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Reviving Extinct Animals

January 2000, Ordesa National Park, Spain. It is heavily snowing. Celia, the very last Pyrenean ibex, is seeking shelter under a pine tree.

But, unfortunately, the pine tree gets covered in snow, and it falls down, and it crushes Celia. She's the very last Pyrenean ibex, and she's now dead. She was 13 years old. It was an unlucky year for Celia, and unlucky for her species.

Fortunately, the year before, scientists had caught Celia, extracted cells from her ear, and put them in liquid nitrogen. And even though in 2000 Celia died, her DNA was still preserved and she could be reanimated.

Scientists took Celia's DNA and put it into a developing cell of a closely related ibex species, took the nucleus out of the cell, which contains all of Celia's cell tissue, and then put that inside a closely related ibex species. They waited for those embryos to develop, and then implanted it inside a surrogate ibex in order to give birth. 500 cloned embryos were produced. 154 were implanted into female goats, which were the surrogates. Only five of those surrogates actually became pregnant, and only one managed to give birth.

On July 30, 2003, a very special ibex was born by c-section in a Spanish research facility. She had wobbly legs, toffee colored fur, and dark doe eyes, and she was a genetic clone of Celia. The Pyrenean ibex had been raised from the dead, and it was the first species to be de-extincted. Everybody was in awe. Unfortunately, the cloned ibex had a severe fall and survived for only seven minutes.

It was unfortunate because it meant that the Pyrenean ibex made history for becoming the first animal to be de-extincted, and the first animal to go extinct twice. The technology of de-extinction is here, and it's very real.

Another close call, this time with a rather remarkable amphibian—a specimen of the gastric-brooding frog. It doesn't incubate its eggs in a pond, like most frogs do. Instead, when the eggs are laid and fertilized, the female frog gobbles them up, and the whole incubation takes place in her stomach. For a matter of weeks during which she can't eat, as she's not allowed to secrete any gastric juices, otherwise she'd consume her own offspring. But once they've gone through their metamorphosis, she

can pull the most unbelievable party trick, and she burps up baby frogs. It's called Propulsive Vomiting.

This incredible creature went extinct in 1983. But in 2011, a team of researchers were able to recover cell nuclei from frozen southern gastric-brooding frog tissue collected in the 1970's. They implanted the cell nucleus into a closely related species – the great barred frog. And some of those eggs managed to form embryos, although none of them actually became tadpoles and frogs.

The same technology that's used with de-extinction is also used to clone living species. The first cloned cat, inevitably called Copycat, was born on December 22, 2001, and lived 18 years. Barbara Streisand, when she lost her favorite pooch, Samantha, in 2017, had her cloned twice. Violet and Scarlet were created using cells from Samantha's stomach. Since then, cloning pets has become big business. Barbara paid $50,000 in order to have Samantha turned into two new dogs.

Is Jurassic Park really possible?

Are scientists going to reanimate dinosaurs from amber and have them walking the Earth? The world's smallest dinosaur, which is a relative of the Archaeopteryx, but just just two inches long, the size of a hummingbird, was discovered in amber in Myanmar in 2020. It's about 100 million years old, and its skull is in almost perfect condition.

DNA has a half-life of 521 years. UV exposure and bacteria break it down, and amber is not a suitable medium for preserving it. However, DNA can last much longer if frozen.

In 2022, a Danish research group managed to extract mastodon DNA from glacial sediments that were 2.4 million years old – DNA that could potentially be used for cloning.

This means that some cool animals could be brought back, as this period coincided with the Great American Biotic Interchange (GABI), when North and South America collided. Many animals that had evolved in isolation in South America became part of this exchange. These included giant ground sloths, terror birds, sabre-toothed cats, and an ancient elephant species.

Of course, top of the de-extinction list is the mammoth. And mammoths mostly disappeared at the end of the last ice age about ten thousand years ago. Although they actually remained on a Russian island until just four thousand years ago, there

were still mammoths around at the same time the pyramids were being built. Since mammoths lived in very cold places, their DNA is in abundant supply. One of the most complete mammoths ever found was in Canada. It was discovered by gold miners in 2022 in Yukon's Eureka Creek. So can the mammoth be brought back? Yes, they can.

Colossal Biosciences, a Texas based biotechnology and genetic engineering company, plans to do that. It managed to raise $225 million in order to bring back the mammoth along with the dodo and the thylacine. Its goals are to enrich biodiversity, replenish vital ecological roles, and bolster ecosystem resilience.

One of the looming threats to the world is the melting of permafrost, which lies beneath the Arctic and traps vast amounts of carbon. If it starts melting, it will release enormous amounts of carbon into the atmosphere – twice as much as is currently there. And it is already melting.

Mammoths are ecosystem engineers – they create grassland by eating trees. There used to be a habitat called the Mammoth steppe during the last ice age, and it was the Earth's most extensive biome, spanned from Spain to Canada and from the Arctic to China. Grasslands reflect sunlight better than forests. Permafrost under grassland melts slower than permafrost under forest.

