Techno-Wizardry and the De-extinction of Celia the Ibex

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On a cold and misty January 6, 2000, a fir tree in the Ordesa valley of the Spanish Pyrenees fell to the forest floor, crushing the last known individual of *Capra pyrenaica pyrenaica*—an ibex species that had been endemic the mountain range between Spain and France since the late Pleistocene.

As the last individual of her species, this ibex, Celia, was what we have come to call an endling. Her story joins that of other endlings, like Martha the passenger pigeon, Benjamin the thylacine (a carnivorous marsupial commonly known as the Tasmanian tiger), Turgi the Polynesian tree snail, and Lonesome George the Galápagos tortoise. Taken together, endlings form a grim and growing collection of extinction stories—a contemporary compendium of Aesop's fables, warning us about ecological catastrophe. They are, inevitably, stories of how we humans carelessly spend nonhuman species.

Celia's species was the first to be declared extinct in the new millennium, a harbinger, perhaps, of species loss and an embodiment of the sixth mass extinction we're living through today. What is particularly poignant about Celia's story, however, is what happened to her and her species in the years immediately following her death and her species' extinction.

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For tens of thousands of years, Celia's species has been known by many names. In English, it's an *ibex*. In Aragonese and Spanish, it's a *bucardo*; a *herc* in Catalan; a *bouquetin* in French. Although we don't know what Pleistocene peoples called the animal, we do know that Upper Paleolithic artists in contemporary Spain and Portugal painted them in panels of their cave art along with aurochs (a European wild ox that went extinct in the 1600s), bison, mammoths, deer, and horses. *Capra pyrenaica pyrenaica* was one of four subspecies of Iberian ibex, two of which are still alive today. This ibex—this bucardo—is an important character in the history of de-extinction and a story that is often overlooked in today's flurry of entrepreneurial enthusiasm about reviving long-dead species.

According to the *Oxford Dictionary of Biology*, "de-extinction" is the "the process of resurrecting species that have gone extinct." Catapulted into popular imagination thanks to Michael Crichton's *Jurassic Park*, the idea that humans could take an animal that had been dead for thousands of years—millions, even—and breathe new life into it is now comfortably part of our cultural lexicon. In the novel, dinosaurs are cloned from ancient dinosaur DNA extracted from mosquitoes trapped in amber. Outside of the novel—for scientists and entrepreneurs actively pursuing de-extinction today—the methods for such resurrections vary, from selectively back breeding wild populations to resemble the lost species, to editing individual genes. However, a fundamental assumption remains:
that what is lost can be found; that what is gone can be recovered. That it is possible to walk back and "correct" history. And in 2003, we saw this science fiction become reality—for a matter of minutes.

De-extinction through cloning is often pitched as a last best effort to save a species when other conservation efforts have failed. In the case of the Pyrenean ibex, ecologists attempted crossbreeding programs in the late 1990s to try and expand the ibex's limited gene pool and see what other ibex subspecies could fill Celia's ecological niche. These programs were unsuccessful, as the ibex population dwindled from three, to two, to one. Nine months before Celia was crushed to death, park rangers and researchers successfully trapped and tranquilized her on April 20, 1999, and took a clipping from one of her ears to gather genetic material. There was an urgency to cryogenically preserving Celia's genetic material because cells collected while she was alive offered the best possibility—the best last resort—that she could be cloned after she was dead.

With Celia's death, cloning efforts to bring the species back to life began in earnest. Using a technique developed in the 1990s known as somatic cell nuclear transfer (the same method used to clone Dolly the sheep in 1996)—a laboratory team in Zaragoza, Aragón, began the complicated, time-consuming, intensive process of cloning Celia. These cloning attempts meant that hundreds of embryos were

transferred to either a pure Spanish ibex subspecies, or to a hybrid of a Spanish ibex male and a domestic goat. Some pregnancies terminated spontaneously and there was only one "success." A single ibex clone was born on Wednesday, 30 July 2003.

> "One bucardo female weighing 2.6k was obtained alive, without external morphological abnormalities," the team clinically reported in its scientific paper, published in *Theriogenology* some six years later. "Although the newborn displayed a normal cardiac rhythm as well as other vital signs at delivery (i.e. open eyes, mouth opening, legs and tongue movements), it suffered from severe respiratory distress after delivery and died some minutes later."

In short, the clone lived for seven minutes and then *Capra pyrenaica pyrenaica* went extinct a second time. A subsequent necropsy revealed that the clone had died of a lung pathology.

