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On the Authenticity of De-extinct Organisms, and the Genesis Argument

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Abstract

Are the methods of synthetic biology capable of recreating authentic living members of an extinct species? An analogy with the restoration of destroyed natural landscapes suggests not. The restored version of a natural landscape will typically lack much of the aesthetic value of the original landscape because of the different historical processes that created it – processes that involved human intentions and actions, rather than natural forces acting over millennia. By the same token, it would appear that synthetically recreated versions of extinct natural organisms will also be less aesthetically valuable than the originals; that they will be, in some strong sense, 'inauthentic', because of their peculiar history and mode of origin. I call this the 'genesis argument' against de-extinction. In this article I critically evaluate the genesis argument. I highlight an important disanalogy between living organisms and natural landscapes: viz., it is of the essence of the former, but not of the latter, to regularly reproduce and die. The process of iterated natural reproduction that sustains the continued existence of a species through time obviously does not undermine the authenticity of the species. I argue that the authenticity of a species will likewise be left intact by the kind of artificial copying of genes and traits that a de-extinction project entails. I conclude on this basis that the genesis argument is unsound.

Keywords

De-Extinction; Extinction; Species; Authenticity

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1. Introduction

Suppose that there is some beautiful natural landscape: of deep canyons; of weatherworn pillars and arches of rock; of multi-coloured rock strata; of wind-sculpted trees and bushes; of fossils, springs, caves, and ancient ventifacts. This landscape is destroyed in order to strip-mine a coal seam. But after the coal has been lugged away the landscape is carefully restored. Coloured layers of rock, complete with inlaid duplicates of fossils, are pasted over the land using a new rock-extrusion technology. This new rock is carved into canyons, pillars, arches, caves and 'ventifacts' by enormous terraforming rock-grinding machines. Soil is trucked in, and a team of landscape gardeners plant new trees and bushes that have been especially grown and sculpted to give them the same windswept look as the originals. The resulting landscape is (let's imagine) indistinguishable from the original landscape. Indeed, we might imagine that it is even more visually impressive than the original landscape because of a few extra flourishes the restoration team kindly throw in 'for free': a new mesa here; a new giant boulder precariously balanced on a pillar of rock there; and so on….

Is the restored landscape just as good, or perhaps even better than the original? The *locus classicus* for this question is Robert Elliot's *Faking Nature*. Elliot calls the idea that the value of a destroyed piece of natural landscape can be fully compensated by restoring the landscape to its original state the 'restoration thesis'. He points out that even a *perfectly* restored landscape, that is exactly like the original, destroyed landscape down to the minutest detail, would still have a different *history* and *genesis* than the original – for it would be the product of deliberate human planning and contrivance, not of impersonal natural forces operating over enormous stretches of time. He notes that we commonly aesthetically value landscapes and environments precisely because of their natural origins – because 'they are unsullied by the human hand' – and he refutes the restoration thesis on this basis.

The present article is about 'de-extinction' – i.e., about the artificial restoration of destroyed natural species – not about the artificial restoration of destroyed natural landscapes. However, the two issues would appear to be intimately related. Resurrecting an extinct species would appear to be the zoological or botanical equivalent of restoring a lost landscape. An argument from analogy therefore suggests that lessons from the one case will carry over to the other. It suggests that organisms produced artificially, using de-extinction technology, will lack aesthetically valuable historical properties of the original population of organisms that died out, and that they will be nothing better than 'cheap knockoffs' of the originals for this reason. Here is an articulation of this idea, by Ben Minteer:

