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A Bioethical Analysis: Should We Use CRISPR To Bring Back Extinct Species

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ABSTRACT

Extinction is a concept that is very well known and for centuries has been considered a direct result of human evolution and change in the environment. Though these reasons stand strong, with recent technology from companies like CRISPR, we can prove that extinction is also a result of scientific causes and with the help of gene-editing, the process of de-extinction is now a possibility. Extinct species such as the woolly mammoth, thylacine and the passenger pigeon are in a process of revival where scientists use the DNA of their closest relatives who are currently existing animals.

A process like this would have been considered impossible and could be seen only in sci-fi movies but now exists as a possibility and not in a realm beyond our reach.This has caused an uproar in the scientific community as scientists cannot determine if this process could help in restoration of habitats and reverse the damage humans have caused over the years or would bringing back these animals be a grave mistake and whether we should interfere or let nature run its course.

This paper evaluates the various possibilities and challenges that can be faced in the process of using CRISPR for de-extinction.

INTRODUCTION

A company in biotechnology, Colossal Biosciences, recently announced their idea and goal of attempting to bring back extinct species, specifically the woolly mammoth, which is a species that has been extinct for nearly 4000 years (Colossal Biosciences), in 2021. Scientists want to do this by modifying the DNA of Asian elephants using certain CRISPR gene editing technology to create animals similar to mammoths that can survive in the Arctic environments (Colossal Biosciences; Shapiro).

CRISPR-Cas9 is an artificially created system for manipulating genomes based on a natural mechanism in bacteria that protects them from viral attacks (Lander). The system mainly includes a gRNA (guiding RNA), which points out the target sequence on DNA and the enzyme Cas9, which serves as molecular scissors that cut DNA at a certain point (Lander; Baltimore et al.). After cutting, the genome can be either disabled or new genetic material can be added to the DNA through the processes of natural repair, thus giving scientists an opportunity to modify genes (Baltimore et al.). Compared to previous genome editing methods, CRISPR-Cas9 is much more efficient and cheaper than other techniques of its kind (Lander; National Academies of Sciences, Engineering, and Medicine).

CRISPR-Cas9 is not used for bringing extinct species back to life by using ancient DNA directly. However, scientists find important genetic variations of extinct animals and insert them into the genome of their nearest living relatives (Shapiro; Church and Regis). For instance, in the case of woolly mammoths' restoration, researchers are currently trying to add important traits of woolly mammoths, like cold-proof hair, fat metabolism, and adaptation to freezing conditions, to the genome of Asian elephants (Colossal Biosciences; Shapiro).

The possibility of de-extinction has sparked conflict between scientists and ethicists. Those in favor of de-extinction argue that bringing back extinct species can help restore habitats, spark innovation for conservation and also increase biodiversity (Shapiro; IUCN). They also argue that they have a moral responsibility to try to reverse the damage humans have caused to ecosystems over the years (Church and Regis). Some also question whether bringing back these extinct species is a justified use of scientific resources (IUCN; National Academies of Sciences, Engineering, and Medicine). Concerns are increasing because scientists wonder if it is right to bring back these animals, considering we don’t have proper habitats for them and this also leads us to question if they would even sustain in this world (Pask et al.; IUCN).

Since CRISPR technology is becoming increasingly advanced, we must decide whether humanity should intervene and attempt to reverse extinction or whether we should let nature run its course. This paper is an overview of the scientific opportunities and possibilities along with ethical and moral concerns that are associated with de-extinction and showcases that although this technology seems promising, it must only be done after ethical consideration.

CRISPR AND THE SCIENCE OF DE-EXTINCTION

De-extinction is a method of restoring the features of extinct animals using the latest biotechnology through insertion of genetic variations in the genome of the closest living relative (Shapiro). The objective of such a study is not to recreate the extinct species from scratch but to develop the proxy species with the major features of the extinct creature (Church and Regis; Shapiro). There have been great advancements in the technology of DNA sequencing and gene editing which made the process of de-extinction more feasible due to the possibility of identifying genes of extinct species and modification thereof (Lander; Baltimore et al.). One of the most efficient technologies in this sphere is CRISPR-Cas9 (Lander). In contrast to the previous gene-editing methods, CRISPR-Cas9 allows for modifying the genes in particular DNA sequence efficiently (Baltimore et al.; National Academies of Sciences, Engineering, and Medicine).

