Rhetorics of Species Revivalism and Biotechnology — A Roundtable Dialogue

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Abstract: This informal dialogue contextualises and explores contemporary practices of nonhuman animal gene-modification in de-extinction projects. Looking at recent developments in biotechnology's role in de-extinction sciences and industries, these interdisciplinary scholars scrutinise the neoliberal impetus driving 'species revivalism' in the wake of the Capitalocene. Critical examinations of species integrity, cryo-preservation, techno-optimism, rewilding initiatives and projects aimed at restoring extinct animals such as the woolly mammoth and bucardo are used to map some of the necessary restructuring of conservation policies and enterprises that could secure viably sustainable – and just – futures for nonhuman animals at risk of extinction. The authors question what alternatives are being ignored in the wake of technoscientific responses to the climate emergency, and interpret the motivations, tactics and tools responsible for commodifying nonhuman animals down to the cellular level. Our conversation on the messy relations within endangered ecologies offers alternative approaches to environmental governance and strategies for addressing the climate and biodiversity crises today.

Keywords: biotechnology, species revivalism, de-extinction, gene-modification, animal ethics, extinction, climate change, technology, conservation

Eva Kasprzycka: *Recent advancements in genetic research, such as the arrival of CRISPR-cas9 in 2012, have intensified the use and production of nonhuman animals in human systems of production. There is now a booming demand and enthusiasm for 'pharm' animals, such as those who are genetically engineered to produce new drugs, vaccines and organs for xenotransplantation. Meanwhile, animals in agriculture are genetically altered to make their slaughtering and rendering more efficient.*[1] *But pharma- and agri-businesses altering nonhuman bodies for consumption and extraction are not the only hosts to scientific programs changing the DNA of nonhuman bodies-to-come. The first live birth of an extinct animal in 2003 has paved the way for scientists, funded by venture capital and Silicon Valley startups, to putatively engage in 'de-extinction'. Researchers and businesses using gene-modification in projects of 'species revivalism' aim to restore a number of extinct species to life – most famously, the woolly mammoth.*

In an era where 200 species become extinct each day, the promise of resurrecting vanished animals is welcomed by many, as evinced by romantic, visionary headlines such as the one featured in National Geographic *in April 2013, 'Bringing Them Back to Life' (Zimmer). Cloning extinct animals is beyond the scope of most potential de-extinction science and practice because the candidate species have been extinct too long and the cellular division necessary for mitosis can only be manipulated with an intact cell extracted from a living organism.*[2] *In the case of the woolly mammoth and the vast majority of extinct species, finding an intact cell is out of the question.*[3] *Because standard cloning methods are not an option, de-extinction science 'resurrects' extinct species by manipulating the DNA of a closest living relative using CRISPR-cas9;*[4] *'recreating' the woolly mammoth might be better described as a refashioning of the Asian or Indian elephant. The enchanted vision of having woolly mammoths roam the steppes of Siberia and bucardos frolicking in Pyrenean meadows speared utopic headlines across multiple, major news sources:* The Wall Street Journal *(Marcus),* The Atlantic *(Anderson),* BBC *(Morse),* The Guardian *(Sample), and even* Fox News *(Musto). Such misleading promises prevent public criticism; these articles fail to acknowledge that the 'return' of the woolly mammoth would actually be the birth of a new species that resembles a woolly mammoth. Despite its promises of 'bringing them back to life', de-extinction initiatives cannot generate facsimiles of mammoths by cutting and pasting the genes of Asian or Indian elephants. How do you respond to those who ask, 'well, isn't cryogenics/synthetic engineering better than nothing?'?*

Charlotte Wrigley: It's an interesting question to ask whether a facsimile of a mammoth or an Indian elephant with mammoth features would produce different reactions, or indeed be noticed by the general public. Our conception of what a mammoth is and looks like is drawn from museum exhibits, skeletons and taxidermied/mummified displays, and is further conceptualised through other forms of media such as cartoons – *Ice Age,* in particular. My point is that what we think to be a mammoth might not be what it was when it was alive; the first full mammoth skeleton displayed in a museum had its tusks placed the wrong way round, for example (Wrigley, 'Ice and Ivory'). Nobody alive has ever seen a living mammoth and I wonder if the question of whether a de-extincted (hybrid) mammoth would be recognisable as an extinct mammoth is pertinent here, or whether we should be querying how people respond to the *idea* of a mammoth. It's one of the most charismatic extinct megafauna, and promotional materials around its de-extinction from the likes of Colossal point to exactly this; the mammoth's status as "Earth's old friend and new hero" demonstrates how a restored mammoth would be configured through a lens of cuddly planetary saviour, despite the fact that a real mammoth was probably rather destructive and dangerous (Colossal). In the same way that a meeting with an adorable polar bear probably wouldn't end too well for a human, the mammoth becoming curated as an almost cartoon like figure softens the ecological and indeed the ethical issues that come with the de-extinction process. The message is: it doesn't matter how we made them or what they look like; it is a force for good.

A necessary discussion in exploring the moral implications of 'species revivalism' is to think about the designation of a species itself. Irus Braverman identifies the classification of nonhuman animals as a way to create a binary between humans and other-than-humans – one that acts as a biopolitical regulatory device. When framing the de-extinction of the mammoth as the *revival* of an extinct species rather than the creation of something entirely new, the ecological and indeed social history of the mammoth's relationship to humans as 'other' is similarly attributed to a new hybrid mammoth. This commodifies the mammoth's life in *relation* to the human but still *separate*, instead of considering the ethical responsibilities humans might have towards any creatures they may create through hybridisation and, of course, to creatures we have pushed towards and beyond the brink of extinction. The focus on species categorisation

means that individual hybridised elephant lives are subsumed into the idea that the mammoth provides a particular ecosystem service for the benefit of humans. If we are to push back on this idea of the nonhuman as utility, we need to also push back on the designation of species that arranges nonhuman life in certain and reductive ways.