> I think … de-extinction proponents too casually and uncritically equate the engineered doppelgängers with the vanished species. Their remarks certainly seem to suggest they think that the introduction of the former somehow recovers all of the values lost with the disappearance of the latter. You don't have to be an essentialist about the 'natural,' however, or cling to outmoded notions of species purity to recognize that there are, as we might say, morally significant differences between the extinct species and the synthesized versions. One key distinction hinges on the co-evolutionary natural history of the lost forms. Although the engineered reproductions may hold other values for conservationists, unlike their progenitors they will not have evolved in relationship to other species within a natural habitat over millennia. And that unique co-evolutionary and ecological narrative is, I believe, an important part of how and why we value wild species. It's a character that simply can't be recreated in a modern genomics lab. (14-15)

In the present article I critically evaluate this argument against de-extinction, which I will call the 'genesis argument'. (The name comes from the idea that de-extinct organisms are inauthentic because they have the wrong mode of genesis.) My conclusion will be that the genesis argument fails, because, strange though it may seem, the aesthetically valuable historical properties of an extinct species *can* be recreated in a biotech lab. In arguing for this conclusion I will show why the analogy between restoring destroyed natural landscapes and resurrecting extinct species is, in fact, deeply misleading.

If I am right and the genesis argument is indeed unsound, then two further questions arise. First, can *some other argument* be used instead to establish the same result, namely, that organisms produced using de-extinction methods will be inauthentic? Second, if no such argument exists – if it really is possible in principle to recreate authentic living members of extinct species – then would it be *ethical* to do this? These are important questions, but I mention them here only in order to note that they are beyond the scope of the present article. However see Siipi for a discussion of the former, and both Cohen and Sandler for a discussion of the latter.

The following section introduces the authenticity question, and explains why its answer is important. Section 3 describes the genesis argument, and distinguishes it from a pair of other arguments that share the same anti-de-extinction conclusion. Section 4 explains why, in my view, the genesis argument is unsound.

2. The Authenticity Question

Why do we value living representatives of a natural species? Why, for example, do we value the New Zealand *kokako* (*Callaeas willsoni*, one of the world's premiere songbirds)? The answer is, of course, complex, having diverse elements (Norton, 1986). The kokako is, for instance, valuable to humanity in part for monetary reasons (as a tourism drawcard), and in part because of ecological services it provides (e.g., seed dispersal). But without question a very large component of the kokako's value to humanity consists of its so-called 'aesthetic amenity value', which is to say, its capacity to stimulate such pleasant feelings and sentiments as joy, awe and wonder in those humans who are lucky enough to see it and hear it sing. What is it about the kokako that gives it this capacity? The answer, again, is complex and multifaceted. Most obviously the kokako is *outwardly beautiful*, with respect to its appearance and song. Secondly, the kokako possesses its fair quota of what might be called *functional beauty*, this being the beauty that inheres in its unique adaptions to its forest home (Cohen; Parsons). To appreciate the kokako's functional beauty is to be awed by how its bodily design, physiology and behaviour realize elegant and efficient solutions to the engineering problem of getting the animal to cause its genes to be perpetuated onwards down the generations. Thirdly, and most importantly for my purposes, the kokako also possesses a large measure of what I will call *ecological beauty*. This is an aspect of its aesthetic value that emerges into view only when one recognizes the *evolutionary process* by which the kokako came into existence and how this process connects the kokako to its physical and living environment: to the mountain forests of New Zealand and to the numerous other species – including predators, prey, competitors, symbionts, and parasites –

with which the kokako has interacted to its benefit and detriment in countless ways over the course of its evolutionary history. To appreciate the kokako's ecological beauty is to appreciate the kokako as an integral part of a relatively stable and fabulously rich and complex natural ecosystem that has arisen over unfathomable aeons of time, that is unique to one particular part of the Earth, and which, through its uniqueness, augments the overall richness of Earth. It is, so to speak, to appreciate the kokako as a character in a beautiful, extravagantly complex and ancient ecological drama that is still playing out, and, in so doing, to appreciate how the coherency, richness and integrity of this drama would be degraded were the kokako to disappear from its cast.

