UK), *Animal tissue into humans*.
[28] E.g., Cavalieri; Singer, *The Great Ape Project*.
[29] Esposito, *The third person*.
[30] Department of Health (UK), *Animal Tissue into Humans*, p. xi.
[31] Sykes; D'Apice; Sandrin, *Position Paper of the Ethics Committee of the International Xenotransplantation Association*, p. 199.

risk of transmitting infectious diseases.[32] Additional reasons cited for the shift include familiarity with pig anatomy and domestication, pigs' rapid growth and reproduction rates, their relative ease of genetic manipulation, the regulatory flexibility surrounding their use, and their long-established status as a human commodity, which results in less public concern over their application in medical research.

Thus, physiological, medico-technical, practical, and ethical considerations converged to make the transition from primates to pigs as source animals appear the obvious choice.

4. Fragile boundaries

Research on pigs has shown that they possess evolved capacities for memory, intelligence, sociality, emotional complexity, and self-awareness[33]—abilities often cited in arguments for elevating primates' moral status and for making personhood claims on their behalf. This undermines any clear-cut boundary arguments between the two species. Even more: it poses a dilemma, since by the same ethical reasoning the use of pigs must appear just as unacceptable as the use of nonhuman primates.

Public campaigning for animal rights and against animal use has often been most effective when the pain and suffering of primates are made visible. Notable examples include the termination of xenotransplantation research in the UK following the publication of an undercover report by the animal rights group Uncaged Campaigns, entitled "Diaries of Despair", which detailed welfare issues involving laboratory animals.[34] The biotechnology company involved, Imutran, was dissolved by its parent firm, Novartis. In other cases, such as the 2020 release of footage and reports by the People for the Ethical Treatment of Animals (PETA) documenting suffering monkeys in the xenotransplantation laboratory at the University of Alabama,[35] there was no significant uptake by popular media and no resulting public mobilization.

In contrast, because pigs are widely consumed as part of many people's diets, their mental and cognitive abilities are often ignored or downplayed to avoid the cognitive dissonance that arises from caring about animals while continuing to eat meat. This phenomenon, known as the "meat paradox", is also discussed under the term "meat-related cognitive dissonance" (MRCD).[36] As a result, there is little public resistance to the idea of using pigs as organ providers for transplantation purposes, and consequently, little hesitation in publicly communicating this practice.

However, the crucial role of nonhuman primates as stand-in models for humans in xenotransplantation is largely absent from public outreach, as well as from public or stakeholder surveys. Lesley Sharp examines the narratives of

[32] Sharp, *Monkey Business*.

[33] Watson, *The whole hog*; Gieling; Nordquist; Van Der Staay, *Assessing learning and memory in pigs*; Marino; Colvin, *Thinking pigs*.

[34] E.g., Sharp, *The transplant imaginary*.

[35] See: Brown, *UAB Experimenters Perform Unauthorized Surgeries, Falsify Records*.

[36] Loughnan; Haslam; Bastian, The *role of meat consumption in the denial of moral status and mind to meat animals*; Bastian *et al.*, *Don't mind meat?*; Benningstad; Kunst, D*issociating meat from its animal origins*; Rothgerber, *Meat-related cognitive dissonance*.

xenotransplantation within the research community, noting their tendency to sideline the near past and near future in favour of framing the field in terms of a distant past and an aspirational long-term future.[37] In this narrative, primates appear as once-used sources in the historical achievements of transplantation pioneers, while visions of the future imagine human patients saved by animal organs—with pigs fulfilling the role where primates once failed.

Nevertheless, there are strong voices within the xenotransplantation research community that question the scientific sustainability of experiments involving nonhuman primates. This skepticism is not necessarily rooted in ethics but in data: nonhuman primates respond to pig antibodies in ways that humans do not, an immune response due to a "fourth xenoantigen".[38] For this reason, continued pig-to-primate transplantation experiments are partly seen as having reached their scientific limits.

