MAMMOTHS AND MASTODONS

TITANS OF THE ICE AGE

at the San Diego Natural History Museum

July 4-November 11, 2013

Educator Guide

Presented by The Field Museum

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The Field Museum

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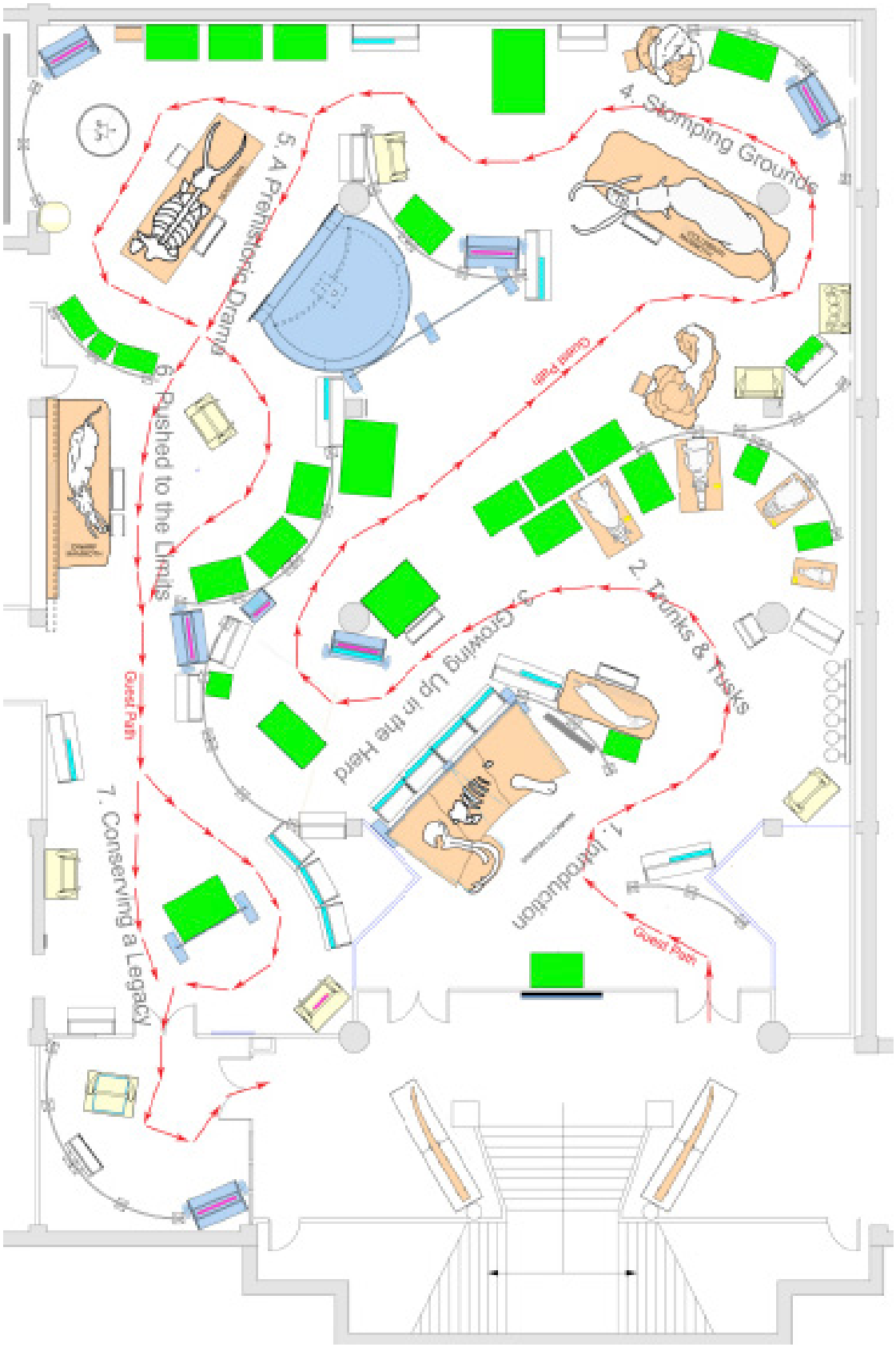
Walking Map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Mammoths and Mastodons: Titans of the Ice Age