The most well-known example would be the woolly mammoth restoration project, spearheaded by Colossal Biosciences (Colossal Biosciences).The researchers have discovered genes involved in the growth of dense fur, fat metabolism, and adaptations to cold environments (Colossal Biosciences; Shapiro). These genes will then be studied and compared to the genetic makeup of the Asian elephant, which is the closest living relation of the woolly mammoth and shares 99.6% of the same genetic code (Shapiro; Colossal Biosciences).This can be achieved through editing the elephant's genome using CRISPR-Cas9 technology where chosen genes from the elephant are modified or replaced with genetic material similar to the woolly mammoth's (Colossal Biosciences; Lander).There are also efforts to bring back the thylacine and the passenger pigeon, despite the fact that each species presents different difficulties to scientists (Pask et al.; Shapiro).These restoration projects could potentially enhance our knowledge in evolutionary biology, functional genetics, reproductive biotechnology, and species conservation (Church and Regis; National Academies of Sciences, Engineering, and Medicine). However, most extinct species' DNA is too fragmented to completely reconstruct their genome in full, not to mention the fact that many characteristics, such as behavior and development, involve a more complicated interaction of multiple genes (Shapiro). An equally crucial question here is whether the de-extinct species will survive in the existing ecosystem. As the ecosystem, climate, food availability, and everything else has changed drastically over time, the re-created species might find it difficult to adjust or even create unexpected consequences in ecology (IUCN; Pask et al.). Thus, de-extinction can be viewed not only as a technological breakthrough but as an ecological experiment as well.

ENVIRONMENTAL RESTORATION AND CONSERVATION BENEFITS

The idea that de-extinction can help restore certain ecological roles and functions that have been lost because of extinction is another compelling argument in favour of de-extinction (Shapiro; IUCN). There were some species that served as the ecosystem engineers and had an effect on their environment through their activities (Shapiro). Woolly mammoths played a similar role since they preserved grassland ecosystems through trampling and seed distribution and thereby kept permafrost cold (Shapiro; Church and Regis). As such ecosystems reflect more light than the forest areas and thereby play a role in keeping the temperature low, it might be possible to use de-extinction to decrease the thawing of permafrost (Shapiro).

In addition to ecosystem restoration, there have been many innovations in biotechnology from de-extinction research that might help the conservation of living species (National Academies of Sciences, Engineering, and Medicine; Church and Regis). The developments in CRISPR-Cas9, reproductive technologies, stem cells, and genome sequencing techniques are currently being studied to increase genetic diversity in endangered species, improve their immunity against diseases, and facilitate captive breeding programs (National Academies of Sciences, Engineering, and Medicine; Lander). In other words, even if de-extinction does not succeed completely, the science and technologies created by such projects can be used to prevent any future extinctions (National Academies of Sciences, Engineering, and Medicine; IUCN).

Yet, these possible advantages need to be viewed in the light of some critical disadvantages. The ecosystems are extremely complex and have undergone significant changes since the time of extinction of numerous animal species (IUCN; Pask et al.). The climate conditions, the availability of food and the interrelation with other living things may not allow for the introduction of reconstructed animals to be successful (IUCN; Pask et al.). Moreover, there is an opinion among the supporters of conservation that the expensive research conducted to resurrect extinct species might lead to the channeling of the funds and scientific efforts needed for the preservation of currently existing animals into the work on the resurrection of extinct species (IUCN; National Academies of Sciences, Engineering, and Medicine).