5. Humanization as dehumanization?

What it means to be human—i.e., humanness—can be identified along two dimensions.[39] Under the notion of human uniqueness, emphasis is placed on characteristics acquired through socialization, such as civility, cognition, and refined emotions. These traits are used to distinguish humans from animals. Human nature, in contrast, is invoked to differentiate us from machines such as robots and is characterized by qualities like vitality, warmth, and emotions—traits understood as being inherent to our species. Consequently, two forms of dehumanization can be distinguished: animalization and objectification. The former calls into question a person's intelligence, rationality, and morality; the latter denies humanity in terms of emotionality, vitality, individuality, and autonomy. These forms are not mutually exclusive and can apply to the same person or group simultaneously.

What, then, we may ask, is the treatment that animals receive when targeted by humans? Ironically, in the case I focus on in this paper—xenotransplantation—the animals involved, namely simians and pigs, are subject to two mechanisms or dimensions: objectification and humanization. As laboratory animals, these beings are treated merely as bodies on which experimental studies are performed, serving as instruments for the potential or actual benefit of humans, who are the ultimate recipients of whatever product, treatment, or therapy proves effective. More broadly, they contribute to basic research that advances scientific knowledge and technological progress.

Pigs, as genetically engineered transgenic beings bred to provide organs for human patients, have become highly valuable commodities, their worth measurable in monetary terms. These pigs are "humanized" in a literal, biological sense through the insertion of human genes into their genetic makeup—but their humanization may be more complex than this.

Within bioethical discourse, the recognition of nonhuman primates' proximity to human capabilities has led to an ethical consensus excluding them as source

[37] Sharp, *Monkey business.*
[38] Cooper, *Advancing xenotransplantation to the clinic.*
[39] Haslam; Loughnan; Holland, *The psychology of humanness.*

animals for xenotransplantation. Apes, in particular, have been removed from such research entirely, not least because of their endangered status. Monkeys such as baboons and macaques are still used, but no longer as source animals; instead, they serve in a more advanced role as proxies for human transplant recipients.

As xenotransplantation approaches clinical trials[40], an open question remains regarding the status pigs will hold once they are firmly established as stand-ins for humans on the donor side of transplantation, effectively substituting for humans as "providers" of life-saving organs.

6. Ambiguity of pig trajectories

Pigs, therefore, occupy an ambiguous role in xenotransplantation. On the one hand, they are objectified and instrumentalized much as in meat production. However, instead of yielding body parts destined to become meat products (ham, bacon, shoulder, etc.), they provide biotechnologically advanced, genetically modified organs as manufactured products. These animals are not used for pleasure (meat, milk, eggs) or entertainment (zoos, circuses, horse racing, cockfighting, etc.). In fact, they are largely hidden from public view and are not intended to come into contact with humans—except for veterinary staff in protective suits—until after death, when their organs are transplanted into human bodies.

To be fair, they serve a far more honourable cause: saving lives. It is also difficult to argue that their husbandry is worse than that of industrially farmed pigs. Admittedly, neither practice meets the standards of species-appropriate care. In xenotransplantation, pigs are kept in sterile environments and often in partial isolation; given their high financial value, their health is meticulously monitored. By contrast, in industrial farming, pigs are kept in overcrowded, noisy, and cramped conditions, often with steel grid floors, minimal space to move, and little attention paid to individual health needs.

On the other hand, the pig takes on the role of a human surrogate, potentially even receiving a moral "upgrade" in the hierarchy of living beings. They replace human organs in two senses: animal parts are transplanted into humans in place of the individual's original organs, and they substitute for human organ donations (allotransplants) by filling the shortage left by the scarcity of human donors. Efforts to replace experiments on nonhuman primates with experiments on deceased persons (those declared brain-dead) have so far been unsuccessful, partly due to ethical objections to using brain-dead individuals for research. From a medicotechnical standpoint, such a replacement would present specific challenges. From an animal ethics perspective, however, substituting experiments on nonhuman primates is imperative—not least to uphold, even if only symbolically, the ethical significance attributed to these primates, as described above.