Adam Searle: In my ethnographic work on the extinction and putative 'de-extinction' of the bucardo [*Capra pyrenaica pyrenaica*] when a cloned individual was born in a laboratory in 2003, I was often struck by the contemporary hype that drove technoscientific intervention in ecology. The hype back then – long before the term 'de-extinction' had been used to describe scientific practice of reviving extinct lineages – was about cloning. Sarah Franklin's *Dolly Mixtures* wonderfully contextualises the inseparability of experimental animals, technoscientific spectacle, and the speculative futures which bring these animals into being. What Franklin calls 'Dollymania' was omnipresent in the late twentieth-century conservation crisis and parallels between Dolly and the last bucardo were being made in the media and public imaginary before the animal's eventual extinction in 2000 (Searle, 'Anabiosis'). Amongst the scientists I interviewed who had cloned the bucardo three years later, they all reflected on a shared hope in the advancement of interspecific somatic cell nuclear transfer, and a belief that cloning could revolutionise science. Alas, further technological interventions, scientific tools, and their associated knowledge practices were developed, and cloning slipped from the scientific discourse, reflecting the familiar cycle of hype and enthusiasm associated with new technologies. New technologies are usually associated with a peak of inflated expectations regarding their potential impacts – imagined as world-changing and ontologically, epistemologically, and existentially profound – followed by a trough of disillusionment when change is modest. Since hype about de-extinction has grown over the last decade or so, alongside the widespread applications and imaginations of genome editing technologies, expectations of a world without extinction have grown (Sherkow & Greedy). Anecdotally, when I began researching de-extinction in 2017, the knowledge of most uninvolved people I'd speak to about my work would be limited to what they'd seen in *Jurassic Park*. Since then, the scientific media landscape has changed significantly, and now most people respond with stories of mammoth or thylacine

cloning – these ideas don't seem to be at the fringes of cultural or social life anymore. But what will happen when the technoscientific realities don't replicate the sociocultural imaginary? Even if scientists manage to recreate a simulacrum or facsimile of a mammoth – as Charlotte rightly notes – there remains a broader discussion about this animal's authenticity; it will never be a truly 'genuine' mammoth on genetic, ecological, or even sociocultural grounds. This hypothetical revenant mammoth, destined for the frontiers of scientific knowledge, would likely lead to certain disillusionment; while locked away in a laboratory it is hard to fulfil the public expectation of an *Ice Age* protagonist.

In response to the provocation 'aren't such interventions better than nothing?', perhaps so – but the choice isn't between CRISPR-elephants or nothing. There are a plethora of ways to care for the more-than-human worlds that we co-create beyond the spectacle of biotechnological intervention. As my research on the bucardo case has shown, the translocation of extant species to vacant ecological niches presents one of many options, and such options should be figure-headed by people whose lives will be directly impacted by ecological intervention; when governance occurs in a vacuum, it will not succeed. Genuine ecological restoration – practices that remediate and recover amidst the fractured ecologies left in the wake of Anthropocene extinction – must thus recognise 'inescapable entanglements of ecological care with care for people' (Papadopoulos et al. 1). Whilst de-extinction remains a literal pet project of billionaires, it is hard to imagine ecological justice at its core.

Richard Twine: I would start by questioning whether there is a 'booming demand and enthusiasm for "pharm" animals?' Who are the actors with this demand and enthusiasm? There is traditionally a lot of hyping of such technologies, including by scientists themselves. If we don't respond to the hyped capitalist promissory with some critical suspicion, I expect we are probably not performing our role as social scientists or (post)humanities scholars properly. When it comes to the promissory of species revivalism there are lots of question marks. Some of these pertain to viability. For example, I remember writing about this issue twenty years ago for a bioethics blog and this timespan would seem to underline the technical challenges ('Bioethics Today'). One can't insist that a techno-scientific imaginary of extinctionless existence is better

than nothing if the techno-science doesn't work. My view would be that the emphasis should be on the politics of land ownership in order to safeguard ecological space for other species. Other questions revolve around the ecological rationale for such revivalism and whether it's in the direct interests of such beings to be brought into existence. Furthermore, 'What pathways are being closed off by this imaginary?' should be a key starting question. Are hybridised nonhuman beings hyped because we have given up on conservation? What are the political-economic contexts of such a pathway? What other practices might species revivalism, if actually possible, normalise, such as pet cloning industries or zoos of 'revived' animals? Is genetic engineering a credible part of a rewilding imaginary? I agree with Charlotte's comments regarding the misrepresentation and discourse of mammoth de-extinction; the produced animal would not *really* be a mammoth and I wonder if conservation becomes a philanthropic veneer for what might be, in fact, the demonstration of scientific power.

