American Museum of Natural History

EXTREME MAMMALS

THE BIGGEST, SMALLEST, AND MOST AMAZING MAMMALS OF ALL TIME

EDUCATOR'S GUIDE

amnh.org/education/extrememammals

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- Suggestions to Help You **Come Prepared**
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ESSENTIAL QUESTIONS

This exhibition uses both living and extinct mammals to trace the ancestry and evolution of this remarkable group of animals. It's a story full of surprises, with quite a cast of characters.

What is a mammal?

You might have grown up thinking that all **mammals** share certain traits, like fur and giving birth to live young – and most living mammals do. But some are hairless, like the river dolphin, while a few others, like the echidna, or spiny anteater, lay eggs. So what defines this diverse group of animals? They all are descended from a common ancestor shared with no other living animals. Mammals can look radically different from each other, but the underlying body plan is still strikingly similar.

What's "normal" for mammals?

The terms "extreme" and "normal" are relative, of course. In mammals, one way to define normal is in terms of traits that are inherited from ancestors, such as producing milk, warm-bloodedness, and four limbs for walking, or **quadrupedalism**. Another way to think about "normal" is what is typically observed in the group. For example, today the typical mammal weighs about one pound, although for most of their history they were generally even smaller. All mammals have both normal and extreme, sometimes unique, features.

How and why are some mammals "extreme"?

As **species** evolve over time, "extreme" traits can arise: **characteristics** that differ widely from those found in ancestors or from the most common condition. Examples include the tiny brain of the extinct, two-ton *Uintatherium*; the bipedal hopping of kangaroos; or the venom of species of *Solenodon*, large shrew-like mammals. Humans also have a mix of both normal traits inherited from early ancestors (we're warm blooded and have differentiated teeth and five fingers and toes) and specialized extreme features (upright **bipedalism**, and big brains relative to our body size).

The six-banded armadillo is almost completely covered by bony, keratin-capped armor plates.

How have mammals evolved in response to changing environments?

As environments change over time, living things must adapt or go extinct. Different traits are favored in different habitats and are passed on to future generations. For example, when various groups of mammals invaded the sea, adaptations like blubber and flippers – which are modified limbs – helped them survive. Gargantuan blue whales can grow far larger than any land animal because water helps support their bulk. Their ancestors lost their teeth but evolved baleen in the upper jaw: rows of flexible plates made of **keratin** that help them capture vast amounts of small crustaceans. Tails also evolved a wide array of forms to help mammals swim, balance, grasp tree limbs, or keep warm.

How have extreme or specialized traits helped mammals adapt and survive?

Over millions of years, every part of the mammalian body was shaped and reshaped through **evolution**, from snout to tail. Sometimes remarkable in form, these adaptations conferred evolutionary advantages, like the extremely long premolars of the extinct marsupial *Thylacoleo carnifex* or rodents' sharp incisors, which never stop growing. **Echolocation** evolved independently in a few specialized groups, including bats, cetaceans (dolphins and whales), and subterranean shrews. Evolving big brains relative to body size distinguishes mammals from other vertebrates, and humans from all other mammals. Much of the increase occurs in the cerebrum, the part of the brain largely associated with thought, memory, most senses, and information processing. Some of the most remarkable adaptations occurred when mammals evolved in isolated areas.

How do scientists study mammals?

Scientists observe mammals in their environments, and analyze modern and **fossil** specimens back in the laboratory. Combining physical and genetic data helps scientists recognize the relationships between species. Today, nearly 25 percent of living mammal species are threatened with **extinction**, even as new species are still being discovered. Scientists find them by exploring – and helping to protect – remote ecosystems in the ongoing quest to learn more about life on Earth.

USEFUL CONCEPTS

Natural Selection and Adaptation

Individuals inherit traits, or features, from their parents. Those members of a species with traits that help them survive in a particular environment — like the sharp, piercing canines and slicing molars of **carnivores** versus the flat grinding teeth of mammals that eat tough grasses — pass on these characteristics. Generation after generation, individuals with the advantageous trait, or **adaptation**, will survive longer and produce more offspring, until most or even all members of the species possess it. Called **natural selection**, this is an important mechanism of evolution.

Convergent Evolution

This refers to situations in which different groups evolve similar adaptations because they live in similar environments. These species may even live on different continents and be far apart on their family trees. For example, high-crowned grinding teeth for chewing tough grasses have evolved independently in a diverse suite of mammals, including bison, horses, elephants, some rodents, and many extinct mammal groups.

