DEAR EDUCATOR,

The instructional resources in National Geographic's *Sea Monsters: A Prehistoric Adventure Educator's Guide* were developed to bring the prehistoric world of the Cretaceous and the adventure of paleontology to life for you and your students. Inside this *Educator's Guide* you'll find:

- > Three activities in each lesson with step-by-step instructions for classroom use.
- > A lesson overview, guiding question, and vocabulary to introduce key concepts and terms.
- > A planner for at-a-glance learning objectives, instructional strategies, and materials.
- > A glossary (page 33) defining key terms.
- > Student handouts (pages 35-47) to support active and engaged learning.

These resources and more are available at **nationalgeographic.com/seamonsters/educators**.
We welcome your feedback.

Enjoy this prehistoric adventure!

National Geographic Education and Children's Programs
nationalgeographic.com/education

NATIONAL GEOGRAPHIC

NATIONAL EDUCATION STANDARDS

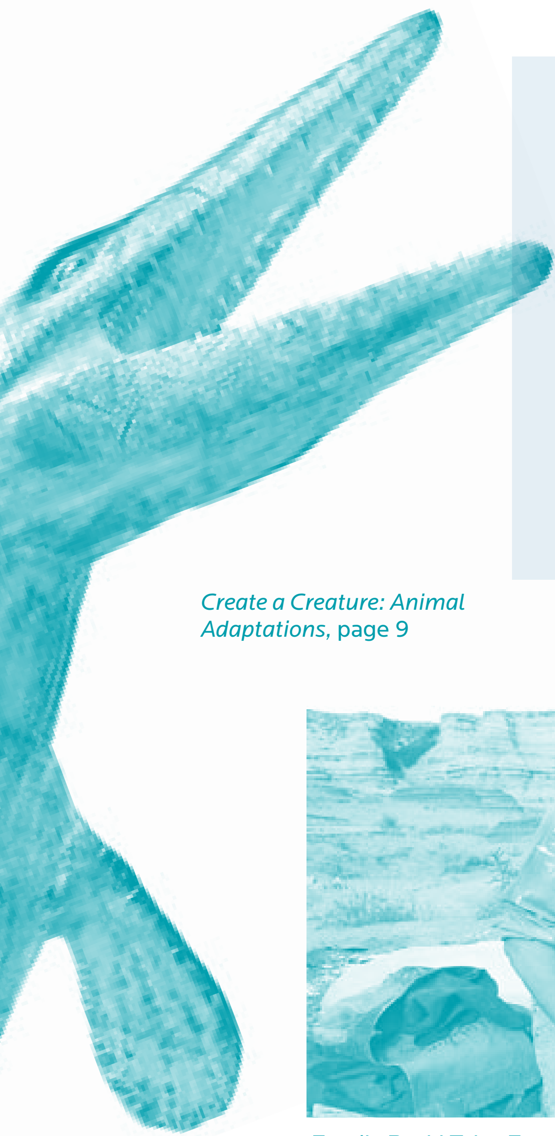
The lessons included in this *Educator's Guide* address the following voluntary National Education Standards:

	GEOGRAPHY	SCIENCE	ENGLISH LANGUAGE ARTS	ART
GRADES 3-5				
Fossils Rock! Tales From the Field	17	G	3, 5	Theater 1, 4
Create a Creature: Animal Adaptations	17	C, G		Visual Arts 3
At Home Under the Cretaceous Seas	8, 17	C, D		
GRADES 6-8				
Science on Screen: Evidence and Inference	17	A, D, G		
CSI: Cretaceous Seas Investigation	7, 17	A, D		
On Exhibit: World Under Water	1, 17	C	3, 5	Visual Arts 3
GRADES 9-12				
Science Forum: Extinction Then and Now	14, 17, 18	C	3, 5	

Accompany a team of paleontologists as they work to solve an 82-million-year-old mystery…

The film *Sea Monsters: A Prehistoric Adventure* transports students 82 million years back in time to the Cretaceous period when an extraordinary diversity of marine life populated vast ocean waters. Over the millennia, changes in Earth's climate and geography have left ancient seabeds dry, revealing fossil evidence of this extraordinary—yet little known—time. In *Sea Monsters: A Prehistoric Adventure,* the scientific process comes alive as discoveries from around the world are woven together to reconstruct the complex puzzle of this prehistoric world.

The lessons in this guide are designed to support the educational use of *Sea Monsters: A Prehistoric Adventure* through standards-based learning. Developed and reviewed with input from scientists, teachers, and museum educators, they are designed to engage students in an array of scientific and geographic concepts through inquiry-based activities.



Earth's History and Geography

How has Earth changed over time? During the late Cretaceous, a warmer climate raised global sea levels. Marine waters inundated continents, forming shallow, inland seas in low-lying areas. One of these, the Western Interior Sea, cut what is now North America in two. To compare then and now, students plot coordinates of Cretaceous period land and water boundaries on a map of present-day United States.

On Exhibit: World Under Water, page 25

Create a Creature: Animal Adaptations, page 9

Fossils Rock! Tales From the Field, page 5

Careers in Science

Paleontologists look for, discover, excavate, and study fossils to learn about life on Earth during prehistoric times. Students learn what it is like to work as a paleontologist through firsthand accounts.

Life Science

Giant turtles, long-necked plesiosaurs, enormous squid. While some of the organisms that lived during the Cretaceous period resemble modern organisms, others look extraordinary. Students research prehistoric animals to learn about their basic habitat needs and adaptations that helped them survive in their environment.

At Home Under the Cretaceous Seas, page 13

Environmental Change and Extinction

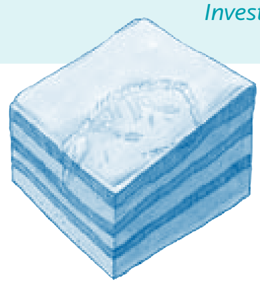
Habitat destruction. Meteoroids and asteroids. Invasive species. Climate change. Scientists study these factors and others to understand extinction. Students research extinction—past and present—and present their findings in a scientific forum.

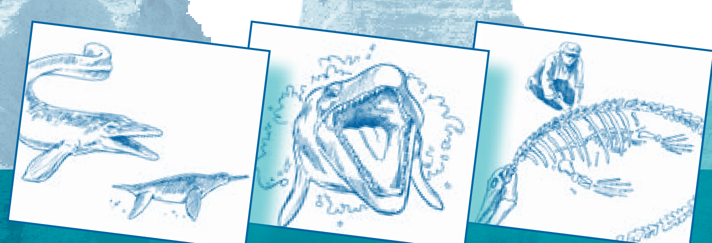
Science Forum: Extinction Then and Now, page 29

Science as Inquiry

Fossils are direct evidence to life on Earth millions of years ago. They provide scientists with clues to the appearance, behaviors, and interactions of prehistoric animals. Site maps are created to document fossil finds. Students examine a site map and then create one of their own.

CSI: Cretaceous Seas Investigation, page 21





Science on Screen: Evidence and Inference, page 17

Evidence and Inference

Sea Monsters: A Prehistoric Adventure utilizes computer-generated animations to reconstruct the Cretaceous world. The film is based on fossil and other scientific evidence, but some details can only be inferred. Students learn to differentiate between direct evidence and inference, and to identify the use of both in a storyboard from the film.

CONTENTS

GRADES 3-5 LESSONS

GRADES 6-8 LESSONS

GRADES 9-12 LESSON

Funded in part by the National Science Foundation

Geography Standard 17 Science Standard G Language Arts Standards 3, 5 Arts Theater Content Standards 1, 4

FOSSILS ROCK! TALES FROM THE FIELD

What is it like to work as a paleontologist? In Activity 1, students listen to or read an interview with paleontologist Paul Sereno, a National Geographic Explorer-in-Residence, to learn about his passion for science and his discovery of SuperCroc in sub-Saharan Africa. In Activity 2, students join a dig with paleontologist Mike Everhart to learn what happens when a scientist in the field suddenly discovers fossil remains. In the Closing Activity, students create a story or conduct an interview and present or record their work for an imaginary radio program.

Vocabulary (see Glossary p. 33)

deep time
excavate
fossil
fossil dig
GPS (Global Positioning System)
jacket
paleontologist
paleontology
prospect
remains
Smoky Hill Chalk
SuperCroc

Try This First!

Show students the picture of paleontologists working on a fossil dig (see back inside cover). Ask students to describe what is happening in the picture. Remind students to use observational skills to look for tools, geographic clues, and the work being done.

Guiding Question:

Why and how do paleontologists study fossils?

Activity	Objectives	Instructional Strategy	Materials
ACTIVITY 1 Meet a Paleontologist 20 min.	Students will: - Learn about the work of paleontologists	- Multimedia Instruction	- "Meet a Paleontologist" (p. 35)
ACTIVITY 2 Join a Dig 45 min.	Students will: - Learn about the tools paleontologists use on a field dig; and - Learn about actions paleontologists take after discovering a fossil.	- Multimedia Instruction	- "Join a Dig" (p. 36) - "Join a Dig" (optional audio file; online only) - Internet access (optional)
CLOSING ACTIVITY "Fossils Rock!" Radio Program 60 min.	Students will: - Write a story or conduct an interview using vocabulary and information from previous activities; and - Present and/or record their work.	- Role-playing	- "'Fossils Rock!' Radio Program" (p. 37) - Audio-recording device such as a digital recorder, computer with a microphone, tape, or audio recorder (optional)

Activity 1

Meet a Paleontologist

20 min.

Students listen to or read an interview with paleontologist Paul Sereno, a National Geographic Explorer-in-Residence, to learn about his passion for science and his discovery of SuperCroc in sub-Saharan Africa.

"Meet a Paleontologist" (p. 35)

Directions:

1. Explain. Scientist Paul Sereno searches for, discovers, and studies fossil remains. Scientists who do this work are called paleontologists. While on a dig in sub-Saharan Africa, Sereno discovered the fossil remains of *Sarcosuchus imperator* ("flesh crocodile emperor"), one of the largest crocodilians to ever walk the Earth. This SuperCroc was 40 feet long (as long as a city bus) and weighed about ten tons.

Note: *Additional information about SuperCroc and Paul Sereno, a National Geographic Explorer-in-Residence, is available online.*

- nationalgeographic.com/explorers-program/eir/psereno.html
- nationalgeographic.com/supercroc

2. Distribute "Meet a Paleontologist" to each student.

3. Listen or read aloud. Ask a pair of students to read the interview aloud, with each student playing the role of interviewer or interviewee.

Note: *This interview has been adapted and abridged for students. The original audio interview was broadcast on National Geographic World Talk (nationalgeographic.com/radio/worldtalk.html) and is available online.*

- nationalgeographic.com/explorers-program/eir/psereno.html (Running time: 19:13)

4. Review and discuss. Check student comprehension. Write new vocabulary words on the board and discuss with students. Have students answer the following questions on a separate piece of paper and then discuss as a class.

- Why does Paul Sereno think science is fun?
  Answer: *He believes that science is about discovery and creativity, and asking questions or finding answers that no one else has.*
- Why does Paul Sereno think it is important to study dinosaurs?
  Answer: *Dinosaurs are a connection to the distant past, a time that we can only dream about or think about scientifically.*
- Where did Paul Sereno find SuperCroc?
  Answer: *In Africa.*
- What did SuperCroc look like?
  Answer: *Its skull was six feet long and its body was 40 feet long.*
- Why do you think it is named SuperCroc?
  Answer: *This prehistoric crocodile was twice as long and many times heavier than modern crocodiles.*

5. Brainstorm. Ask students to brainstorm additional questions they might have about paleontologists and their work. Write this list on the board and suggest that students look for answers to these questions as they watch *Sea Monsters: A Prehistoric Adventure.*

Note: *The film* Sea Monsters: A Prehistoric Adventure *primarily profiles prehistoric marine reptiles, which are not classified as dinosaurs but lived at the same time.*

View *Sea Monsters: A Prehistoric Adventure.*

Activity 2

Join a Dig

Students join a dig with paleontologist Mike Everhart to learn what happens when a scientist in the field suddenly discovers fossil remains.