More mammoths = less trees = more grassland = more permafrost. Brilliant. But if there is snow on top of that, rather than making it colder, it insulates, keeps the heat in, and actually the permafrost melts faster. Big mammoths dig it up and create holes, and release some of that heat, and it actually stays much cooler.

How are they going to do that?

With Celia, there was the whole nucleus and the entire genome. In this case, there are just fragments of DNA. Colossal Biosciences will decode the mammoth's genome, and compare it with its closest living relative, which is the Asian elephant. Then using CRISPR gene editing technology, they splice mammoth DNA fragments into the genome of the Asian elephant, and place that fetus into an Asian elephant to give birth. It will be a hybrid of elephant genes and mammoth genes, a sort of mammophant.

How does evolution work?

There is a thought that evolutionary change is really slow, but sometimes it happens really fast. Back in 2017, a British ecologist called Colin Donoghue was studying evolution at Washington University, and was measuring hurricane lizards. There was hurricane Irma and Maria struck the islands that he was working on, and his life got a whole lot more interesting because when he went back and measured the lizards again, he found that the surviving lizards had longer toes because that's how they'd hung on in the hurricane. In the space of just a few years, the lizards' average size of toes changed dramatically.

What does this have to do with mammoths?

Colossal have got their hands on 23 different mammoth genomes, and they go back from 10,000 years ago to 700,000 years ago. That's 690,000 years of evolutionary change, and a lot can happen in that time.

No species stands still. It's constantly evolving alongside its environment. And when these mammoth genomes were mapped, scientists found that there are big differences in the genome that code for the way that mammoths store fat, how much earwax they have, their body odor, their salt taste sensitivity, and the size of their ears. Ear size in particular is quite important because that's how elephants control their temperature. Now is the era of climate change and choosing the right size ears is crucial. This newly created mammophant can possess all sorts of genetic flaws. There is a big problem with this mission.

Very noble goals. Which are going to be deconstructed

Welcome to Pleistocene Park. It exists today, founded by a Russian geophysicist, and consists of a 16-kilometer park filled with around 100 animals roaming freely, including bison, muskox, moose, yaks, horses, and reindeer, all trampling the ground in an effort to keep the permafrost frozen. The park is investigating whether large herbivores can slow or even reverse permafrost thaw. Their studies show that if scientists de-extinct the mammoth, there could be significant climate benefits. Mammoths would help create a mammoth steppe. They'd dig into the snow, allowing the cold to permeate and minimizing the insulating effect. Mammoths

could prevent the carbon dioxide levels in the Earth's atmosphere from tripling. Mammoths to the rescue?

But how many mammoths are required to be created? What is the price tag on that? What's the amount of methane those mammoths are going to produce? Are they going to survive climate change? A Cambridge group of scientists have published a paper in Nature on how climate change killed mammoths. The climate warmed, it got really wet, and that killed the vegetation, and the mammoths starved to death.

Should a different animal be chosen?

What about the auroch? It was also an ecosystem engineer. It was also big, but not as big as a mammoth. The auroch weighed a thousand kilos and was about two meters tall. They roamed all across Europe, and were hunted to extinction in 1672. And like elephants, aurochs created grassland.

European nature thrives in an open habitat mosaic. At Knepp, UK, longhorn cattle are successfully used to perform the role of the aurochs. Oostvaardersplassen, in the Netherlands, pioneered rewilding. Since the 1980s, deer, horses, and cattle have been introduced to manage the habitat. However, the wolf was missing, and as a result, there were too many herbivores, leading to a catastrophe in which many herbivores died.

The group Rewilding Europe has a big plan to bring the aurochs back. But instead of using de-extinction technologies, they are using IVF techniques and backbreeding ancient cattle breeds, as all cattle contain auroch genes. Selective breeding cannot create an auroch, but it can produce a taurine breed. This is the closest possible animal to an auroch, which fills the same ecological niche and helps rewild European habitats.

What does de-extinction often forget?

The biggest concern about these plans is animal behavior. There is a case with the elephant Nzou. They say that elephants never forget, but this particular elephant, who lives in Zimbabwe, has actually forgotten she's an elephant. She was raised with buffalo and now thinks she's one of them.

This sort of imprinting happens, if animals are not raised by their own species. In that case the elephant imprinted on the buffalo, which was all fine until one of the buffalo challenged her over dominance. And she ended up killing the buffalo. And, she has killed 14 to date.

Another example of a project that went a bit awry occurred in Pilanesberg National Park in South Africa. When Pilanesberg was created in the 1970s, there were no elephants, so they were moved from Kruger National Park to Pilanesberg. These were all young, teenage elephants—there were no older elephants. In the early 1990s, the ecologist there discovered a dead rhino. Then he found 12 dead rhinos, and eventually, there were 50 dead rhinos. The culprits he identified were grumpy male teenage elephants, chock-full of hormones. Basically, male elephants go through a period called "must"—a heightened hormonal, testosterone-driven state. In this state, male elephants march around looking for females in heat, with urine dribbling down the backs of their legs, and pick fights. Older males travel solo when in must. But these young, teenage elephants went a bit berserk.

They were full of hormones, and didn't know how to behave. They required adult role models. Six adult male elephants were brought to Pilanesberg, and almost immediately, the problem stopped.

