Will we kill off today's animals if we revive extinct ones?

De-extinction hopes to revive mammoths, gastric frogs and other missing species, but it might undermine the conservation of creatures that still survive.

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The rebirth of an extinct frog species may come from the freezer, not the stomach. The gastric brooding frog, when it existed on Earth, swallowed its eggs, transformed its stomach into a womb and vomited up its young once sufficiently grown. But the frog disappeared from the mountains of southern Australia shortly after it was discovered in the 1970s, persisting only as a few frozen specimens in the bottom of a scientist's freezer.

The cells in those tissues should have been ruptured by the swelling ice crystals that formed within and around them. But some of the cells remained reasonably intact, according to paleontologist Michael Archer of the University of New South Wales in Australia, who is attempting to resurrect the species via his Lazarus Project. He and his colleagues transplanted the nucleus of that cell and others like it into hundreds of eggs from a closely related species. "Last February we saw a miracle starting to happen," Archer announced for the first time to the crowd at the TEDx De-Extinction event on March 15 at the National Geographic Auditorium. "One of them began to divide." (Archer's group has not published the work yet.)

While tadpoles may be a long way off, let alone a viable frog, the southern gastric brooding frog might be the first species brought back from the dead permanently. The first de-extinction happened in 2003, although it lasted all too briefly. Scientists coaxed a clone of an extinct ibex from Spain to birth from a special hybrid goat. But the cloned bucardo bore a third lung and couldn't breathe properly, dying within 10 minutes.

Although this early effort failed, the growing cohort of resurrection projects raises a central question: Does extinction mean forever, anymore? If not, do we have an obligation to bring species back? "If it's clear that we exterminated these species, we not only have a moral obligation to see what we can do about it but a moral imperative to do something if we can," Archer argued. The new science of synthetic biology aims to make it possible for him to fulfill that moral imperative.

Sixth extinction

Humans have killed off many species, both iconic and common. A lighthouse keeper's cat Tibbles—aided by a few feral cats perhaps—caught and killed nearly every single Stephens Island wren just as they were discovered by science in 1900. Hungry sailors ate the Steller's sea cow to death within a century of its discovery. The Xerces Blue butterfly disappeared with the sand dunes from San Francisco in the 1940s as

that city swelled. The American chestnut, once the most abundant tree in eastern North America, succumbed to a fungal blight imported from Asia by humans.

"As a human species, we have been amazingly efficient at making things extinct," noted conservation scientist Kate Jones of University College London at the TEDx DeExtinction event.

As the extinction rate swells thanks to habitat loss, over-hunting and human-induced climate change, the world may be on pace to lose half of all species by the end of this century—a reality dubbed the sixth extinction because it would represent the sixth mass die-off of life in Earth's history. Of course, the other five were caused by climatic, planetary or astronomic events.

The de-extinction effort is being led by a group of scientists and others, ranging from synthetic biologist George Church of Harvard Medical School to environmental gadfly Steward Brand of the Long Now Foundation and its Revive & Restore project. They have banded together to see if new genetic tools might enable them to bring back even more species, as Archer is attempting to do with the gastric brooding frog. Their first target is the passenger pigeon, which once was so abundant it darkened the skies of eastern North America.

A similar bid by scientists in South Korea to revive the woolly mammoth—an even more scientifically challenging feat because it has been extinct for thousands of years—may garner the most attention, however. And no need to stop there; extinct human species, like the Neanderthal, could be revived as well, or even sabre-tooth cats—although species that have been extinct for more than a few thousand years are unlikely to be found preserved with enough DNA intact to permit their restoration. (Say goodbye to Jurassic Park.)

As the bucardo example shows, however, de-extinction will be no easy feat. For the bucardo, scientists will not only need to get a female clone to survive, they will also need to find a Y chromosome to make a male bucardo and then stitch that into the cloned DNA. Another approach, championed by Robert Lanza of Advanced Cell Technology, is to forego cloning and instead create stem cells from the ancient DNA. That would then enable Lanza or other scientists to create sperm or egg cells that bear the DNA of endangered or extinct species—and can provide the genetic code to restore or resurrect them.

Going from DNA to a stem cell of some kind, that is then coaxed into becoming a sperm or egg cell, and finally grows into a mammoth, however, is a process still beyond even the most advanced genetic science. "You cannot realistically change one or 10 percent of a genome and have that go to term," Lanza noted in an interview with *Scientific American*, which is the reason for multiple implantations when attempting to impregnate. But "this is the beginning. It's not going to stop."

Furthermore, as paleogenomicist Beth Shapiro of the University of California, Santa Cruz, reminded the TEDx audience, creating an embryo is just the first step in bringing any extinct species back. There is also the mammoth challenge of restoring the world—or at least the ecosystems—that the elephant relatives inhabited, among other hurdles. And given the perilous plight of still extant elephant species, humanity has yet to show that it can manage the survival, let alone the revival, of a pachyderm.

Keep it cool

Still, there are lessons to be learned from the mammoth, not least the importance of cold. The Arctic "is the best place for the long-term preservation of DNA," Shapiro said. "It's cold and it's been cold for at least the last million years."

Just as mammoth DNA has waited in the Siberian tundra, preserved by constant cold temperatures, the cold of the San Diego's frozen zoo may be the key to ensuring that today's biodiversity makes it through the next few centuries of the Anthropocene intact. This ark, maintained at a steady -197 degrees Celsius, holds the cells of 503 mammals, 170 birds, 70 reptiles and 12 amphibians and fish—out of an estimated 10 million animal, plant, microbe and fungal species on the planet. The collection displays a bias toward charismatic megafauna and thus against the uncharismatic microfauna that keep the planet alive. The cold Svalbard seed vault in Norway performs the same function for crops—species that, despite their importance to us, have dwindled in biodiversity as genetic engineering has created specialized variants that now dominate the landscape.

Some conservationists also pour cold water on the very idea of de-extinction, worrying that it could enable the extinction of yet more species by diverting funds from proven efforts to sustain them, such as protected areas, intensive management of small surviving populations, even advertising campaigns to reduce the consumption of endangered species. We might bring the mammoth back while letting its relatives slip away. "At this moment, brave conservationists are risking their lives to protect forest elephants from armed poachers," noted biologist David Ehrenfeld of Rutgers University at TEDx. "And we're talking in this safe auditorium about bringing back the woolly mammoth?"

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