45 min.

"Join a Dig" (p. 36) or "Join a Dig" (audio; nationalgeographic.com/seamonsters/educators)

Directions:

1. Explain. In 2002, paleontologist Mike Everhart was prospecting, or looking, for fossils in Kansas when he came across a wonderful discovery. In this activity, students will read or listen to his firsthand account of this find and then answer questions.

Note: *Additional information about Mike Everhart's work is available online.*

oceansofkansas.com

2. Distribute "Join a Dig" to each student.

3. Listen to the story. Play the "Join a Dig" audio recording narrated by the scientist, or read the story aloud. Students can read along as they listen. The audio recording is available online.

nationalgeographic.com/seamonsters/educators

4. Review learning. Write new vocabulary words on the board and discuss with students. Then use the following questions to lead a class discussion on the story. Have students answer the following questions on a separate piece of paper and then discuss as a class. Alternatively: Discuss the following questions with the whole class.

What actions did Everhart take to find and collect the fossil remains?

Possible answers:

- *Observe*
- *Identify*
- *Photograph*
- *Locate*
- *Excavate (remove) dirt*
- *Sketch*
- *Protect*
- *Transport*

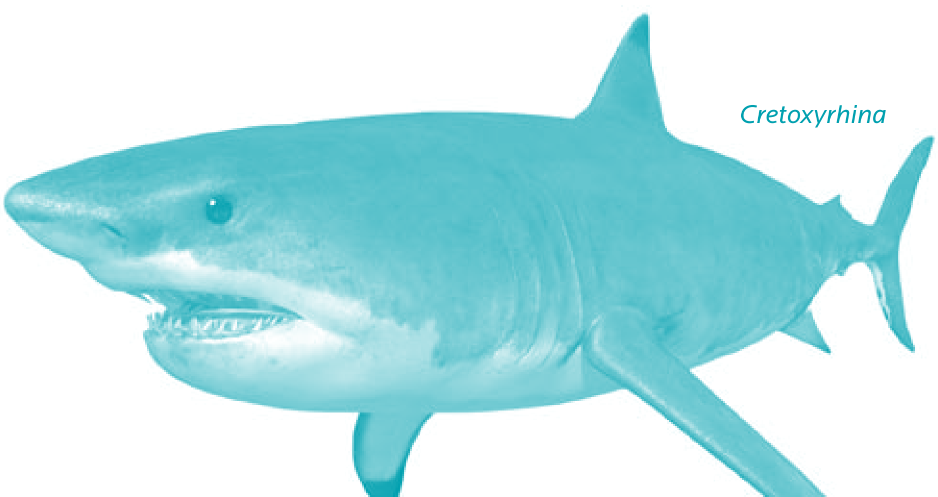
What tools did Everhart use? Why were they helpful?

Possible answers:

- *Map and GPS data to record the location of the fossil*
- *Camera and notebook to document the fossil*
- *Large pick, shovel, small knife, ice pick, and small brush to remove dirt and excavate the fossil*
- *Wet paper towels, burlap, plaster, plastic, and a plaster frame to protect the fossil*
- *A van to transport the fossil*

ADAPTATIONS

This activity contains content-area reading and listening. Support students who have difficulty comprehending some of the text by providing scaffolding such as reinforcing vocabulary concepts, using words in context, predicting, summarizing and clarifying key points, and modeling comprehension strategies.



Cretoxyrhina

Closing Activity

"Fossils Rock!" Radio Program

60 min.

Students synthesize their learning to write a story or conduct an interview. They will orally present or record their work for a fictional radio program.

"'Fossils Rock!' Radio Program" (p. 37)

Directions:

1. **Explain.** Students will create a story or conduct an interview for a fictional radio program called "Fossils Rock!". They can work in groups or individually, as appropriate.

2. **Distribute "'Fossils Rock!' Radio Program" to each student.** Review the directions with students.

3. **Student presentations.** After students have had time to prepare their story or interview, have them present their work to the class. Students can pretend they are recording an imaginary radio program called "Fossils Rock!".

Option: Student work can be recorded using a computer with a microphone, or an audio or video recorder.

STUDENT ASSESSMENT

Rate student work on a scale from one to five on each of the following categories: creativity, accurate use of vocabulary, accurate understanding of paleontology, organization of main ideas.

BACKGROUND INFORMATION

Paleontology is a science dealing with the life of past geological periods as known from fossil remains. Paleontologists look for, discover, excavate, and study fossils to learn about life on Earth during prehistoric times.

Geography Standard 17 Science Standards C, G Visual Arts 3

CREATE A CREATURE: ANIMAL ADAPTATIONS

Students learn that animals undergo adaptations—changes to body parts and behaviors—that help them survive. In Activity 1, students learn how scientists name all living things—including animals and plants that lived in prehistoric times. In Activity 2, students investigate adaptations in modern and prehistoric animals. In the Closing Activity, students apply what they have learned to produce a drawing, a description, and a correctly named imaginary prehistoric sea creature.

Vocabulary (see Glossary p. 33)

adaptation	*ops*
behavior	*ped or pes*
bi	*rex*
cephal(o)	*rhino*
cerat(o)	*saur(us)*
ichthy	*tri*
mega	*tyrann*
micro	*uni*
odon or oden	*vor(e)*

Try This First!

Tell students to write "marine reptile" on a piece of paper and then put their pencils down. Then have them try again, this time without using their thumb to grip the pencil. Point out that the thumb is a body part that provides an advantage when using a tool. Explain that writing and spelling words are learned behaviors. Both the thumb and the writing are examples of adaptations.

Guiding Question:

What body parts and behaviors help animals adapt to their environment? What can scientific names tell us about animal adaptations?

Activity	Objectives	Instructional Strategy	Materials
ACTIVITY 1 What's in a Name? 45 min.	Students will: - Learn how Greek and Latin word parts are used to name an animal; and - Learn about the science rules and conventions for naming a new animal.	- Discussions - Large-group Instruction	- "Greek and Latin Words Parts" (optional; online only)
ACTIVITY 2 How Do Animals Adapt? 45 min.	Students will: - Learn about the term "adaptation"; - Understand how adaptations—changes in body parts or behaviors—help animals survive; and - Identify different types of adaptations.	- Computer-assisted Instruction - Discussions - Large-group Instruction	- Internet or library resources - "Animal Adaptations" (p. 38)
CLOSING ACTIVITY Design-a-Saurus 30 min.	Students will: - Create a drawing of a real or imagined prehistoric marine reptile; - Make anatomical drawings that represent a body part adaptation; and - Give a real or imagined prehistoric marine reptile a name based on scientific naming conventions.	- Large-group Instruction - Small-group Instruction - Student Presentations	- Art Supplies - Paper

Activity 1

What's in a Name?

45 min.

Students learn how scientists name a living thing in one of three ways: by reference to the location where an organism was found; in honor of a person with some connection to the discovery; or by reference to a unique body part or behavior.

"Greek and Latin Word Parts" (optional; nationalgeographic.com/xpeditions/lessons/17/g35/greeklatin.pdf)

Directions:

1. Explain. Scientists use Greek and Latin words and scientific conventions to name plants and animals, including prehistoric marine reptiles. There are three approaches: to reference the location where an organism was found; in honor of a person with some connection to the discovery; or to reference a unique body part or behavior.

One way scientists name living things is by the location where the animal lived or was first discovered. The mosasaur, a "Meuse River lizard," is named after a tributary of a river in the Netherlands, where the first known specimen was discovered. Ask students if they can guess where the *Argentinosaurus* was first discovered.
Answer: *Argentina.*

Group Activity. Brainstorm some names of imaginary prehistoric sea creatures if they were discovered in your local area. Write the names on the board.

2. Explain. Other dinosaurs are named after famous people or for the lucky person who found them. The *Mosasaurus hoffmanni* is named after C.K. Hoffman. Ask students who *Nedcolbertia* is named after.
Answer: *Ned Colbert (Dr. Edwin "Ned" Colbert).*
Or *Ricardoestesia?*
Answer: *Richard Estes.*

Group Activity. Brainstorm some names of imaginary prehistoric sea creatures named after famous people and then after the students themselves.

3. Explain. The last approach is to name animals by their body part, behavioral adaptations, or by whole body descriptions. Example: Englishman Richard Owen coined the word *Dinosauria* from "dino," (terrible) and "saur" (lizard). An *Ichthyosaur* is an "ichthy" (fish) + "saur" (lizard).

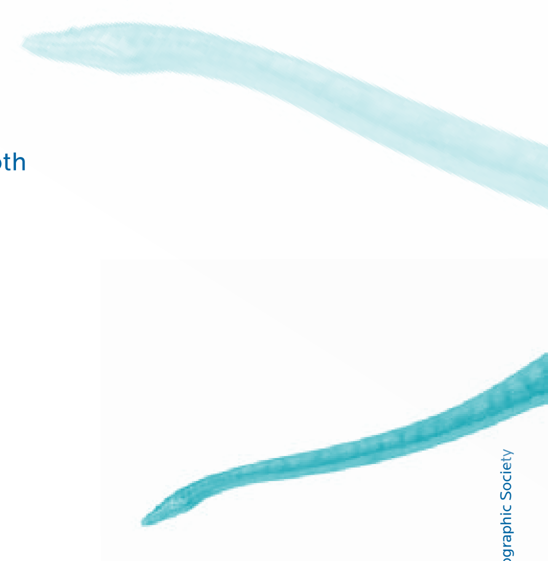
4. Group Activity. Write the following Greek and Latin word parts on the board. Ask students to invent names for imaginary prehistoric sea creatures using three word parts (prefix, root word, and suffix). List these names and descriptions of the animals on the board. Example: a "Megabiceratosaurus" ('big two-horned lizard'). Additional Greek and Latin word parts are available online.

nationalgeographic.com/xpeditions/lessons/17/g35/greeklatin.pdf

Note: *This activity has been simplified for young students. Scientists would not mix Greek and Latin word parts.*

Greek and Latin Word Parts

bi–two
cephal(o)–head
cerat(o)–horn
ichthy–fish
mega–large
micro–small
odon or oden–tooth
ops–eye or face
ped or pes–foot
rex–king
rhino–nose
saur(us)–lizard
tri–three
tyrann–tyrant
uni–one
vor(e)–eating



Activity 2 How Do Animals Adapt?

Students are introduced to adaptations—changes in body parts or behaviors—that helped prehistoric marine reptiles survive in the Cretaceous period.

45 min.

"Animal Adaptations" (p. 38)

Directions:

1. Explain. Introduce the term "adaptation" to the students. An adaptation is a behavior or body part modification (change) that helps an animal survive where it lives. Explain that adaptations can occur through modified behavior (example: working in groups, swimming in schools to avoid predators) or modified body parts (example: chemical defense, camouflage, different limb shapes).

Ask students to brainstorm other examples.
Possible answers: *Modified body parts such as eyes (ability to see at night, ability to see far away, ability to see under water), keen sense of smell, large teeth, many teeth, claws, body size; modified behaviors such as playing dead, food selection, migration.*

2. Discussion. Tell students that, like modern day animals, prehistoric animals also adapted body parts and behaviors in order to survive. In *Sea Monsters: A Prehistoric Adventure*, they will encounter incredible sea creatures that lived 82 million years ago. Ask the class to look for adaptations—body parts or behaviors—that helped these creatures survive.

View *Sea Monsters: A Prehistoric Adventure*.

