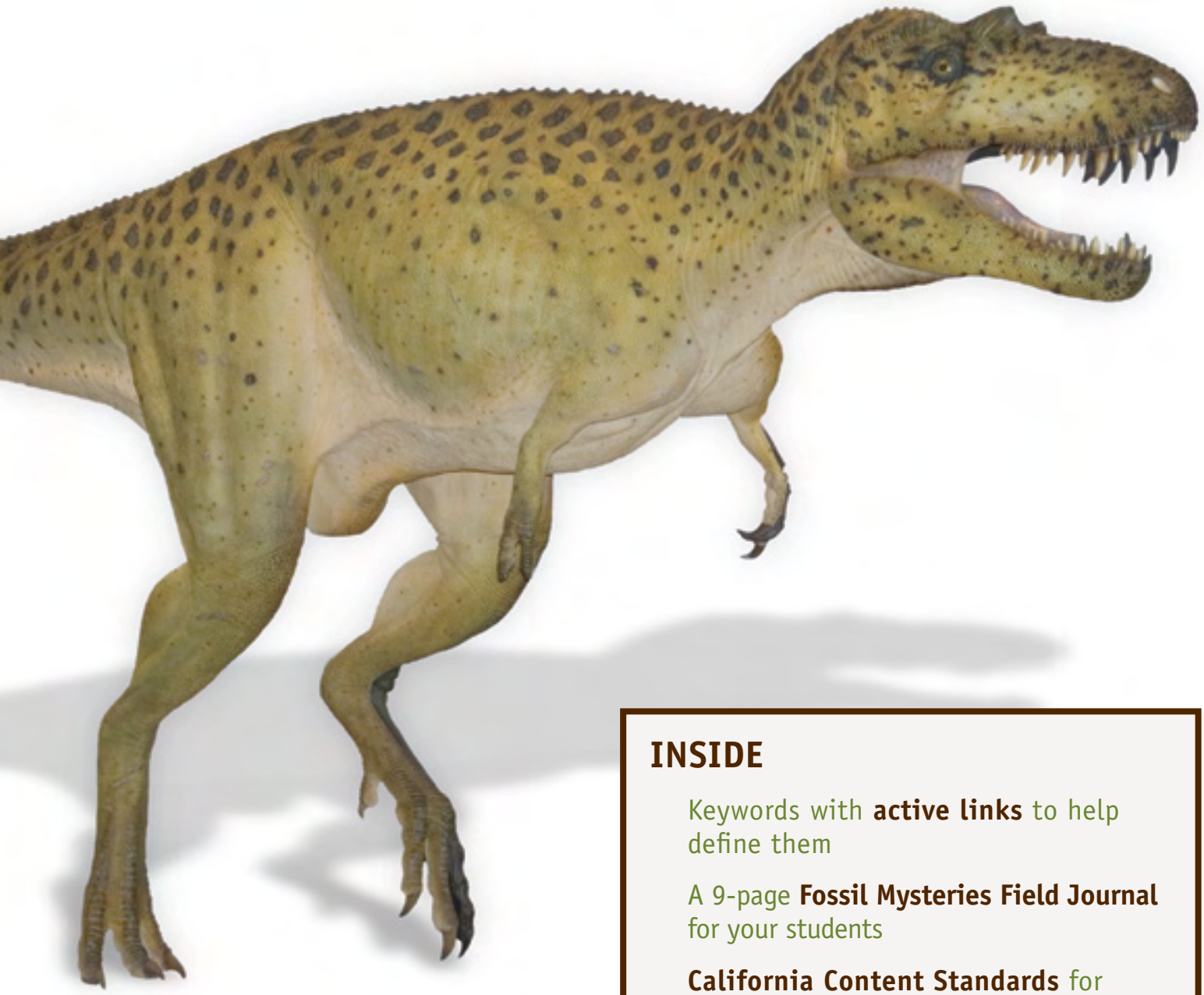
San Diego Natural History Museum

FOSSIL MYSTERIES

Teachers' Guide



INSIDE

Keywords with **active links** to help define them

A 9-page **Fossil Mysteries Field Journal** for your students

California Content Standards for each applicable section

Guide made possible through the generous support of the Ellen Browning Scripps Foundation.

