



How to Clone a Mammoth: The Science of De-Extinction

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Could extinct species, like mammoths and passenger pigeons, be brought back to life? The science says yes. In *How to Clone a Mammoth*, Beth Shapiro, evolutionary biologist and pioneer in "ancient DNA" research, walks readers through the astonishing and controversial process of de-extinction. From deciding which species should be restored, to sequencing their genomes, to anticipating how revived populations might be overseen in the wild, Shapiro vividly explores the extraordinary cutting-edge science that is being used--today--to resurrect the past. Journeying to far-flung Siberian locales in search of ice age bones and delving into her own research--as well as those of fellow experts such as Svante Paabo, George Church, and Craig Venter--Shapiro considers de-extinction's practical benefits and ethical challenges. Would de-extinction change the way we live? Is this really cloning? What are the costs and risks? And what is the ultimate goal?

Using DNA collected from remains as a genetic blueprint, scientists aim to engineer extinct traits--traits that evolved by natural selection over thousands of years--into living organisms. But rather than viewing de-extinction as a way to restore one particular species, Shapiro argues that the overarching goal should be the revitalization and stabilization of contemporary ecosystems. For example, elephants with genes modified to express mammoth traits could expand into the Arctic, re-establishing lost productivity to the tundra ecosystem.

Looking at the very real and compelling science behind an idea once seen as science fiction, *How to Clone a Mammoth* demonstrates how de-extinction will redefine conservation's future.

How to Clone a Mammoth: The Science of De-Extinction Details

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From Reader Review How to Clone a Mammoth: The Science of De-Extinction for online ebook

Nikki says

The topic contained within How to Clone a Mammoth greatly interests me and this is one of numerous books I've read on ancient DNA. Overall I felt as though Shapiro's writing style was not terribly enjoyable or clearly put forth at times. The book could have been much shorter, especially if all of the repetitive material was removed. Why Shapiro insisted on repeating some things nearly or exactly verbatim numerous times is beyond me because they were never the potentially difficult to understand aspects of ancient DNA. I also felt as though Shapiro attempted to be entertaining with some of her stories but they always fell flat. In addition, Shapiro broke up stories or explanations to interject with other material that could have easily been moved elsewhere to have a smoother transition between stories/topics. Unfortunately I really think Shapiro could have benefited by an editor or a better one because the topic is interesting and she is knowledgeable.

P.S. Elephant DNA sequencing really needs to become a priority considering how decimated by poaching the populations are becoming. I did appreciate Shapiro noting that taking elephant eggs and/or impregnating an elephant in order to birth a pseudo Mammoth was a bad idea considering troubles they are already facing.

Disclosure: ARC received from Netgalley & publisher in exchange for an honest review. (They may regret this.) Any and all quotes were taken from an advanced edition subject to change in the final edition.

Holly Bik says

Shapiro knows how to tell story, and I found her mix of anecdotes and science to be very compelling. Even though I'm a researcher who uses genomics, I learnt a lot about the science behind ancient DNA and attempts to engineer species to be "unextinct".

Edison G.S. says

Very informative content.

This book will be fascinating for anybody into science and evolution. It is very informative; It provided me with interesting new facts but also gave great explanations of concepts I already knew such as PCR.

The book has changed the way I see extinction. So far I have thought that we humans are responsible for the extinction of the majority of species. After reading this book I take a biological approach to this issue. Humans are a species which evolution involves the destruction of other species. If we look at this as scientists, humans are merely surviving. Just as any animal, we seek to expand our territories. Sure we are smarter and should know better and protect the lesser species, but our biological nature moves us towards selfishness instead of thinking about animals and plants or the environment.

Regardless, if we cause a massive extinction, other species will appear and one day even we will go extinct. This book made me think so much about evolution and how de extinction is incredibly challenging and

almost unachievable.

I took out a star because bit was too repetitive at times and a lot of chapter 4 felt like very unnecessary info. There are few mistakes that make it look less professional but nothing too significant.

Polaris Hall says

I really enjoyed this book. It was a great way to be introduced (or reintroduced) to a variety of topics regarding genetic editing, cloning, and de-extinction without getting too heavy. It was a fun read I could pick up anywhere without worrying about having to have a laser-focus to understand.

Cora says

How to clone a Mammoth is a book about the science of de-extinction. The author takes the reader through the current science and answer the questions of what is possible, impossible, and improbable with the science using the projects to resurrect mammoth and passenger pigeons as examples. She answers questions such as is it possible, how is it possible, and if it is should we do just because we can. I think it was a great review of the science that the important questions surrounding it. Shapiro is realistic in her outlook of what the future of de-extinction may look like. I felt like I learned a lot and was able to follow the science presented. There were times, however, that I found myself zoning out reading about some of the genetics (and I have taken a graduate level genetics class) so I am not sure how someone with no background would feel about those passages.