Now, let's imagine that the kokako went extinct. Or, better, let's switch our focus to a very close relative of the kokako, namely the New Zealand *huia* (*Heteralocha acutirostris*), which is in fact already extinct (so, no imagination required). The huia was valuable to humanity for essentially the same reasons that the kokako is valuable. Indeed, where its outward beauty and charisma were concerned, the huia was arguably even more valuable to humanity than the kokako, being foremost among the avian stars of the New Zealand bush (revered as sacred by the Māori, and coveted by Victorian and Edwardian collectors who soon hunted it to extinction). Suppose we were to set about making the huia de-extinct.[1] The method used would probably be *primordial germ cell transplantation* (Shapiro 81, 153–158). It would proceed roughly as follows. The genomes of both the huia and the kokako would be sequenced (with DNA being sourced from museum specimens in the case of the huia), and points of genetic divergence noted. A living cell would be taken from a kokako. The DNA of this cell would be modified, by snipping out any kokako genes that differ from the corresponding huia genes, and by pasting in artificially synthesized huia gene replacements. The now-modified cell would then be prompted to replicate many times, and the resulting collection of reengineered cells would be transformed into so-called 'primordial germ cells'. These cells would be injected into the bloodstream of a foetal chicken, from where they would migrate into the gonads of the developing chicken. The resulting chimeric chicken would, when mature, then be mated with another chimeric chicken, produced the same way. All going well, the birds that hatched from the resulting clutch of eggs would have the genomes, appearance, physiology and behaviour, not of chickens, or of kokako, but of huia – for they will have been conceived by the merging of a huia-like sperm and eggs.

Let's suppose that this is done, not once, but multiple times, with different sets of huia alleles being inserted on each occasion. In this way a founder population of huia-like birds is created that is large enough and genetically diverse enough to sustain a conventional captive breeding program. Eventually huia-like animals produced within this captive breeding program are translocated back into the wild, where (let's suppose) they thrive.

And so, success? Is the huia now extinct no longer? Is it now 'de-extinct'? Has the huia been resurrected, and a great conservation victory won?

Two radically different possibilities suggest themselves. The first possibility is that the newly created huia-like animals *are authentic members of the huia species*. They are not just 'huia-like', but huia 'in the flesh'. They are the 'genuine articles', so to speak, the 'real McCoys'. They are *conspecific* with the huia that died out. In this case the extinction of the huia species will truly have been 'reversed' or 'undone', in the sense that the huia's population size will, thanks to our efforts, have been boosted from zero to a considerably larger number. If this possibility obtains then a great conservation victory will indeed have been won: for we will have succeeded in bringing huia back from the dead, and, what's more (the icing on the cake) in re-establishing a thriving population of huia in the wild.

The second possibility, of course, is that the huia-like creatures that we have gone to such pains to create are, despite their physical similarity to the huia of yore, *not* authentic members of the huia species. They are mere 'fakes', 'copies', 'simulacra', or 'artifices', that – while closely resembling huia in genetic, physiological and behavioural respects – are not genuine huia themselves. That is, they are not *conspecific* with the huia that died out. Thus, the huia species will still have a total population-size of zero and the huia's conservation status will still be 'extinct'. If this possibility obtains then the de-extinction attempt will have been a failure. Rather than resurrecting huia, we will merely have replaced huia with a population of synthetic doppelgängers. Moreover, by releasing these artificial 'pseudo-huia' or 'Franken-huia' we have created into the wild we will, arguably, have further marred and sullied the naturalness of the wilderness itself. The wilderness will no longer be as wild as it was, for the huia-like creatures that now constitute part of its ecology will be technological artefacts, not members of any natural species.

Since we have these two possibilities, we also have a question: viz., which of the two possibilities will in fact obtain if we go ahead and use de-extinction technology to create a population of huia-like animals? I will call this the 'authenticity question'. I frame it more precisely as follows:

> *The authenticity question:* Would a creature created using de-extinction technology, which meets some sufficiently stringent condition for being genetically, physiologically and behaviourally similar to members of an extinct species, *E*, itself be an *authentic member* of *E*, or not?