Eva: *Discourse promoting the genetic modification of other animals has been particularly favourable in the 21st century; projects like* Revive and Restore, The Frozen Ark, CryoArks *and other private and public initiatives that perform intensive animal testing have secured plenty of long term and substantial funding. The fact that genetic research on other animals is done using trial and error, whereby animal subjects 'with no outward sign of the desired change' are 'simply throw[n]… away', is never alluded to in popular or scientific media reporting on this research (Davis 178). Keeping the conditions of animal experimentation and its ambiguous outcomes peripheral in political discourse is good for business, argues Karen Davis. Examining the history of agri-business's genetic research on production animals, many CAS scholars have detailed how countless animals are routinely being 'modified' and 'trashed' when failing to meet the expectations of those who engineered their inception. The maternal labour necessary for cloning, bioengineering and hybridising is extensive, yet never communicated in news or peer-reviewed articles. Descriptions of the conditions in which female surrogates are held are omitted – so is their subjection to forced reproduction, which involves pregnancies, multiple miscarriages, stillborn births and eventually being killed and disposed of as biowaste (Weisberg). In your research, upon which grounds do you see biological reproduction distinguished from biotechnological reproduction? In your opinion, how does the separation occult gendered labour?*

Richard: I think there is a combination of the denial of maternal labour in which it is predictably backgrounded and cases which I have described as disturbing and uncanny where biotechnological reproduction has exploited tropes of maternal labour. Thus, I have previously examined the literature of biotech companies such as Newsham Choice Genetics who named one of their pig maternal 'lines' SuperMom™ described as follows:

> Newsham took maternal genetics to a higher level when they developed SuperMom, designed to enter your breeding herd, yield large litters, support them through weaning, and remain in your breeding herd for the long haul. Healthy and robust, SuperMom provides you with lower involuntary cull and death rates. Not only does she produce more pigs, but SuperMom has the milk production that allows her to wean vigorous pigs – giving them the edge they need for healthy average daily gain and feed efficiency. (cited in Twine, *Animals* 110-11)

Here being subjectified as a 'she' was deemed useful to corporate marketing but jars alongside the language of death and culling. Traditional tropes of maternal care and fecundity are drawn upon and into biotechnological reproduction helping to naturalise new forms of breeding.

Charlotte: The biological labour of the surrogate elephant who might gestate a hybrid mammoth embryo does tend to be one of the things raised when discussing the ethical issues of de-extinction, and Colossal has stated they are working on an artificial womb to bypass these concerns (as rarely reported in the media as they may be). I think the interesting question of gender regarding the mammoth emerges through the heteropatriarchal dominance of the science itself. Firstly, it is almost exclusively men doing this work – or, at least, spearheading it– which fits with the masculine bias of this sort of 'pioneering' science that Donna Haraway has deconstructed so thoroughly. But more broadly, de-extinction science maintains patriarchal power structures that are entangled with reproductive labour. Vincent Bruyère writes that 'men have vouched to give birth to mammoths, which will in turn ensure that men have a future to remember' (127). I agree with this statement, but what this future for men depends on is the ability of female mammoths to give birth to young and continue the population. Lee Edelman

identifies a process he calls 'reproductive futurism' that I think is important for thinking about de-extinction in the context of ecosystem restoration; within a reproductive futurism, the reproductive – and white – nuclear family and the figure of the child are lauded, whilst other forms of becoming and kinship are discarded as deviant. With reproduction being such a core tenet of de-extinction science, it necessarily discards any creatures that cannot fulfil that promise.

Adam: I share a similar critique of the gendered nature of laboratory work by surrogate animals. In the bucardo case – which I believe we still have a lot to learn from when posing hypothetical questions of de-extinction – countless experimental animals were enrolled into the production of the clone of an extinct taxon. The bucardo's closest extant subspecies, the Spanish ibex (*Capra pyrenaica hispanica*), had a similar reproductive cycle and identical gestation period, but the stress of captivity was detrimental to reproductive success. To negotiate these differences, scientists cross-bred domestic goats with Spanish ibex to enable a cloned 'bucardo' embryo to develop in the domestic goat-Spanish ibex hybrid held in captivity. These surrogate mothers are nearly always excluded from stories of the bucardo cloning in the scientific media, which favour the headline-grabbing cloning attempt of an extinct subspecies (Searle, 'Spectral Ecologies'). It is ethically imperative to centre the lives of these animals who are excluded from technoscientific spectacle and, as critics rightly point out, it is the work of those of us who qualitatively study the practices of science and technology to render these surrogates visible.

Eva: *CAS scholars have discussed the way genetic engineering amplifies nonhuman animal abstraction; capitalisation of gene-editing and its patenting potentials have become instrumental in shaping an understanding of nonhuman animals as being uniform commodities, data, codes and raw material that is readily available for re/production (Shanks & Greek). Biocapitalism's capture of life's productive and reproductive capacities means that it is increasingly a form of genetic capitalism, giving a new twist to*

Fredric Jameson's assertion that it is now easier to imagine our ecological collapse and planetary extinction than it is to imagine the end of capitalism. How have you thought about the politics of genetic capitalism in light of your work on biotechnology and the exploitation of nonhuman animals?

Richard: I think rather that the hopefulness of living in an epochal crisis is that it does make the imagining of the end of capitalism that bit easier. The social and ecological contradictions teeming in the extinction crisis are visible in new ways and anti-capitalism is once again speakable – even if terms like the Anthropocene help to conceal the politics of the crisis (Moore). However, to the extent that biotechnological practices are shaped as partners in protectionism and through new dreams of capital accumulation, then assuredly we can contest these practices as deflecting attention away from systemic critique. I have analysed biotech's protectionism most clearly in relation to what I called the molecularization of sustainability which, to an extent, heralded a shift in farmed animal production genetics (*Animals*). Although the naked, brutal application of genetics to the productivity of farmed animal bodies has hardly disappeared but intensified – often wrapped into a general imaginary of biotechnology suffused with philanthropic and charitable meanings such as feeding the Global South – the shift in farmed animal genomics has enabled an eco-modern deployment of genetic capitalism as an answer to the (now partly admitted) ecological exploitation of the animal-industrial complex. So, we see all these strategies for tackling the methane emissions of farmed ruminant animals that effectively maintain and protect the profitability of the animal-industrial complex, rather than being a serious attempt to roll back the ecological crisis. This brand of protectionism is also why the Intergovernmental Panel on Climate Change in 2022 and 2023 watered down key sections of their sixth assessment report to remove explicit mention of the necessity of transitioning to plant-based diets, thanks to lobbying from countries who are key players in the animal-industrial complex.