Bethk says

How to Clone a Mammoth: The Science of De-Extinction by Beth Shapiro. Copyright 2015 Princeton University Press. New Jersey.
ISBN 978-0-691-15705-4
Recommended: 5 Star.

I read this book as a pre-release e-book obtained through NetGalley, provided by the publisher.

The book's title certainly gets attention because producing living, giant mammals such as mammoths would get a lot of attention. However, quickly the reader is led to having more realistic expectations of what is being done, or can currently or in the foreseeable future be possible to do to re-create extinct species. I personally found the book to be a fascinating read.

Of course, tiny improvements in the various sciences or discoveries which make de-extinction more plausible make big headlines. However, closer examination shows that many of these things are not possible with current technology nor with existing scientific knowledge. Possibly they could be. But, headlines of "Scientists will soon clone a mammoth" attract much more attention than, "Scientists breed rats which could live where extinct kangaroo rats did."

Technological and scientific challenges of sequencing ancient DNA were discussed, and, contrary to popular

opinion, we have only barely scratched the surface of DNA sequencing of living organisms, including our own and other organisms which are important or detrimental to us. We have a lot more to learn in this regard! Specifically though, the prospect of getting any DNA from long-extinct creatures, such as dinosaurs out of fossils, is not possible. Jurassic Park will forever remain in the realm of science fiction.

Certainly, cloning, or genetically-engineering cells to grow into creatures which are identical to other creatures which are extinct is appealing. However, it may not be possible, and even if it is possible, it might not be the most efficient or economical way to get a creature to take up the biological niche that an extinct species did. Genetic engineering is a controversial topic, and plants or animals which were de-extincted in this fashion might be regulated as GMOs. There was a long discussion of this in the book about what these would be, legally: Endangered species, or would they be GMOs - or would they if they were not intended as food? It might be more efficient to use more tried-and-true technologies such as selective breeding or back-breeding to produce varieties of existing animals or plants which would have similar traits, and take the same ecological niche as the extinct species did. For instance, the ecological effects of having a large, elephant-like mammal roaming the northern tundras and sub-Arctic were explored, but if we selectively bred Asian elephants which are most-closely related to mammoths or even African elephants so they could live and stay warm enough in cold climates, might this not have the same effect? Would it matter if they were not actually the same species as the mammoths that dominated these cold regions thousands or tens of thousands of years ago? The author believes not. It also would not have the same sensationalistic popular appeal, and would not attract donors. Indeed, this could be an expensive project.

Cloning technology may offer one more tool in the ecologist's toolbox to ensure that recently-extinct species are not gone forever once the last one dies. It may be possible to produce a small number of them. Recreating populations in this manner also has challenges, not the least of which would be that they would need to be bred in captivity for at least some time, then protected once they got out.

Much of the book involves ecology. If a species goes extinct, might it cause other species to also go extinct, or might it cause the proliferation of some other species, to the point where they become a pest and cause problems of their own? It also explores how this could cause animal suffering, such as using a smaller animal to gestate a larger one, or harvesting eggs from a female for use in cloning. This will become less of a problem once artificial wombs that can gestate these clones is invented, but it's not here now.

What are all of the ecological ramifications of de-extincting various lifeforms? Is it wise? Why did it go extinct to begin with, and why won't that immediately repeat? Certainly, some things, such as smallpox, are best left extinct. Re-extincting other, beneficial creatures may have ecological effects too, and it might take their former environment some time to re-adapt to their presence, just as it did to their absence.

Melek says

As someone that simply runs away from everything that is related to biology in some way or another, I found *How to Clone a Mammoth* a very interesting science book. It is simple, fun and very informative at the same time. The only possible negative thing about it is that it could have been shorter, I didn't find every chapter necessary, yet 240 pages are short enough for a book like this, so I can't really complain about it.

Updated on 30.06.15: I set the rating as 3/5.

Jake Leech says

This is absolutely superb. Shapiro, a scientist working in this field, covers all the bases of de-extinction in a sophisticated and in-depth manner, but without ever getting too technical. She writes clearly and well, is realistic about the obstacles and limitations involved, and makes a very convincing argument that maybe our cloned mammoths don't have to be perfect, or even super-close copies of the originals.