Let an *authentic de-extinction* be the creation of authentic new members of a previously extinct species. Let a *de-extinction sceptic* be someone who thinks that the answer to the authenticity question is negative, and who thus thinks that authentic de-extinctions are impossible.

If de-extinction sceptics are correct then de-extinction methods will never be able to create authentic new members of an extinct species, no matter how effective these methods might be in creating organisms that are outwardly and inwardly physically similar to extinct organisms. It would follow that synthetic biologists who use expressions like 'de-extinction', 'resurrection biology' and 'regenesis' are, in effect, guilty of promising something they cannot deliver. These terms strongly suggest an ability to *undo* or *reverse* the extinction of a species, but if the answer to the authenticity question is negative then the old conservationist rallying cry that 'extinction is forever' expresses an inviolable truth – a truth that no amount of technological wizardry can get around.

On the other hand, if the answer to the authenticity question is affirmative then de-extinction technology is capable, at least in principle, of delivering on its promises, by genuinely enabling the resurrection of extinct species. The implications of an affirmative answer for wildlife conservation are hard to estimate, but in the long term they would surely be immense.

One way of seeing this is by considering the IUCN's Red List ranking system for the conservation statuses of species (IUCN), which is as follows:

Least concern
Near threatened
Vulnerable
Endangered
Critically endangered
Extinct in the wild
Extinct

Here 'Extinct' is the end of the road; the point of finality. But if one supposes that the answer to the authenticity question was known to be affirmative, and if one looks ahead twenty, fifty, or five hundred years, to a future of ever-burgeoning extinction rates as the Holocene mass extinction unfolds, and to a future of ever-more potent biotechnology, it seems likely we will need to add another category to the bottom of the above list, namely:

Irrevocably extinct

If a species is extinct, yet still salvageable because it is amenable to de-extinction, then it will not be irrevocably extinct, for with our help it might one day cease to be extinct, and move back up the list.[2] On the other hand, if a species' de-extinction is no longer possible – say, because any last vestiges of its DNA have long since degraded to gibberish, or because the species was dependent on an ecology that has been destroyed and cannot be recreated – then it will be not only extinct but irrevocably extinct too. In the brave new world of wildlife conservation that an affirmative answer to the authenticity question would make possible, a species will only truly have reached 'the end of the road' when it becomes irrevocably extinct.

Ways in which species de-extinction technology might conceivably be used in a conservation context include:

(1) Species resurrection.

(2) Triaging and 'managed extinction'. The highest priority species to save when limited resources mean not all can be saved will be those that are not readily amenable to de-extinction, say, for animal husbandry reasons.

(3) Ecological restoration, via the creation of (possibly inauthentic) ecological proxies for lost keystone species. (Shapiro; Turner)

Application (3) might be a useful tool in the conservationist's toolkit even if the answer to the authenticity question is negative, since – as both Shapiro and Turner point out – a proxy for an extinct keystone species could perform a valuable ecological role even if it was not itself an authentic natural species. But applications (1) and (2) will be tenable only if the answer is affirmative.

3. The Genesis Argument Against De-Extinction

De-extinction sceptics have offered various reasons for thinking that the answer is negative. Gunn (1991) contends that it is part of the very concept of 'extinction' that extinctions, properly so-called, are *irreversible*. If this is right then the notion of 'de-extinction' is flatly conceptually incoherent, it being built into the concept of extinction that 'extinctions are forever'. However, Gunn's position has been convincingly rebutted by Helena Siipi (2014), who shows that even if we accept Gunn's characterization of the 'extinction' concept (which we probably shouldn't, since there seems to be no conceptual incoherency in the idea of a species that *was extinct* being *extinct no longer*), then at most it follows that we should not *describe* a species as having ever gone 'extinct' if its numbers fell to zero but were subsequently boosted above zero again. It does not follow that it is impossible to boost the numbers of a species in this way. In other words, at best Gunn establishes only a minor linguistic point, about how we should use the word 'extinction' (and, by extension, 'de-extinction').