My work has attended to the politics of naturalisation which have been at play in the politics of genetic capitalism. Proponents of both GM- and farmed animal genomics initially tried to strategically emphasise continuity between genome-editing approaches and selective breeding. There were two major flaws in their strategy. Firstly, they are qualitatively different

techniques that *do* intensify the scope of control over other species. Secondly, proponents wrongly assumed that selective breeding was both uncontroversial and ethically benign. The advent of CRISPR gene editing is interesting in this respect. Partly because the language of gene editing continues what Eugene Thacker referred to as 'informatic essentialism', the idea that the body can be understood as information;[5] but also because CRISPR uses genetic modification as a moral foil. In this way of thinking, GM = bad, but CRISPR ≠ GM, therefore CRISPR = acceptable. Such discursive shifts have not stopped CRISPR from becoming embroiled in concerns over eugenics, but pointedly, as I have argued, that is a term that helps to structure the human/animal binary (*Animals* 87-8).

Charlotte: I agree with Richard that we must analyse the molecular turn in genetics and other biomedical sciences. The implementation of freezer storage and other forms of cellular preservation allowed for new forms of genetic research that recategorizes what life is and where it's found. Hannah Landecker identifies the 'thread of life', her term for the way cells outside the mortal individual body become continuously linked across boundaries of sex, species and even time. We can see this very clearly within debates around de-extinction, in which viable cellular material from creatures long extinct continues to exist and circulate. Cellular life after death/extinction is particularly interesting in regard to what is left of mammoths because they have been extinct for so long – since long before human-built museums and laboratories existed – but the fact that so many bodies are found almost perfectly preserved in permafrost adds another layer to the thread of life. As permafrost thaws and mammoth bodies are revealed, the material effects of climate change become harder to ignore, thus stimulating a response that requires the transferral of mammoth cellular material into freezer systems to maintain the 'life' of their DNA. Such practices of 'genetic rescue' are clear examples of biovalue, where commodity value is found within what is extracted *from* organic bodies, or as Catherine Waldby puts it: 'the mining of death to increase the value and productivity of life, its technical augmentation' (142). That the potential 'resurrection' of the mammoth is now found within their DNA, their particular genetic attributes (cold adapted blood, fur, smaller ears, etc.) and their genetic compatibility with the Indian elephant, means the mammoth is no longer attached

to either their body or their environmental milieu. The mammoth's specific history is discarded in favour of fungible and transportable body parts that can rebuild a *future* mammoth free of its weighty kinship bonds and ancestry; a prospective future that embodies the idea that the free market and technoscientific progress will provide the solutions to environmental problems such as climate change and extinction.

Eva: *Also missing from scientific and public-media accounts of the genetic re-creating of extinct species is the fact that conservation dollars are stringently limited; the benefits of 'bringing back' one lost species diverts resources from protecting the extinction of species that are currently on the brink. De-extinction pools resources and enthusiasm and directs them towards biotechnologies that promise to undo the damage of anthropocentric practices, rather than to reinvent or limit anthropocentric practices that actively push species into peril. When confronted with issues of food security and mass-extinction, public opinion is easy to sway in favour of futuristic initiatives using technologies that herald human exceptionalism. Obligations of preserving what species are left becomes nonessential if the public is beguiled into believing lost species can be revived in petri dishes. The manufacturing of GM-animals allows consumers to guiltlessly continue 'business as usual' with added freedom – the responsibility of maintaining what biodiversity remains is confidently delegated to lab-coats performing various experiments in out-of-sight laboratories. Do you think such an approach compares to our complacency in addressing a climate crisis that threatens all life, humans and nonhumans alike? Do you see species revivalism influencing collective and/or individual response to the Anthropocene? Can we understand 'techno-fixes' as a part of the language or tools perpetuating extinction denialism or, worse yet, does 'techno-salvation' repress the collective will necessary to restoring earth's climate to its pre-industrial state?*

Richard: The politics of species revivalism may serve to give people the false impression that humans and other animals are not vulnerable in the face of the ecological crisis because ultimately technology is there, in this very modernist sense, in a salvatory role. So yes, there is a disavowal of preventative action, a failure to contest incumbent practices and a reluctance to

bring understandings of *why* ecologies are being destroyed into popular discourse. In this way, relying on 'species revivalism' for tackling biodiversity loss is the close cousin of a climate mitigation policy that pins most of its hopes on carbon capture and storage.

Charlotte: I'm not sure that it's true that public opinion is easy to sway in favour of techno-fixes and easy ways out. Of course, it's true that largely Western capitalism has created a solutions-based economy, where large and complex issues such as climate change and food security are met with so-called quick fixes from the market. However, there are many examples of slower, smaller acts of change such as a sustained shift in eating more plant-based food (in the West that is – many cultures have a long history of plant-based diets), making more ethical purchases, reducing plastic and so on. People react very positively on the whole towards 'hands off' rewilding projects; a recent poll revealed four in five Britons support such practices of slower, more holistic forms of conservation ('Rewilding Britain'). Meddling around with genetics is certainly an ethical issue for many people, not least from a religious point of view (Cohen). However, what we need to be careful about is the response from the neoliberal market to profit from and commodify responses to environmental problems. We should be wary of the narrative that technological solutions to 'natural' problems are necessarily bad, and instead interrogate who exactly the technology works for and who is pushing it as a solution. There is a danger in becoming mired in nostalgia when it comes to thinking about the many 're-' words that proliferate current environmental thinking: rewilding, restoration, resurrection, return, revival. The fact is that we are not going to restore the earth's climate to its pre-industrial state; of course this does not mean we should give up trying to address the climate crisis or reverse fossil fuel emissions, but instead of looking backwards into the past, we must imagine new and better futures that dismantle the presupposition of a certain way of life predicated on consumption, capitalism, and colonialism.