3. Continue discussion. Describe some of the challenges that the prehistoric marine reptiles faced in the film.
Possible answers: *Protecting their young, defending themselves, finding food.*

4. Distribute "Animal Adaptations" to each student. As a class, review the model of the giraffe. Next, have students participate in a guided classroom discussion or do library or online research to complete the rest of the handout.

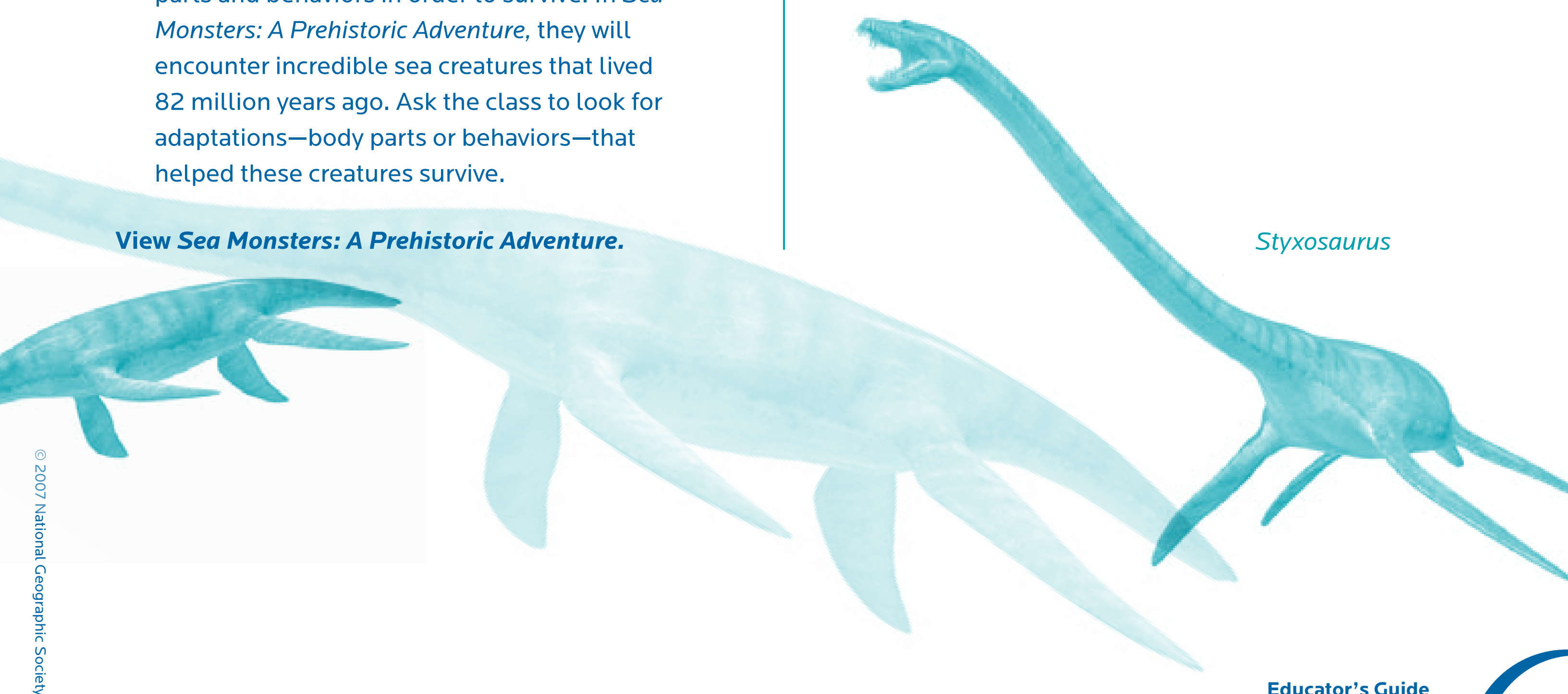
Suggested Online Resources:

National Geographic: Sea Monsters—A Prehistoric Adventure
nationalgeographic.com/seamonsters

National Geographic Magazine: Sea Monsters—Multimedia
nationalgeographic.com/ngm/0512/feature3/multimedia.html

National Geographic: Animals
nationalgeographic.com/animals/

5. Discussion. Ask students to discuss what they learned about adaptations in modern and prehistoric animals.



Styxosaurus

Closing Activity

Design-a-Saurus

30 min.

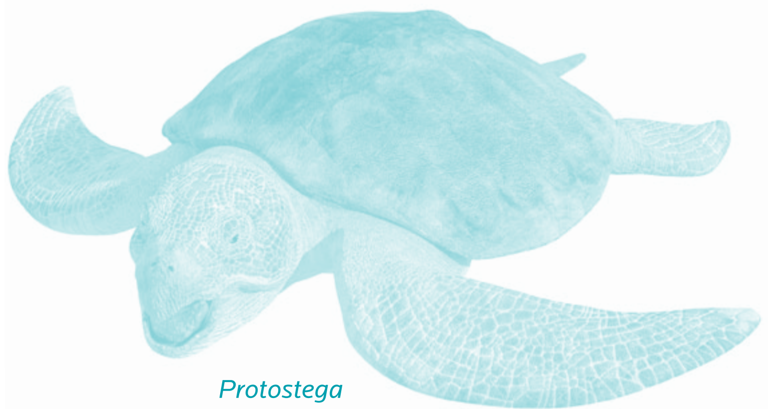
Students create a drawing of a real or imagined prehistoric sea creature and name the creature after a place of discovery, an honored person, or an adaptation.

Directions:

1. **Review.** Ask students to think of the different adaptations they have discussed or seen in the film. Review the three ways scientists name something that is living or was once alive—after a person, a place, or an adaptation. Tell students that paleontologists often draw animals that they study.

2. **Start activity.** Tell students they are going to create a profile of a real or imagined prehistoric marine reptile. To complete the assignment, students should:

   - Draw the real or imagined animal.
   - Label one or more adaptations, noting how it helped the animal survive in its environment.
   - Draw and label a map of where it was found and who first discovered it.
   - Name the prehistoric marine reptile. If it is an imagined animal, create and explain the name by science rules—after an adaptation, a place, or a person. If it is a real animal, explain the origins of its name.
   - Write one or more declarative sentence(s) about the animal.



Protostega

3. **Student Presentations.** Have students share their work with the class. Students should introduce their animal by name, describe the animal (including its body part and behavioral adaptations), and how those adaptations helped it survive in its environment, and determine if the animal is named after a person, a place, or an adaptation.

STUDENT ASSESSMENT

Students who master this lesson should have completed the "Animal Adaptations" handout with correct information about the animals researched. They should also create a drawing of a marine reptile that has one or more adaptations. Their created animals should be named after an adaptation, a location, or a person. The focus of the drawings are the adaptations shown and the way the creature is named. Emphasize the functions of the adaptations, not how well the drawings are made. Declarative sentences should accompany their drawings that accurately describe the adaptations. Students should be able to apply what they learned about adaptations (body parts or behaviors as a way to successfully survive in their surroundings) to modern animals. They should be able to give examples of adaptations from animals of which they are familiar.

Geography Standards 8, 17 Science Standards C, D

AT HOME UNDER THE CRETACEOUS SEAS

Students learn that habitats meet the basic needs of animals in several ways. In Activity 1, they investigate prehistoric sea creatures to learn about their life and how they met their basic needs. In Activity 2, students research animals featured in *Sea Monsters: A Prehistoric Adventure.* In the Closing Activity, students build on this information to create and play a 'bingo' game.

Vocabulary (see Glossary p. 33)

- Cretaceous period
- habitat
- invertebrate
- mya
- prehistoric
- reptile
- seaway
- vertebrate
- Western Interior Sea (Seaway)

Try This First!

Share this definition: "Habitats are the natural environments of plants and animals." Ask students to brainstorm things that make up a habitat. *Suggested responses: water, air, trees, rain, snow, sand, etc.* Explain that Earth has many habitats and that each type of habitat is unique. Oceans, forests, deserts, and tundra are habitats. Rivers, lakes, and wetlands are also habitats. Even under water there can be habitats such as shallow-water or deep-water zones. A combination of many things—including temperature, soil, available food, rainfall, and geographic location—create a habitat.

Guiding Question:

Did prehistoric animals have the same habitat needs as modern animals?

Activity	Objectives	Instructional Strategy	Materials
ACTIVITY 1 Habitat Needs 20 min.	Students will: - Learn about the term "habitat"; and - Learn about the four basic survival needs of all animals.	- Discussions - Large-group Instruction	
ACTIVITY 2 What Swam in the Cretaceous Seas? 40 min.	Students will: - Research marine animals from the Cretaceous period; - Understand how habitats provide animals with critical elements necessary to survival; and - Collect and organize information about a prehistoric creature.	- Discussions - Small-group Instruction - Large-group Instruction - Computer-assisted Instruction	- "Cretaceous Seas Fact Sheet" (p. 39) - Internet or library resources - Art supplies, including markers or crayons
CLOSING ACTIVITY Cretaceous Seas Bingo 60 min.	Students will: - Answer questions about prehistoric creatures; and - Play a bingo-style game to reinforce information about prehistoric marine reptiles.	- Discussions - Large-group Instruction	- "Cretaceous Seas Bingo Pictures" (p. 40) - "Cretaceous Seas Bingo Card" (p. 41) - Tape or Glue - Scissors - "Cretaceous Seas Fact Sheet" (Activity 2 handout) - Markers (app. 20 per student), beans, rice, plastic chips, pennies, etc.

Activity 1 Habitat Needs

20 min.

Students learn that a habitat satisfies basic needs necessary for an animal to survive and will research the habitat needs of modern-day animals.

Directions:

1. Review. Write this definition of "habitat" on the board: "The place or environment where a plant or animal naturally or normally lives and grows."

2. Brainstorm. Ask students to brainstorm four basic survival needs that that all animals require from their habitat. Tip: Prompt students to think about things that are essential for survival. Four basic survival needs include:

- Food
- Shelter from weather and predators
- Water
- A place to raise young

3. Model an example. Model an example for students, e.g.

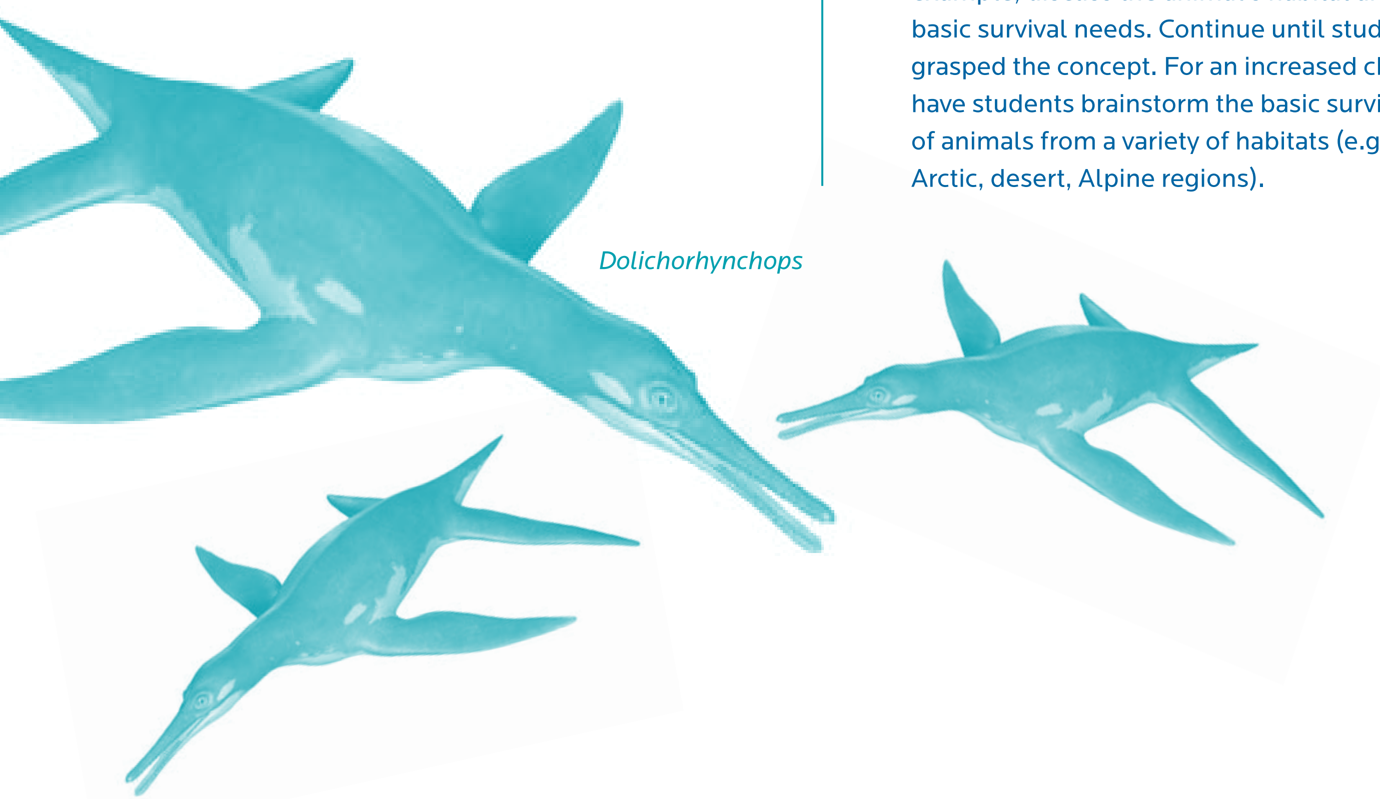
Animal: salt water crocodile

Habitat: coastal marshes, estuaries, and shallow marine waters

Basic survival needs include:

- Food – carnivorous (eats meat), including fish, birds, reptiles, and mammals
- Shelter from weather and predators – have camouflage and can submerge for long periods of time
- Water – provided by diet and from freshwater sources
- A place to raise young – female prepares and guards a nest until the young hatch and are released

4. Brainstorm. Ask the class to brainstorm other examples using animals they are familiar with (e.g. dog, cat, hamster, bird, horse). For each example, discuss the animal's habitat and basic survival needs. Continue until students have grasped the concept. For an increased challenge, have students brainstorm the basic survival needs of animals from a variety of habitats (e.g., jungle, Arctic, desert, Alpine regions).



Dolichorhynchops

Activity 2 What Swam in the Cretaceous Seas?

Students research marine animals from the Cretaceous period.

40 min.

"Cretaceous Seas Fact Sheet" (p.39)

Directions:

1. Introduce the film. Explain to students that the basic survival needs of animals have remained basically the same over millions and millions of years. Even in prehistoric times, animals required food, shelter, water, and a place to raise their young in order to survive. In *Sea Monsters: A Prehistoric Adventure* students learn about sea animals and their habitat during a fascinating chapter in Earth's history.

View *Sea Monsters: A Prehistoric Adventure.*

2. Distribute "Cretaceous Seas Fact Sheet" to each student.

3. Divide class into small groups. Working in small groups, students can use Internet or library resources to complete the "Cretaceous Seas Fact Sheet."

Suggested Online Resources:

National Geographic: *Sea Monsters—A Prehistoric Adventure*

nationalgeographic.com/seamonsters

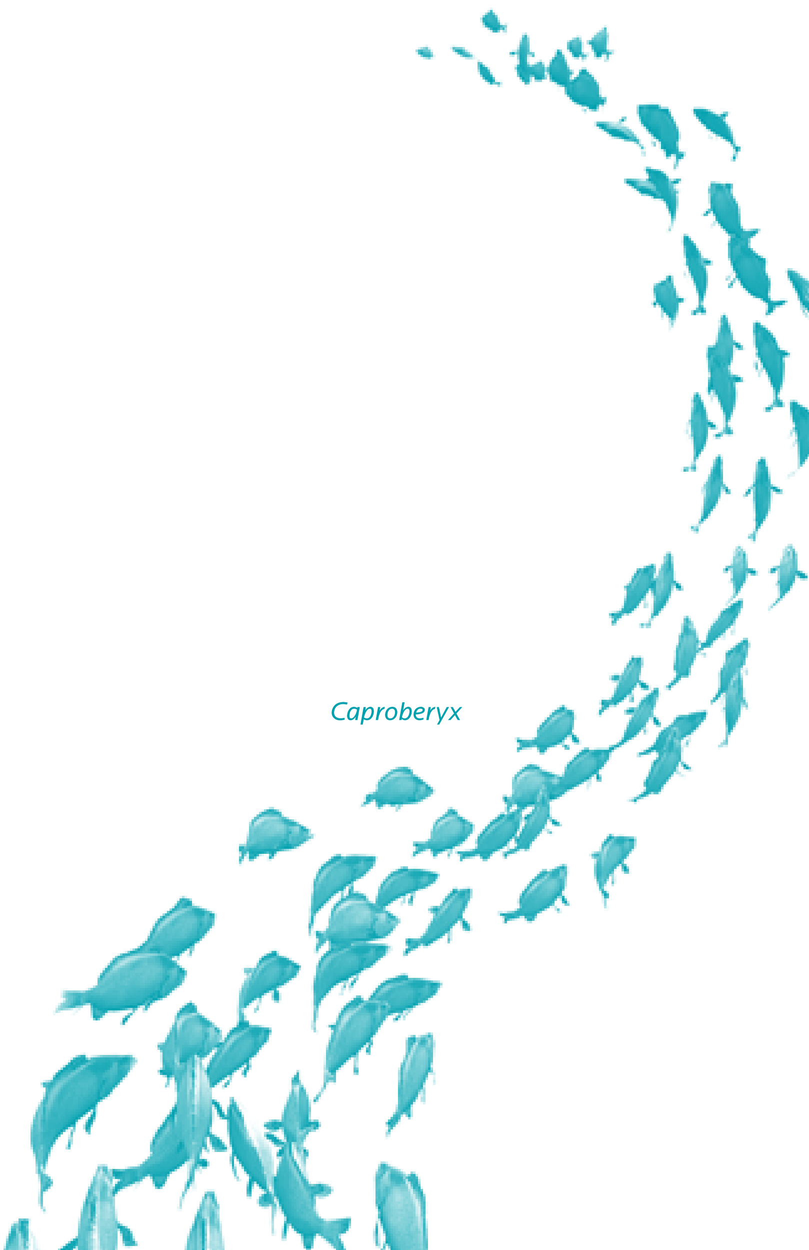
National Geographic Magazine: When Sea Monsters Ruled the Deep

nationalgeographic.com/ngm/0512/feature3/index.html

4. Review answers.

Answer Key:

1. *Tusoteuthis*
2. *Hesperornis*
3. *Dolichorhynchops*
4. *Xiphactinus*
5. *Cretoxyrhina*
6. *Henodus*
7. *Protostega*
8. *Ammonite*
9. *Tylosaurus*
10. *Styxosaurus*



Caproberyx

Closing Activity Cretaceous Seas Bingo

Students create a bingo card and play a bingo game by answering the questions they researched in Activity 2.

60 min.

"Cretaceous Seas Bingo Pictures" (p. 40)
"Cretaceous Seas Bingo Card" (p. 41)

Directions:

1. Distribute the "Cretaceous Seas Bingo Pictures" and "Cretaceous Seas Bingo Card" to each student. One page is filled with 30 images of sea creatures, and the other is a blank card with 25 spaces. Tell students to cut out the animal picture squares and mix them up. Students should randomly select 25 animal pictures to glue or tape in each blank square. They will not use all of the pictures.

2. Distribute markers. Each student will need approximately 20 markers to use when they are playing the bingo game.

3. Explain game rules:

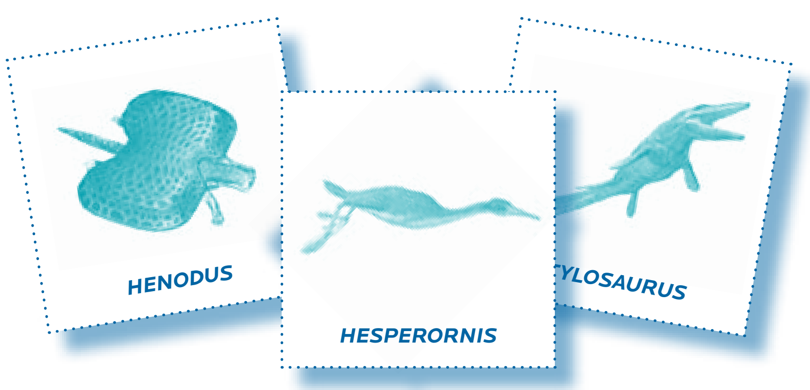
- Students play the game individually with the bingo card they created and their completed "Cretaceous Seas Fact Sheet" (Activity 2).
- You will call out clues from the "Cretaceous Seas Fact Sheet." Players use their fact sheet to look up the correct answer. Then, they look on their bingo card for an image of the correct answer and place a marker in this space. They may place only one marker if they have more than one image of the animal.
- Players compete to be the first to fill five spaces in a row, column, or diagonal.
- You will continue calling out clues until a player wins and announces "Cretaceous Seas Bingo!"

4. Start the game by asking the first question. Keep track of clues (and answers) you have used. Continue asking questions until a student announces that they have won. Check their card to make sure they have the correct answers. If one of the answers is incorrect, you should continue the game. If it is a winning bingo card, the round is over, and students should clear their cards so that a new round can begin.

NOTE TO TEACHER

Although habitats like deserts and rain forests are very different, together they form a complex life-support system for every living thing on the planet. The first photographs of Earth from space allowed us to see our planet for the first time as it is, a small blue sphere moving through the blackness of space. People began to use the term "Spaceship Earth" to help explain the idea that we must all work together, like the crew of a spaceship, to take care of all the habitats that make our planet home.

Spaceship Earth: The Mother of All Habitats
nationalgeographic.com/geographyaction/habitats/intro.html



Geography Standards 17 Science Standards A, D, G

SCIENCE ON SCREEN: EVIDENCE AND INFERENCE

Paleontologists and filmmakers use evidence and inference to reconstruct the past. In this lesson, students explore the relationship between evidence and inference, and learn how scientific research informs the development of a science-based film. In Activity 1, students observe and apply evidence and inference. In Activity 2, students study a storyboard from *Sea Monsters: A Prehistoric Adventure* to understand the role of scientific research during the development of the film. In the Closing Activity, students storyboard a new scene, applying scientific thinking supported by evidence and inference.

Vocabulary (see Glossary p. 33)

evidence
fossil
inference
observation
paleontology
prey
scavenge

Try This First!

Ask students: Imagine you're producing a scientific film about an extinct animal that lived millions of years ago. How would you know what it looked like and how it behaved? Explain that scientists study fossils to learn about an animal's size and skeletal structure, when and where it lived, and sometimes what it ate or was eaten by. They study behaviors of living animals for clues to their ancient relatives. Scientists and filmmakers make models and use computers to help bring the past to life.

Guiding Question:

How do filmmakers use evidence and inference to make a science-based film about prehistoric marine reptiles?

Activity	Objectives	Instructional Strategy	Materials
ACTIVITY 1 Unpack the Evidence 20 min.	Students will: - Understand the definitions of evidence and inference; and - Distinguish between evidence and inference.	- Discussions - Visual Instruction - Large-group Instruction	- Student or teacker backpack filled with school items
ACTIVITY 2 Behind the Scene: Science Notes 35 min.	Students will: - Identify examples of evidence and inference; and - Learn how filmmakers incorporate evidence and inference to create science-based films.	- Discussions - Visual Instruction - Large-group Instruction	- "Behind the Scene: Science Notes" (p. 42)
CLOSING ACTIVITY Storyboard a Scene 45 min.	Students will: - Create and present a storyboard based upon scientific notes.	- Discussions - Visual Instruction - Large-group Instruction	- "Behind the Scene: Science Notes" (Activity 2 handout)

Activity 1

Unpack the Evidence

20 min.