Other de-extinction sceptics have argued that the authenticity question should be answered in the negative on the basis that animals created using de-extinction techniques won't be 100% perfect reproductions of their extinct 'forebears' (Shapiro 10, 205; Switek). The recreated animals might fall short of being identical to the originals in any of numerous respects: in protein coding DNA, in regulatory DNA, in so called 'junk' DNA that doesn't perform any protein coding or regulatory role, in epigenetic markers, in mitochondrial DNA, in gut flora, in learned 'cultural' behaviour, in interactions with an altered environment, and so on. However, as I have argued in (Campbell 754), this argument is undermined by the fact that we do not in general declare one species to have passed out of existence and a new species to have taken its place every time there is some small change in the genetics, or physiology, or behaviour, or gut flora, of the species' population. Our species concept is tolerant of variations in the properties of a species' living population over time, provided they are not too extreme. To the degree that it leaves room for a population's properties to vary without the species' integrity being undermined, so too it leaves room for a de-extinction project to be successful even if the 'before' and 'after' versions of the population differ from each other in the same types of sufficiently minor respects. It is a vexed and important question just *how tolerant of change* the species concept might be (the concept is surely vague, not admitting of crisp cut-off points), but it is at least clear that it doesn't require copying to be of *perfect* fidelity.

Both the anti-de-extinction arguments just mentioned are unconvincing. De-extinction sceptics need to avail themselves of a better argument. Is there any such argument in the offing? The 'genesis argument', which will occupy my attention throughout the remainder of this article, might well appear to fit the bill.

The genesis argument turns on the question as to whether creatures created by de-extinction technology would be valuable in all the same respects as the extinct originals they replaced. Let's consider this question in relation to the example of the huia. Would the huia-like products of a de-extinction attempt be valuable in all the same respects as the original huia? Assuming that the newly created birds are sufficiently accurate genetic, physiological and behavioural copies of the original huia, then they would certainly be just as valuable in *some* respects. They would, for instance, be capable of performing the same ecological services (such as seed dispersal) as the original huia. They would be just as outwardly beautiful as the originals. They would be just as functionally beautiful as the originals too, since they would be every bit as capable of surviving and propagating their genes in the New Zealand bush. But the key point to notice is that the huia-like birds we have made would, due to the very fact that *we have made them*, seemingly not possess the *ecological beauty* of the original huia. The original huia were the products of many millions of years of genetic trial and error in the forests of primeval New Zealand, and of countless interactions between ancestral huia and all the numerous other species that have lived in these forests. Their new huia-like replacements will, in contrast, have originated from the drawing boards, DNA synthesizing machines, and intentions (good, or otherwise) of a team of synthetic biologists. The new birds will – so it seems – owe their genesis not to the impersonal forces of evolution operating over enormous stretches of time in the complex environment of the New Zealand bush, but to us. Whereas the original huia were quiescently natural, untouched by the human hand (until, that is, the very end, when we touched and destroyed them), the new huia-like birds will be quiescently artificial, having been created by the human hand right down to their very genetic building blocks. Just as a restored version of a destroyed natural landscape would lack the natural history of the original landscape, and hence lack much of the aesthetic value of the original landscape, so too, it would seem, a de-extinct version of the huia would, in lacking the evolutionary origins of the original huia, also lack the ecological beauty of the originals. The de-extinct 'huia' would for this reason not be true huia at all. They would not be authentic members of the huia species. They would stand in a relation to the original huia similar to the relation that a print of a Picasso stands to the original Picasso: they would be *mere* reproductions. As for the huia, so too for attempts to resurrect other extinct species.