Wednesday, July 30, 2003 [was] a turning point in the history of biology. For on that date, all at once, extinction was no longer forever," geneticist George Church and science writer Ed Regis jubilantly—evangelically, even—declared to their readers in *Regenesis: How Synthetic Biology Will Reinvent Nature and Ourselves*, published in 2012. Synthetic biology combines genetic engineering with evolutionary biology, and with other biological disciplines, to actively design or redesign organisms with new, "useful," and human-centric purposes. This sort of bio-enterprise was, of course, subjected to harsh critique in Michael Crichton's sci-fi worlds. Back in Zaragoza, Aragón, though, *Jurassic Park* wasn't fiction. Those seven minutes seemed to prove that extinction wasn't necessarily the end of the evolutionary line for a species.

Which begged the question, however: now what? Now that it's possible to resurrect a species—at least for seven minutes—what do we do with that? What species should be next?

For almost twenty years, the answer was "nothing." Although the successful cloning of Dolly the sheep is widely acknowledged to have ushered in an era of stem cell research that has had wide-ranging effects, no other organism has yet been brought to life the way Celia's clone was. But interest and appetite for creating a long-extinct organism has been re-kindled since 2022, when the start-up bio-engineering company Colossal Biosciences, founded in 2021 by Harvard and MIT-based geneticist George Church and serial entrepreneur Ben Lamm, recently announced it will "de-extinct" a thylacine and a woolly mammoth—each one an icon of extinction and loss in its own unique way.

Thylacines, known in historical records as Tasmanian tigers, wolves, or hyenas, had dark, distinctive stripes running from behind

the shoulders to the tail, short, rounded ears, powerful jaws, and dense, short fur. They were marsupials (like kangaroos and koalas) and their females carried joeys in a back-opening pouch. Around two million years ago, thylacines were found in mainland Australia as well as Tasmania; by the time European settlers arrived on Tasmania, historical estimates suggest that there was a population of roughly 5,000 thylacine individuals.

Thylacines were hunted to the brink of extinction by European settlers, erroneously convinced that thylacines were a threat to their sheep. By the 1930s, several thylacines still lived in captivity as the numbers of the species dwindled. *Thylacinus cynocephalus* went extinct in Tasmania when the last known individual—an endling we now call Benjamin—cruelly died in captivity in 1936. By the end of the twentieth century, the thylacine had become a mascot and a warning in Australia and Tasmania, spurring on legislation to protect other threatened and endangered species.

Charitably, bringing back the thylacines—a species that isn't very far removed from living memory—could be a way of making up for the vicious, systematic way that humans hunted the species to extinction and callously allowed Benjamin to die locked out of his enclosure one cold winter night in Hobart. Penance, perhaps. Realistically, though, it is just too little, much too late.

Moving much further back in time and to other continents, woolly mammoths (*Mammuthus primigenius*) roamed across glaciated Europe, Asia, and North America for hundreds of thousands of years, becoming extinct roughly ten thousand years ago. (Some relict populations lived as recently as four thousand years ago.) The exact cause of their extinction has been debated for decades—whether their demise was driven by humans overhunting them in the Pleistocene, or whether woolly mammoths were unable to survive when the world's climate changed millennia ago, a warming that ended the last glacial cycle.

It's an understatement to say that woolly mammoths capture the imagination, and have done so for centuries. As long as people have thought about the Pleistocene, these massive proboscideans have stood out as icons of an Ice Age. It's hard to argue that a woolly mammoth couldn't offer an imagined peaceful, primordial Pleistocene here in the twenty-first century's world-literally-on-fire-all-the-time Anthropocene.

In Colossal's laboratory world, a baby woolly mammoth—or, more accurately, a baby woolly mammoth-adjacent organism—will be created by combining woolly mammoth DNA with Asian elephant DNA, via CRISPR gene editing, and then transferring an embryo to gestate in an Asian elephant's womb. Unlike Celia, however, this sort of woolly mammoth isn't a copy of an organism that has ever existed, but rather a uniquely twenty-first century animal.

According to its website, Colossal claims that "[combining] the science of genetics with the business of discovery, we endeavor to jumpstart nature's ancestral heartbeat. To see the Woolly Mammoth thunder upon tundra once again. To advance the economies of biology and healing through genetics. To make humanity more human. And to reawaken the lost wilds of Earth. So we, and our planet, can breathe easier."