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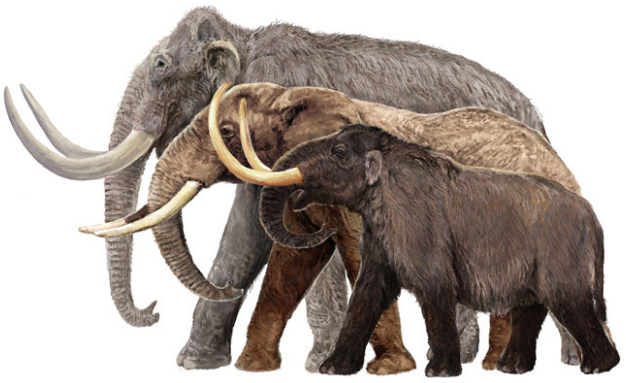

This sketch shows a Columbian mammoth, an African elephant, and an American mastodon (from back to front). *Illustration by Velizar Simeonovski*

Millions of years ago, colossal mammals roamed Europe, Asia, and North America. From the gigantic mammoth to the massive mastodon, these creatures have captured the world's fascination. Meet "Lyuba," the best-preserved baby mammoth in the world, and discover all that we've learned from her. Journey back to the Ice Age through monumental video installations, roam among saber-toothed cats and giant bears, and wonder over some of the oldest human artifacts in existence. Hands-on exciting interactive displays reveal the difference between a mammoth and a mastodon, offer what may have caused their extinction, and show how today's scientists excavate, analyze, and learn more about these amazing creatures. Explore the lives of these mysterious titans of the Ice Age at the San Diego Natural History Museum.

Main Themes

The following themes are threaded throughout the Mammoths and Mastodons exhibition and may be useful in framing how the exhibition connects with your curriculum:

- Mammoths evolved into several different species and inhabited diverse environments on four continents.
- Mammoths and mastodons came to have an important role in the lives of early humans.
- The natural history of mammoths and mastodons is inferred through their remains found throughout the world and by studying their relatives, modern elephants.

Correlation to Standards

Mammoths and Mastodons: Titans of the Ice Age is correlated to the California State Content Standards. Full text of standards available at http://www.cde.ca.gov/index.asp

Science

All grades- Abilities necessary to do scientific investigation and experimentation.
Grade K- Life Science 2, Earth Science 3b
Grade 1-2- Life Science 2a–d, Earth Science 3d
Grade 3- Life Science 3a–c
Grade 4- Life Science 2, 3a–c
Grade 5- Life Science 2c
Grade 6- Ecology
Grade 7- Genetics; Evolution; Earth and Life History; Structure and Function in Living Systems
Grade 9-12- Biology/Life Science; Ecology; Evolution

History-Social Science

Kindergarten- Learning and Working Now and Long Ago 4.2, 6.3
Grade 1- A Child's Place in Time and Space 2.4
Grade 6–12- Chronological & Spatial Thinking; Research, Evidence & Point of View; Historical Interpretation

Planning for Learning

- This educator guide provides an overview of the themes and content presented in *Mammoths and Mastodons.* We encourage you to explore the exhibition first-hand before visiting with students. Upon booking a program, Educators presenting a valid educator ID receive free general admission to the Museum. (3D movies are not included in general admission)
- Visit the exhibition website to read more about mammoths and mastodons, access an online photo gallery and view additional resources: fieldmuseum.org/mammoths.
- We suggest planning your field trip around the use of one to two galleries or one theme in multiple galleries to focus your students' learning experience. Focused Field Trip suggestions are provided in this guide. When conducting field trip activities, please be conscious of traffic flow.

How to Use this Guide

- For every gallery in the exhibition we provide a **Gallery Overview** and **Guiding Questions** – questions that can be answered through exploration in each gallery. Guiding questions are a great way to focus your students' learning. The answers provided are brief and may be expanded by exploring the exhibition and its website: fieldmuseum.org/mammoths.
- This guide provides **Focused Field Trip** activities. A focused field trip includes a pre-visit activity, an activity to do within the exhibition, and a post-visit activity. Use the activities as they are, or modify them to suit your instructional needs.
- **Additional Resources** and **Key Terms** are provided at the end of the guide.

Trunks and Tusks: Meet the Proboscideans

Elephants, mammoths, and mastodons belong to a group of mammals called **proboscideans** (pro-bo-SIH-dee-ans). The name comes from the proboscis or trunk, a feature many of these animals share. The first proboscideans appeared in Africa about 55 million years ago. Over many generations, they evolved into over 150 different species that ranged across the globe.