Here, by way of a summary, is a formalized version of this 'genesis argument' against the possibility of authentic de-extinction:

P1. The historical properties of organisms, notably their ancient, evolutionary origins, contribute substantially to their value to humanity (by contributing to their ecological beauty, and thus to their aesthetic amenity value).

P2. The historical properties of organisms that have gone extinct will not be possessed by reproductions of these organisms that have been created using de-extinction technology (because such historical properties are not 'carried over' by the de-extinction process).

P3. If organisms created using de-extinction technology lack a substantial element of what made the original organisms valuable to humanity, then they are not authentic members of the same species.

C. Reproductions of extinct organisms created using de-extinction technology will not be authentic members of the same species.

4. A Refutation of the Genesis Argument

If authentic de-extinction is possible, then the genesis argument must have at least one faulty premise. I will now argue that P2 is false. In explaining why P2 is false, I will begin by highlighting an important weakness in the analogy between restoring a destroyed natural landscape and resurrecting an extinct species. To this end, consider the following pair of cases:

Case 1. I visit a natural landscape, of canyons and coloured rock strata. Impressed by its beauty, I hope that one day my grandchildren will get to see it too. The landscape is, however, destroyed by a strip-mining venture before my grandchildren are born. But the land is subsequently restored, using terraforming technology, to look just as it used to look: new layers of rock are extruded over it, and canyons are carved through this new rock by terraforming machines. One day my grandchildren get to see the *restored version* of the landscape. Has my hope been fulfilled? No. The original landscape was ancient. Its layers of rock had been laid down as sediment in the bottom of a sea millions of years ago. Its canyons had been formed by streams cutting through these layers over aeons. These historical properties of the original landscape, involving its ancientness, were a major contributor to its aesthetic value. It is this *ancient* landscape I wanted my grandchildren to see. The new, terraformed landscape, of brand new layers of rock and brand new canyons, is, for the very reason of its newness and humans' role in making it, not as good, not as aesthetically valuable, as the landscape it has replaced. This is Robert Elliot's point, already familiar from the opening passages of this article.

Case 2. I go into the New Zealand bush, hear a kokako sing, and hope that one day my grandchildren will get to enjoy the same exquisite experience. However the kokako I heard singing eventually dies and turns to dust. So too do all the other kokako that were alive when I heard the kokako sing. But before they all die, many of them reproduce, carrying their lineages forward. And before their offspring die in their turn, many of them reproduce themselves too. Eventually, after many generations of kokako have come and gone, my grandchildren walk into the bush and hear a kokako sing. Has my hope been fulfilled? This time the answer is 'yes'. When I hoped that my grandchildren would one day get to share my experience of hearing a wild kokako sing, my hope was not they would get to hear *numerically the same kokako I heard* – it being perfectly obvious that this particular kokako would be long dead and gone by the time my grandchildren were born. Rather my hope was that my grandchildren would get to hear *some as-yet unconceived* kokako sing, a creature instantiating the same evolved design as the creature I heard, because it was created, via a process of iterated reproduction, from the same stock.

What do these two cases show? Where natural landscapes are concerned, a reproduction is, in general, *not as good as the original*. It is not as aesthetically valuable, because it has a different history than the original, and because its history matters greatly to its aesthetics. The same will typically be true of reproductions of destroyed artworks or of destroyed historical monuments. In contrast, where natural organisms are concerned, a reproduction is normally *every bit as good as the original*. Every natural organism is, after all, nothing but a product of reproduction; of the copying of genes and traits from one generation to the next. It is of the very essence of living organisms that they reproduce, then die. It is not likewise of the essence of natural landscapes (or artworks, or historical monuments) that they reproduce, then die. A natural species is like a relay team, with each generation of organisms passing the baton to the next, before itself dropping by the wayside. Nothing similar is true of natural landscapes.

