Ancient DNA from rare fossil reveals that polar bears evolved recently and adapted quickly

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A rare, ancient polar bear fossil discovered in Norway in 2004 is yielding a treasure trove of essential information about the age and evolutionary origins of the species whose future is now seen as synonymous with the devastation wrought by climate change.

A paper published in the current issue of the Proceedings of the National Academy of Sciences by researchers at the University at Buffalo, Penn State University, the University of Oslo and other institutions is filling in key pieces of the evolutionary history of polar bears and brown bears, including their response to past climate changes.

"Our results confirm that the polar bear is an evolutionarily young species that split off from brown bears some 150,000 years ago and evolved extremely rapidly during the late Pleistocene, perhaps adapting to the opening of new habitats and food sources in response to climate changes just before the last interglacial period," says Charlotte Lindqvist, PhD, research assistant professor in the UB Department of Biological Sciences and lead author on the paper with Stephan C. Schuster at Penn State's Center for Comparative Genomics and Bioinformatics.

"Very few polar bear fossils have been found, leading to widely varying estimates of exactly when and how polar bears evolved," explains Řystein Wiig, polar bear expert and co-author at the University of Oslo's Natural History Museum. "Because polar bears live on the ice, their dead remains fall to the bottom of the ocean or get scavenged. They don't get deposited in the sediments like other mammals."

But in 2004, an Icelandic geologist found a rare, well-preserved, 110,000- to 130,000-year-old jawbone and canine tooth fossil in the Svalbard archipelago of Norway. This specimen was subsequently sent to Wiig for analysis.

UB's Lindqvist, who was working at Oslo's Natural History Museum as a postdoctoral researcher, extracted DNA from the sample after drilling into the bone and tooth to obtain the powder to analyze.

When she arrived at UB in 2008, she obtained tissue samples from modern polar bears and brown bears and began analyzing them at UB's New York State Center of Excellence in Bioinformatics and Life Sciences after starting the collaboration with Schuster at Penn State.

This work resulted in the sequencing of the complete mitochondrial genome of the fossil; they then used that information to develop mitochondrial sequencing of the other bears and to construct phylogenies

showing that the ancient polar bear evolved within the lineage of brown bears.

"Since the brown bears from Alaska's Admiralty, Baranof and Chichagof Islands are the polar bears' closest relatives, it was crucial to include them in our study in order to more precisely date when polar bears appeared as a distinct species," Lindqvist explains. "The fact that our ancient polar bear lies almost directly at the splitting point between this unique group of brown bears and polar bears, that is, close to their most recent common ancestor of the two species, was very intriguing. It provided an ideal opportunity to ultimately settle the time of polar bear origin."

"This is, by far, the oldest mammal mitochondrial genome to be sequenced," says Schuster. "It's about twice the age of the oldest mammoth genome that has, to date, been sequenced."

The mitochondrial genome refers to all the DNA in the mitochondrion, the energy-producing component of most eukaryotic (complex) cells. Lindqvist explains that ancient DNA studies have tended to focus on the mitochondrial genome because it generally reveals characteristics useful for evolutionary analyses and allows for DNA to be retrieved from ancient samples most easily.

To conduct their analyses, the researchers used a variety of techniques, including isotope analyses, high-throughput genomic sequencing, bioinformatics and phylogenetic analysis, which traces evolutionary relationships among species.

While their data demonstrate how adaptive polar bears have been historically, Lindqvist cautions against assuming that they will, therefore, also be able to adapt to current and future changes in the Arctic.

"We have found that polar bears actually survived the interglacial warming period, which was generally warmer than the current one," she says, "but it's possible that Svalbard might have served as a refugium for bears, providing them with a habitat where they could survive. However, climate change may now be occurring at such an accelerated pace that we do not know if polar bears will be able to keep up."

Ultimately, she notes, the polar bear species may prove less adaptive.

"The polar bear may be more evolutionarily constrained because it is today very specialized; morphologically, physiologically and behaviorally well-adapted to living on the edge of the Arctic ice, subsisting on a few species of seals," she says.

Lindqvist and Schuster are considering working on sequencing the nuclear genome of the ancient polar bear, work that they expect will reveal even more about polar bear evolution.

Provided by University at Buffalo

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