contents

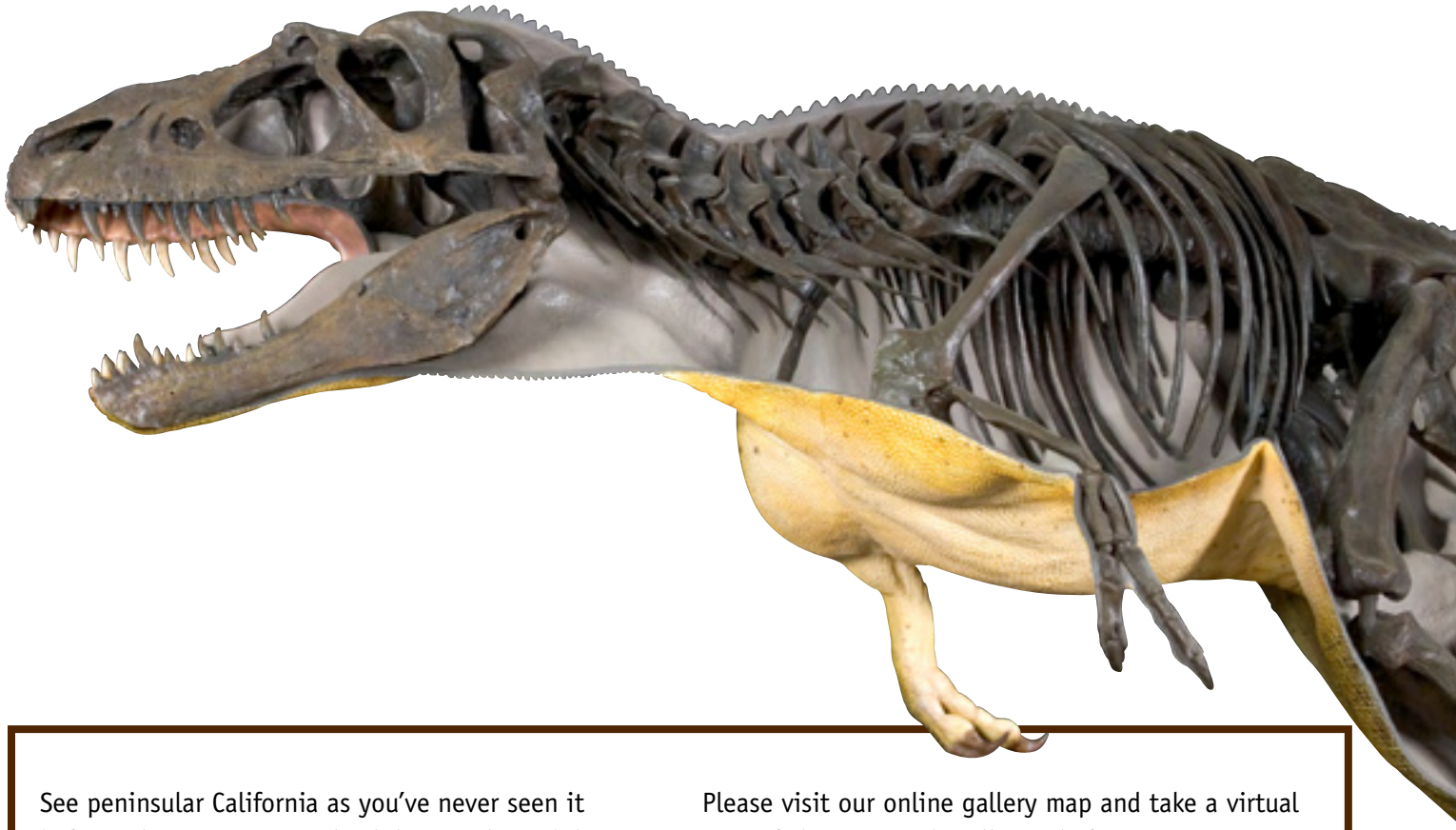
Dear Educator,

Welcome to Fossil Mysteries. This guide includes an exhibition overview, links, and inquiries to help make your Museum visit an engaging educational experience. Please accept our invitation to share your students' work with us for possible inclusion in future versions of this guide or for display at the Museum.

References to California Content Standards are included. Full text of the standards is available at ***http://www.cde.ca.gov/be/st/ss/***.

If you have questions related to this guide please call the Museum Education Department at 619.255.0311 or email education@sdnhm.org.

About FOSSIL MYSTERIES



See peninsular California as you've never seen it before! The specimens and exhibits in this exhibition are the records of our region's distant past. You will see hundreds of real fossils, 12 large murals of prehistoric vistas, and more than 70 original models of plants and animals including a dramatic walk-in diorama of an Eocene Epoch forest.

Please visit our online gallery map and take a virtual tour of the six epoch galleries before your visit: ***http://www.sdnhm.org/exhibits/mystery/exh_map.html***. You are also welcome to tour the galleries in advance of your registered visit.

Prepare KEY CONCEPTS

"The general idea of evolution is that the present arises from materials and forms of the past."

National Science Education Standards

Evolution

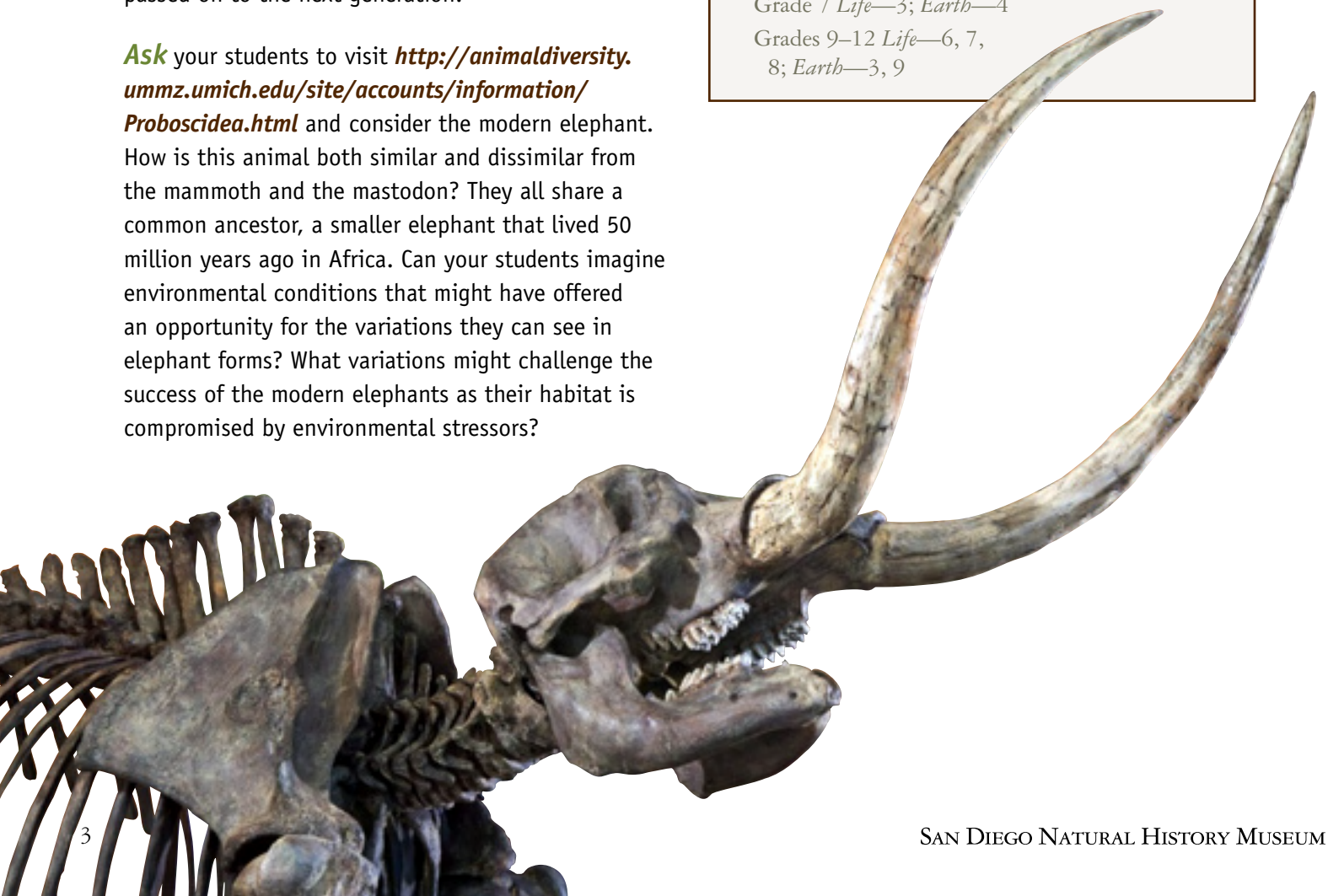
Biological evolution is the idea that all living creatures have descended with modification from common ancestors. Fossils offer testable evidence of evolutionary patterns because they are evidence of past forms that are both similar and dissimilar to modern species. Life forms change or remain consistent over time because of natural selection. Natural selection is the process by which the characteristics that help an organism to survive are passed on to the next generation.