So much for the disanalogy between natural species and natural landscapes. Now, why is this disanalogy important where de-extinction is concerned and where the soundness of the genesis argument is in question? The answer is simply this: just as natural reproduction involves the copying of genes and traits from one generation to the next, so too does the type of artificial reproduction that is the cornerstone of a de-extinction project. To this extent there is nothing 'special' or 'different' about de-extinction. It is just a way for organisms to reproduce themselves, albeit a way that happens to involve a great deal of technological and human midwifery, and that happens to result in the 'offspring' being born into the world years, decades or centuries after the 'parents' have died. It is, so to speak, a form of 'highly delayed, human-assisted reproduction'. One way for a huia to reproduce her genes and traits is by mating with another huia. Another way for her to reproduce her genes and traits is by being shot by a collector, then stored in a museum, and then used as the genetic template for the creation of new birds by synthetic biologists many decades later.

Let's focus on some particular huia that was shot by a collector. Call her 'Beta'. Let's imagine that Beta's genome is now being used by synthetic biologists to create new huia-like birds. Let's call one of the freshly-minted, de-extinct, huia-like birds that they have created, 'Gamma'. Since Beta was a natural-born huia of the original, ancestral huia population, it is obvious that she possessed a full quota of evolutionary history and associated ecological beauty. According to the genesis argument's second premise, P2, Beta's evolutionary history (and thus her associated ecological beauty) will not be 'carried over' by the de-extinction process to Gamma. But why not? To see why P2 is problematic, notice that Beta was herself the product of reproduction. Beta had a mother – 'Alpha' as we will name her. Alpha had a full quota of evolutionary history and ecological beauty, and in reproducing her genes and traits to create Beta, she transmitted this history and ecological beauty to Beta. Plainly, therefore, it is possible for an organism's evolutionary history and ecological beauty to be transmitted to future organisms via the reproduction of genes and traits. It happens all the time.

Indeed, the mechanism by which it happens is not especially mysterious. By way of understanding the mechanism, consider an analogy. Suppose an architect creates a design for a house. One group of builders then builds a house to the specifications of the architect's design. A second group of builders then builds a second house, by slavishly copying the design of the first house. The second house will not share all the same historical properties as the first house. For example, it will have been built at a later date, by a different group of builders. But the two houses will still share at least one important historical property in common: viz., that *of being instantiations of the architect's design*. The second house inherits this property from the first house by direct virtue of its being an accurate, high-fidelity reproduction of the first house. The general principle here is this:

> *The copying principle:* If A instantiates a design created by X, and B is a high-fidelity copy of A, then B also instantiates the design created by X.

As for the architect and reproductions of houses, so too for evolution and reproducing organisms. What is the historical property of a living organism that underpins its ecological beauty? On a rough first pass, it is the property *of having been designed by natural selection to efficiently reproduce its genes in a given historical environment of evolutionary adaptation*. For example, on a rough first pass the historical property Alpha possessed in virtue of which she was ecologically beautiful was the property *of having been designed by natural selection to efficiently reproduce her genes in the wood-chiselling, insect-, fruit- and leaf-eating, arboreal niche of primeval New Zealand*. Alpha successfully transmitted this property, and thus her ecological beauty, to her daughter, Beta. How did this happen? Well, in just the same way that the architect's design was transmitted from the first house to the second – namely, by the operation of the copying principle. Alpha's genes and traits were of ancient, evolutionary design. These genes and traits were successfully copied, to make Beta. And so Beta's genes and traits were also of ancient, evolutionary design. It is as simple as that. Facts about the evolutionary origins of the huia's design are passed from a copy, to a copy of the copy, to a copy of the copy of the copy, and so on, down the generations.