[40] First human clinical trials on kidney xenotransplantation received approval in the United States See: Mallapaty; Kozlov, *The science behind the first pig-organ transplant trial in humans.*

6.1 Commodification via alienation

Estimates of the costs or monetary value of genetically engineered pigs for xenotransplantation are not publicly available. However, the cost of xenografts is assumed to be significantly higher than that of allotransplant procurement.[41] Some genetically engineered pig producers have suggested market values of around USD 1 million per pig kidney.[42] The global xenotransplantation market was valued at approximately USD 13 million in 2021 and is projected to rise to USD 25 million by 2029.[43] As products and commodities, engineered pigs form part of "biocapital".[44] Kaushik Sunder Rajan introduced the term to highlight that the life sciences are not solely about producing knowledge; they are deeply intertwined with market logics, where biological entities—such as genes, cells, and bodies—become forms of capital through processes like patenting, commodification, and commercialization.[45] He examines the entanglement of bioscience and contemporary capitalism, which he terms "technoscientific capitalism". Like any other form of capital, biocapital creates financial winners and losers in the "bioeconomy".[46] In this sense, xenotransplantation also risks exacerbating issues of social justice and inequality.[47]

Given the time, effort, and financial resources invested in xeno-pigs, they have become formidable monetary assets—commodities that generate both hope[48] and hype[49]—and that are essential to sustaining a venture-capital-driven industry.

Like pigs in the meat industry, we rarely, if ever, encounter these animals directly. Instead, we encounter their products: either packaged meat—portioned, weighed, and wrapped in plastic—or manufactured organs and other body parts of transgenic origin. In both cases, alienation characterizes the human–pig relationship. The intended effect is to avoid associating the product with a living being, and thus with the death for which one might bear moral accountability. In xenotransplantation, this alienation may also pre-empt questions about the recipient's sense of identity or self-perception.

6.2 The stand-in human

The ethical elevation of nonhuman primates—manifested in their humanization or personification, depending on the underlying ethical rationale—is reflected in xenotransplantation by their reassignment from organ source to organ recipient (in pre-clinical studies), with pigs now taking on the donor role. While nonhuman primates still participate in the experimental stage of xenotransplantation, their role represents an "upgrade," so to speak, within the hierarchy of species involved in this research. Owing to their human-likeness, they

[41] Vasudev; Cooper, *How much will a pig organ transplant cost?*
[42] E.g.: Agence France-Presse, *A US farm breeds pigs for human kidney transplants*.
[43] Data Bridge Market Research, *Unlocking the Future of Medicine*.
[44] Sharp, *The transplant imaginary*; Carr, *Species of contagion*.
[45] Sunder Rajan, *Biocapital*.
[46] OECD, *The bioeconomy to 2030*.
[47] Sparrow, *Xenotransplantation, consent and international justice*.
[48] Brown, *Xenotransplantation*; Kögel *et al.*, *Engineering organs, hopes and hybridity*.
[49] Carr, *Species of contagion*, applying Sunder Rajan's conceptual framework to xenotransplantation.

can serve as stand-ins for human recipients.[50] They receive organs in place of humans—a position that humans themselves have only recently begun to reclaim. With this "privileged" role in the xenotransplantation research process, it becomes clearer why the use of nonhuman primates can still be regarded as ethically permissible, even after they have been declared beings of sufficient moral worth not to be used as source animals. Their ethical approximation to humans reduces the alienation felt toward them, sparing them from the instrumentalized role of organ source and granting them the questionable honour of serving as recipients in pig-to-nonhuman-primate transplantation experiments. Ultimately, however, this shift has led to a reduced demand for and use of nonhuman primates in xenotransplantation research.