The notion of a 'Good Anthropocene' in which humans accept their roles as dominant geologic agents and become stewards of the planet is a dangerous one if not combined with a thorough dismantling of Western white supremacy and capitalism. Anna Tsing identifies a simplification of ecological processes in the Anthropocene that follows the logic of the colonial

plantation in regulating human and nonhuman life. The dominance of Western ontological thought buttressed by the neoliberal market creates a scenario in which invariably those who have spearheaded the environmental destruction and biodiversity loss that generates the *need* for conservation get to profit from its solution, and embeds a sense of mastery predicated on a human-nature dichotomy. What technofix solutions such as species revivalism – and many geo-engineering technologies – perpetuate is the continuation of destructive practices that, as you say, drive species to the brink of extinction and contribute to the climate crisis, with the idea that mitigation absolves and legitimises such practices. It does not.

Eva: *Ben Mezrich's book* Woolly *illustrates how mammoth de-extinction was incited by a journalist asking George Church: is it possible? This grandiose question incited an innovative train of thought about how an extinct species could be recreated by changing genomes in existing relatives. Only later was the ecological argument added in order to justify why one should potentially do it, giving rise to initiatives like Revive and Restore, Colossus, eGenesis, etc. Similarly, research on the passenger pigeon's natural history seems to vary in accordance with the feasibility of de-extinction. Conclusions seem secondary; advocates of these projects find ways to fit them into the ecological narratives. In what ways does species revivalism capitalise on the climate crisis?*

Richard: It's no great surprise that in the Capitalocene (the preferred term of several writers who have critiqued the Anthropocene concept for being obfuscatory, apolitical and ahistorical[6]), capitalism attempts to creatively produce nature so as to consolidate and prolong itself. What you are calling 'species revivalism' is a promissory discourse that attempts to reassure the profligate Global North and any economy based around 'fantasies of eternal growth', to use Greta Thunberg's phrase, that business-as-usual is a possibility even in the face of climate and biodiversity crises ('Greta Thunberg's Full Speech'). It's ok to use air-travel because you can pay for carbon offsetting, it's ok to kill species into extinction because we can recreate them in a lab. Welcome to capitalocenic protectionism. The climate and biodiversity crises are already experienced as de-territorialisation for human and nonhuman animals alike. De-extinction seems

to extend this by assuming that not only can we move species around geographically with ease and free of consequence, we can also 'play' with the temporal contexts of species too. As others in this conversation have outlined, such assumptions are beset by their simplifications.

Charlotte: One of the main proponents of de-extinction has been Stewart Brand, who started his environmentalism journey as a hippy in the sixties helping to supply off-grid self-sufficient communes but who has now adopted more of a technophilic approach. He now heads the longtermist organisation, 'The Long Now Foundation', which in turn funds Revive and Restore and has deep links to George Church's de-extinction efforts (they travelled to the Pleistocene Park together). Brand's approach is one of techno-optimism in which he posits that not only can the planet's environmental problems be solved by technology, but also that humans have a moral imperative to do so given we have now become, as Brand puts it, 'as gods' ('Stewart Brand'). Some scholars have referred to this stance as indicative of a 'good Anthropocene' (Bennett et al.), where the designation of humans as top geological agents is an opportunity rather than a cause for concern. De-extinction therefore occupies a perfect solution for the techno-optimist in that it offers both a technoscientific fix but also fulfils an ecological niche. The sixth great extinction, for example, becomes pathologized as an enclosed problem to be fixed *by* resurrection biology, rather than an ongoing process of unravelling lifeworlds and relations (van Dooren, *Flight Ways*). It doesn't seem that any plan to mobilise de-extincted creatures as ecological 'fixes' is doing so in good faith; to do so would require a long term, localised strategy that introduces new species to the ecosystem slowly. Of course, we don't know how any practical application of de-extinction science for conservation might work in the absence of any successful de-extincted creatures, but I'm extrapolating that they will be mobilised as 'quick wins' in a planet beset with environmental crises. In this sense, the source of these crises – hypercapitalist, resource consumptive businesses and billionaires – becomes obscured by the ability of a 'Good Anthropocene' to offer so-called solutions that allow the ecological destruction so inherent to the Anthropocene's definition to continue unhindered.

Adam: As Charlotte rightly highlights, the technocratic notion of a 'Good Anthropocene' unleashes particular dreams of controlling nature and environmental catastrophe, despite the unknown 'political, social, and ecological dangers' which could accompany intervention strategies (Stengers). When de-extinction is presented as the logical solution to hugely complex, heterogeneous, and unequally experienced events related to the sixth mass-extinction, the ability to think otherwise about intervening in it is more difficult. Hypothetically de-extincted mammoths that are re-imagined as climatic engineers – through their presumed capacity to sequester permafrost carbon as a byproduct of their grazing habits – are thus presented as a matter of life and death. Supporters of de-extinction who legitimise their urgency through this ecological justification thus proliferate a narrative that forecloses alternative approaches to intervention (Wrigley, *Earth Ice*). It speaks volumes, as you rightfully highlight in your question, that this justification has often been an afterthought in the case of mammoth de-extinction.