Students practice scientific thinking to understand evidence and inference.

Directions:

1. **Preparation.** Prepare a backpack with books and other items you will show the class. Include items students can use to hypothesize about the person who owns the bag.

2. **Group activity.** Show students the backpack and ask them to use scientific thinking to learn more about this backpack. As you examine the backpack and its contents, guide students through the following steps.

3. **Ask students, "What can you observe?"** Prompt students to describe the backpack and the contents inside.
   Possible answers: *size, color, style, descriptions of objects as they are shown.*

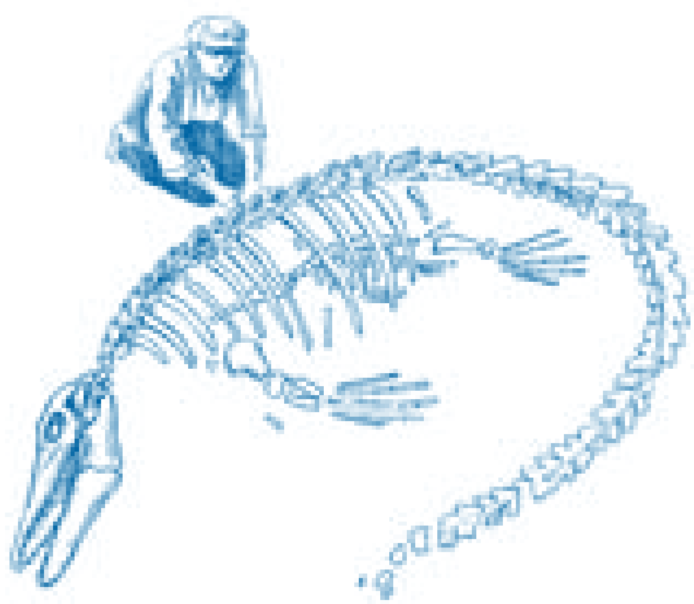
4. **Ask students, "To whom does it belong?"** Ask students what they can infer about the person who owns the backpack, based on the information they have acquired. What behaviors can they infer about the owner, based on the contents and how they might be used?

5. **Write "evidence" and "inference" on the board, and discuss these terms with students.**

   Evidence is data that can be measured, observed, examined, and analyzed to support a conclusion. Ask students to share what they know about the backpack and its contents that are based on evidence.
   Possible answers: *descriptions of the bag and its contents.*

   Inference is an explanation derived by reasoning. Ask students to share information they acquired during the backpack activity that is based on inference, i.e. ideas they have that cannot be directly observed in the contents.
   Possible answers: *Descriptions of the type of person who may own the bag and how they used the objects found inside.*

6. **Making a connection.** Introduce students to the work paleontologists do. Paleontologists search for, uncover, and study fossil remains, which is evidence of prehistoric animals. Like the backpack activity, paleontologists draw inferences from the evidence they uncover. Example: A shark's tooth embedded in a fossilized bone may lead a paleontologist to infer that a shark bit the animal.



Activity 2 Behind the Scene: Science Notes

35 min.

Students create a chart to identify examples of evidence and inference in a scene from *Sea Monsters: A Prehistoric Adventure.*

"Behind the Scene: Science Notes" (p. 42)

Directions:

1. Review. Review the concepts of evidence and inference. Ask students to look for examples of these concepts as they watch the film, *Sea Monsters: A Prehistoric Adventure.*

View *Sea Monsters: A Prehistoric Adventure.*

Discussion. Discuss the film with students. What elements did they think were based on evidence? What elements did they think were based on inference?

2. Distribute "Behind the Scene: Science Notes." Explain that one of the scientific advisors on the film has shared his notes from a scene in the film. Ask students to read the notes on the handout.

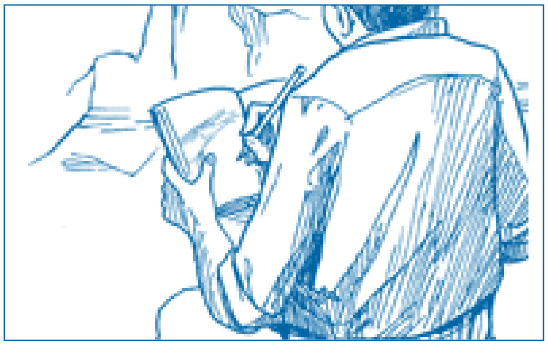
3. Create a chart. On a separate piece of paper, have students make a chart with two columns. Students should label these columns "Evidence" and "Inference." Across from each example of evidence, students should list the inferences based on it (sometimes there is more than one).

Note: *There are seven examples of evidence and ten examples of inference. See answer key below.*

4. Review and discuss. Discuss students' answers. Ask them to share their reasoning. What physical evidence supports an answer of "evidence"?

Answer Key:

Evidence	Inference
1. Based on Sternberg find in 1918—a *Dolichorhynchops* (nicknamed "Dolly") within the ribs of a *Tylosaurus* (we'll call "Tylo").	1. Since only the skeleton of the Tylo remains, we assume the region is where the stomach was, but can't say for sure.
2. Tylo lacked hands to hold prey.	2. Thus, it had to either bite and shake large chunks out of prey, or swallow prey whole.
3. Like snakes, Tylo had two rows of teeth way back on the roof of the mouth.	3. Like snakes, we believe it used these teeth to help swallow prey.
4. Dolly had a short, rigid body and long flippers.	4. Flippers may have worked like wings to help it "fly" under water—similar to a penguin.
5. Tylo had a long body and tail.	5. It probably swam with an eel-like movement. 6. Thus we suppose it was a much slower swimmer than Dolly. 7. One way a slow Tylo could have caught a fast Dolly was if Dolly was dead (and Tylo scavenged). 8. Another way was if Tylo made a surprise attack.
6. We can see from Dolly skeletons that its blind spot was immediately behind and below its body.	9. We can assume that could have been the direction of a surprise attack.
7. Fossil skin impressions show Tylo had very small, overlapping, lizard-like scales.	10. Since most large marine animals are drab and/or dark, we assume the same might have been true for Dolly and Tylo.



Closing Activity

Storyboard a Scene

45 min.

Students storyboard a new scene, applying scientific thinking supported by evidence and inference.

Directions:

1. **Introduce the activity.** Students will storyboard frames of a new scene using the scientific notes on the handout in Activity 2. Students should note the evidence and inference that supports their scene.

   Note: *Students can use the storyboard in Activity 2 as a model.*

2. **Student presentations.** Display completed storyboards on the wall and ask students to present their work to the class.

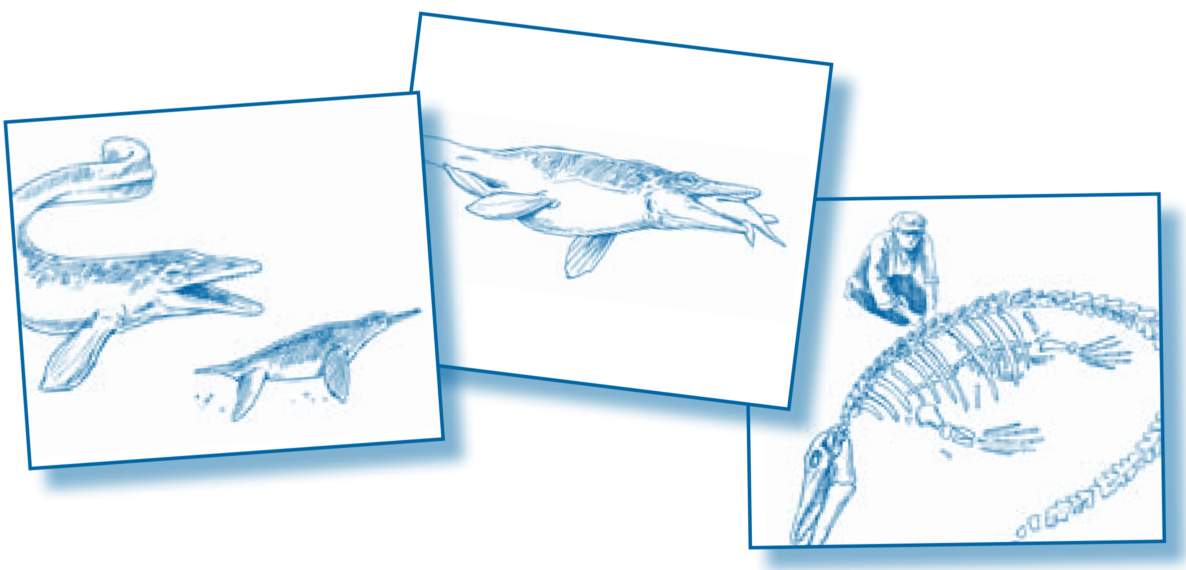
3. **Discussion.** While the events depicted in *Sea Monsters: A Prehistoric Adventure* are based on scientific evidence, the storyline of the prehistoric animals is a dramatization. Why did the filmmakers use this approach? What challenges do filmmakers face when they set out to create a film that is both scientifically accurate and entertaining?

STUDENT ASSESSMENT

Assess students' storyboards based on their appropriate depiction and labeling of evidence and inference in their scene and their creativity in developing a new storyline.

NOTE TO TEACHER

Watching videos, television, and movies are popular activities for students at home and at school. It is important to help students understand that a science-based film is supported by scientific thinking and science content. When faced with a subject depicted in a film that cannot be directly observed—such as prehistoric marine reptiles—students should critically examine the evidence used to support the information presented. They should be able to differentiate between information based on evidence and information based on inference.



Geography Standards 7, 17 Science Standards A, D

CSI: CRETACEOUS SEAS INVESTIGATION

Every fossil has a story to tell. In this lesson, students learn how paleontologists study fossils from prehistoric times to gain insights into animals and their interactions. In Activity 1, students participate in a class activity to learn how fossils provide important clues to past life. In Activity 2, students examine a site map based on an actual discovery to gain a rare glimpse into the final moments of two extinct sea creatures. In the Closing Activity, students examine a fossil discovery in order to make their own site map.

Vocabulary (see Glossary p. 33)

- cartilage
- conical
- evidence
- fossil
- inference
- intact
- late Cretaceous
- mosasaur
- paleontologists
- paleontology
- predator
- prehistoric
- prey
- remains
- sedimentary rock
- vertebrae

Try This First!

Ask students, "What is a fossil?" Explain that the study of fossils and the fossil record is called "paleontology" and that scientists who specialize in this research are called "paleontologists." Next, distribute and discuss "A Fossil Forms," a student handout, on page 43.

Guiding Question:

How do scientists analyze fossil evidence to reconstruct life in prehistoric times?

Activity	Objectives	Instructional Strategy	Materials
ACTIVITY 1 Cretaceous Clues 25 min.	Students will: - Learn how fossils provide evidence about a prehistoric plant or animal; and - Learn how evidence found in fossils is used to understand prehistoric life.	- Large-group Instruction	
ACTIVITY 2 "Impossible Fossil" Site Map 25 min.	Students will: - Identify information from a site map; - See how paleontologists record information; and - Learn how fossil evidence is used to understand prehistoric life.	- Discussions - Visual Instruction - Large-group Instruction	- "'Impossible Fossil' Site Map" (p. 44)
CLOSING ACTIVITY Create a Site Map 45 min.	Students will: - Examine an illustration and scientific notes; and - Create a site map to record a fossil discovery.	- Individual Instruction - Large-group Instruction	- "Creat a Site Map: Parts 1 & 2" (pp. 45-46) - Ruler

Activity 1

Cretaceous Clues

25 min.

Students learn how fossils provide important clues to past life.