Unless the world desires a lot of randy teenage Frankenmammoths, beating the crap out of muskox in Pleistocene Park, some adult role models will be required there. Not just males, but females too, because females are the matriarchs.

Elephants are incredibly complex social creatures. They can communicate acoustically, visually, through touch, chemicals, and even seismically, they send rumbling messages long distances that they then pick up and listen to through their feet. If scientists recreate a mammoth, or a mammophant, how are these mammoths going to learn how to behave without elders?

Experiments with captive breeding

Captive breeding experiments have not been successful either. Captive-bred animals struggle to be reintroduced into the wild. For example, a panda, which is much less socially complex than an elephant, is essentially solitary for most of the year. But the experiment has not gone well. In the Chinese panda breeding centers in Chengdu and Wolong, the pandas looked like pandas, but they didn’t behave like pandas because they were not raised by wild pandas. Pandas have this reputation for being

pathetic animals that are bad at reproduction. That’s just complete rubbish. Pandas are perfectly capable of reproducing; they just don’t like doing it in a concrete cell.

In the wild, when a female is in heat, she'll mark trees and spread her pheromones around, attracting a bunch of different male pandas, who then have a sort of urinary competition. It’s like a urinary Olympics: the males try to squirt their pee the highest up a tree. Then, the female will sniff to see who reached the highest.

The Chinese have managed to get around the problem of panda reproduction in zoos by using artificial insemination. Many pandas have been created in captivity, but the trouble is that they were raised by humans. In 2006, the first captive-bred panda was released into the wild at Wolong Nature Reserve after three years of wilderness survival training. Ten months later, Xiangjiang was found dead, savaged by wild pandas. He didn’t know how to interact with them and was killed. Raising pandas in captivity and then releasing them into the wild can be compared to throwing a chihuahua into a pack of wolves.

Of the 10 pandas that have been released, nearly as many have died in the process. Two have died in the wild from attacks or infections, and another six have died in a pre-release program. Since 1995, more pandas have been removed from the wild than have been released.

The issue with inbreeding depression

The other part of Colossal's mission is to de-extinct the dodo. In 2021, the Colossal group, using a specimen in Copenhagen's Natural History Museum, sequenced the genome. It should then be compared with the dodo's nearest living relative, the endangered Nicobar pigeon, to figure out which genes will be needed. But why should it be de-extincted?

While mammoths are considered ecosystem engineers, dodos are not. They were responsible for spreading the seeds of the tambalacoque tree, but now tortoises fulfil that role. There's no real need to bring the dodo back, and there’s no place for it to live. The dodo cannot be reintroduced to the mainland because it would not survive. The only place suitable for the dodo, with no invasive species, is a small island off the coast of Mauritius, which still has forests and could essentially serve as a living museum for it.

What will happen then is that they won’t be able to have many dodos, and the population will suffer from inbreeding depression. When there are just a handful of

remaining animals, genetic diversity disappears, and the species can no longer adapt to change, like the hurricane lizards did. It would also be highly susceptible to disease and parasites.

There are only two remaining northern white rhinos: both are females, a mother and daughter. Because no males are left for them to mate with, they are considered functionally extinct—the walking dead. However, there is a plan to use their eggs and sperm harvested from the last male northern white rhino, now deceased, to create test-tube rhinos and implant them into southern white rhinos. The challenge, however, is that even if this process is successful, the genetic diversity will be extremely low.

Colossal has a plan: they are now examining a catalogue of museum samples of northern white rhino specimens from the past, including bones, dry skin, and preserved organs. These samples could be used to extract ancient DNA, which may help restore lost genetic diversity in the cell lines and produce more northern white rhino embryos, ultimately preventing inbreeding.

The black-footed ferret was once assumed to be extinct. Then, a surviving individual was discovered, prompting biologists to gather the last 18 black-footed ferrets and do an intensive breeding program. But these ferrets were highly genetically similar. To address this, cloning technology was used to introduce DNA from another black-footed ferret population that had been frozen and preserved. This led to the creation of Willa, who was three times more genetically diverse than the entire existing population of black-footed ferrets. Two more genetically diverse ferrets were later produced, significantly increasing the genetic diversity of the remaining population. The goal is to establish a stable population of 3,000 ferrets across their natural range. A similar approach was taken with Przewalski's horse.

De-extinction technology becomes viable and useful when used as a tool to support animals on the brink of extinction. It can help prevent genetic similarity, reduce inbreeding depression, and aid in their recovery. However, the biggest challenge remains: where will all these animals live?

There is climate change and habitat destruction. These technological solutions absolve personal responsibility and suggest that science is going to save the world. People don't need to make difficult changes, and can carry on with the consumer culture that's destroying the planet. The de-extinction technology is more of the hubristic thinking that got humanity into this miserable point in the first place.

It's the sort of Elon Musk solution to the environmental catastrophe. But what the planet really needs are holistic solutions that involve people making personal sacrifices and difficult decisions.

Let's focus on the present instead of obsessing over the past. But of course, that isn't as sexy or sci-fi as bringing back the mammoth.