Mammal Reproduction

The ancestor of all mammals almost certainly laid eggs, as do most vertebrates and a tiny minority of living mammals, the **monotremes** — like the platypus and echidnas of Australia and New Guinea. But the vast majority of modern mammals are **placentals**. They've evolved to give live birth to babies that are nourished for a long time inside the mother's body, using an organ called a placenta. A few hundred other living species (and many more fossil forms), like koalas and kangaroos, are **marsupials**; their young are born very immature and much of their development occurs while drinking milk, typically inside a pouch on their mother's belly. The group Mammalia is named for mammary glands, which produce milk — as all mammal species do.

Koala, a marsupial

Come Prepared

Before your visit, review the **Essential Questions** to see how the exhibition's educational themes connect to your curriculum. Identify what you'd like your students to learn from ***Extreme Mammals***, and how they could continue learning back in the classroom. Visit the *Extreme Mammals* website at **amnh.org/extrememammals** to learn more about the exhibition.

This Guide includes **Activities** for ***Before You Visit***, ***During Your Visit***, and ***Back in the Classroom***, and **Student Worksheets** for grade levels K–2, 3–5, 6–8, and 9–12. These activities are designed to be used together to focus your visit around one or two themes. Here are some other ways to explore the *Extreme Mammals* exhibition:

- You (and your class chaperones) can use the **Teaching in the Exhibition** section of this guide as you move through the gallery with students.
- You can create student worksheets using the **Teaching in the Exhibition** section.
- You can distribute copies of the **Map of the Exhibition** to chaperones and/or students, and let them choose their own paths.

Visit amnh.org/education/extrememammals for:

- information on field trips, reservations, lunchrooms, and other useful tips to help plan your visit
- free resources, including activities and references

Correlation to Standards

Your visit to the *Extreme Mammals* exhibition can be correlated to the standards listed below. Visit **amnh.org/resources/rfl/web/extrememammalsguide/standards.html** for a full listing of relevant NYS Science Core Curriculum Standards and NYC Scope & Sequence.

National Science Education Standards

K–4

Life Science: • C1: The characteristics of organisms • C2: Life cycles of organisms • C3: Organisms and environments

History and Nature of Science: • G1: Science as a human endeavor

5–8

Life Science: • C1: Structure and function in living systems • C2: Reproduction and heredity • C5: Diversity and adaptations of organisms

9–12

Life Science: • C3: Biological evolution

TEACHING IN THE EXHIBITION

The *Extreme Mammals* exhibition uses fossils, models, live animals, interactives, videos, and more to engage individuals with all learning styles. This guide divides the exhibition into ten areas, which are indicated on the map and described below.

1. Introduction

Overview: Living and fossil mammals exhibit a huge range of shapes and sizes.

Exploration:

- **Animal models:** Have students compare and contrast these life-size models of the largest land mammal and the smallest mammal that have ever lived. Point out that despite all the differences, we're all mammals.

Guiding Questions:

- What do the largest and the smallest mammals have in common with each other? With humans?

2. What is a Mammal?

Overview: Mammals are defined by common ancestry, not by physical characteristics – although inherited traits do help us recognize relationships between mammals.

Exploration:

- **Video:** Encourage your students to watch the video, focusing on the traits shared by living mammals.
- **Skulls:** These show how specialized teeth and skull anatomy evolved in the ancestors of mammals. Ask students to compare the skulls and how they've changed over millions of years.

- **Cladogram:** The wall-size evolutionary tree shows where mammals fit in the tree of life and how all mammals have evolved from a common ancestor. Point out the many branches. Ask students what this shows about mammal evolution.

Guiding Questions:

- Most living mammals have certain traits in common. Why? What are they?
- How do scientists determine what a mammal is?

3. What is Extreme?

Overview: "Extreme" traits differ widely from those found in ancestors, or from the most common, typical, or "normal" form at any moment in time. Most mammals possess a combination of extreme and normal features.

Exploration:

- **Human, *Uintatherium*, and opossum skeletons:** Ask students to distinguish between normal and extreme characteristics in each of these species.

Guiding Questions:

- What are some examples of extreme and normal characteristics in these three mammals?
- Are humans extreme or normal? Why?

4. Head to Tail: Heads

Overview: Mammalian bodies have been modified by evolution. Some of these changes are found in the head.

Exploration:

- **"Headgear" and skulls of living and extinct mammals:** Point out to students that headgear can be formed from teeth, bones, and even hair. Ask them how horns and antlers are similar, and different.
- **Skulls with teeth:** Invite students to compare and contrast the different types of mammal teeth, and to use the mirror to compare them to their own teeth.