The proboscidean family tree traces the ancestry of mammoths, mastodons, elephants and their relatives back through 55 million years of evolutionary history. From their cradle of evolution in Africa, proboscideans dispersed into Asia, Europe, and eventually into the Americas. In Africa, scientists have found nearly complete fossil skeletons of one of the earliest proboscideans *(Moeritherium)*, but complete skulls are rarely found. To understand what these animals looked like, scientists create composites or combinations of skull parts from different individuals.

This skeleton of an American mastodon shows the beast's tusks have a more pronounced curve than those of today's elephants.
Photo by John Weinstein © The Field Museum

Guiding Questions:

1. **Are mammoths the ancestors of elephants?**

   No. Neither animal is the ancestor of the other. Instead, mammoths and elephants are close relatives and belong to the same family, Elephantidae. In Africa, about six million years ago, a branch of Elephantidae split into three groups: Loxodonta, *the ancestors of African elephants;* Elephas, *the ancestors of Asian elephants; and* Mammuthus, *the earliest mammoths.*

2. **Where did the first proboscideans originate? From there, where did they disperse?**

   The first proboscideans originated in Africa. From there they migrated into Asia and Europe. The proboscideans that migrated into Asia then crossed over into North America on the Bering Land Bridge. Once in North America proboscideans spread throughout the continent and eventually into South America.

Growing up in the Herd: The Life of a Mammoth

This illustration shows four female woolly mammoths in their herd. Fossil records indicate that herds consisted of adult females and young calves. When male mammoths reached young adulthood, they left their herd.
Illustration by Velizar Simeonovski © The Field Museum

What was life like for young mammoths? How were they raised and nurtured? Who were their family members? Scientists try to answer these questions by studying evidence such as fossil bones, tissue remains, and DNA. They also observe living elephants to better understand the likely behaviors and lifecycles of mammoths.

About three million years ago, mammoths extended their range beyond Africa by moving into Eurasia. Over time, these mammoth populations became isolated from one another, eventually evolving into new species as a result of adapting to different environments.

Sometimes, nearly intact mammoths are found in the permafrost of Siberia, providing scientists with a wealth of information about their lives. During much of the Pleistocene, or last great Ice Age, large herds of woolly mammoths roamed the Earth. Because many of these animals lived and died in cold, dry regions, their remains are often well preserved, giving scientists much to study.

Lyuba is the most complete and well-preserved mammoth specimen ever found—and the most studied. This female woolly mammoth died in Siberia about 42,000 years ago. She was about one month old at the time of her death. By studying her DNA, bones, stomach contents, internal organs, teeth and tusks, as well as the area where she was found, Lyuba provides scientists with valuable information about a population of mammoths for which few samples exist.

An international team of scientists studied Lyuba after her discovery, performing an autopsy and DNA analysis. *© RIA Novosti*

Guiding Questions:

1. **What parts of Lyuba are scientists using to learn about her life history? What have they learned?**

   Scientists are studying Lyuba's well-preserved DNA to learn more about mammoth history in Siberia. Her teeth help scientists determine how long she spent in her mother's womb, when she was born, and her approximate age when she died. Lyuba's intestines show what kind of nourishment she received. X-rays and CT-scans combined with forensic examinations reveal Lyuba's distinctive mammoth features and her bone structure. Examination of Lyuba's trunk, mouth, esophagus and trachea help scientists suggest her cause of death.

2. **What was one adaptation that resulted from mammoths living in cold environments?**

   Mammoths eventually evolved thick fat layers beneath their skin. They also had a warm "undercoat" of fur and an "overcoat" of guard hairs—some up to three feet in length—to protect against the wind.

Stomping Grounds: Where Mammoths Roamed

As one group of proboscideans dispersed out of Africa, about 20 million years ago, they moved across Europe and Asia into the Americas. Over their long evolutionary history, proboscideans were able to adapt to diverse environments: Asian elephants in tropical forests; woolly mammoths in cold, dry steppes; and mastodons in temperate woodlands. In the American West, Columbian mammoths shared the landscape with other animals and plants. Today, scientists use clues from the past, such as plant pollen and animal dung, to help re-create diverse mammoth habitats.

