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News

Ancient polar-bear fossil yields genome

Oldest mammalian DNA sequence reveals link to brown bears.

Matt Kaplan


A fast evolver, but not fast enough to avoid climate change.*Ø. Wiig/University of Oslo's Natural History Museum*

DNA from a 110,000–130,000-year-old polar-bear fossil has been successfully sequenced. The genome, from a jawbone found in Svalbard, Norway, in 2004, indicates when polar bears (*Ursus maritimus*) diverged from their nearest common relative, the brown bear (*Ursus arctos*).

Because polar bears live on ice and their remains are unlikely to be buried in sediment and preserved, polar-bear fossils are very rare. So even the discovery of a jawbone and canine tooth — the entirety of the Svalbard find — is impressive. But far more important, is that when molecular biologist Charlotte Lindqvist, then at the University of Oslo's Natural History Museum and now at the University at Buffalo in New York, drilled into the jaw, she was able to collect intact mitochondrial DNA.

Mitochondria — organelles found in animal cells — have their own DNA and can replicate. And because there are many mitochondria per cell, mitochondrial DNA is easier to find in fossils than the nuclear DNA.

Lindqvist wondered whether this mitochondrial DNA could illuminate the evolutionary history of how and when polar bears diverged from brown bears. To find out, she worked with Stephan Schuster, a molecular biologist at Pennsylvania State University in University Park, and a team of colleagues to sequence the genetic material she had collected.

Bring the bear necessities to life

The team found that the mitochondrial DNA strands were fragmented and partly degraded. The strands of mitochondrial DNA were broken up and some of the base pairs, such as adenine and cytosine, were altered by decay. Even so, because the DNA was preserved in a region so dry and cold, it was less damaged than is usual for such ancient DNA.

 The cold and dry conditions where this ancient polar bear jaw and canine were fossilized kept DNA within well preserved.*Ø. Wiig/University of Oslo's Natural History Museum*

The team used high-throughput sequencing to isolate short fragments of DNA. Because the DNA from many mitochondria was mixed in the fossil, the team got many reads for exactly the same sections. This meant that the researchers could detect and compensate for degradation events.

It is the oldest mammalian mitochondrial genome yet sequenced — about twice the age of the oldest mammoth genome, which dates to around 65,000 years old.

"Many researchers would have thought it impossible to retrieve DNA from a bone specimen as old as this polar bear," says Eske Willerslev, an evolutionary biologist at the University of Copenhagen. "The result is a true eye opener — it gives hope to future projects trying to genome sequence truly old bone specimens."

Wherever I wander, wherever I roam

The researchers then compared the fossil DNA sequence with the DNA sequences of modern brown and polar bears. They found that the fossil DNA shared many of the gene sequences found in brown bears and lacked many that polar bears have. This raised the question of whether the ancient bear lived like a polar or brown bear.

A comparative analysis of stable isotopes in the fossil's canine tooth with isotopes collected from the teeth of modern polar and brown bears showed that the fossil bear's diet was similar to that of modern polar bears — mostly marine mammals such as seals and small whales. There was no evidence that the bear had fed on the mix of freshwater fish, land mammals and plants that make up the brown-bear diet. Palaeontologists also excavated fossils of arctic marine animals in the sediment where the bear fossil was found. These indicated that the animal had clearly been living in an arctic marine environment as modern polar bears do and not the inland locations that brown bears prefer.

"Morphologically and behaviourally it was a polar bear, but genetically, it was almost a brown bear. This fossil is amazing since it looks to be pretty much at the exact point when polar bears split from brown bears," says Lindqvist.

The team reports in *Proceedings of the National Academy of Sciences* that the fossil indicates polar bears broke away from the brown bear lineage not more than 150,000 years ago and evolved from being terrestrial predators into their modern niche of ice-dwelling hunters in just 10,000–30,000 years[1].

"This is one of the most exciting things to come up in polar research in the past 20 years," says Ian Stirling, an ecologist at the University of Alberta in Edmonton, Canada. There have been questions about whether polar bears diverged from brown bears a million years ago or more recently, he says, and "it is great to see such strong data clarifying that the divergence is recent".

Yet their history of quick adaptation will do little to help the bears survive global warming. "Extremely fast from an evolutionary perspective is tens of thousands of years, not decades. If warming continues at the high rate that we are seeing today and the bears' ice habitat is destroyed, the species is going to be in serious trouble," says Lindqvist.

References

1. Lindqvist, C. *et al. Proc. Natl Acad. Sci. USA* advance online publication doi:10.1073/pnas.0914266107 (2010).