Guiding Questions:

- What are different kinds of teeth used for?
- What are some of the functions of headgear?

5. Head to Tail: Reproduction

Overview: Reproduction is one of the main features that differentiates the three living groups of mammals: placentals, marsupials, and monotremes. (See "Useful Concepts.")

Exploration:

- **Taxidermy and fossil specimens:** Invite students to examine these specimens, as well as the video, and explore how each of these groups gives birth.

Guiding Questions:

- How do different types of mammalian mothers care for their young?
- How do the gestation periods for each of the three major groups compare? What are some of the benefits of a long pregnancy? The drawbacks?

Live animals! Ask students to describe how sugar gliders move and interact.

6. Head to Tail: Bodies

Overview: All mammals share a common body plan, but evolution has resulted in astonishing variations on the arrangement of bones, muscles, and skin.

Exploration:

- **Glyptodont armor:** Students can "try on" the model and imagine having this much armor. Ask how it might compare to having spines or scales.
- **Hair and fur:** Point out that hair, horns, scales, hooves, and fingernails are all made of the same material, keratin. Invite students to touch and explore the specimens.

Guiding Questions:

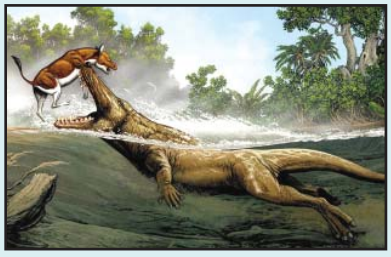
- What are the various functions of hair and fur?
- How do different body coverings benefit mammals? How do these coverings relate to environmental conditions?
- Which would you rather have, venom or armor? Why?

7. Mammals in Motion

Overview: Ancestral mammals lived on land. Some groups of mammals later adapted to move through other environments like the sky and the ocean.

Exploration:

- **Walking whale model:** Explain that like most other mammals, all whales are descended from an ancestor with four limbs and feet. Ask students whether *Ambulocetus* lived in water or on land, and to support their answers.



***Ambulocetus*, an amphibious early whale with legs, probably hunted small mammals much as today's crocodiles do.**

- **"Lucy" pelvis:** Look closely at the diagram comparing "Lucy's" pelvis with those of chimpanzees and humans. Ask students how these mammals moved, and how human locomotion is unique.
- **Bats, flying squirrel, and Mesozoic gliding mammal:** Have students note the similarities between the bat wing and their own arm. Ask them to compare bat flight to the gliding of the squirrel or the Mesozoic mammal (*Volaticotherium*).

Guiding Questions:

- How do most mammal bipeds (those that walk on two legs) get around?
- Many groups of mammals evolved to live in water. How did their bodies change?

8. Extreme Climates

Overview: Environments change with time, and so do the mammals that inhabit them.

Exploration:

- **Diorama of the Eocene and Images of Today:** Ask students to compare conditions on Ellesmere Island 50 million years ago to those today.

Guiding Questions:

- How are the mammals in each scene adapted to their environment?
- What are some of the ways in which major climate change has affected mammal diversity?

9. Extreme Isolation

Overview: When mammals are geographically isolated, they can evolve extreme traits or can come to resemble unrelated species elsewhere. (See "Useful Concepts.")

Exploration:

- **Monkey skull:** Have students read the displays, and ask them to explain how the skull solved the puzzle of how and when monkeys reached South America.
- ***Scarrittia* case:** Point out that these South American species all belong to the same group, and resemble a wide range of groups found on other continents.

Guiding Questions:

- What kinds of extreme forms have evolved in places that once were isolated?
- Why is isolation so important in the origin of different, distinctive, and "extreme" forms?

10. Extreme Extinction

Overview: Although sometimes rapid, and affecting vast numbers of species, extinctions are part of the history of life. One mammal, *Homo sapiens*, is contributing to what may become the next mass extinction (the "Sixth Extinction").

Exploration:

- **La Brea Tar Pits walk-through display:** These mammals are only 11,000 years old, but all are extinct. What does this tell us about how fast extinction can occur? How does it affect species diversity?
- **Tasmanian wolf specimen:** Ask students to think about what is unusual about this marsupial.

Guiding Questions:

- What human activities contribute to extinction?
- How can preserving existing habitats slow extinction rates and lead to the discovery of new species?

ONLINE RESOURCES

Abundant online resources for grades K-12 are available through the Museum's Education site (**amnh.org/education**) and Resources for Learning (**amnh.org/education/resources**), which you can browse by topic, search by keyword, and sort by type and grade level.