Daphne says

Decent pop-sci book about cloning, but it did get repetitive. I enjoyed reading from a scientist directly involved in the field, but one part really stuck out for me. She mentioned the idea of cloning carrier pigeons would be unpopular because no one wants a billion of them flying around North Eastern America, but she never acknowledges that there is no requisite that there would have to be 1 billion for a stable population. It just seemed odd she got hung up for several pages about the massive number of potential cloned carrier pigeons when she several times acknowledged that breeding populations for others would/could be much smaller.

Hilary says

Last year I received *Resurrection Science* as an ARC from *Netgalley* and eagerly devoured it. This book was released around the same time, but I was unable to get my hands on it until the local library carried it. I'm quite happy that I was patient enough to get it, as the book was an incredibly rewarding read.

Resurrection Science focused primarily upon the ethical side of de-extinction. It went into the various types of extinction, their causes, and whether or not bringing them back in an abbreviated fashion - forever in captivity, unable to be reintroduced - is that fair? *How to Clone a Mammoth* touched upon these aspects briefly, but failed to really address those aspects of de-extinction in a satisfactory way. Ultimately, however, that is all right. It addressed other aspects of de-extinction quite beautifully.

How to Clone a Mammoth concerns itself with the scientific and practical aspects of the process. The author, Beth Shapiro, is intimately involved with *Revive & Restore* - one of the small number of groups championing de-extinction as a way to revive lost ecosystems and aid in encouraging biodiversity where it has been lost. She goes into detail about the importance of de-extinction on that front, and in turn, how the public often views it differently.

The book is a good work of lay-science, perhaps a bit more sophisticated than Bill Bryson's work in *A Short History of Nearly Everything* but nothing that should put a more casual reader off. She covers the more complex science well, but focuses mainly upon dispelling myths and practical solutions to the problems that may arise.

Personally, being deeply interested in de-extinction and believing in it as a possible solution to some environmental problems, I loved the work. While I do see its capacity for causing potential issues, I ultimately think it will be good - particularly when it comes to places like Pleistocene Park. I hope to see many more books tackling these issues in the near future, and look forward to eventual headlines trumpeting

the return of the mammoth. Even if it's simply, in truth, only an elephant with some mammoth genes. :)

Adam McPhee says

De-extinction is an idea that will become "a reframing of possibilities as momentous as landing humans on the moon was."

This, I believe, is why people like me are so captivated by the idea of de-extinction. Not because it is a means to turn back the clock and somehow right our ancestors' wrongs, but because de-extinction uses awesome, exciting, cutting-edge technology to take a giant step forward. De-extinction is a process that allows us to actively create a future that is really better than today, not just one that is less bad than we anticipate.

I've been enamoured with pleistocene rewilding for some time now. It's such a beautiful dream. You don't even have to resurrect extinct species to start, just restore similar megafauna to the empty spots in an ecological niche. Shapiro's description of a new New Mexico is sublime: donkeys, wild horses, asian elephants and tortoises reintroduced to help restore the landscape, with packs of lions and cheetahs keeping their numbers in check. This, after all, is what North America looked like before humans showed up, and I think we have a duty to restore such a vision. You wouldn't even have to hurt the endangered populations of Africa and Asia to make it happen: the author points out you'll find enough animals just by closing North American zoos.

And that's before you even start cloning extinct species. The author gives a thorough overview of the challenges being faced by those trying to bring back mammoths and passenger pigeons: finding frozen mammoths, mapping and editing the genome, creating a clone (or adapting to the impossibility of such in birds), helping it adapt to its new environment and socializing it, dealing with antiquated and scaremongering GMO laws. There's also plenty of justification for doing so: a large enough herd in Siberia's Pleistocene Park might help regulate the permafrost, keeping all that methane in the ground (though we really would need to get cracking).

I admit some of the hard science went over my head. I'm still not entirely sure how the CRISPR/CAS9 genome editing tool works. And epigenetics, for that matter, still confuses me. But what an idea! The advances made in ancient DNA labs and genome engineering in general are also well documented: glow-in-the-dark chickens and ducks siring chickens and so on.

De-extinction will, of course, be risky. We don't know and cannot predict every outcome of resurrecting the past. The conservation success stories of the present day prove, however, that taking risks can be deeply rewarding. Removing every living California condor from the wild was an extraordinarily risky strategy to preserve the species, but one that undoubtedly saved them from extinction. Restoring gray wolf populations to Yellowstone National Park was both risky and, to a degree, unpopular, but the park is now flourishing in a way that it had not been since its establishment in 1872, when wolves and other predators were actively exterminated. Allowing deer, cattle, and other wild animals to take over abandoned land in Europe was touted as both crazy and dangerous, but these reestablished wilderness areas stimulated a widespread

shift in attitudes toward wildlife. They inspired new policies aimed at protecting natural spaces and the species that occupy these spaces. How will the world react when the first genetically engineered elephants are strolling casually through Pleistocene Park?