For pigs, one can diagnose an increase in alienation. In addition to being hidden from public view—housed in specific-pathogen-free facilities that are just as inaccessible as industrial pig farms—they are also further alienated from their unmodified conspecifics. While indistinguishable to the eye, the transgenic pig possesses a different genetic makeup.[51] Typically, these animals undergo "triple knockout" modifications—loss-of-function mutations eliminating the pig-specific antigens αGal, Neu5Gc, and Sda—to prevent rejection of the transplanted organ in humans. Additional knockouts may target porcine endogenous retroviruses (PERVs) or limit organ growth to achieve a better permanent size fit. Human genes are also inserted to enhance compatibility, for instance, by preventing immune attack through complement regulatory proteins and by regulating blood coagulation and inflammation. The genetically modified pigs (GM pigs) used in experimental "compassionate use" or "expanded access"[52] procedures in the United States—produced by two biotechnology companies—had 10 and 69 genetic edits, respectively, with the latter figure including 59 additional edits to eliminate all detectable PERV elements from that pig line's genome.[53]

Once xenotransplantation reaches the clinical stage, the pig in pig-to-human transplantation serves as a human stand-in—but on the opposite side of the donor–recipient equation, taking the donor position that humans occupy in allotransplantation. In this role, pigs become "noble," albeit involuntary, donors of the "gift of life" to humans. Symbolically, they are elevated into the human realm, serving as twofold stand-ins: for humans as donors, and for human body parts as such—albeit only post-mortem. By "sacrificing" their lives, they live on in another form, as functioning organs in human bodies and as givers of second chances at life.

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[50] As Sharp, *The transplant imaginary*, argues, laboratory animals always stand in for humans insofar as they are expected to approximate or simulate human conditions. In other words, drugs or treatments that prove effective in laboratory animals are ideally taken to indicate effectiveness when applied to humans with the same conditions or diseases. Here, I restrict the notion of animals standing in for humans to whole-bodied individuals, including their assumed human or personified role (and the moral value attached to it) as either "donor" or "recipient" of a transplant. In this framework, the established clinical standard of allotransplantation—humans donating grafts to other humans—serves as the "original" case, with both roles substituted by different animal species in xenotransplantation.

[51] Lei *et al.*, *Genetic engineering of pigs for xenotransplantation to overcome immune rejection and physiological incompatibilities*; Ali *et al.*, *What genetic modifications of source pigs are essential and sufficient for cell, tissue, and organ xenotransplantation?*

[52] "Expanded access" is the terminology used by the Food and Drug Administration (FDA) of the United States that is responsible for the allowance for medical treatments such as xenotransplantation.

[53] Peterson *et al.*, *Physiological basis for xenotransplantation from genetically modified pigs to humans*.

This choice of words is not meant to be cynical; I am well aware that pigs themselves are indifferent to whatever noble reasoning may be invoked to justify their deaths. Yet, in the symbolic realm, shifts in the ordering of meanings can have consequences for the treatment of animals in the future.

Unlike meat, which is consumed, digested, and excreted, transplanted animal organs are integrated as permanently living parts of the human recipient's body—responsible for keeping the organism alive as a whole. As such, these organs carry a different connotation, and pigs themselves acquire a new significance compared to their counterparts bred for chops or ribs.

So far, there have been no systematic reports on xenotransplant recipients' views of their incorporated xenografts and the animals from which they came. However, studies with xeno-islet recipients reveal various strategies for negotiating the origin of the transplanted material: normalization (accepting animal use as natural for humans) or avoidance (downplaying or ignoring the animal origin due to discomfort), sometimes driven by negative stereotypes about pigs or feelings of guilt.[54] Thus, acknowledging that an animal had to die so that one might live—and that its organ remains inside one's body—may lead recipients to downplay the pig's moral value as a way to manage guilt or deflect criticism.