Ask your students to visit ***http://animaldiversity.ummz.umich.edu/site/accounts/information/Proboscidea.html*** and consider the modern elephant. How is this animal both similar and dissimilar from the mammoth and the mastodon? They all share a common ancestor, a smaller elephant that lived 50 million years ago in Africa. Can your students imagine environmental conditions that might have offered an opportunity for the variations they can see in elephant forms? What variations might challenge the success of the modern elephants as their habitat is compromised by environmental stressors?

During your visit students will see fossil evidence of both mammoths and mastodons.

California State Science Content Standards

Kindergarten and Grade 1 *Life*—2
Grade 2 *Life*—2; *Earth*—3
Grade 3 *Life*—4
Grade 4 *Life*—3; *Earth*—4
Grade 6 *Life*—5; *Earth*—2
Grade 7 *Life*—3; *Earth*—4
Grades 9–12 *Life*—6, 7, 8; *Earth*—3, 9



Earth Processes

Earth's crust moves: it grows, shrinks, and is reshaped in a recycling process called ***plate tectonics***. The crust is broken into large rigid plates that travel toward, away from, against, and beneath each other. Gravity is the main mechanism driving plate motion as dense cold oceanic plates are pulled toward the mantle. Hot buoyant rocks rise on the opposite edge of a plate and pour out along spreading boundaries.

Plate motion creates, destroys, and deforms Earth's surface. Earthquakes and volcanoes provide some of the contemporary evidence for this dynamic process while rocks and fossils evince tectonic events of the past. A six-inch shark tooth may seem out of place in the Carrizo badlands, far from the ocean, but 15 million years ago as moving plates were stretching western North America, a long, narrow basin formed and ocean waters flowed in to create a gulf as far north as Palm Springs.

Ask your students to consider how fossil evidence of ***Carcharodon megalodon*** found in the desert is a clue about the process of plate tectonics.

During your visit your students will be able to manipulate models that describe tectonic plate movement.

California State Science Content Standards

Kindergarten and Grade 1 *Life*—2
Grade 2 *Life*—2; *Earth*—3
Grade 3 *Life*—4
Grade 4 *Life*—3; *Earth*—4
Grade 6 *Life*—5; *Earth*—2
Grade 7 *Life*—3; *Earth*—4
Grades 9–12 *Life*—6, 7, 8; *Earth*—3, 9

Extinction

Life on Earth is a delicately balanced system. Large-scale extinctions happen when major chemical, physical, or biological systems cannot adjust to environmental changes. Since life began, whole lineages of animals and plants have become extinct. More than 99% of all life that has ever existed is estimated to be extinct. This estimate is based upon our understanding of diversity within modern living systems and myriad extinct forms in the fossil record.

Paleontologists recognize several major periods of mass extinction. One such event occurred 65 million years ago. Dinosaurs, ***mosasaurs***, ***pterosaurs***, and ***ammonites***, as well as many species of plants, insects, birds and marine plankton all perished.

This disruption of life on the land and in the ocean coincided with the impact of a six-mile-wide asteroid near Chicxulub, Mexico. At the time of the impact, global atmospheric changes resulted from vast amounts of shattered rock and asteroid debris hurled into the stratosphere. Earth darkened, and for months photosynthesis halted. Burning forests and vaporized rocks releasing carbon and sulfur dioxides brought global warming and acid rains. Most

plants and animals had little time to adapt, and mass extinctions resulted. However, some species of plants and animals did survive.

Ask your students to suggest what features might indicate an organism's ability to survive a cataclysmic change in the environment?

During your visit your students will see a piece of the rock that holds a clue about the cosmic catastrophe that contributed to the extinction of many Cretaceous species like the dinosaurs.

California State Science Content Standards

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Grade 2 *Life*—2; *Earth*—3
Grade 3 *Life*—4
Grade 4 *Life*—3; *Earth*—4
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Ecology

Ecology is the study of how living things and their environment interact with one another. Understanding a community's food web is an essential thread of ecology because it illustrates connections between predators and their prey.

During the Pliocene Epoch 5 to 1.8 million years ago, our region was home to a dynamic marine ecosystem that included several species of whales. These large warm-blooded animals have enormous energy requirements and prodigious appetites. How is it that the environment could support all of these big eaters?

Paleontologists use knowledge of living ecosystems to help define the patterns that may have existed in ancient habitats. Modern species of whales have different feeding strategies and consume different kinds of prey. Baleen whales filter water or mud to collect prey too tiny for a toothed whale. Did their ancestors with similar skeletons behave in the same way? It's likely. Sometimes, however, fossils have puzzling jaws and teeth for which there is no known modern analogue.

Ask your students what other kinds of fossil clues about an ecosystem might paleontologists look for if they were to discover a puzzling set of teeth?

During your visit your students will see the fossil evidence of a small porpoise nicknamed the "half-beaked" porpoise. The purpose of its peculiar jaw is still a mystery.

California State Science Content Standards

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Grade 2 *Life*—2; *Earth*—3
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Explore MUSEUM ACTIVITIES

Evolution

How do fossils reveal the process of evolution?