Directions:

1. Explain. Tell students that fossil evidence provides clues about past life. By studying an individual fossil, for example, a paleontologist can infer the age, size, brain capacity, locomotion, feeding preferences, and other information about an animal that lived millions of years ago.

2. Class activity. Write "Fossil Evidence" on the board. Tell students that fossils provide evidence about an animal's physical appearance, behaviors, and interactions with other animals. Create a chart on the board with two columns labeled "Fossil Evidence" and "Clues to ...?" Write the first evidence as "serrated teeth." Prompt students to make inferences about this evidence, i.e., *the animal may eat meat.* Ask students to explain their reasons for this, i.e., *sharp teeth are needed to tear flesh.* Continue with the other "Fossil Evidence" listed in the chart below.

Possible answers:

Fossil Evidence	Clues to...?
sharp teeth	*may eat meat*
extremely long neck	*reach for food quickly or hard to reach places*
bones not fully developed	*possible juvenile*
marks on bones	*signs that other animals bit, chewed, or scavenged*

Xiphactinus

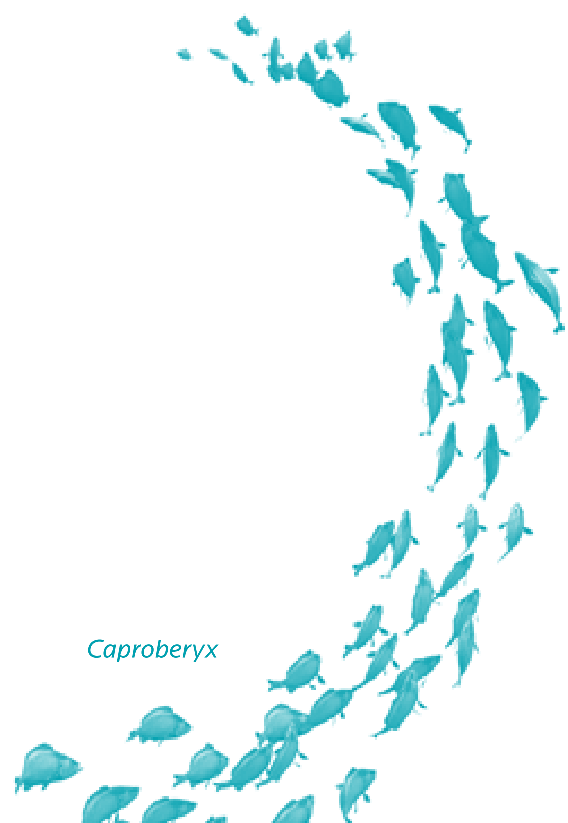
3. Building on learning. Now have students consider what clues two or more fossils together might provide. Sometimes this fossil evidence provides clues about the interactions between prehistoric animals. Have students brainstorm different ways in which animals behave and interact with one another.

Possible answers: *parasite/host, predator/prey, family group, communal group, reproduction, or feeding.*

Then have students try to come up with some examples of fossil evidence to make inferences about possible animal interactions.

Possible answers:

Fossil Evidence	Clues to...?
two different animal bones together	*possible interactions – parasite/host, predator/prey, family group, communal group, reproduction, or feeding*
clam shells inside rib cage	*animal ate clams*



Caproberyx

Activity 2 "Impossible Fossil" Site Map

Students examine a site map based on an actual discovery to gain a rare glimpse into the final moments of two extinct sea creatures.

25 min.

"'Impossible Fossil' Site Map" (p. 44)

Directions:

1. Distribute "'Impossible Fossil' Site Map" to each student. Tell students that paleontologists make careful field observations, notes, and drawings when they discover and excavate a fossil. This recorded information provides clues for the paleontologist and, in this case, may provide information about the life and death of prehistoric marine reptiles.

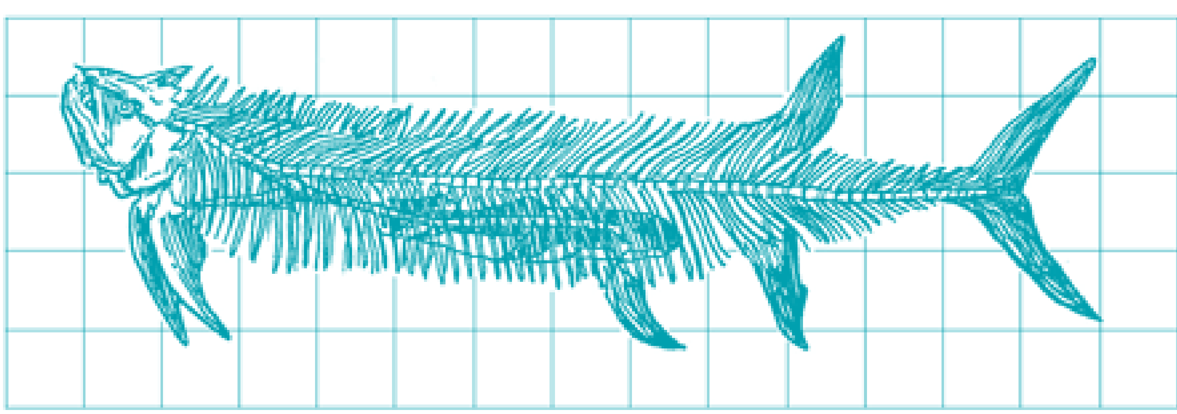
2. Review. Ask students to recall the possible clues they found in the evidence discussed in Activity 1. Remind them that physical evidence can provide a record of an animal's physical appearance, behavior, and interactions with other animals. Review the types of animal interactions.

3. Complete the handout and discuss. Explain that this site map is modeled after the famous "fish in a fish" fossil discovery. Ask students why this is an appropriate name?
Answer: *Because the ribs of the larger fish surround both sides of the smaller fish.*

View *Sea Monsters: A Prehistoric Adventure.*

4. Discuss. Ask students to name examples of animal interactions shown in the film. Next, ask students to recall examples of fossil evidence that supported some of these interactions. It may help to prompt students to recall these two examples: shark tooth found in *Dolichorhynchops* limb; *Xiphactinus* skeleton with fossilized fish skeleton found inside its stomach.

Answer Key:
1. Smoky Hill Chalk, Gove County, Kansas
2. *Xiphactinus* and *Gillicus*
3. 87-82 mya (during Cretaceous)
4. *Gillicus* inside ribs of *Xiphactinus*
5. *Xiphactinus* ate *Gillicus*
6. *Xiphactinus* ate *Gillicus*
7. about 3 feet long



Gillicus inside a Xiphactinus

Closing Activity

Create a Site Map

45 min.

Students examine a fossil discovery in order to make their own site map.

"Create a Site Map: Parts 1 & 2" (pp. 45-46)

Directions:

1. **Distribute "Create a Site Map: Parts 1 & 2" to each student.** Also, return "'Impossible Fossil' Site Map" (Activity 2) to each student.

2. **Start the activity.** Allow students time to review the vocabulary words, the sketch, and the notes, or review together as a class.

3. **Review Directions.** Tell students that they will play the role of a paleontologist by creating a site map based on this fossil find. They can use the "'Impossible Fossil' Site Map" (Activity 2) as a model.

4. **Create a site map.** Students can work alone or in groups.

5. **Student presentations.** Have students present their work to the class. Discuss any interesting ideas or evidence.

STUDENT ASSESSMENT

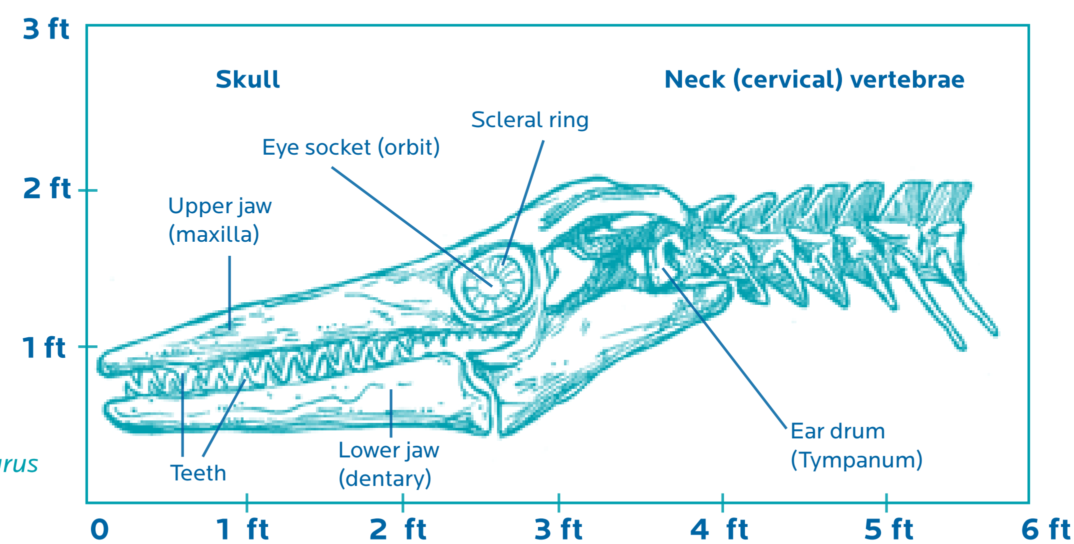
Score student site maps and notes according to the following criteria. Students should:

- Include a scale for the site map. *(Note: one square equals one foot)*
- Draw the *Tylosaurus* to scale. *(Note: the skull is four feet; the seven vertebrae are one foot, eight inches)*
- Include at least four observations based on the field notes.

BACKGROUND INFORMATION

How do fossils form?

Only a small percentage of all living plants and animals become fossils. Most are either scavenged or decay before they can be buried and, even then, there is no guarantee that they will be preserved. Specific conditions are required for fossils to form. Plants and animals that die and are quickly buried by mud, sand, volcanic ash, or other sediments are most likely to become fossilized. Once the plant or animal is buried and the sediment has hardened, other factors—including oxygen, sunlight, microorganisms, permineralization and other geologic forces—play an important role. Even with millions of years to form, a fossil is the result of a rare and unique process, and it must be found and analyzed in order to become part of the fossil record. The study of fossils and the fossil record is called paleontology.



Tylosaurus

Geography Standards 1, 17 Science Standard C Language Arts Standards 3, 5 Visual Arts Standard 3

ON EXHIBIT: WORLD UNDER WATER

Students create a museum-style exhibit showcasing their understanding of the time, geography, and marine life of the Cretaceous period. In Activity 1, students plot coordinates of the landforms and waterways of the Cretaceous period on a present-day map of the United States. In Activity 2, students research and produce a graphic organizer on a prehistoric marine reptile. In the Closing Activity, students incorporate their work into a museum-style exhibit.

Vocabulary (see Glossary p. 33)

- Cretaceous period
- fossil
- habitat
- landmass
- marine reptiles
- mya
- predator
- prey
- Western Interior Sea (Seaway)

Try This First!

After watching *Sea Monsters: A Prehistoric Adventure,* tell students they are going to create an exhibit called "World Under Water: A Prehistoric Adventure." Brainstorm ideas for the exhibit. Ask students what questions the exhibit should answer. If necessary, prompt students to think about "what, where, when, and why." Write answers on the board. This list can help students brainstorm topics the exhibit might cover.

Guiding Question:

What would you include in an exhibit about the Cretaceous seas?