Another possible strategy, however, is to extend credit not only to the medical staff and the technological innovation involved but also to the animal itself, recognizing its role as the bearer of life-saving organs. This could contribute to elevating pigs' perceived moral status, balancing concerns about self-esteem (the idea that incorporating parts from a cognitively advanced and intelligent being might sit better with one's identity than parts from a lower-ranked animal) and countering stereotypes that portray pigs as dirty, greedy, lazy, or unintelligent.

7. A speculative scenario

According to the Food and Agriculture Organization of the United Nations (FAO), global meat production reached 361 million tonnes in 2022—an increase of 55% compared to the year 2000.[55] While meat consumption has stagnated in some high-income countries, global per capita meat consumption is projected to rise by 0.9 kg per year.[56] High-income countries still consume several times more meat than other nations; despite accounting for only 17% of the world's population, they are responsible for 35% of global meat consumption.[57]

As Julian Koplin convincingly argues, analogies in bioethics—such as the claim that using pigs for transplantation is less bad than using them for meat production, and therefore must be ethically permissible—should not be accepted at face value. Instead, they warrant critical re-examination of the underlying practices.[58] Yet, current trends in animal use and meat production show no signs of reversing. In this light, the greatest future challenge to xenotransplantation's public reputation may emerge from the rise of cultivated (in vitro) meat.

[54] Lundin, *The boundless body*; Lundin, *Creating identity with biotechnology*.
[55] FAO, *World Food and Agriculture*.
[56] OECD/FAO, *OECD-FAO Agricultural Outlook 2025-2034*.
[57] OECD/FAO, *OECD-FAO Agricultural Outlook 2025-2034*.
[58] Koplin, *'It's Not Worse than Eating Them'*.

The emerging field of meat cultivated from animal cells—grown in living systems or bioreactors—has moved well beyond the proof-of-concept burger to structured, whole-cut products. For now, scalability and economic viability remain significant hurdles.[59] However, once cultivated meat achieves price parity with meat from slaughtered animals, one may expect the market for the latter to contract sharply. Choosing animal-derived meat in the presence of equally affordable, animal-harm-free alternatives would signal moral bankruptcy—whether in one's own eyes or in the perception of others. As the conventional meat market declines, xenotransplantation could attract increased scrutiny as one of the last major industries reliant on killing animals, drawing attention from animal rights and welfare organizations as well as from a public that, until now, has largely ignored it—an indifference that has helped facilitate its relatively smooth development. If xenotransplantation becomes a standard clinical practice by that time, pigs could benefit from their enhanced image as ethically elevated stand-ins for human life-savers.

One question for the future, however, extends beyond the animals themselves: how will the human recipients be (de)coded? Haslam et al. identify modern medicine as an example of the objectifying form of dehumanization, in which patients are treated as "mindless bodies" receiving standardized interventions, with little regard for autonomy or individuality.[60] In xenotransplantation, matching bodies and body parts occurs at a molecular level: porcine genes are knocked out or modified, human genes inserted, drugs and immunosuppressants administered, and human recipients selected based in part on their individual sensitivity to human and pig antibodies. As Thomas Lemke observes:

> If as a consequence of bioscientific innovations the living body is regarded today less as an organic substratum than as molecular software that can be read and rewritten, then the question as to the foundations, means, and ends of biopolitics needs to be posed in a different manner.[61]

8. Conclusion

The sentiment that one should not tinker with natural boundaries has also been raised in opposition to xenotransplantation. Yet, tinkering with such boundaries can be seen as the quintessential feature of modern science and medicine. Moreover, the very premise of these objections—a clear-cut division between nature and culture—has been eroded for some time. This is a central insight of the field now known as Science and Technology Studies,[62] though it also can draw on much older metaphysical traditions.

