Ethics of de-extinction and genetic sciences

i) Identify a problem that genetic tools could potentially be, or currently are, used to solve.

Our planet is currently in the process of the sixth mass extinction. A colossal amount of biological diversity has been lost in recent decades. The rate of species extinction is at least one hundred times as much as the normal rate throughout geological time (1). It seems that humans are to blame, as we are responsible for climate change; we co-opt resources, fragment habitats, spread pathogens, introduce non-native species to many ecosystems, and kill some species directly (2). Biodiversity loss at this rate is a huge problem for humanity because it means lessened opportunity for medical discoveries and economic development. This issue needs to be addressed because “ The variety of life is our insurance policy. Our own lives and livelihood depend on it” (3).

“ De-extinction” could potentially fix this problem by bringing back extinct keystone species to increase biodiversity and improve the function and stability of particular ecosystems that humanity is dependent upon.

ii)Outline how the solution would work.

Main method: Creating hybrids/Genetic engineering:

Even if a species is extinct, if there is just one corpse that has been preserved until the current time, we can take DNA from that corpse and mix it with the closest living relative of the extinct species, to produce a creature that is very morphologically similar to the extinct species. The problem with this method is that after something dies its DNA starts slowly degrading. The

half-life of DNA is 521 years (4), which means that every 521 years since the death of the organism, half of their DNA is not viable for mixing with the closest living relative. Therefore bringing back animals that have been extinct for longer periods of time means they will look less like they are supposed to than animals that have only been extinct for short periods of time. For example we can’t de-extinct a dinosaur, as they have been extinct for approximately 65. 5 million years (4), not enough genetic material would remain in a preserved specimen. But it could be possible to de-extinct a woolly mammoth, as they’ve only been extinct for 4000 years, and preserved specimens have enough viable genetic material. The most feasible way to de-extinct woolly mammoths is to grow a “ hybrid elephant” that has had its genome edited (using CRISPR) to have woolly mammoth traits, in an artificial womb. For example, the woolly mammoth genes for specific traits are known from inspecting the DNA of frozen mammoth carcasses.

Other methods:

Somatic cell nuclear transfer:

Cloning :

It’s possible to take a preserved carcass of an extinct animal, extract a nucleus, and insert it into the egg of a close extant relative. Then that egg is put into a surrogate mother to grow. This option is only viable for recently extinct species because an entire cell needs to be preserved.

Artificial insemination:

This method is basically the same as cloning except a preserved gamete is used as opposed to a nucleus, so the product in this case would not be a clone.

Guiding breeding:

We can take a population of the closest living relative to the species we wish to de-extinct and guide their phenotype and genotype through selective breeding. This doesn't really seem like de-extinction to me though, as it will take a long time to achieve an animal that isn't quite the same as the species we want to de-extinct. I think the product of this method would be a " cheap knock-off" compared to our other available methods of de-extinction.

iii) Describe the environmental, economic, and social impacts of the genetic solution. These could be both real and potential impacts

Environmental impacts:

Resurrecting a keystone species and putting them back in their ecosystem could help the overall ecosystem, as the species would once again be able to play their vital role. The Thylacine was an extremely important apex predator in Australia until it went extinct in 1936. (5). Now Australia only has one apex predator, the dingo. Apex predators have extremely important roles in their ecosystems, and it's been shown that dingoes are crucial in maintaining biodiversity in Australia. Relying on only one apex predator is risky, because if something happens to the current Dingo population, the ecosystem would most probably fall apart completely, resulting in huge

losses of biodiversity. Also, Dingoes alone cannot keep down the invasive rabbit population, which have had many significant negative impacts on Australia’s ecosystem, and threaten lots of endemic species. The resurrection and re-introduction of the Thylacine as a top predator seems to be a perfect answer to these problems. The ecosystem could be stabilised, rabbits could finally be eradicated, and overall biodiversity loss could be greatly reduced.