But—and here's the catch—it is left as an exercise to the imagination precisely which tundra these woolly mammoths will thunder across amid today's melting permafrost. Or how a genetically modified elephant makes humans more human. Or how offering investors a chance to create a Mr. Snuffleupagus jumpstarts nature's ancestral heartbeat. The environment in which this woolly mammoth lived is long gone, its social context extinct along with its species. As a myriad of people have long pointed out in a plethora of ways, de-extinction via cloning is a very narrow definition of a species and a very limited understanding of what "bringing it back" would entail. The idea that a historical organism—or a historical species—could successfully and ethically exist outside of its historical context requires a, shall we say, colossal degree of mental flexibility.

Despite overwhelming scientific obstacles, a legion of logistical issues, and never mind the, well, mammoth ethical questions that surround this "de-extinction," there's still a heroic romanticism to bringing back an extinct animal. Recycling soda cans, or riding the bus to reduce a carbon footprint, seems like laughably mundane green behavior compared to seeing a long-extinct species in the flesh. This techno-wizardry—this extravagant *ta-da*! showiness of producing a new organism—offers a neat, sleek "product" with a hazy go-to-market strategy that somehow manages to acknowledge human-perpetrated species loss without the bother of having to solve big, complicated problems associated with our human-driven environmental destruction.

Woolly mammoth calves are, purportedly, expected in 2025.

Twenty years ago, de-extinction was still, more or less, the stuff of science fiction. "In 2003 the word 'de-extinction' didn't exist," cultural geographer Adam Searle pointed out to me in an interview. "De-extinction is something we're currently in the process of trying to figure out. And part of that is how we tell stories of de-extinction now."

Incidentally, amid the techno-brouhaha of bringing a thylacine and a woolly mammoth back to life, Celia is curiously—tellingly—absent. Colossal's website, for example, has a primer on how CRISPR technology works, but there is no mention of Celia or her story. (There is a page on their site devoted to elephant conservation with the note, "Preservation is a key component of de-extinction. From

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the Asian to the African elephants, all Elephantidae species are in trouble due to climate change, disease and habitat loss. Colossal is working to help them. Before it's too late.")

In the current zeitgeist of de-extinction, Celia and *Capra pyrenaica pyrenaica* slide into the background. It's almost as if we can't decide whether Celia's de-extinction story should be read as a proof of concept or as a cautionary tale, so we simply don't engage with it. "You have to wonder what the story will look like and how it will be told in 50 years," Searle observed.

It's possible that the story of Celia and current de-extinction attempts are, actually, not as removed from *Jurassic Park* as we might like to think. Searle spent his graduate career studying Celia's story, compiling a cultural history through a series of ethnographic interviews. He found that most tellings of the "Celia the ibex" story focus on cloning, and on the hope that we hang on a technological fix for addressing threatened species. But Searle also found that in Torla, the village near where Celia died, she was known as "Laña the bucardo," where she was a symbol of conservation and a firm connection to people's geographic identity. In other words, there is more to the animal than her double extinction.

"What might it mean, then for ibex to return?" Searle wrote in one of his academic publications about Celia in 2020. "These animals are not bucardo—rather, they are ecological and cultural proxies. The ways in which they are understood to *belong* in the Pyrenees is not straightforward, but shaped by myriad issues linked to tourism, hunting, and nationalism, among others."

In other words, even if another ibex is cloned in another lab, it will never be a bucardo—that moment is gone, as well as the species. (Crichton actually made this very point back in 1990, before Celia's clone had eked out seven minutes of life, and before bio-engineering startups were actively working to recreate iconic, extinct species.) Take that one step further and any mammoth, any thylacine, any organism without its context and narrative is simply an organism without a species. It's a character in search of a narrative.

Today, conservation efforts for two other subspecies of ibex have created cautious optimism about ibex populations rebounding in the Pyrenees. In a different sort of de-extinction story, populations of ibex—primarily western Spanish ibex—have been introduced in the French Pyrenees in an effort to rewild the species in much the same way that the takhi (Przewalski's horse) has been rewilded into

Mongolia. Fall 2020, for example, saw something like 70 ibex kids born in France, in a part of the Pyrenees where the ibex had previously been found and then hunted to local extinction, much as they had been in Spain. These ibex—this population—is a uniquely twenty-first century animal, filling the niche of the extinct Pyrenean ibex.

The population now stands at roughly 400 individuals. ▲

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