Eva: *What, in your opinion and expertise, is a wiser alternative to 'resurrection biology'? Have you come across any instances in which biotechnology has provided viable, realistic and timely approaches to the extinction crisis? Are there any cases in which you've felt excited for biotechnology and what it can do to improve the lives of nonhumans? Or have you only seen evidence of the opposite?*

Richard: This question very much speaks to the special issue of *Configurations* that I co-edited with Neil Stephens in 2013. We assembled papers that critically probed whether biotechnology might have a latent liberatory imaginary or pathway for nonhuman animals. With a broad definition of biotechnology this included reflection upon technologies such as cultured meat. I have previously argued that biotechnology could have a minor role in de-domestication, in terms of helping the robustness of certain species that could transition from farmed commodification to being in some sense 're-wilded' (Twine 'Is Biotechnology Deconstructing Animal Domestication?'). We already see versions of selecting genotypes for higher welfare and 'robustness' in animal welfare sciences.[7] In the commercial context such qualities typically get wrapped into notions of productivity, but they could have an alternative application in the

context of limited forms of rewilding and in conservation genetics. However, you asked about the wiser alternative to 'resurrection biology' and for me that is the systematic fight against corporate expansion into habitats and the incredible opportunity to rewild land that could emerge alongside transition to plant-based diets. Of the habitable land on Earth (104 million square kilometres), almost fifty percent (fifty-one million square kilometres) is used for agriculture. Of this, seventy-eight percent (forty million square kilometres) is used to farm nonhuman animals, including land used for feeding the production animals (Ritchie). Change to the global food system has immense political obstacles but it is integral to so many social, environmental and interspecies justice issues. Tackling the profligate use of land, water and food by animal agriculture is central to addressing our contemporary threats of climate breakdown and to species flourishing.

Charlotte: I tend to be of the rather pessimistic outlook that whilst neoliberalism and extractive capitalism organise the conditions for life, there can be no 'good' applications of biotechnology; it will always, and necessarily, lead to exploitation in the pursuit of profit. This does not, of course, mean that there can be no benefits to nonhumans or conservation efforts through biotechnology. Largely, I think, this benefit is found in more local and embodied applications that eschew planetary scale, techno-utopic designs. Thom van Dooren, writing on a living biobank (where creatures exist as whole organisms rather than genetic material) for snails in Hawaii, finds hope in the methodical and embodied acts of care shown by the conservationists ('Banking'). There is an argument to be found in the work biobanks can do in stimulating attention towards experiences of loss and grief, or reorienting practices of care and attention. Perhaps these examples can cause us to pause and reflect on the reasons why they are necessary in the first place, although I am dubious as to how much impact this can have. Whilst many museums and non-profits involved in bio- and cryobanking are doing so as part of their commitment to preservation and safeguarding – and indeed, many are not (yet at least) even involved in practical conservation efforts, let alone attached to de-extinction experiments –

their existence is surely oriented towards 'real world' action. What shape that action will take is dependent on devising an ethic that foregrounds nonhuman flourishing, resists profit-driven application, and practices slow and careful responsibility.

Adam: If the goal of de-extinction is 'to re-establish dynamic processes that produce healthy ecosystems and restore biodiversity' – as claimed by Colossal – then there are many tools available to conservation which at least attempt to achieve these objectives without the use of biotechnologies at the genetic scale. Take, for instance, the reintroduction of the Eurasian beaver to landscapes across northern Europe after a series of local extinctions caused by overhunting. Beavers are a keystone species that can engineer a range of ecological niches due to the effects of their dams on river flow, microclimate and microbiotic composition (Lorimer). Through archival analysis, Dolly Jørgensen shows how the beaver's return to Sweden owed its success to its status as a 'people's project' driven by a shared sense of guilt: a community-led initiative that 'advocated stewardship' of nature rather than 'touting human mastery' over it (Lorimer 48). In its current deployment – animated by the extractive logics of capital – it is hard to imagine biotechnological intervention in the extinction crisis as a humble people's project. On the contrary, and to reiterate Charlotte's point, it is facilitated and driven by the pursuit of profit, quick fixes, and returns on investment.

Eva: *I worry that the management and edifice of biobanks and cryogenic zoos will be modelled after current 'repositories' of captive animals. In actuality, zoos don't breed captive and endangered animals with the intent of replenishing threatened populations in their native ecosystems. Zoos and other forms of captive-conservation have dismal track-records in reintroducing endangered nonhuman animals to their natural habitats[8] (Pierce & Bekoff[9]). Are there parallels to be drawn between the conservation measures made in zoos and de-extinction laboratories? Do you see the categorization of extinction continuing into nomenclatures of 'functionally extinct' to 'genetically extinct'?*

Adam: Yes, and in this case the debate would similarly revolve around authenticity.[10] Questions would emerge like: can 'extinction' really be overcome or undone if the animal is never present in uncontrolled or wild conditions? Can the bottleneck effect of a founding, de-extinct population really reflect the diversity of the population it seeks to revive? In my research, I often found myself asking people related to the bucardo's extinction and attempted de-extinction the same question: if the experiment had been successful, what would the situation be like now? Answers differ substantially, but they all revolve around the same point, namely that one individual alone cannot restore an extinct population. In the case of mammals at least, I believe the distance between an animal being born in a de-extinction laboratory and a healthy animal being born in the wild is as technically complex as the initial feat of 'bringing back' an extinct animal. To this end, then, a hypothetically living, breathing, mammoth-like elephant is much closer to a taxidermied specimen in a natural history museum than a mammoth which roamed the tundra thousands of years ago.