- **Extreme Mammals Exhibition: amnh.org/extrememammals**
  (Grades K–12)
  This online version of the exhibition highlights fun facts, videos, and interactives – including the chance for visitors with webcams to see themselves "holding" a 3D model of the shrew-like *Batodonoides*, the smallest mammal that ever lived.

- **Extreme Mammals for Educators: amnh.org/education/extrememammals**
  (Grades K–12)
  Resources across all grade levels include a "Tree of Life" video and a "Soar with Bats" interactive. There are three categories of activities: living mammals, extinct mammals, and the Tree of Life.

- **Zoology OLogy: amnh.org/ology/zoology**
  (Grades 3-5)
  This site gives younger students the chance to explore big ideas about mammals and other animals though games, puzzles, and interactives. They can examine how six cool mammals move, explore the *Extreme Mammal* photo gallery, use masks to compare their teeth to those of different mammals, and make a moving-mammal flip book.

- **Science Bulletins: amnh.org/sciencebulletins**
  (Grades 6-12)
  Videos, interactives, and essays introduce middle- and high-school students to biologists and conservationists who study mammals around the world. Learn about the reintroduction of Mongolia's takhi to its homeland (*The Last Wild Horse*); the challenge of returning Thailand's captive elephants to the forest (*Wild at Heart*); the first clone of a threatened species (*Cloning and Conservation*); and the diverse and endangered primates of the world's largest island (*Lemurs of Madagascar*).

FUN FACTS

- There are more than **5,400 species** of mammals living today!
- ***Batodonoides*** is the smallest mammal that ever lived. It weighed as much as a dollar bill.
- The **blue whale** is the largest animal – mammal or otherwise – ever known. It can grow to nearly 200 tons (400,000 pounds)!
- **Humans** are extreme in many ways: large brains, upright locomotion, and sparse body hair.
- The placid-looking male **platypus** has a secret weapon: spurs on its hindfeet that deliver toxic venom!
- **Koalas** are not bears. They're marsupials and are more closely related to kangaroos.

CREDITS

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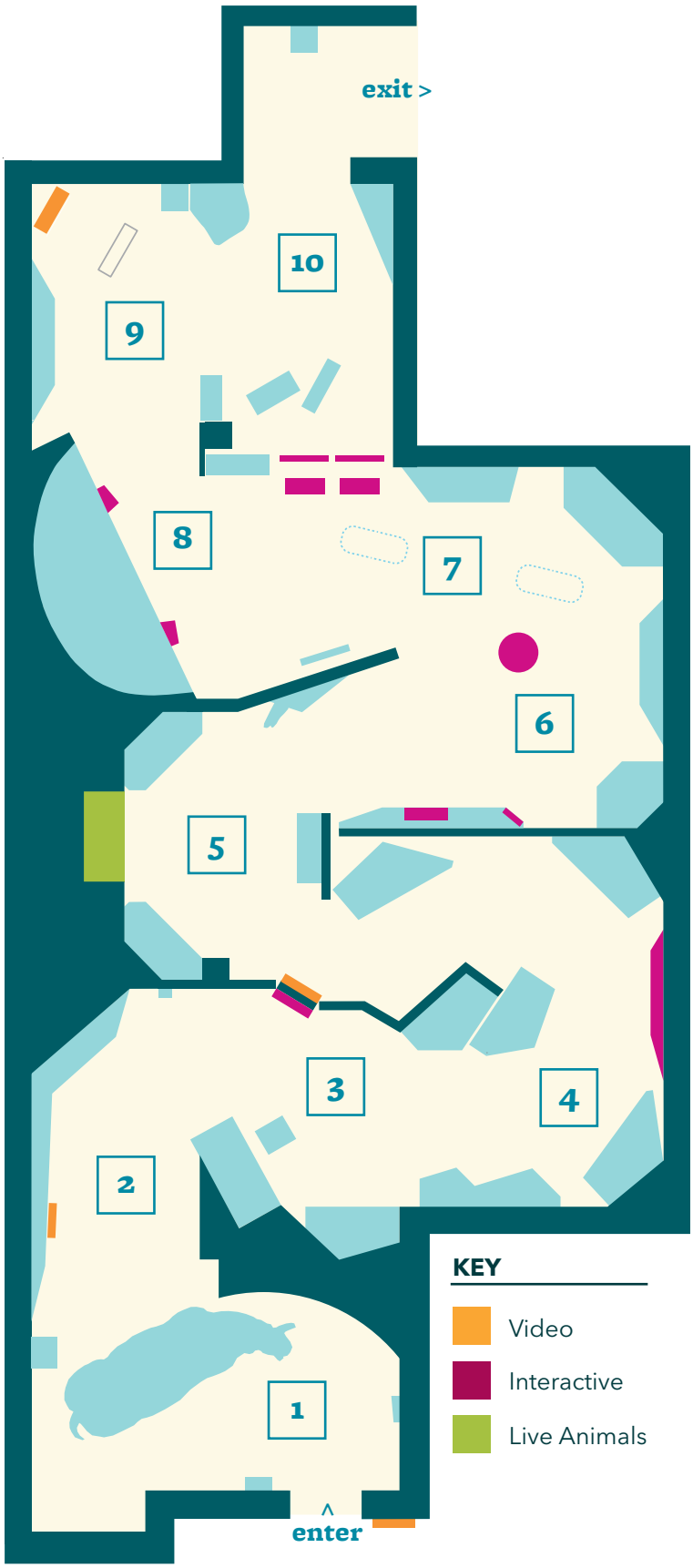
MAP OF THE EXHIBITION