Activity	Objectives	Instructional Strategy	Materials
ACTIVITY 1 Mapping the Cretaceous 40 min.	Students will: - Learn about the Cretaceous period geography of the land-mass that today is the United Sates; and - Plot latitude and longitude coordinates on an outline map of the United States.	- Individual Instruction	- "Mapping the Cretaceous" (p. 47) - Markers, colored pencils, or crayons
ACTIVITY 2 Cretaceous Creature Research 45 min.	Students will: - Learn about prehistoric marine animals of the Cretaceous period; - Do collaborative research; and - Construct graphic organizers.	- Cooperative Learning - Research - Visual Instruction - Small-group Instruction	- Internet or library resources - "Creating a Graphic Organizer" (optional; online only)
CLOSING ACTIVITY Create the Exhibit: World Under Water 90 min.	Students will: • Synthesize understanding of the geography and marine life of the Cretaceous period; • Conduct additional research on Cretaceous marine animals; and • Create a section of a museum-style exhibit.	- Hands-on Learning	- Poster board - Markers, colored pencils, or crayons - Glue - Scissors

Activity 1 Mapping the Cretaceous

Students plot coordinates on a present-day outline map of the United States to delineate the landforms and waterways of the Cretaceous period.

40 min.

"Mapping the Cretaceous" (p. 47)

Directions:

1. **Introduce.** Tell students that they will set the stage for their exhibits by completing a map handout to illustrate what the landscape of the United States looked like millions of years ago during the Cretaceous period.

   Note: *Scientists have determined the area of the Western Interior Sea by analyzing the types of rocks and marine fossils found within the rock strata of North America. The study of the origin, composition, and development of rock strata is called* stratigraphy.

2. **Distribute map handout.** Explain that students will use coordinates to plot and draw Cretaceous-era outlines of land and water areas on a map of the present-day United States. After they plot the outlines, they will color land and water and add labels.

3. **Discuss.** After students have completed the assignment, review their work, and discuss how the appearance of the United States was different during the Cretaceous period than it is today. Which states were under water?

4. **Collect student work so that it can be used in the Closing Activity.**

ADAPTATION

This activity can be done as a whole group activity with teacher-led, guided instruction.

Earth, 82 mya and Present Day.

Activity 2 Cretaceous Creature Research

45 min.

Students do research to complete a graphic organizer of a selected marine reptile.

"Creating a Graphic Organizer" (optional)
nationalgeographic.com/xpeditions/guides/graphicorg.pdf

Directions:

1. Divide the class into small groups.

2. Staging the activity. Write this list of prehistoric marine animals on the board, and ask each group to select a different animal to research: *Dolichorhynchops, Xiphactinus, Protostega, Tylosaurus, Tusoteuthis, Cretoxyrhina, Hesperornis, Ammonite, Styxosaurus,* and *Platecarpus.* Explain that each group will do Internet or library research on their selected animal and that they will create a graphic organizer with their findings.

Note: *If helpful to students, distribute and review "Creating a Graphic Organizer," an optional resource available online.*
nationalgeographic.com/xpeditions/guides/graphicorg.pdf

3. Ask each group to take out a blank piece of paper. Tell students to put the name of their animal in the center of their graphic organizer. Discuss possible categories for the graphic organizer. Suggestions: physical characteristics, habitat, life cycle, diet, size, predator/prey relationships, when and where they lived, and when they went extinct.

Background Note: *Each graphic organizer will be different and there is no one correct way to construct a graphic organizer. Remind students to read, compare, connect, and summarize the information in their graphic organizers. Remind them to discuss all ideas, and listen to feedback.*

Ammonite

Suggested Online Resources:

National Geographic *Sea Monsters: A Prehistoric Adventure*
nationalgeographic.com/seamonsters

National Geographic Magazine— When Sea Monsters Ruled the Deep
nationalgeographic.com/ngm/0512/feature3/multimedia.html

Natural History Museum of Los Angeles County: Savage Ancient Seas
nhm.org/sas/home.html

Natural History Museum of Los Angeles County: Journey Through Time
nhm.org/journey

4. Collect the graphic organizers to save for the Closing Activity.

ADAPTATION

Some students may need additional time and support to complete their graphic organizers. You may choose to work individually with these students. Remember to clarify any difficult concepts, and encourage students to focus on how the information can be categorized as they construct their organizers. You may wish to review vocabulary to help facilitate learning.

Closing Activity Create the Exhibit: World Under Water

90 min.

Students incorporate their work into a museum-style exhibit.

Tusoteuthis

Directions:

1. Small group activity. Have students regroup. Return completed work from Activities 1 and 2 to each group. Explain that as a final step, each group will build on their work to create a section of a classroom science museum exhibit that explains the geography and marine life of the Cretaceous period.

2. Staging the activity. Each group should include the following components in their work:

- Information from their map (Activity 1)
- Information from their graphic organizer (Activity 2)
- Additional images, text and drawings of their prehistoric marine reptile

Exhibit. Arrange each group's contribution into a class exhibit, "World Under Water: A Prehistoric Adventure." Students should make sure to include interesting information about their animal, including possible predator/prey relationships with other animals in the exhibit.

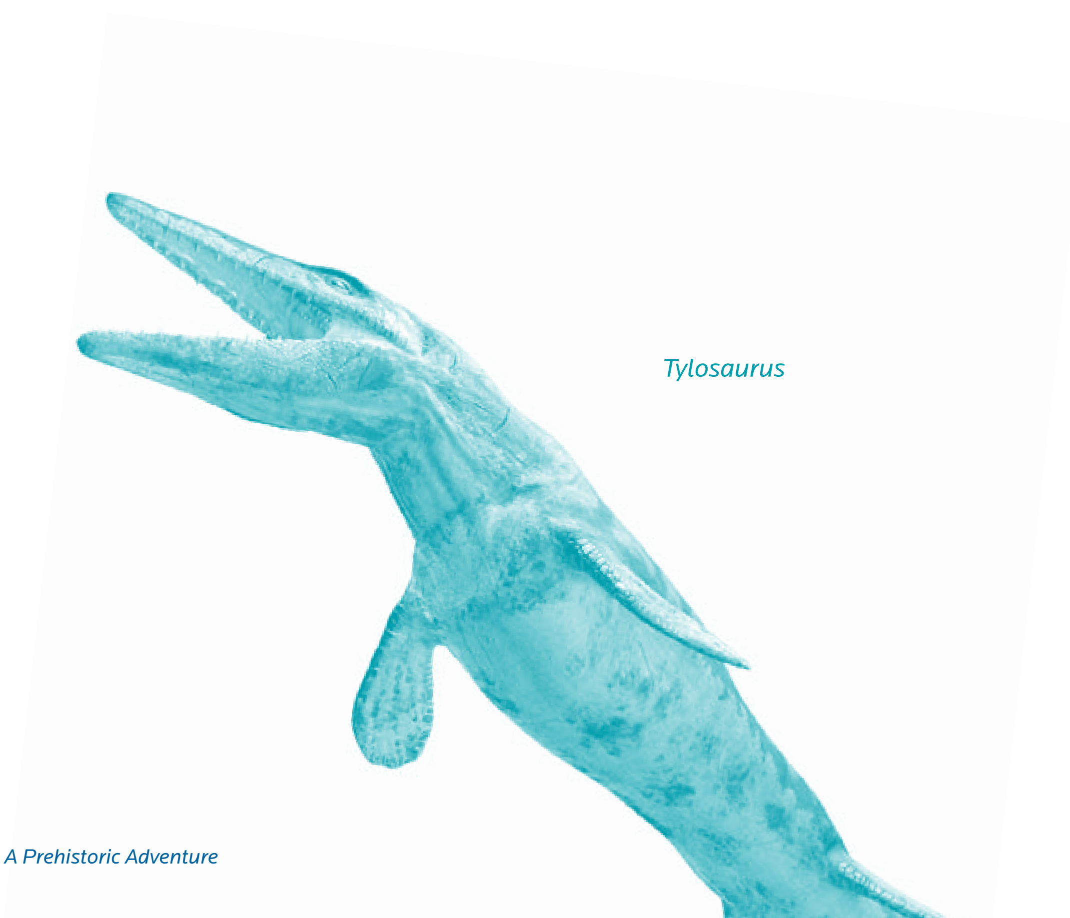
3. Presentations. Ask each group to present an overview of their section to the class.

STUDENT ASSESSMENT

Rate the students on a scale of one to five on the following categories: creativity, accuracy of information, visual appeal, inclusion of required components (information from map handout, graphic organizers, and research), and flow of information.

EXTENDING THE LESSON

If students are familiar with the concept of ecosystems, they might focus their exhibit on the components of a Cretaceous marine ecosystem and include the scientific evidence to support their portrayal.



Tylosaurus

Geography Standards 14, 17, 18 Science Standard C Language Arts Standards 3, 5

SCIENCE FORUM: EXTINCTION THEN AND NOW

Students compare and contrast causes for extinction, past and present. In Activity 1, students gain background knowledge on the topic of extinction and related terms by creating a three-section illustrated brochure. In Activity 2, students conduct research on the extinction of prehistoric or modern marine animals and compile graphic organizers summarizing what they learned. In the Closing Activity, students compare research findings, synthesize information, and create and present their summaries in a science forum.

Vocabulary (see Glossary p. 33)

- biodiversity
- climate change
- conservation
- endangered species
- evolution
- extinction
- habitat
- sustainability

Try This First!

In 2004, there were an estimated 15,589 species on the "threatened list." Ask students if they believe that species today could become extinct, like many, if not all, of the dinosaurs did. (Some paleontologists believe that birds are descendants of dinosaurs.) Discuss what people can do to protect species from extinction.

Source: World Conservation Union (IUCN) *2004 Red List of Threatened Species. A Global Species Assessment* (iucnredlist.org/info/introduction)

Guiding Question:

What factors contribute to the extinction of a species? Have these factors changed over time?

Activity	Objectives	Instructional Strategy	Materials
ACTIVITY 1 Eco-Illustrations 90 min.	Students will: - Gain background knowledge on extinction and related terms; and - Create an illustrated brochure.	- Discovery Learning	- Internet or library resources
ACTIVITY 2 Extinction Then and Now 40 min.	Students will: - Research the extinction of prehistoric marine animals and threats to modern-day marine animals; and • Use a graphic organizer to structure research.	- Cooperative Learning - Inquiry Research	- Internet or library resources - "Creating a Graphic Organizer" (optional; online only)
CLOSING ACTIVITY Science Forum 90 min.	Students will: - Learn about the extinction of prehistoric marine animals and threats to contemporary marine animals; - Create a presentation; and - Participate in a science forum.	- Discovery Learning - Hands-on Learning	

Activity 1 Eco-Illustrations

90 min.

Students do online or library research to gain background knowledge on extinction and related terms in order to create an illustrated brochure.

Directions:

1. **Staging the activity.** Divide the class into eight groups. Assign each group one of the following terms:
   - Extinction
   - Biodiversity
   - Habitat
   - Climate change
   - Conservation
   - Sustainability
   - Evolution
   - Endangered species

2. **Instructions.** Explain that each group will research its term and create a brochure. Each brochure should include:
   - The word and its definition
   - An original symbol that illustrates the meaning of the word
   - A brief description of the symbol's meaning
   - Excerpts of three news articles from the past year that include the term in context
   - Research sources

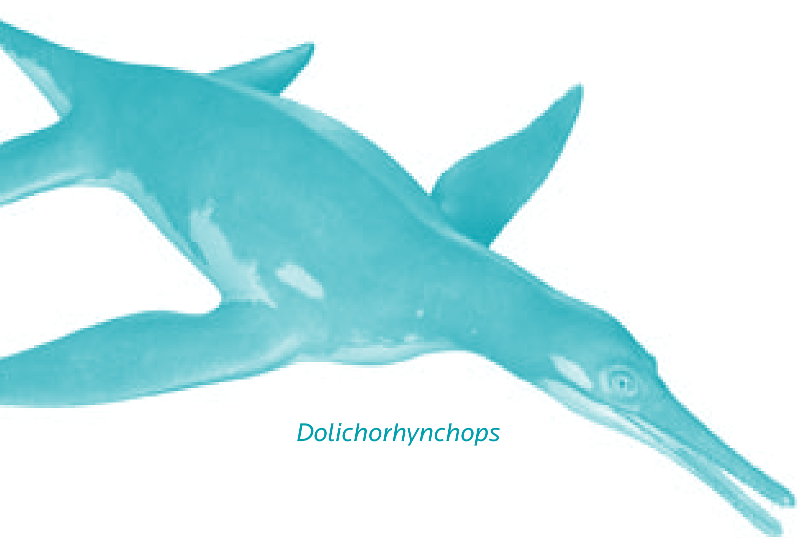
   Note: *Students may present their work as a Word document, PowerPoint slide presentation, a web page, or a short video clip.*

3. **Students presentations.** Have each group share its brochure with the entire class. Tell students that they will use their brochures in a science forum in the Closing Activity.