The Eocene rainforest diorama contains reproductions of many species. These interpretations are based on the fossil evidence in the gallery and an understanding of modern plants and animals. Some of the life forms are quite exotic and unfamiliar while others look much like modern species. The ancient opossum looks very like its modern descendent.

Ask the students to do a field survey using the animal identification cards provided in the gallery, and to organize their data into three categories: species that have changed little and are still living in San Diego, animals that no longer live in San Diego, and animals that are extinct. Ask the students to think about modern carnivores—dogs, cats, weasels and bears—and then ask them to study the fossil jaws in the carnivore exhibit case. Do they look like the jaws of modern carnivores?

Fossils reveal the process of evolution by allowing us to see both changes and consistencies in life forms over great expanses of time.

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Earth Processes

How can the life story of a single rock reveal the movement of Earth's crust?

The Miocene gallery includes interactive displays, maps, and fossils to introduce and reinforce the concept of plate tectonics. Ask your students to discuss, draw, or write the story describing the progress of the red rhyolite cobbles in the gallery. How did these smooth red rocks from Sonora, Mexico, get into San Diego's backyards?

Born in magma they eroded from ancient volcanoes, tumbled through waterways and were deposited on coastal plains that rifted away from the mainland to form peninsular California. Visit the OmniGlobe and watch carefully for the formation of the Baja California Peninsula.

The movement of Earth's tectonic plates as they are destroyed and renewed in a continuing process is recorded in the geologic record.

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Extinction

How does knowledge of past extinctions shape our ideas about endangered species?

Fossil Mysteries contains many prehistoric animals that may be unfamiliar, like the ***brontothere***. Others like the ***sea cow***, the ***camel***, and the ***walrus*** are more familiar, and the fossil record shows that only a few million years ago these creatures lived here, far from their modern ranges.

A mass extinction of large mammals in North America occurred within the last 13,000 years as the sea levels rose and the climate warmed and dried. Changes in landforms and climate affect vegetation zones and the availability of food. What are some other things that might determine an animal's success in a changing environment?

Ask your students to count how many animals represented in the Pleistocene gallery are still living in our region. There are several. Then ask them to choose an animal from the Pleistocene that is now extinct. The rat is a survivor. How are its size, habitat, food requirements, and reproduction rates different from those of an animal that became extinct such as the ***Dire Wolf***?

What inferences can your students make about the cause or causes of extinction? What inferences can they make about the future survival of the mountain lion, the last large predator, in southern California?

An animal's size, diet, habitat range, and reproduction patterns may influence its ability to survive in a changing environment.

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Ecology

How does a fossil clue help to describe a prehistoric habitat?

Ask students to study the mural in the Oligocene gallery and to observe the life and landforms. How does the Oligocene savannah differ from the rainforest of the Eocene gallery? How did the paleontologists and artists recreate these unseen vistas?

Dense forest habitats favor animals different from those who populate open grasslands. Take a look at the deer-leg interactive in the biomechanics gallery to see the skeletal adaptations which enhance this animal's ability to run fast and far. Then study the gibbon interactive. The gibbon is built for climbing trees.

Fossil evidence of tree dwelling animals suggests the presence of trees. Fossils of fleet-footed ungulates, like the deer, suggest the need to outdistance predators over stretches of open terrain.

We can make inferences about an ancient habitat by looking at the adaptive features of its inhabitants.

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Grade 7 *Life*—3; *Earth*— 4
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Expand CLASSROOM ACTIVITIES

We want to hear from you. Please share your students' work with us. Contact the School Programs Manager at 619.255.0311 or education@sdnhm.org to submit student artwork, writing, or photos.

It's a mystery. How do you solve it?

Fossils are used like evidence in a crime-scene investigation to interpret the unseen distant past. You can learn about the how the mystery of Rinney, the Museum's ankylosaur, was solved at ***http://www.sdnhm.org/exhibits/mystery/interactives.html***.

Write a play or draw a story board about Rinney's demise. You can tell the story from the past to the present or start with the dig and work back to the ankylosaur's last day.

California State Science Standards

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Grades 9–12 *Life*—6, 7, 8; *Earth*—3, 9

California State English Language Arts Standards

Grades 1–12 *Writing*—1, 2

California State Visual and Performing Arts Standards

Kindergarten–Grade 12 *Creative Expression*—2; *Connections, Relationships, Applications*—5

Here today, gone tomorrow. Why should we solve it?

How can the information we get from fossils about prehistoric climate change help us to understand Earth today? When we understand the changes and extinctions of the past we find out more about our world.

Can you think of any reasons why people might want to know and understand Earth processes? Think about the things you use and the natural resources used to make them. Think about California's earthquake history. Visit ***http://www.sdnhm.org/education/teachers/tguides.html*** and investigate the natural history of water in our region. Why is it important to know about past cycles of drought and precipitation?

The study of Earth processes and prehistory improves our lives by giving us the information we need to protect the environment. Write a persuasive essay saying why you think geology and paleontology are important sciences for understanding the future health of our planet.

California State Science Standards

Grade 4 *Life*—3; *Earth*—4
Grade 6 *Life*—5; *Earth*—1, 2
Grade 7 *Life*—3; *Earth*— 4
Grades 9–12 *Life*—6, 7, 8; *Earth*—3, 9

California State English Language Arts Standards

Grades 5–12 *Writing*—1, 2

Long, long ago

Create a classroom timeline mural for southern California. Visit ***http://www.sdnhm.org/exhibits/mystery/fg_timeline.html***. Using linked poster boards or lengths of butcher paper, have teams create epoch panels. Students may use sketches of plants and animals made during the museum visit to illustrate the final work. Visit ***http://www.sdnhm.org/exhibits/mystery/fieldguide.html*** for further reference.

California State Science Standards

Grade 2 *Life*—2; *Earth*—3
Grade 3 *Life*—4
Grade 4 *Life*—3; *Earth*—4
Grade 6 *Life*—5; *Earth*—1, 2
Grade 7 *Life*—3; *Earth*— 4
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California State Visual and Performing Arts Standards

Kindergarten–Grade 12 *Creative Expression*—2; *Connections, Relationships, Applications*—5

Lions and Camels and Walrus! Oh my!