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GLOSSARY OF TERMS

Bipedalism: using two feet to stand and move on land (by walking, hopping, or running). Relatively few modern mammal species are bipeds.

Smilodon, a saber-toothed cat, lived in the Americas between 2.5 million and 10,000 years ago.

Carnivore: an animal that eats primarily meat, whether scavenged or hunted. Most living species of the mammal order Carnivora (dogs, bears, cats, seals, and their relatives) are carnivores like their common ancestor, but some have evolved to eat primarily fish, fruit, or even leaves.

Cladogram: a tree-like diagram that depicts the evolutionary history of a group of organisms. Branching points are where new, advanced features appeared, and species diverged from common ancestors.

Characteristic: any feature or trait of an organism that can be measured, counted, or otherwise assessed, such as hair color or number of limbs. Characteristics help biologists distinguish one species from another.

Echolocation: the process of emitting sound waves and listening to the echoes to navigate and locate food – or "biological sonar." Echolocation evolved independently in bats, cetaceans (dolphins and whales), shrews, and some other mammals.

Evolution: the process by which populations accumulate genetic changes over time that are passed on from ancestors to subsequent generations, or descent with modification. (See "Useful Concepts.")

Extinction: the death of every member of a biological species or all species in a bigger group of organisms. The vast majority of species that have lived on Earth are now extinct.

Fossil: Typically preserved in rocks, fossils are any remains or traces of ancient life. Examples include bones, teeth, shells, leaf impressions, nests, and footprints. Fossils document how organisms changed over time, and how they're related to one another.

Herbivore: an animal that eats plants, like horses and mice. In the food web, herbivores link primary producers (plants) and consumers such as predators (carnivores).

Keratin: a fibrous protein that is the main component of structures that grow from the skin, such as hair, hooves, nails, claws, and horns.

Mammal: a class of vertebrate animals descended from the common ancestor of living placentals, marsupials, and monotremes. Almost all mammals share certain physical characteristics: they have hair, they're warm-blooded, and they produce milk to nurse their young.

Not a wolf at all, the Tasmanian wolf (*Thylacinus cynocephalus*) was a carnivorous marsupial that went extinct in 1936.

Marsupial: a group of a few hundred living (and many more fossil) mammal species named for a distinctive pouch (called the marsupium) in which many species carry their young. Born tiny and very undeveloped, the young feed on their mother's milk for an extended period of time, often in a pouch.

Monotreme: a group of living mammals that lay eggs instead of giving birth to live young, as the vast majority of living mammals do.

Placental: Placental mammals bear live young, which are nourished before birth through a specialized organ (a placenta) that attaches to the mother's uterus as an embryo grows. Although most living placental species are rodents and bats, this diverse group also includes whales, elephants, shrews, armadillos, and humans, among many other species.

Prehensile: adapted for grasping or holding. This adaptation confers many advantages, in feeding (the giraffe's tongue), locomotion (the monkey's tail), drinking and defense (the elephant's trunk), and other activities.

Quadrupedalism: using four limbs or legs to move. Most land mammals are quadrupeds.

Species: a basic unit of biological classification. A species is often defined as a group of organisms that share ancestry and characteristics, and can interbreed and produce fertile offspring.

A tree-dwelling relative of the raccoon, the kinkajou can use its fully prehensile tail as a "fifth hand" when climbing.