Woolly mammoths evolved smaller ears and woolier coats over the 700,000 years that they roamed the Siberian steppes

April 7 2023

A photo of a woolly mammoth tusk, from which the authors sequenced the entire genome. The tusk was discovered in northeastern Siberia in 2015 and has been radiocarbon dated to ca 18,000 years before present. Credit: Love Dalén

A team of researchers compared the genomes of woolly mammoths with modern day elephants to find out what made woolly mammoths unique, both as individuals and as a species. The investigators report April 7 in the journal *Current Biology* that many of the woolly mammoth's trademark features—including their woolly coats and large fat deposits—were already genetically encoded in the earliest woolly mammoths, but these and other traits became more defined over the species' 700,000+ year existence. They also identified a gene with several mutations that may have been responsible for the woolly mammoth's miniscule ears.

"We wanted to know what makes a mammoth a woolly mammoth," says paleogeneticist and first author David Díez-del-Molino of the Center for Palaeogenetics in Stockholm. "Woolly mammoths have some very characteristic morphological features, like their thick fur and small ears, that you obviously expect based on what frozen specimens look like, but there are also many other adaptations like fat metabolism and cold perception that are not so evident because they're at the molecular level."

To identify genes that were "highly evolved" in woolly mammoths—meaning they had accrued a large number of mutations—the team compared the genomes of 23 Siberian woolly mammoth with 28 modern-day Asian and African elephant genomes. Twenty-two of these woolly mammoths were relatively modern, having lived within the past 100,000 years, and sixteen of the genomes had not been previously sequenced. The twenty-third woolly mammoth genome belonged to one of the oldest known woolly mammoths, Chukochya, who lived approximately 700,000 years ago.

"Having the Chukochya genome allowed us to identify a number of genes that evolved during the lifespan of the woolly mammoth as a species," says senior author Love Dalén, professor of evolutionary genomics at the Center for Palaeogenetics in Stockholm. "This allows us to study evolution in real time, and we can say these specific mutations are unique to woolly mammoths, and they didn't exist in its ancestors."

A photo of study co-author Marianne Dehasque working in the ancient DNA lab at the Centre for Palaeogenetics in Stockholm. Credit: Jens Lasthein

Not surprisingly, many genes that were adaptive for woolly mammoths are related to living in cold environments. Some of these genes are shared by unrelated modern-day Arctic mammals. "We found some highly evolved genes related to fat metabolism and storage that are also found in other Arctic species like reindeer and polar bears, which means there's probably convergent evolution for these genes in cold-adapted mammals," says Díez-del-Molino.

While previous studies have looked at the genomes of one or two woolly mammoths, this is the first comparison of a large number of mammoth genomes. This large sample size enabled the team to identify genes that were common among all woolly mammoths, and therefore likely adaptive, as opposed to genetic mutations that might only have been present in a single individual.

"We found that some of the genes that were previously thought to be special for woolly mammoths are actually variable between mammoths, which means they probably weren't as important," says Díez-del-Molino.

Overall, the 700,000-year-old Chukochya genome shared approximately 91.7% of the mutations that caused protein-coding changes in the more modern woolly mammoths. This means that many of the woolly mammoth's defining traits—including thick fur, fat metabolism, and cold-perception abilities—were probably already present when the woolly mammoth first diverged from its ancestor, the steppe mammoth.

A photo of study co-author Love Dalén with the Yuka mammoth, whose genome was included in the analyses. Credit: Ian Watts

However, these traits developed further in Chukochya's descendants. "The very earliest woolly mammoths weren't fully evolved," says Dalén "They possibly had larger ears, and their wool was different—perhaps less insulating and fluffy compared to later woolly mammoths."

More modern woolly mammoths also had several immune mutations in T cell antigens that were not seen in their ancestor. The authors speculate that these mutations may have conferred enhanced cell-mediated immunity in response to emerging viral pathogens.

Working with ancient mammoth DNA comes with a slew of hurdles.

"Every step of the way, things are a bit more difficult, from fieldwork, to lab work, to bioinformatics," says Díez-del-Molino.

"Apart from the field work, where we have to battle both polar bears and mosquitos, another aspect that makes this much more difficult is that you have to work in an ancient DNA laboratory, and that means that you have to dress up in this full-body suit with a hood and face mask and visor and double gloves, so doing the lab work is rather uncomfortable to put it mildly," says Dalén. "I would like to highlight Marianne Dehasque, the second author of this paper, who did the herculean effort of performing lab work on most of these samples."

All the mammoths whose genomes were included in this study were collected in Siberia, but the researchers hope to branch out and compare North American woolly mammoths in the future. "We showed a couple of years ago that there was gene flow between woolly mammoths and the ancestors of Colombian mammoths, so that's something that we will need to account for because North American woolly mammoths might have been carrying non-woolly mammoth genes as well," says Dalén.

More information: Genomics of adaptive evolution in the woolly mammoth, *Current Biology* (2023). DOI: 10.1016/j.cub.2023.03.084

Provided by Cell Press

Citation: Woolly mammoths evolved smaller ears and woolier coats over the 700,000 years that they roamed the Siberian steppes (2023, April 7) retrieved 23 June 2024 from https://phys.org/news/2023-04-woolly-mammoths-evolved-smaller-ears.html