Visitors to *Mammoths and Mastodons: Titans of the Ice Age* will be able to see fossil skulls, as well as life-size replicas of these ancient beasts.
© http://www.paleoart.com

In the early 1800s, the first scientific expeditions to Siberia collected remains of woolly mammoths. These early discoveries sparked the public's fascination with woolly mammoths and their wintry habitats. In places like Siberia and Alaska, cold permafrost helps preserve mammoth remains, and the abundance of woolly mammoth bones here often leads people to believe that mammoths only lived in snowy, cold climates. But in fact, during the last Ice Age, many of these areas were drier and less snowy than they are today. Different species of mammoths lived in warmer climates, but their remains are often less well preserved in these regions.

During the Pleistocene, or last great Ice Age, mammoths lived alongside many other mammals—many now extinct. They shared their North American habitat with other herbivores like rabbits, antelopes, camels, horses and giant ground sloths—the largest herbivores after mammoths and mastodons. Powerful carnivores also populated these regions: dire wolves, short-faced bears, and American scimitar-toothed cats—perhaps the most successful predators of mammoths.

Guiding Questions:

1. **Why do some people think woolly mammoths only lived in snowy, cold climates?**

   Some people think this because these are the environments where ancient animals' remains preserve well. Mammoth remains do not preserve as well in warmer climates; thus fewer remains are uncovered in areas characterized by warmer climates.

2. **How do scientists better understand what the mammoth diet was in a particular region?**

   Scientists analyze mammoth dung to determine what mammoths ate. For example, preserved mammoth dung from a cave in Utah named "Bechan" contains fragments of vegetation suggesting a diet rich in grasses, sedges, and other plants. These plants suggest that Utah, during the time of the mammoths, was fairly dry with pockets of wetlands.

A Prehistoric Drama: Sharing the Stage with Humans

For tens of thousands of years, humans lived alongside mammoths and mastodons. Early peoples painted images of mammoths inside the caves of southwest Europe. And in North America, people hunted both mammoths and mastodons with spears. Some scientists hypothesize that humans directly caused the extinction of mammoths and mastodons. Others suggest that climate change was to blame. Whatever the cause, by 12,000 years ago, nearly all mammoths and mastodons had disappeared from mainland Eurasia and North America.

Thomas Jefferson, America's third President, was also a naturalist. He commissioned William Clark (of "Lewis and Clark") to go west after Clark had returned from his exploration of the Louisiana Purchase to collect mastodon bones for Jefferson's private collection. During his 1807 expedition to Big Bone Lick, Kentucky, William Clark uncovered spear points along with the bones of mastodons. Clark's find was the first to suggest that early peoples once hunted mastodons in North America.

In addition, depictions of mammoths from Paleolithic times have been found in Eurasia, but no prehistoric images of mammoths are known to exist in North America. In 2007, however, underwater archaeologists found what appears to be a rock carving of a mastodon in Lake Michigan's Grand Traverse Bay. And in 2009, an amateur fossil hunter in Vero Beach, Florida, found what appears to be an engraving of a mastodon (or mammoth) on ancient bone. Scientists are trying to authenticate both objects.

Humans were clearly influenced by these great beasts. This depiction of a mammoth, painted on the walls of Rouffignac cave in France, dates back 15,000 to 20,000 years ago. *© Jean Plassard, Grotte de Rouffignac*

Guiding Questions:

1. **What was the first evidence in North America that people once hunted mastodons?**

   Spear points found alongside mastodon bones in Kentucky. William Clark found these remains during an 1807 expedition requested by then president Thomas Jefferson.

2. **What is one physical difference between mammoths and mastodons?**

   Mastodons are shorter and stockier than mammoths and evolved differently shaped skulls, tusks and teeth. Mastodons evolved cone-shaped cusps on their molars adapted to pulverizing leaves, twigs, and bark while mammoths have more flat ridges which are better suited to a diet rich in grasses.

MAMMOTHS AND MASTODONS
TITANS OF THE ICE AGE

Pushed to Their Limits: Mammoths in Miniature

As the last mammoths became isolated in the far corners of the Northern Hemisphere, an interesting thing happened, they actually shrank in size. Over time, mammoths evolved smaller bodies as their range diminished. Rising sea levels, due to melting ice sheets, trapped some mammoths on islands. Other mammoths swam to and colonized islands, such as California's Channel Islands. Here, smaller mammoths were adapted to island life better than their larger, mainland cousins.