I can't wait to find out.

Scott says

How to clone a mammoth? In short, you can't. Also not clone-able? Passenger pigeons. For reasons different from the mammoth. But we might one day genetically engineer animals from close living relative species that contain genes similar to the extinct species, and that may be just as good from an ecological point of view. Interesting stuff without being too technical. Recommended.

Rachel (Kalanadi) says

I get the sense that de-extinction is so new, it doesn't yet provide enough material for a full length book... but too much for an essay. Awkward. This is most likely due to the unengaging writing style, rather than a lack of actual things to talk about, since other books exist on this topic (or at least this is my guess).

This book raises some great questions about the ethics and challenges of de-extinction that I hadn't thought about yet, but became clearly repetitive by the end.

Brian says

Not enough science and too much preaching and pessimism.

I didn't find this book enjoyable to read, the tone of the book made it a total downer.

A better title would have been "We shouldn't and can't clone a Mammoth so stop asking", but I guess no one would have bought the book.

Chloe says

This book was enjoyable, but it felt like a long-winded essay or undergraduate thesis. I guess that's what one should expect with a book with this title - I'm used to reading very informal science-y books aimed at the general public, which tend to jump from topic to topic without much depth. This book, and Beth Shapiro, are clearly from a very academic background, and although I didn't mind it for the most part, a lot of the science went over my head. I think some of these concepts make more sense to me when illustrated, so this wasn't the best format to be presenting genotypes and nucleotides and CRISPRs in. Overall, fun (loved Shapiro's tidbits from the field) but, fair warning, a bit science heavy and academic.

Dan Schwent says

How to Clone a Mammoth: The Science of de-Extinction is a book detailing the trials and tribulations involved in bringing an extinct species back to life.

I got this from Netgalley.

Okay, here's the deal. I found this book very interesting but also very repetitive. After the fourth or fifth description of a possible cloning method, only to have it explained yet again why it wouldn't work for a mammoth, I was ready to commission Bill Bryson to write a cloning book for me.

There were a lot of interesting concepts, like back-breeding, that I'd never heard of. Apparently scientists in Europe have been back-breeding cows to produce something very much like an aurochs for decades. Could the same process be used to create something mammoth-ish from Asian elephants?

The book painstakingly chronicles the trials and tribulations of retrieving intact-ish DNA from frozen mammoth carcasses. Apparently dogs will gnaw bits off of a mammoth carcass once you get it out of the ground.

While de-extincting mammoths was the title feature, other species were covered, like the passenger pigeon, the dodo, and the woolly rhinoceros. I found it really interesting that mammoths survived well into human history and scientists still aren't sure why they went extinct in the first place. There was also some speculation that re-introducing mammoths or mammoth-infused Asian elephants to Siberia could turn the tundra into a grassland in just a few seasons. Interesting things to ponder.

The bottom line is the book covered some interesting topics but could have been more interestingly written. Three out of five stars.

Wanda says

How to clone a mammoth? Well, you can't yet. So this is not an instruction manual. Cloning requires a living somatic (body) cell from a creature and a living egg from the same or a very closely related species. Mammoths are not currently living creatures, therefore, there will be no cloning of mammoths. Cue relief for all the terrified folks out there.

This was a very interesting read, it covered a lot of ground—not just scientific issues, but the moral & ethical issues surrounding the subject too. I found it to be quite balanced—not overly enthusiastic about cloning but not scared to death of the prospect either.

The most interesting things I learned?

1. Birds cannot be cloned. But there are other ways that they can be genetically modified, as the chicken farming industry has discovered.
2. The closest living relative to the mammoth is the Indian elephant

3. There is a Pleistocene Park in Siberia and the animals in it are certainly changing the vegetation (in a good way, if you think the tundra should be greener & more lush)
4. The only DNA you get out of animals trapped in amber is fungal DNA (sorry Jurassic Park).
5. Working with ancient DNA is very difficult because it is so easily contaminated and there is modern DNA just hanging in the air, waiting to contaminate everything!
6. The most likely scenario is to splice mammoth genes into the elephant genome and produce a mammoth-like animal which could play the same ecological role as the ancient animal did.