ANIMAL WELFARE AND ETHICAL CONCERNS

Among the key ethical issues connected to de-extinction is the welfare of the animals during the process of research itself (UNESCO; National Academies of Sciences, Engineering, and Medicine). The creation of the new extinct creature will require multiple attempts of genome editing, implanting of the embryo into a surrogate mother, and other procedures until finally a living being is created (Shapiro; National Academies of Sciences, Engineering, and Medicine). Some embryos will not develop, some may contain mutations and defects, have low survival rates, etc (National Academies of Sciences, Engineering, and Medicine). At the same time, the use of the procedures described may be quite stressful for the body of the surrogates themselves, especially endangered animals like the Asian elephant (UNESCO; Shapiro).

An additional ethical issue involves the quality of life for animals that will be brought back to life (IUCN; UNESCO). The difference is that unlike other species, de-extinct animals will be entering a world that has undergone a significant amount of transformation since their extinction (IUCN). Their habitat may not be the same anymore; their diet may have changed; and their interactions with other animals may be quite different from what they were before (IUCN; Pask et al.). Therefore, these animals may have problems surviving or acting normally (IUCN; Pask et al.).

Those in favor suggest that such ethical issues may be addressed with further development in biotechnological techniques, methods of reproduction, and animal welfare standards (National Academies of Sciences, Engineering, and Medicine; Lander). Genome editing technologies have enabled greater accuracy of manipulation, while reproductive technologies might minimize failed pregnancies and failed embryo transfer (Lander; National Academies of Sciences, Engineering, and Medicine). Moreover, the strict ethical control of institutions' review boards and animal welfare committees can guarantee that the research is conducted ethically and solely for the benefit of science and conservation greater than its risks (UNESCO; National Academies of Sciences, Engineering, and Medicine).

However, a number of ethicists believe that there is a moral duty on the part of people to conserve the biodiversity that already exists rather than trying to create the species that have become extinct (UNESCO; IUCN). This is because a lot of money, skill, and technology will be required for the purpose of de-extinction, which could otherwise be used for saving endangered species, restoring ecosystems, and preventing future extinctions (IUCN; National Academies of Sciences, Engineering, and Medicine). Thus, even though de-extinction may offer scientific prospects, it will depend upon ethics for acceptance (UNESCO; IUCN).

ECOLOGICAL RISKS AND UNINTENDED CONSEQUENCES

However, despite the potential scientific possibilities provided by de-extinction, there are certain difficulties involved that should not be neglected (IUCN; National Academies of Sciences, Engineering, and Medicine). Ecosystems are complicated systems of interactions formed during thousands of years, and the introduction of extinct species may disturb these systems in an unexpected way (IUCN; Pask et al.). There have been many changes in the habitats after the extinction of the particular species caused by climatic changes, urbanization, habitat destruction, or invasive species' intrusion (IUCN). Therefore, re-created animals may have trouble adapting to current conditions, competing with other species for limited resources, or causing changes in established relationships within the ecosystem (IUCN; Pask et al.).

Scientifically speaking, de-extinction is also constrained by the availability and quality of ancient DNA (Shapiro). In the case of DNA extracted from extinct organisms, there are chances that it may be incomplete, damaged, or in pieces (Shapiro). Consequently, it becomes difficult for the scientists to create the entire genetic makeup of the extinct organism in its precise form (Shapiro; Church and Regis). Therefore, in the case of de-extinction, the genomes of living organisms that are similar to the extinct organisms are used, while some genes related to particular traits are edited (Shapiro; Lander).

One significant limitation is that most biological traits are the product of influences other than just a single gene (National Academies of Sciences, Engineering, and Medicine; Shapiro). Behavior, physiologies, immune systems, and development result from the interactions between many genes and their environments over the lifetime of the organism (National Academies of Sciences, Engineering, and Medicine). As such, even if scientists succeed in duplicating physical traits such as dense fur and resistance to the cold, there is no assurance that their creations would exhibit behaviors, reproduce, or function biologically the same way as their ancestors (Shapiro; IUCN).