But in most cases this is a very risky proposition, as most extinct species ecosystems have probably changed radically from the time they went extinct to now. Ecologists know that the environment you place a species in can strongly affect what role it has and what impacts it makes, therefore there is no reason to think that any de-extincted species would just re-assume its former place in the ecosystem. Experience has shown that the roles species play change radically over time as ecosystems change. (6) Also it won’t be exactly the same species, it may be very similar but it won’t be a perfect resurrection of a species. History has shown that two very phenotypically similar species can have devastatingly different effects on the environment. Take for example, the common North American reed, (Phragmites). Native variants of *Phragmites* were a mostly insignificant part of wetlands across North America. When very closely related Eurasian variants were introduced, they became impenetrable thickets which outcompeted native plants, disrupted nutrient cycles, and had a significant negative impact on the ecosystem. Now millions of dollars is wasted each year to keep Eurasian Phragmites under control. “ Organisms that look like one another and share genetic material aren’t necessarily interchangeable”. (6)

Economic impacts:

Scientists have predicted that the process of De-extinction would be extremely expensive. Dr Stephan Schuster predicts that it would cost at least 10 million dollars to de-extinct a single woolly mammoth. There would also be the additional cost of maintaining the population of the species that you've resurrected. It doesn't see reasonable to spend so much money, time and resources when the probability of successfully de-extincting a single individual is unknown. There are many potential factors to consider, like how resistant the target species would be to current diseases. Diseases and hosts co-evolve, therefore if we re-introduce a species that has been gone from this world for a significant period of time, it will probably be highly susceptible to a range of diseases that have evolved since the time our species went extinct. Spending at least 10 million dollars and a lot of time, to create one woolly mammoth which dies from a basic disease as soon as it's released into the wild seems like a huge waste. A lot of different individuals would have to be resurrected in order to promote diversity and hence resistance to disease, which would cost an exorbitant amount. This is already looking to be a very costly task that would take a long time, and that's only after considering how to combat a single issue. It's impossible to foresee and plan for all the other potential problems that could present themselves. At this high price, and probable low success rate at this point in time, surely the money and resources would be better spent on maintaining our extant biodiversity instead.

It has been argued that if we resurrected a charismatic animal like a sabre tooth tiger or a woolly mammoth and put it in a zoo, it could eventually pay

for its own de-extinction with all the profit the zoo would make from people coming to see it. This could solve the issue of using money and resources that would be better spent on conservation of extant animals. But this raises the question; is it really ethical to create an animal just to have it live out its life in captivity? I don’t think so.

Social impacts:

However, one positive social implication of a previously extinct animal living its life in a zoo would be increased conservation awareness. There could be entire zoos dedicated to the showcasing of previously extinct animals. These zoos could massively change the attitude people have towards conserving biodiversity by showing them the amazing biodiversity that was lost in past extinction events and then comparing that to the amazing biodiversity that is being lost right now because of the human-induced sixth mass extinction event. This would be a massive step in increasing conservation awareness in the general population.

The other possibility is that “ de-extinction zoos” could have the complete opposite effect. If people think that any animal that goes extinct can just be “ brought back to life”, they may start not caring about conservation at all.

A big ethical problem around de-extincting an organism like a woolly mammoth is that the success rate of Somatic cell nuclear transfer is very low. This year, Chinese scientists created the first primate clones (long-tailed macaques), but they only succeeded in creating two clones, out of the sixty embryos placed in surrogate mothers (7). The closest living relative to the woolly mammoth is the Asian elephant, which is a critically endangered

species that only ovulates approximately once every 18 months. They are the best choice to be a woolly mammoth surrogate mother. I don’t believe that it’s ethical to waste potentially hundreds of Asian elephant embryos on trying to recreate a mammoth when those embryos could all contribute to maintaining the extant, endangered population of Asian elephants.

iv) Make a decision on whether the genetic solution to the problem should or should not be used. Back up your opinion.

I don’t think that De-extinction is currently a good solution to the problem of maintaining and restoring biodiversity. The risks of a) The project of de-extincting a species being a failure and a big waste of money, time and resources, and b) potential unforeseen negative impacts of introducing species into ecosystems that have changed over time from before the species went extinct, are too great. The costs vastly outweigh the benefits. It’s much more ethical to engage in tried and tested practices focused on maintaining the biodiversity of extant species, than to risk resources on this virtuous, yet naïve scheme. De-extinction is simply by no means an effective or efficient way to halt the sixth mass extinction.

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