Contributing to the "ontological turn" in anthropology, Philippe Descola and Eduardo Viveiros de Castro develop their thinking from their work on Amerindian perspectives, as does Eduardo Kohn, who, however, prioritizes the semiotic over the ontological, proposing a "semiotic ecology" in which humans, animals, plants,

[59] Hauser *et al.*, *Challenges and opportunities in cell expansion for cultivated meat*.
[60] Haslam; Loughnan; Holland, *The psychology of humanness*.
[61] Lemke, *Biopolitics*.
[62] E.g.: Latour, *We have never been modern*; Haraway, *A manifesto for cyborgs*; Haraway, *When species meet*.

and spirits are all enmeshed in a shared web of signs.[63] Descola describes a "society of nature" in which animals, plants, and even landscape features are treated as intentional subjects.[64] Similarly, Viveiros de Castro emphasizes that Amazonian peoples conceive of animals, plants, and spirits as persons, thereby defying modern distinctions between nature and culture, animal and human.[65] In this perspective, all Amazonian subjects—equipped with a soul or intentionality—see themselves as persons, indeed as "human." It is always the *other* who is regarded as nonhuman. As he writes: "The common condition of humans and animals is not animality but humanity."[66] What separates species is not the possession of culture (as modern Western thought assumes), but differences in bodies. Culture, in Amazonian thought, is what unites beings; nature is what separates them. To understand others means to take their perspective. Cannibalism—the incorporation of another's body parts—in this view, is not merely an act of consumption, but the assimilation of "the signs of his alterity, the aim being to reach his alterity as point of view on the Self."[67] In Amazonia, as Carlos Fausto argues, prey needs to be transformed (foremost through cooking or roasting) into an object (food) in order to prevent the effects of engaging with the subject or spirit part of the killed being, as would likely occur if consumed raw.[68] This effect, however, is not foreign to Western civilization. In particular, fleshy organic components can cause repulsion and unease among recipients, as they tend to be linked to their original bearers.[69] Objects out of place have, in Mary Douglas' terms, their "half identity" clinging to them.[70] In the case of transplanted animal organs, they are live material that is supposed to stay alive. They cannot be absorbed or purified and hence retain this identity.[71]

In one of his late papers, Claude Lévi-Strauss provocatively stipulates that "we are all cannibals", pointing to medical ways of incorporating human material, whether through blood transfusions or the transplantation of body parts.[72]

I am not advocating, naively, that xenotransplantation patients should adopt the perspective of the animal whose parts they have received. Rather, this perspective can teach us to acknowledge alterity instead of downplaying the differences between beings. Recognizing a shared "culture" that prevails over natural differences separating us could be a powerful concept—not only for those transgressing "natural" boundaries, but for society at large. Given that humans and nonhumans increasingly participate in a shared ecological and epidemiological life—marked by zoonotic disease and environmental devastation—this is likely to become even more pertinent. It also invites us to see animals as having their own perspectives, deserving of respect—a respect that seems to have been lost in the case of animals used in industrial processing.

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[63] Kohn, *How forests think*.
[64] Descola, *Beyond nature and culture*.
[65] Viveiros de Castro, *Cannibal metaphysics*.
[66] Viveiros de Castro, *Cannibal metaphysics*, p. 68.
[67] Viveiros de Castro, *Cannibal metaphysics*, p. 142.
[68] Fausto, *Feasting on people*. This differentiation allows Fausto to distinguish between anthropophagy and cannibalism.
[69] Haddow, *Embodiment and everyday cyborgs*. As such, when it comes to body incorporation, artificial devices are preferred because they don't have a history, in contrast to fleshy material.
[70] Douglas, *Purity and danger*.
[71] Cook; Osbaldiston, *Pigs hearts and human bodies*.
[72] Lévi-Strauss, *We are all cannibals*; Lévi-Strauss, *A Lesson in Wisdom from Mad Cows*. He also makes the point that eating others includes the identification with them.

The notion of "standing in" for humans, as discussed in this text, goes beyond the mere physical presence of a body. It reflects the ethical standing of a species in relation to humans. The next step would be to appreciate the *individual* animal—not merely as a representative specimen, but as a subject with its own intentionality.

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