The pygmy mammoth of California's Channel Islands was only about the size of a large horse and was a separate species from its close relative, the larger Columbian mammoth of the mainland. This mammoth species was specially adapted to island life where smaller mammoths had the advantage; they ate less food and were more agile, navigating hillier terrain more easily than their massive mainland cousins and also were not under predatory pressure from large carnivores.

Some groups of woolly mammoths survived on small islands well past the end of the Pleistocene. Woolly mammoths lived until 5,700 years ago on St. Paul Island, Alaska; and some roamed on Wrangel Island, Siberia, until about 3,700 years ago.

Guiding Questions:

1. **How were pygmy mammoths better adapted to changing climate than larger mammoth species?**

   Pygmy mammoths were better able to adapt to life on an island because they ate less food and were more agile, and thus better able to navigate the hilly terrain. This smaller body size was advantageous on the smaller islands.

2. **How did some mammoths end up living on islands?**

   Rising sea levels from melting ice sheets trapped some mammoths on islands. Other mammoths swam to islands, like California's Channel Islands.

This atlatl (spear thrower) is a carved reindeer antler in the shape of a mammoth. *© The Trustees of The British Museum / Art Resource*

Unlike dinosaurs, mammoths and mastodons lived side-by-side with humans. This piece of mammoth ivory, carved in the shape of a horse, is one way humans utilized mammoths—as a vehicle for art. *© Reunion des Musees Nationaux / Art Resource*

Conserving a Legacy: The Surviving Cousins

The evolutionary cousins of mammoths and mastodons–elephants–are still with us today. But for how long? As human populations expand into once-wild places, elephant populations in Africa and Asia are declining. Scientists are investigating the extinction of mammoths and mastodons to gain insight into the conservation of elephants today. Zoologists, park rangers, and everyday people are working around the world to save the last of the great proboscideans.

The savanna elephant is one of two surviving species of elephant in Africa today. The other is the forest elephant. Savanna elephants travel in matriarchal herds—family groups led by older females. Male elephants leave the herd as teenagers and live mainly solitary lives. In the late 1800s, an estimated five million savanna elephants roamed Africa. Today there are less than half a million, due largely to poaching and diminishing habitat caused by climate change and competition with humans. Savanna elephants are at home in the grasslands of Africa, and wild populations currently survive in southern Africa, eastern Africa, and parts of western Africa. African forest elephants, however, are at home in the tropical and subtropical forests of Africa. Currently, wild populations of forest elephants live in West and Central Africa. Like the savannah elephant, wild populations of the forest elephant have dramatically declined during the 20th Century to an estimated 100,000 individuals, primarily due to hunting, poaching, and habitat loss.

The Asian elephant is the most endangered species of elephant in the world today. Current estimates suggest that only about 30,000 Asian elephants survive worldwide. They are at home in tropical and subtropical forests of southeast Asia, and current wild populations survive in India, Nepal, Bhutan, Bangladesh, Sri Lanka, Myanmar, Thailand, Laos, Cambodia, Vietnam, China, Malaysia and Indonesia. Escalating threats to survival of this species come from the rapidly expanding human populations in Asia, which in turn are driving the loss, degradation, and fragmentation of elephant habitat.

Guiding Questions:

1. **What is the most endangered species of elephant today? Approximately how many of these elephants still survive? Where are these elephants found?**
   The Asian elephant is the most endangered elephant species today; only about 30,000 survive worldwide. Wild populations are found in India, Nepal, Bhutan, Bangladesh, Sri Lanka, Myanmar, Thailand, Laos, Cambodia, Vietnam, China, Malaysia, and Indonesia.

2. **What is a matriarchal elephant herd?**
   An elephant family led by older female elephants. African savanna elephants travel in matriarchal herds. Male elephants leave the herd as teenagers to live predominantly solitary lives.

Mammoths and Mastodons: Adaptations and Environments

Corresponds with various galleries in the exhibition.

Pre-Visit Activity

Assess students' prior knowledge of mammoths and mastodons by asking: what do you know about mammoths and mastodons, what did they look like, where did they live? Capture student knowledge through a KWL chart, illustrations, or a brief write-up. Provide students with a basic introduction to proboscideans, share some images of mammoths and mastodons, and explain that these large mammals lived in diverse environments. Use the models of mammoth and mastodon teeth (available through the Nature to You Loan Library http://www.sdnhm.org/education/teacher-resources/nature-to-you-loan-program/) to introduce the concept that mammoths and mastodons were adapted to survive in the environments in which they lived.