Now we reach the crucial point. The very same process that results in Beta inheriting Alpha's evolutionary background and ecological beauty will also result in Gamma inheriting

Beta's evolutionary background and ecological beauty. After all, just as Beta was created by the copying of Alpha's genes and traits, so too Gamma is created by the copying of Beta's genes and traits.[3] Admittedly, in the latter case the copying is accomplished by artificial, technological means, and it occurs more than a century after Beta (and all other huia) expired. But this is irrelevant where the copying principle is concerned. Beta's genes and traits were of ancient, evolutionary design. Beta's genes and traits have – let us stipulate –been successfully copied with high fidelity by the synthetic biologists, in order to create Gamma. Thus it follows, by the copying principle, that Gamma's genes and traits are also of ancient, evolutionary design. P2 is, for this reason, false. P2 says that the historical properties of the pre-extinction population of organisms will not be carried over by the de-extinction process to the new, post-de-extinction population. It assumes that there are no historical properties of a thing that will reliably be inherited by a copy of that thing. But the copying principle tells us that this is wrong. There is at least one historical property of a thing that will reliably be inherited by high-fidelity copies of that thing: namely, the property *of instantiating a given design*. And it is precisely this kind of property – a property involving (ancient, evolutionary) design – that underpins the ecological beauty of organisms.

P2 is false for reasons just explained. By why then does it appear so plausible on its surface? One reason for its apparent plausibility is because of the analogy with things like natural landscapes and artworks. It is certainly true that a restored version of a destroyed natural landscape, or a replica of a destroyed Picasso, lacks the history, and thus much of the value, of the original. But as we have seen, this analogy is badly misleading. Natural organisms are always destroyed as a matter of course (i.e., they 'die'), but the historical property they possess that makes them ecologically beautiful is not usually destroyed with them. Rather, this property (of having an ancient, evolutionary design) survives onwards through time, by being transmitted, through a copying process, into descendants of the organisms.

A second reason for P2's apparent plausibility is because of a seeming contradiction in the idea of an animal *artificially created in a biotech lab* having an *ancient evolutionary design*. However, a few moments of careful thought show that any appearance of a contradiction here is illusory. Imagine that Gamma – the newly recreated huia-like bird – is released into the New

Zealand bush. We see her there, probing for huhu grubs in a rotting log with her long curved beak. She is supremely adapted to this environment. With her unique beak, she can readily exploit abundant food sources that no other animal in the forest can access. Whence came the wonderful design Gamma instantiates – a design so perfectly calibrated for forging a living in New Zealand's forests? Did it come from the synthetic biologists who made her? No. They built her, but had no part in designing her. (We can imagine that they wouldn't even know where to begin.) Evolution was her architect. The synthetic biologists merely took the design that evolution laid down and created a flesh and blood animal faithful to its specifications. They did not design her genes. They copied them, from birds in the ancestral population. She is *descended* from these ancestral birds, from which her genes were copied, and so she is part of a phylogenetic lineage, leading back into the depths of prehistory.

In conclusion, although P2 appears superficially plausible, it is in fact false, and the reasons it appears plausible are easily seen to rest on misunderstandings. Since the genesis argument against de-extinction has a false premise, it is unsound. Perhaps there are good reasons to doubt the authenticity of de-extinct organisms, but the genesis argument isn't one of them.

Notes

[1] The huia has a raft of properties that make it an especially promising candidate for de-extinction (Campbell).

[2] Cases in which a species is *both extinct and salvageable* stand in contrast to cases of 'functional extinction', wherein a species is *neither extinct nor salvageable* (as when there is only a single organism left, or as when the remaining population is too inbred to be viable).

[3] Of course, it is crucial for Beta's traits, as well as her genes, to be successfully copied into Gamma; which is to say, for the copied genes to be correctly phenotypically expressed. In order to achieve this the synthetic biologists must not only recreate Beta's genome, but also ensure: (i) that the genome is inserted into an egg cell with sufficiently huia-like physiological and biochemical properties (perhaps a kokako egg cell will do); and (ii) that the egg grows in a sufficiently huia-like developmental environment (perhaps the oviduct of a surrogate chicken mother will do).

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