In light of such scientific and ecological uncertainties, it is recommended by many scientists that de-extinction should be carried out carefully on a case-by-case basis (National Academies of Sciences, Engineering, and Medicine; IUCN). It is essential to conduct rigorous ecological risk assessment along with setting up a monitoring program before releasing the recreated organisms in the natural environment (IUCN). Even though the development of new technologies in biotechnology opens up new possibilities, there should be some ecological considerations in the de-extinction process (IUCN; UNESCO).

COUNTERARGUMENTS AND LIMITATIONS

Despite being an area of growing scientific interest, there has been considerable debate about the role of de-extinction in biodiversity conservation because many scientists believe that de-extinction does not represent the best way of biodiversity conservation (IUCN; National Academies of Sciences, Engineering, and Medicine). The most frequent critique of de-extinction programs has been that de-extinction requires a lot of money, high technology, and research time that could have been devoted to protecting living endangered species (IUCN; National Academies of Sciences, Engineering, and Medicine). Given the fact that numerous species of animals are endangered due to habitat loss, global warming, pollution, and poaching, some conservation biologists claim that extinction prevention must come before attempts to reverse past extinctions (IUCN).

A further major drawback is the fact that the technology involved in bringing about de-extinction is still experimental and lacks the capability of fully resurrecting the extinct species (Shapiro; National Academies of Sciences, Engineering, and Medicine). The fossilized DNA is incomplete and deteriorated, and this compels the scientists to resort to assembling a genome with the DNA of a living relative of the species (Shapiro). Therefore, the organisms produced through the process will most likely be genetically different from the extinct species and could rather be seen as modifications of the species with some selective characteristics of the species involved (Shapiro; Church and Regis).

However, despite these issues, those who advocate for de-extinction maintain that the field does not compete with conventional approaches towards conservation, but instead, compliments them (Church and Regis; National Academies of Sciences, Engineering, and Medicine). A lot of technological progress made in the field of de-extinction research, such as CRISPR-Cas9, genome sequencing, stem cell biology, and reproductive technology, has proven to have practical applications in the areas of species preservation, enhancement of genetic diversity, and further development of conservation programs (Lander; National Academies of Sciences, Engineering, and Medicine). In addition, scientific discoveries in the area could help gain deeper insights into the field of evolutionary biology (Church and Regis; Shapiro).

Ultimately, the entire issue of de-extinction speaks to the larger issue of the place of humans in preserving biodiversity on Earth (UNESCO; IUCN). In an age where science and technology have made it possible to do so much more than was ever thought possible before, there is the need for society to ponder how best to utilize all these possibilities (UNESCO).

CONCLUSION

Utilization of CRISPR-Cas9 technology for de-extinction purposes is undoubtedly one of the most impressive achievements in contemporary biotechnology (Lander; Baltimore et al.). It is possible to say that through the development of genome editing technologies, scientists were able to push the boundaries of their research further (Lander; National Academies of Sciences, Engineering, and Medicine). In addition to the opportunity to revive extinct species, de-extinction projects helped to achieve considerable progress in genetics, reproduction biology, and conservation science that can be applied for endangered species and to enhance knowledge about the evolution process (Church and Regis; National Academies of Sciences, Engineering, and Medicine). Nevertheless, while there are many advantages associated with these technologies, there are also many ethical, ecological, and technical challenges associated with them (UNESCO; IUCN).

Current evidence suggests that de-extinction should not be viewed as a replacement for traditional conservation efforts but rather as a complementary area of scientific research that must be approached with caution and responsibility (IUCN; National Academies of Sciences, Engineering, and Medicine. Continued advances in biotechnology may make the recreation of extinct traits increasingly feasible, but scientific capability alone does not justify implementation without careful ethical consideration and ecological evaluation (UNESCO; National Academies of Sciences, Engineering, and Medicine). Ultimately, the success of de-extinction should not be measured solely by whether an extinct species can be recreated, but by whether the knowledge and technologies developed through this research contribute meaningfully to biodiversity conservation and the protection of life on Earth (IUCN; UNESCO).

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