Field Trip Activity

At the Museum, visit the *Mammoths and Mastodons* exhibition. Ask students to gather information about three proboscidean species: Columbian mammoths, American Mastodons, and pygmy mammoths. Students should sketch the mammals and record information about their adaptations specific to the environments in which they lived. Be sure the students look for the models of teeth examined in class; these are located in *Mammoths and Mastodons: Titans of the Ice Age* as well as our very own *Fossil Mysteries* Exhibition.

Post-Visit Activity

Once back in the classroom, ask students to artistically recreate the animals they studied, carefully illustrating the adaptations and environments of each species. You may want students to create large murals or even dioramas demonstrating their knowledge of these proboscideans. Have students add labels to the murals or dioramas, stating specific adaptations and how the adaptation helped the species survive in its environment. Once complete, ask students to present their findings using their final project.

Students can share their learning with the world by contributing to the Encyclopedia of Life. Add text and comments on the mammoth's diet, habitat, and life style. Scan and upload student's drawings and they may appear on the mammoth page. For more information on how to use the Encyclopedia of Life, visit education.eol.org/educators/mammoths_mastodons.

Science Today: Life of Lyuba

Corresponds with the **Growing up in the Herd: The Life of a Mammoth** *and other galleries.*

Pre-Visit Activity

Ask students to explore National Geographic's *Waking the Baby Mammoth* on-line interactive about Lyuba at channel.nationalgeographic.com/episode/waking-the-baby-mammoth-3630/Overview22#tab-interactive (be sure that students only explore the "interactive"; the other information on the site will be examined in later activities). After investigating, ask students to share what they think life was like for Lyuba and possible causes for her death. Scientists have asked these same questions and are also currently working to identify the answers. Since mammoths are no longer living, how do students think scientists learn about Lyuba? What evidence do scientists use to reconstruct past mammoth life?

An artist's rendering of what Lyuba might have looked like while alive. Lyuba is the best-preserved baby mammoth ever discovered. *Illustration by Velizar Simeonovski © The Field Museum*

Field Trip Activity

At the Museum, enter the ***Mammoths and Mastodons*** exhibition and go to the Growing up in the Herd gallery. Once there, have students gather information about how and what scientists have learned about Lyuba. More information about the processes and evidence scientists use can be found throughout the exhibition.

Post-Visit Activity

Back in the classroom, ask students to visit National Geographic's *Waking the Baby Mammoth* Web site again; this time view the video featuring the processes and tools scientists used to learn about Lyuba: channel.nationalgeographic.com/episode/waking-the-baby-mammoth-3630/Overview22#tab-Videos/06530_00. After viewing, have students write an article for a newspaper announcing Lyuba as a new scientific discovery and explaining how scientists are reconstructing her life from different lines of evidence.

Evolution of Mammoths and Mastodons

Corresponds with the **Trunks and Tusks: Meet the Proboscideans** *and other galleries.*

Pre-Visit Activity

Begin exploring the evolution and migration of proboscideans by asking students where they think mammoths originated. To where did they migrate? What environments did they live in? Show students a map of mammoth migration: school.discoveryeducation.com/schooladventures/woollymammoth/migramap.html.

Discuss what is depicted on the map and have students develop a hypothesis about the evolution of mammoths as they dispersed throughout four different continents; how did mammoths evolve as they populated different environments throughout the world?

Field Trip Activity

At the Museum, go to the **Trunks and Tusks: Meet the Proboscideans** gallery in the ***Mammoths and Mastodons*** exhibition. Using an outline map of the world (only outlines of continents are needed), ask students to create a migration map for mammoths, carefully recording information about the mammoths living in each region and what the environment was like. As students travel through the rest of the exhibition, they should be sure to continue adding notes about adaptive changes that occurred as the mammoths migrated and eventually evolved. Pay special attention to the evolution of teeth and changes in size of the mammoth.

Post-Visit Activity

Back in the classroom, ask students to share their findings. Discuss the accumulative evolutionary changes seen in mammoths throughout time and across the four continents. Were their hypotheses supported by the evidence in the exhibition? Why are teeth important indicators of evolutionary change? Why did mammoth size and stature change over time? Why did the general size of mammoths eventually decline?