The author points out quite clearly that bringing back exactly one mammoth would be a bad idea. They, like other elephant species, were very social animals and having a lone individual would be needlessly cruel. Also, any mammoth would have to be raised by elephants and would necessarily be influenced by that upbringing. Its behaviour is unlikely to be genuine mammoth behaviour. Both extant elephant species are endangered, so using females of these species to gestate mammoth babies is probably not a good idea—they need to be producing more baby elephants, not indulging our desires to resurrect an extinct animal (and with a gestation period of almost 2 years, they are already very slow-reproducing animals).

A very interesting read, especially as I went to the movie Jurassic World on the weekend (the SeaWorld like scene with the Mosasaur is awesome and I finally see why my online women friends are enthusiastic about Chris Pratt). Plus, I heard on the radio this morning that cattle geneticists are considering splicing genes to make white Black Angus cattle, which would theoretically be less heat-stressed in this climate-changed world we inhabit. Because I had just finished this book, I actually knew a little something about the process that was being described!

djcb says

Entertaining pop-sci about "de-extinction", ie. the effort to bring back extinct animals, with mammoths being the poster-children, but it also includes e.g. passenger pigeons, dodos and others.

The writer is a one of the prominent scientist in the fields, and provides an overview of the science of de-extinction -- something which is, of course, still something for the future, if ever. There are still many technical hurdles; and by lowering the standards a bit (e.g. targeting slightly hairier elephants instead of "real" mammoths since we don't have its genome) we might be able to get there.

Book also tries hard to show how de-extinction could be *useful*; wasn't fully convinced that de-extinction is the most practical way to solve various environmental problems... That being said, can't wait for mammoths or "mammoth" to make a come-back!

Nikki says

For a title which sounds like a how-to book, this book spends an awful amount of time pointing out the ways in which cloning a mammoth is not possible. A lot of science is stuff I was well aware of, but it's presented engagingly and clearly, so it was still an enjoyable read. It's not purely about mammoths, although they are one of the main species considered: after all, they're thought to have played a significant part in the

sustainability of the tundra they inhabited. A lot of the book concerns cases like that: cases where reintroducing an animal to an ecosystem might bring it back into balance.

Despite science fiction's hopes, cloning an extinct animal is still pretty far off — but it does depend on the methods you use. Shapiro uses a fairly broad definition of cloning, discussing back breeding as well: the process by which a current species is selectively bred to restore features of an ancestral or related species.

There's a lot of interesting stuff here, including an explanation of why you can't clone birds in the same way as Dolly the sheep was cloned. Fascinating stuff, and well presented. And if it's a bit of a killjoy to know that mammoths aren't so easily cloned, I think the interest of the science and discussed ethical issues still makes it worth it.

Originally posted here.

Patty says

So, yes, there is indeed an effort on to bring the Woolly Mammoth back from extinction, either through cloning (led by teams from Japan and South Korea) or through editing the genomes of modern-day Asian Elephants (led by a team from Harvard, with celeb-scientist George Church at the helm). Working on another aspect of the project, Sergey Zimov, assisted by his son Nikita, have already established a nature reserve in remote northeastern Siberia to provide a habitat for the potential mammoths – and of course they have named it Pleistocene Park, because there is no way to talk about this topic without a million references to Jurassic Park. The Zimovs have also provided the impetus for this project by arguing that mammoths would churn the soil and trample the snow as they grazed, thus exposing the permafrost to the freezing temperatures of the air in a Siberian winter, and thereby slowing down global warming.

Shapiro is herself a scientist, one who specializes in recovering and reading Ancient DNA, and it really shows in this book. She understands the science of cloning, sequencing genomes, editing DNA, epigenetic influence on gene expression, and more, and explains it all in a clear and comprehensible way.

She's also the most cynical by far of any of the de-extinction authors I've read; she's skeptical not just of if it's really possible to bring back woolly mammoths, but also if it's a good idea in the first place. She goes deep into many of the arguments against de-extinction and admits that she agrees with many of them. She takes the stance that de-extinction doesn't really "count" unless we can progress all the way to releasing a viable population of the species into the wild, and therefore attention deserves to go to species that will most have a beneficial effect of their ecosystems.

Despite this somewhat negative view, Shapiro is actually involved in a de-extinction project herself (Revive & Restore's effort to de-extinct the passenger pigeon), and I feel like the practicality this gives her infuses the whole book. She's spent years grappling with the questions of how to do this and why, and there's a solidness, a down-to-earthness, to her answers that other authors just don't have. Highly recommended if you really want to know the ins and outs of the science behind de-extinction.