During your visit, your students saw many large mammals that are now extinct or ***extirpated***. Today only one large predator lives in our immediate region, the mountain lion. This creature often makes the news when one ventures into a developed area. Is there a future for this last big mammal in southern California?

San Diego County has been identified as a "hotspot" of biodiversity. Research what this means and then identify a threatened species of plant or animal in your area. How can an understanding of recent and distant extinctions represented in the exhibition inform our civic decisions about present-day land use and development? What efforts can individuals exert as a positive force for conservation?

Helpful links:

http://www.sandiego.gov/planning/mscp/index.shtml

http://interwork.sdsu.edu/fire/resources/overview_bioderversity.htm

California State Science Standards

Grade 4 *Life*—3; *Earth*—4
Grade 6 *Life*—5; *Earth*—2
Grade 7 *Life*—3; *Earth*— 4
Grades 9–12 *Life*—6, 7, 8; *Earth*—3, 9

California State Visual and Performing Arts Standards

Kindergarten–Grade 12 *Creative Expression*—2; *Connections, Relationships, Applications*—5

Spell it out! Fossils are fascinating.

Write acrostic poems using the four E's of the exhibition; evolution, ecology, extinction, Earth processes.

Example:

Earth is an engine of
Cycles that can be
Observed in
Living and nonliving aspects.
Ocean, lithosphere, sky—
Graven in the fossil record
Years in millions are scored.

California State Science Standards

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Grade 7 *Life*—3; *Earth*— 4
Grades 9–12 *Life*—6, 7, 8; *Earth*—3, 9

California State English Language Arts Standards

Grades 5–12 *Writing*—1, 2

Glossary RESOURCES

Fossil Mysteries Glossary link

http://www.sdnhm.org/exhibits/mystery/fg_glossary.html

More reading

The Discovery of Evolution, David Young. Cambridge University Press and the Natural History Museum, London, 1992.

Evolution vs. Creationism, An Introduction, Eugenie C. Scott. University of California Press, Berkeley, 2004.

Future Evolution: An Illuminated History of Life to Come, Peter Ward. Henry Holt and Company, New York, 2001.

The Rise and Fall of San Diego, Patrick Abbott. Sunbelt Publications, San Diego, 1999.

Earth: An Intimate History, Richard Fortey. Alfred A. Knopf, New York, 2004.

Planet Ocean: A Story of Life, the Sea, and Dancing to the Fossil Record, Brad Matsen. Ten Speed Press, Berkeley, 1994.

Life History of a Fossil: An Introduction to Taphonomy and Paleoecology, Pat Shipman. Harvard University Press, Cambridge, 1981.

No Turning Back, Richard Ellis. Harper Collins, New York, 2004.

The Cretaceous World, Peter Skelton. Cambridge University Press, Cambridge, 2003.

T. rex and the Crater of Doom, Walter Alvarez. Princeton University Press, Princeton, 1997.

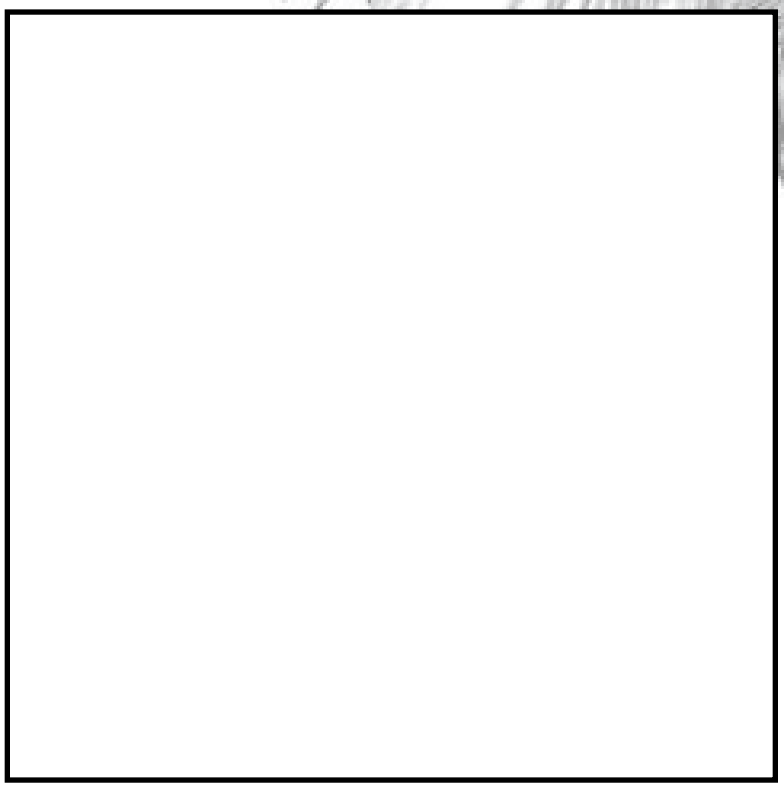
FOSSIL MYSTERIES
Field Journal

1. How many animals can you find in the Eocene rainforest? Fill the boxes below with drawings of the animals you see, one in each box:

Did you look above and below? Some animals are small and camouflaged.

2. On this page draw an Eocene animal in its habitat. Does it live in the trees, the water or the forest floor?

3. Take a good look at *Tapocyon*'s teeth. Draw them.
Do these teeth look like the teeth of modern carnivores?
Write the names of three modern animals that have similar teeth.