Charlotte: I can absolutely see this happening, and it already is. And it raises all sorts of other questions such as: which genes are privileged in this scenario? Is it the entire genome that is valued or merely (as in the case of the mammoth) certain features or traits that are constructed as the 'essence' of the species? And, of course, we get into complicated and often problematic debates around genetic purity or genetic robustness, which is certainly the case in zoo-based captive breeding: a recent example would be the captive breeding programme and release of Scottish wildcats who have a baseline genetic purity of seventy-five percent; the breeding programme considers the Scottish wildcat to be functionally *and* genetically extinct. This has caused some tension with groups who consider only one-hundred percent genetic purity to be acceptable[11] ('Scottish Wildcat Action'). Captive breeding and release programmes – as limited as they are – are so often mediated by anthropocentric categorisations such as charisma value, notions of authenticity and so on.

When species are reduced to genetic material, however, in the context of the cryobank, this introduces yet another layer of abstraction. Joanna Radin and Emma Kowal's book *Cryopolitics* identifies a shift in Foucauldian biopolitics that renegotiates life in relation to

coldness: a process of preservation which generates 'a zone of existence where beings are made to live and are *not allowed to die*' (6). The cryobank becomes a machine through which life is recategorized as genetic, the material process of freezing facilitating a semblance of control, implying a temporal stasis of both life *and* death. Extinction in this space is much less clear cut when there is the *potential* to use preserved genetic material for future conservation efforts. If a creature is genetically extinct in the wild yet its genetic material is intact in the cryobank, how do we make sense of this? As the concept of a 'frozen zoo' is still relatively new, it remains to be seen whether they will have any effect on practical conservation work, but it is important to highlight how they redefine extinction.

Eva: *Thinking about species designation is in itself complicated, even outside of the manufacturing of pseudo-mammoths and thylacines. When used by animal advocates in contexts of representing nonhuman animals' interests, species specificity helps us better define and conceptualise approaches to treating individual animals with integrity. To be sure,' say Sue Donaldson and Will Kymlicka, 'it is essential to assert the right of animals to species-specific forms of flourishing ('doing rabbit things" in order to 'feel rabbit pleasures")' (67). In more-than-human discourses in science and technologies, there exist serious epistemological limitations and, as Charlotte points out, biopolitical regulatory devices that influence our understanding of animal welfare and 'species integrity'. Politics of exclusion are inherent to the borders between species; after all, species designation determines which subjects deserve the law's protection and which can be actively killed or placed closer to proximities of dying. In your work, how have you seen the troubling of boundaries between species influence the organisation of conservation and approaches to extinction? Do you think synthetic biology has problematised definitions of species purity or biological temporality?*

Adam: George Church told a packed-out audience at *National Geographic*'s auditorium in Washington D.C. that he was 'trying to recreate species from information alone' (Church). This gesture from a leading figure in synthetic biology exemplifies the ontological status of species from the perspective of applied biotechnology in de-extinction science: a genomic sequence that

can be clearly defined, which maps on to a desired, distinct, animal. Yet in conservation practice, taxonomic politics are messy. Officially, the bucardo was a subspecies of Iberian ibex (*Capra pyrenaica pyrenaica*), which meant concern about its population decline were rare throughout the twentieth century. Contemporary phylogenetics, however, suggest that the bucardo was a distinct evolutionary unit from the Spanish or Alpine ibex (Ureña et al.). The bucardo's extinction, albeit profoundly significant in Pyrenean culture, politics, and identity (Searle, 'Hunting Ghosts'), was therefore internationally overlooked due to the perceived lesser importance of a subspecies extinction relative to that of species (Heise). Ideas about bringing extinct biota back are similarly coalesced around taxonomic borders. I have argued elsewhere ('Spectral Ecologies') that a broader ontology of de-extinction – one focussing on the 'mundane' aspects of ecological restoration, like introductions of biota that have been spatially or temporally absent from landscapes, ecologies and human understandings of them – can perhaps allow us to think about de-extinction beyond spectacular narratives of technoscience (Friese & Marris). For instance, ecologists released Spanish ibex (*Capra pyrenaica hispanica*) to the Pyrenees in 2014, and this distinct animal has established a viable population in the bucardo's wake. The introduced ibex looks like the bucardo, in the bucardo's historical habitat. Despite this uncanny difference, what purpose would cloning the bucardo serve now that its ecological niche is occupied, other than to cross a technoscientific frontier? If extinction and de-extinction are conceptualised beyond the vernacular of genetics – and our understandings of these concepts also account for the affective entanglements between bodies, matter, and meaning, as invaluable qualitative work across Extinction Studies has exemplified – then we might find grounds for mutualistic flourishing that don't depend on taxonomy (Radin & Kowal). Only then would the prevention of localised extinctions, like those surrounding the bucardo, be conceived as 'worthwhile' for many powerful players in environmental governance.

Charlotte: It isn't merely within species revivalism or synthetic biology that these blurring of species lines and boundaries are happening. I'm thinking specifically of the Pleistocene Park which aims to restore the mammoth's ecosystem through rewilding large herbivores onto the tundra, with designs to eventually provide a habitat to de-extincted mammoths. The project

isn't exactly fussy when it comes to procuring species for the northern subarctic steppe grassland that was teeming with biodiversity during the last glacial period. Aside from the already cold-adapted animals they have procured relatively locally, such as reindeer, musk oxen, and moose, the Park's directors have brought creatures from much warmer climates, such as goats, camels, sheep and cows. Their idea is to almost 'fast track' evolution; if these animals can survive and breed, their offspring will be better cold-adapted. The owner of the park, Sergey Zimov, once boasted to me that he could cold-adapt an elephant within ten generations by moving northwards one offspring at a time. He's convinced that by the time he reaches the tundra, he'd have a mammoth. Whilst he is a rather eccentric guy (and thankfully doesn't have any elephants to test his theory on), his goals for the Pleistocene Park raises interesting questions regarding what is understood as species behaviours and habitat. Arctic tundra is certainly not the habitat of a camel, but a camel being 'out of place' at the park whilst simultaneously fulfilling a place-specific, ecological role demonstrates that boundary making practices around species definition are oftentimes messy and unhelpful. Of course, this example generates all sorts of ethical questions regarding an animal's rights to a comfortable life and the ability to flourish, as you so rightly point out Eva.