Students can share their learning about mammoths and mastodons with the world by contributing to the Encyclopedia of Life. For more information on how to use the Encyclopedia of Life, visit education.eol.org/educators/mammoths_mastodons.

On-line Resources

The San Diego Natural History Museum's *Fossil Mysteries* website:
http://www.sdnhm.org/exhibitions/current-exhibitions/fossil-mysteries

The Field Museum's *Mammoths and Mastodons* Web site: fieldmuseum.org/mammoths

The Encyclopedia of Life: education.eol.org/educators/mammoths_mastodons

The Encyclopedia of Life (EOL) *Mammoths and Mastodons* species pages will feature new fossil photographs from The Field Museum Collections accompanied by reliable and comprehensive species descriptions. These and related pages can be used as a way for your students to learn and share their knowledge about the animals and plants of the Pleistocene Epoch. Visit EOL to find activities that engage your students in learning about Pleistocene biodiversity and ecosystems. There are a wide range of activities for students of different ages and abilities that can be used for quick reinforcement or as a long-term project. Activities include: adding information about Pleistocene species from the *Mammoths and Mastodons* exhibition to the EOL, uploading original artwork of Mammoths and Mastodons based on the featured fossil photographs, and uploading photos from a biodiversity scavenger hunt that links the *Mammoth and Mastodons* exhibit to permanent Field Museum exhibits such as *Evolving Planet*. Your students will not only enjoy learning about Mammoths and Mastodons, but also help build the Encyclopedia of Life!

National Geographic *Waking the Baby Mammoth* Web site:

channel.nationalgeographic.com/episode/waking-the-baby-mammoth-3630

The Field Museum's *Evolving Planet*: fieldmuseum.org/evolvingplanet

The Field Museum's *The Ancient Americas*: fieldmuseum.org/ancientamericas

University of Michigan – Museum of Paleontology: paleontology.lsa.umich.edu/

Local Excavation Links:

Recent Proboscidean Discoveries —September 2007 Webcast (with Adobe Presenter™)
http://www.sdnhm.org/archive/research/paleontology/demere_webcast/index.htm

Excavation site in Oceanside reveals fossils of mammoth, mastodont, and tapir—August 2002
http://www.sdnhm.org/archive/research/paleontology/oceanside02.html

Fossil Discoveries in Downtown San Diego:
http://www.sdnhm.org/archive/research/readings/fn_0909.php

Books:

Agenbroad, Larry D., and Lisa Nelson (2002). Mammoths: Ice Age Giants. Minneapolis: Lerner Publications Co.

Arnold, Carolina and Laurie Caple (2002). When Mammoths Walked the Earth. New York: Houghton Mifflin Company.

Auel, Jean M (1985). The Mammoth Hunters. New York: Crown Publishing Group.

Bardoe, Cheryl (2009). Mammoths and Mastodons: Titans of the Ice Age. New York: Harry N. Abrams Co.

Lister, Adrian, and Paul Bahn (2007). Mammoths: Giants of the Ice Age. London: Frances Lincoln Limited Publisher.

O'Brien, Patrick (2002). Mammoth. New York: Henry Holt and Company.

Wheeler, Lisa (2006). Mammoths on the Move. Orlando, Florida: Harcourt, Inc.

Wilson, Ron (1984). Woolly Mammoths. Vero Beach, Florida: Rourke Enterprises, Inc.

Key Terms

*The following terms are found within the **Mammoths and Mastodons** exhibition:*

Proboscideans: Members of an order of mammals that includes the living elephants and their extinct relatives, such as mammoths and mastodons; defined especially by their trunk.

Proboscis: A long, flexible snout found on members of the order Proboscidea.

Pleistocene: A period of time from about 1.7 million to 11,000 years ago, which includes the world's most recent period of glaciation, or Ice Age.

Herbivore: An organism that feeds primarily on grasses and other plant materials.

Carnivore: An organism that feeds primarily on other organisms.

Permafrost: Permanently frozen ground, generally occurs when temperatures remain below 0°C for several years.

Matriarchal/Matriarchy: A form of social organization in which the leader or head of the group is a female.

Mammoth: Proboscideans from genus *Mammuthus*, alive during the Pleistocene; most easily identified by the long curving tusks and, in northern species, a covering of long, shaggy hair.

Mastodon: A genus of proboscideans largely defined by the shape of their teeth, having blunt and conical molars.