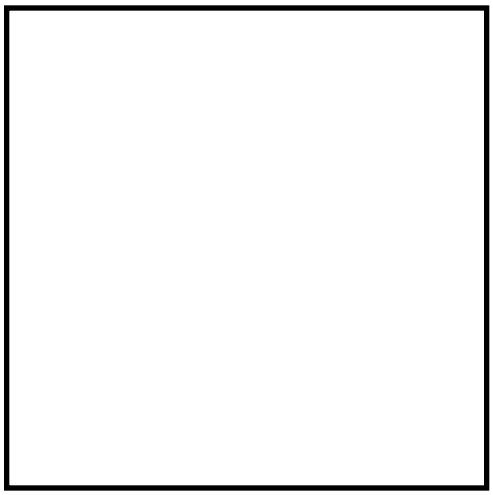
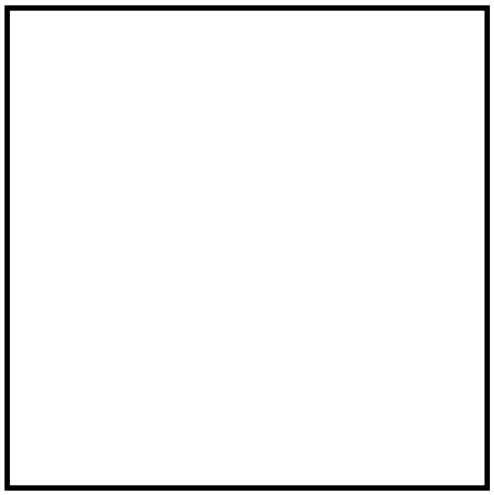
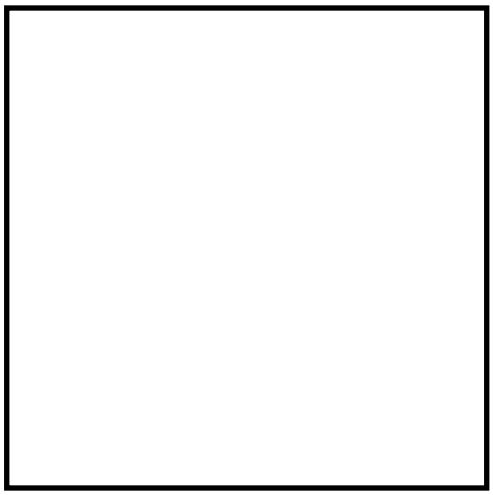


***Tapocyon*'s teeth**

_____, _____

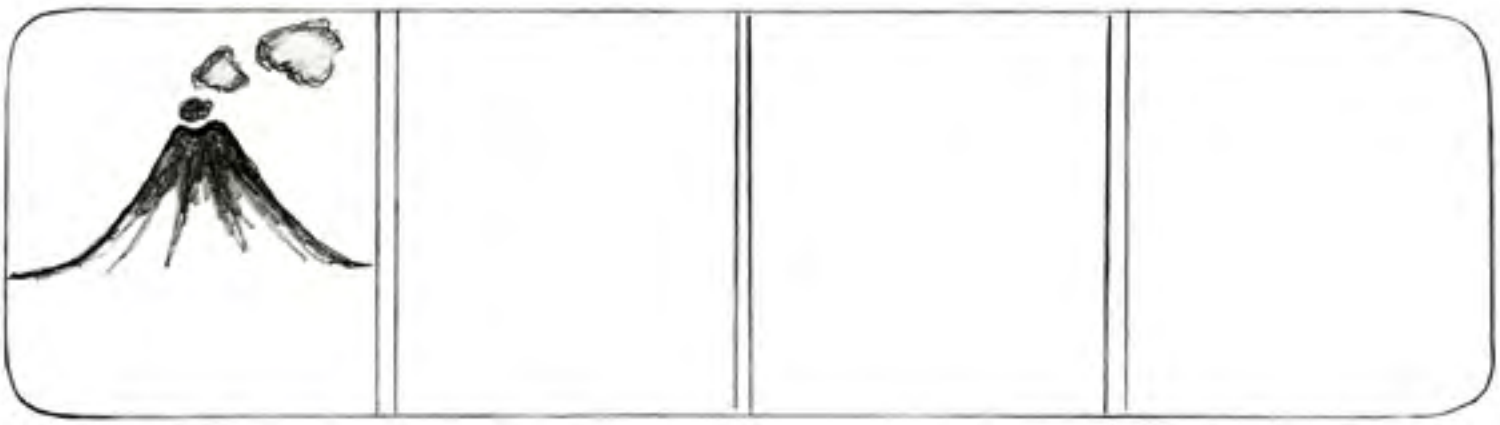
and _____ **have teeth like *Tapocyon*.**

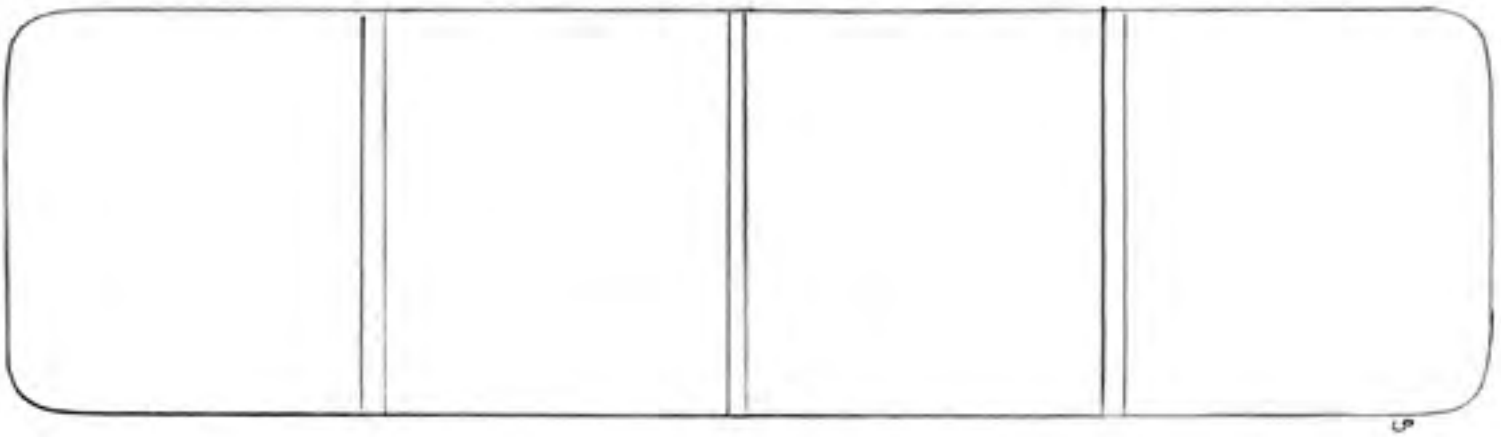
4. Find some other teeth and draw them.