In my book, *Earth Ice Bone Blood*, I argue for a more nuanced, more generative understanding of what extinction – and therefore species categorisation – is, to make space for localised extinctions, inhuman extinctions, cultural extinctions and so forth. Carving such a space out of the popular discourse maintains that whilst extinction is the end of something, it is also the beginning of something else. I am certainly not advocating for abandoning species categorisation as it relates to a creature's *Umwelt* (von Uexküll) or its use within conservation practice, but I agree with Adam in that uncritically coupling 'species' with 'extinction' can lead to problematic approaches within de-extinction trajectories. By ontologically querying the definitions of species and extinction, there is room to acknowledge the other, perhaps messier, relations that form within ecologies.

Eva: *Using existing elephants as surrogate mothers to 'mammophants' is biologically and socially questionable for reasons you all have expertly expressed. Even if scientists are successful in creating a hybrid embryo containing genetic traits from the Ice Age giant that disappeared four-thousand years ago, it's an entirely different feat to produce a breeding population. It takes twenty years for a baby female elephant —or in this case, 'mammophant'— to reach sexual maturity and reproduce. Further yet, 'the Arctic is not the same as when the mammoth went extinct' says Joseph Bennett. Having novel species survive winters in Siberia might be another example of forcibly reconstructing nonhuman animals to reflect* certain *human desires. Getting grazing herds back to the Subarctic steppe will be a century-scaled project; many of us can agree that it would be wiser to spend money and resources on the living and not the dead.*

And what I mean by 'the living' isn't limited to the nonhuman animals that steadily decline into populations that are 'threatened,' 'vulnerable,' then 'critically endangered'. It is not only the brutal objectification and commodification of nonhuman animals at stake, here. The laissez-faire, start-up culture approach of biotechnology fails to respond to the ethical imperative of urgent and immediate action. Techno-fixes allow people who occupy positions of global privilege and power to prioritise their convenience and desires over global health. De-extinction sciences embody a colonial-capitalist – and deeply patriarchal – mindset that determines which lives matter; investing in the resurgence of certain species under the guise of 'planetary health' allows us to withhold care from certain populations, human and nonhuman alike.

Notes

[1] For example, biotech company Acceligen has active projects in producing hornless cows, featherless chickens and pigs who don't experience sexual maturity. Although such measures are an appeal to animal welfare and could be considered a response to animal advocates' opposition to painful practices of dehorning cattle, 'cleaning' chickens and castrating piglets without anaesthesia, producing GM-nonhuman animals that eliminate the need for such practices effectively eliminates the cost of human labour necessary to conduct them.

[2] In fact, the 2003 cloning of the bucardo – the first and to this date and only time an extinct animal has been 'brought back to life' – a relatively unique case given that scientists were working with intact cells extracted from the last individual when alive. There is irony in this event inspiring a movement that later became known as 'de-extinction science' given its technical uniqueness (Searle, 'Anabiosis').

[3] Although, some organisations are still trying such as Sooam Biotech in South Korea and Kindai University in Japan (Yamagata, K. et al.).

[4] CRISPR stands for Clustered Regularly Interspaced Short Palindromic Repeats. Often described metaphorically as a pair of 'molecular scissors', this form of synthetic biology has revolutionised genome-editing and recombinant DNA technologies through repurposing a naturally occurring molecule in immune systems to cut and paste genomic sequencing within living cells (Redford and Adams). The swift rise and now ubiquitous use of CRISPR is owed to a Silicon Valley start-up culture that sets this biotechnology apart from earlier developments – such as the zinc finger method – with regard to its easy, low-cost and precise application.

[5] Noted in and enriched by Lynda Birke's *Feminism and the Biological Body*.

[6] See Jason Moore's *Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism* and 'The Capitalocene, Part I: on the Nature and Origins of our Ecological Crisis'.

[7] For example, Accelegin uses genetic manipulation to produce cows that have 'improved heat tolerance', 'localised climate adaptation' and are more 'pest resistant' (*Accelegin*).

[8] In a 2015 study on captive breeding programs and their benefit to endangered species, Paul Dolman concludes that 'without conservation in the wild, there is no point in captive breeding'. Given the complicated nature of introducing captive-bred nonhuman animals to their natural habitats, most reintroduced animals die (Jule et al.).

[9] Marc Bekoff, Dale Jamieson and many other animal activists have detailed lesser-known cruelties zoo animals face; healthy, captive nonhuman animals that don't fit into a zoo's breeding program are intentionally killed or enter illegal breeding programs after being sold to circuses. Such animals also find themselves sold to the black market, fuelling the exotic animal pet and parts trade.

[10] See Christopher Lean's 'Authenticity and Autonomy in De-Extinction' and Helena Siipi's 'The Authenticity of Animals'.

[11] See also Aurora Fredrikson's 'Of Wildcats and Wild Cats: Troubling Species-based Conservation in the Anthropocene' and Charlotte Wrigley's 'Nine Lives Down Love, Loss, and Longing in Scottish Wildcat Conservation'.

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