Write four sentences comparing and contrasting the teeth you have drawn here to *Tapocyon*'s teeth.

5. How did the smooth red rocks (the rhyolites) travel from Sonora, Mexico, to San Diego's backyards?
Draw a comic strip to tell the story.





**6. Choose an extinct animal from the Pleistocene gallery.
What do you think are some reasons this animal became extinct?**

I think the _____

became extinct because _____

_____

_____

_____

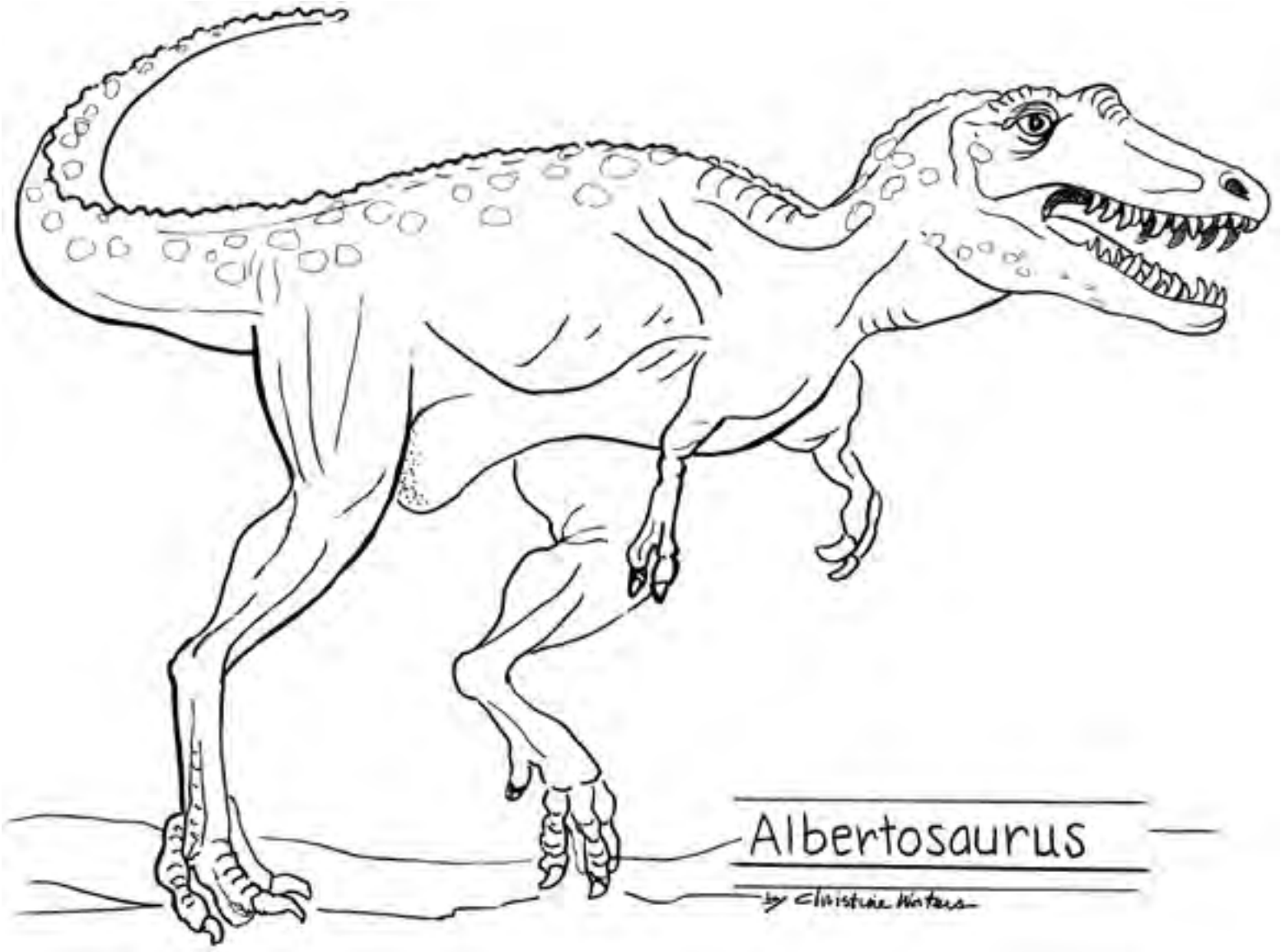
_____

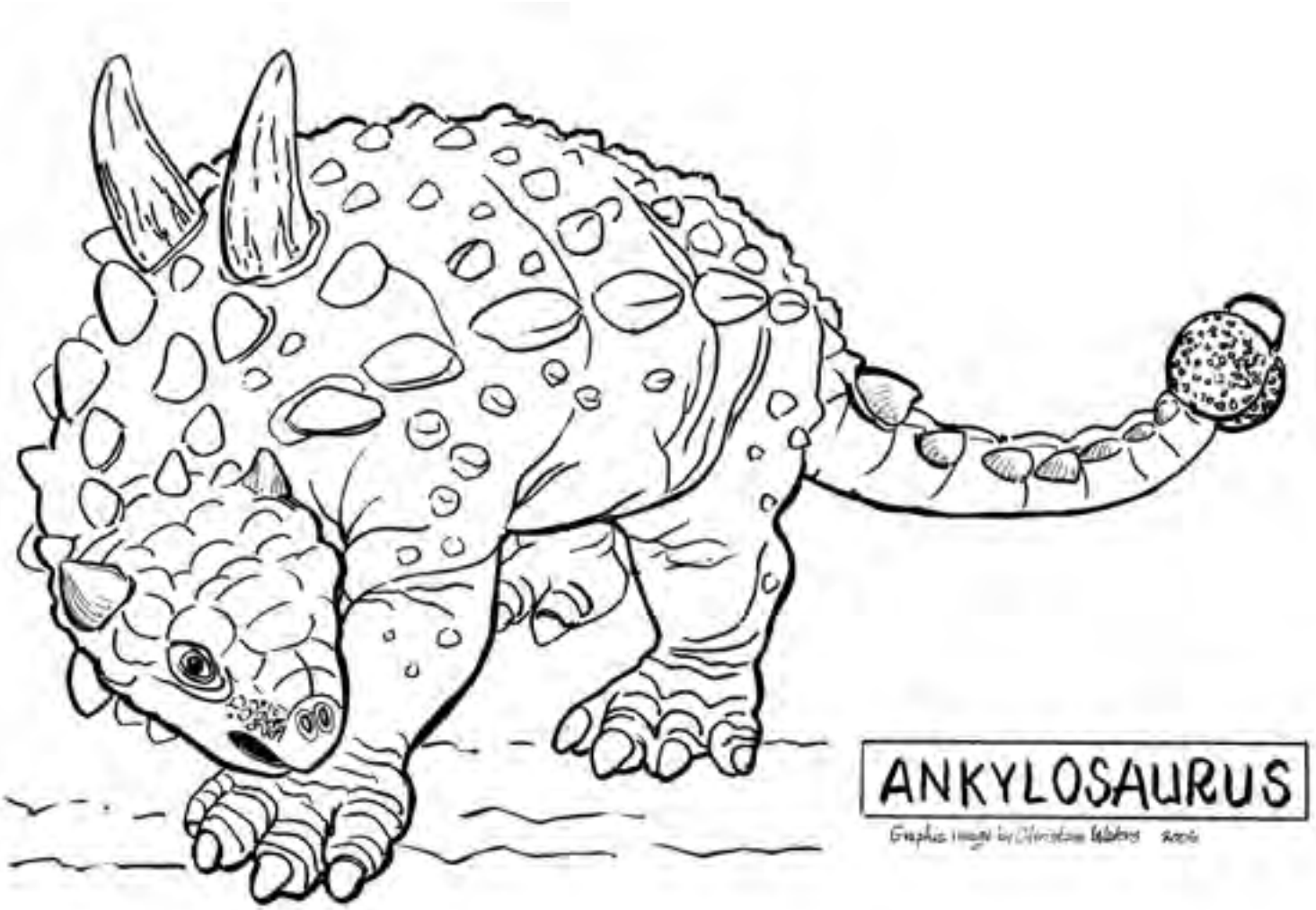
_____

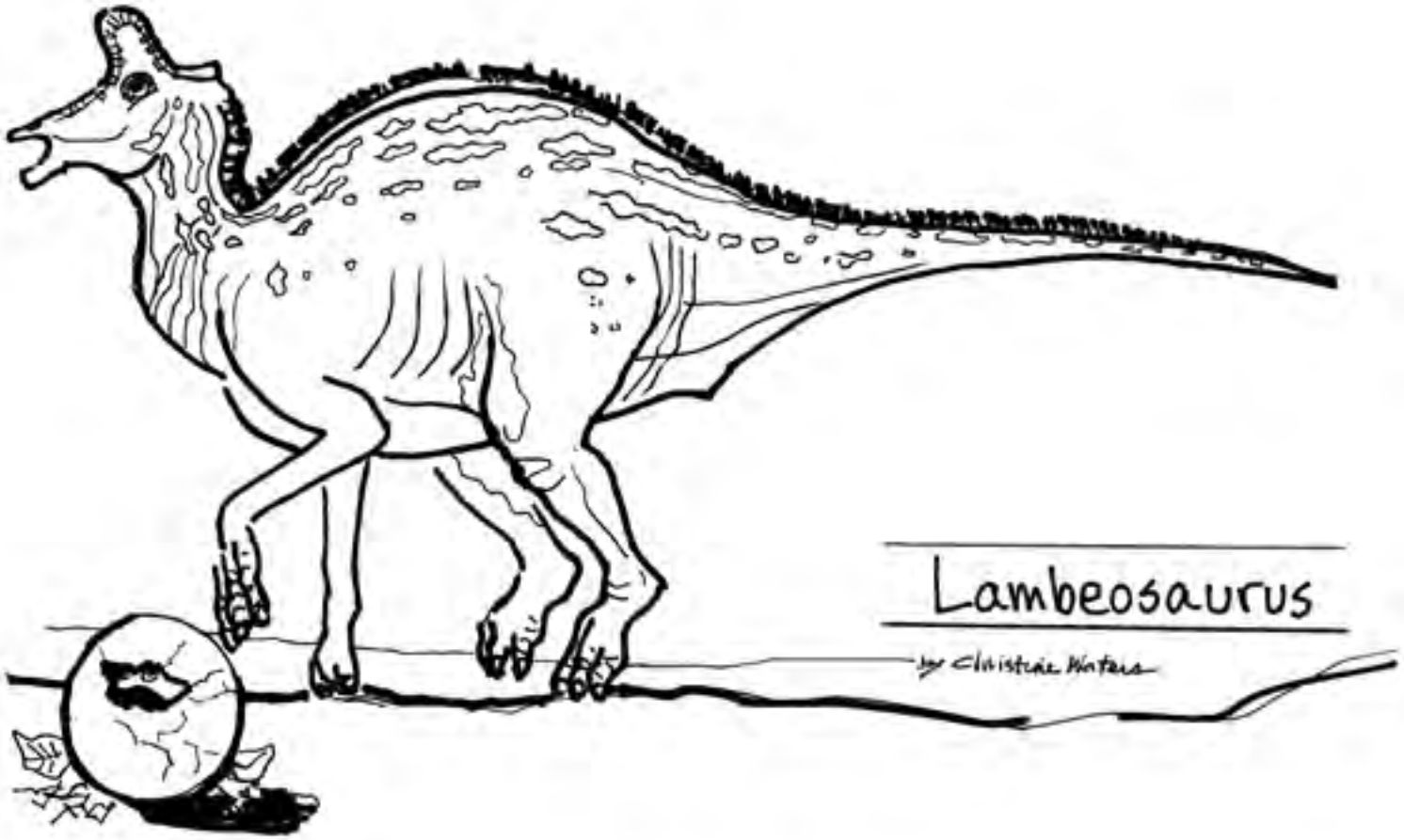
_____

_____

_____


Albertosaurus
by Christine Hintze


ANKYLOSAURUS


Lambeosaurus

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