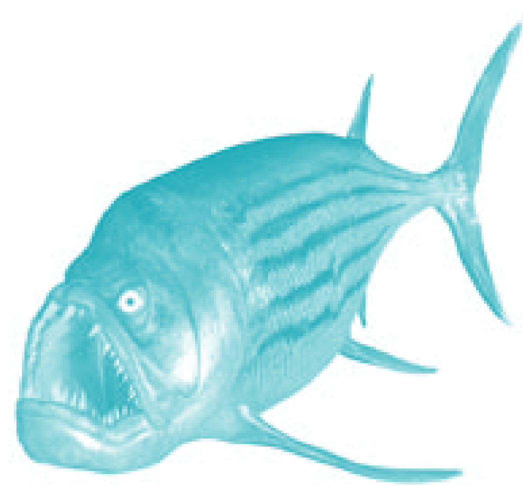
Students should view *Sea Monsters: A Prehistoric Adventure* prior to Activity 2.

ADAPTATIONS

If students have difficulty with these terms, you may wish to spend additional time reinforcing the meanings of the words. One way you can do this is by having the students write sentences using the vocabulary words in context to demonstrate that they understand the definitions.

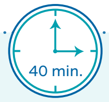


Dolichorhynchops



Xiphactinus

Activity 2 Extinction Then and Now



Students research the extinction of prehistoric marine animals and threats to current-day marine animals and develop graphic organizers to structure their research.

"Creating a Graphic Organizer" (optional)
nationalgeographic.com/xpeditions/guides/graphicorg.pdf

Directions:

1. Instructions. Explain that students will use online or library resources to research animal extinction—past or present—and that they will create a graphic organizer with their findings. Tell students that they will later use their research in a science forum in the Closing Activity.

Note: *If helpful to students, distribute and review "Creating a Graphic Organizer," an optional resource available online.*

nationalgeographic.com/xpeditions/guides/graphicorg.pdf

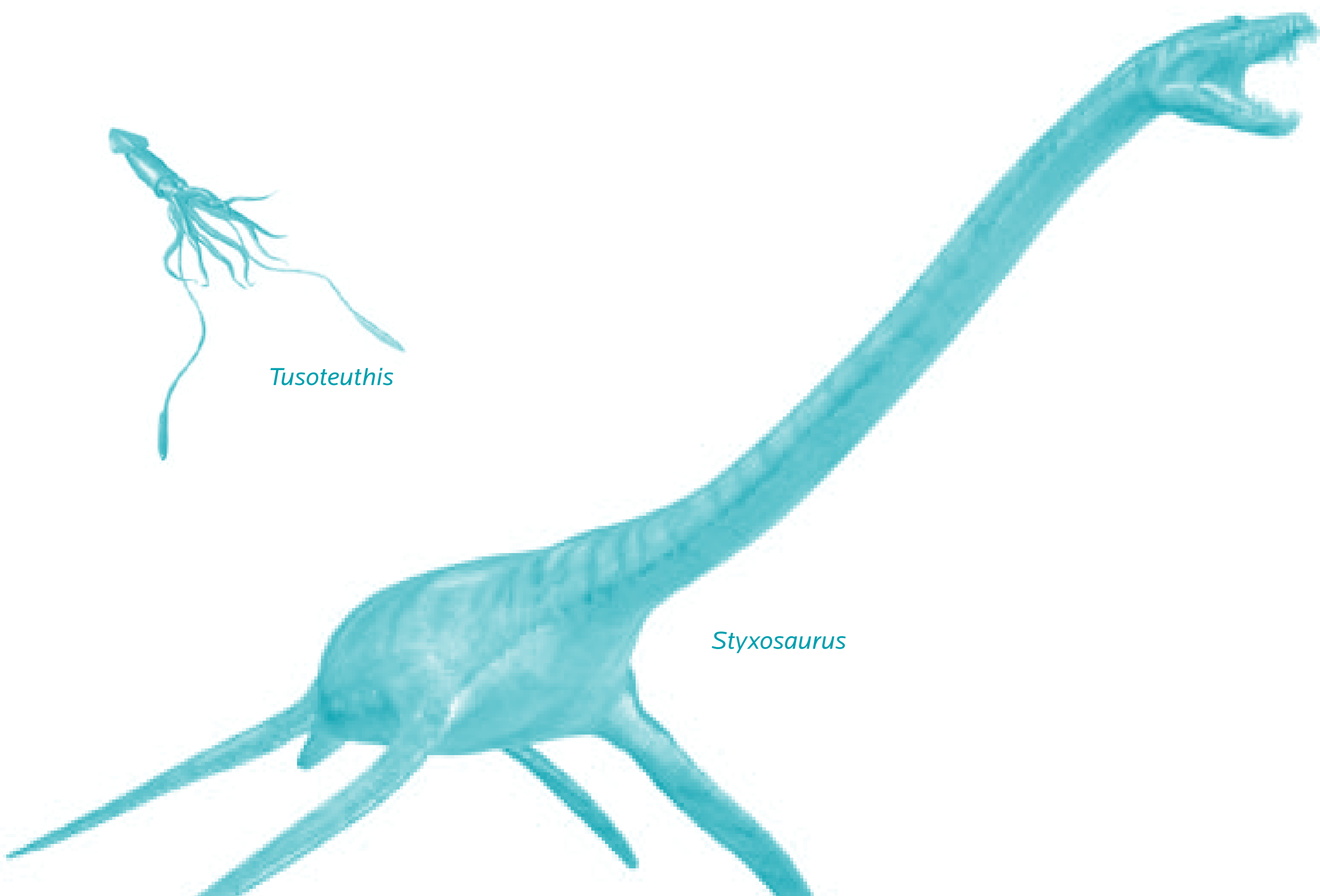
2. Divide the class into small groups. If possible, divide class into an even number of small groups. Half of the groups will research the extinction of prehistoric marine animals; the other half will research current threats to modern marine animals. Each group should select one animal on which to focus their research.

Note: *Remember to collect and save completed graphic organizers for the Closing Activity.*

3. Allot time for students to prepare presentations.

ADAPTATIONS

Some students may need additional time and support to complete their research and their graphic organizers. You can read information aloud, make predictions, ask students to restate what they read, and model note-taking strategies to enhance comprehension. Remember to clarify any difficult concepts, and encourage students to focus on the reasons for extinction and threats to species.



Tusoteuthis

Styxosaurus

Closing Activity

Science Forum

90 min.

Students integrate the factual knowledge they have learned about the extinction of prehistoric marine animals and threats to contemporary marine animals through the creation and presentation of their research findings in a science forum.

Directions:

1. Divide the Class into Research Teams. Each team should include students who researched prehistoric extinction and students who researched present-day conditions.

2. Instructions. Tell students they are going to prepare presentations as part of a science forum. To complete this activity, each team should:

- Prepare a seven- to ten-minute presentation comparing and contrasting the extinction of prehistoric marine animals and threats to today's endangered species.
- Incorporate brochures and graphic organizers produced in Activities 1 and 2.
- Include an action plan with at least three suggestions for what people can do to help species currently deemed to be under threat of extinction.

3. Presentations and Discussion. Have students regroup to make presentations and participate in a science forum. After each group has finished its presentation, lead the class in a discussion reviewing key points on the threats to the current environment, the possible lessons we can learn from the past, and what people can do to protect threatened species today.

STUDENT ASSESSMENT

Rate the students on a scale of one to five based on the following components:

- Comparison of extinction of prehistoric marine animals and the threats to today's marine animals.
- Quality of information in brochure.
- Quality of synthesis in graphic organizer.
- Suggestions for what to do to help threatened species.
- Participation in forum discussion

Henodus

GLOSSARY

adaptation a modification of an organism or its parts that makes it more fit for existence under the conditions of its environment; This heritable trait is passed from generation to generation.

behavior anything that an organism does involving action and/or response to stimulation

bi two

biodiversity the variability of all living organisms (including animal and plant species); of the genes of all these organisms; and of the terrestrial, aquatic, and marine ecosystems of which they are part

cartilage a type of tough, flexible tissue

cephal(o) head

cerat(o) horn

climate change gradual changes in all the interconnected weather elements on our planet

conical cone-shaped

conservation planned management of a natural resource to prevent exploitation, destruction, or neglect

Cretaceous period the last period of the Mesozoic era from 145 to 65 million years ago (mya); considered the last period of the age of dinosaurs

data the information collected during a scientific study

deep time the theory that Earth is billions of years old and has had a long history of development and change

endangered species a species threatened with extinction

evidence data that can be measured, observed, examined, and analyzed to support a conclusion

evolution a theory that the various present types of animals and plants on Earth developed from simple organisms and that the distinguishable differences are due to modifications in successive generations

excavate to carefully dig up buried objects to find information about the past

extinct no longer existing

extinction the condition of being extinct or no longer existing

fossil a remnant, impression, or trace of an organism of past geologic ages that has been preserved in Earth's crust

fossil dig scientific investigation of fossil sites

fossil record the total collection of fossils in the world

geologic timeline a representation that is used to describe Earth's history, especially as recorded in rock

GPS (Global Positioning System) a system of satellites and receiving devices used to determine the location of something on Earth

habitat the place or environment where a plant or animal naturally or normally lives and grows

ichthy fish

inference an explanation derived by reasoning; to derive as a conclusion from facts or premises

intact undamaged

invertebrate a group of animals without a backbone that has an exoskeleton or is soft-bodied

jacket a protective casing made out of plaster that is used to transport fossil specimens

landmass a large area of land

late Cretaceous the second half of the Cretaceous period, from 105 to 65 million years ago (mya)

marine reptiles a group of mostly large, carnivorous animals many of which lived in the oceans during the Mesozoic era

mega large

micro small

mosasaur giant marine reptile that lived during the Cretaceous period

mya million years ago

observation the act of noting and recording phenomena, actions, or events, often involving measurement with instruments

odon or oden tooth

ops eye or face

paleontologist a scientist who studies past geological periods as known from fossil remains

paleontology a science dealing with life of past geological periods as known from fossil remains

ped or pes foot

predator an animal that hunts other animals for food

prehistoric "before history;" the period of time (making up most of Earth's history) that occurred before the invention of written records

prey an animal that is hunted and eaten by other animals

prospect to explore for useful or valuable things, such as fossils

remains bones and other animal parts found in paleontological sites

reptile a cold-blooded vertebrate animal that usually has scales and claws; includes prehistoric land, air, and water creatures

rex king

rhino nose

saur(us) lizard

scavenge to feed on dead or decaying matter

seaway shallow inland waterway connected to the ocean

sedimentary rock a rock made from the consolidation of solid fragments, as of other rocks or organic remains, like small shells, or by precipitation of minerals from solution

site map a map depicting the details of a site, usually made by recording all observable surface features

Smoky Hill Chalk an area of the Smoky Hill river valley in western Kansas that contains numerous outcroppings of soft, white, sedimentary rock known as chalk

SuperCroc a nickname for *Sarcosuchus imperator,* an extinct genus of crocodile and one of the largest reptiles that ever lived

sustainability the use of resources in such a manner that they will never be exhausted

tri three

tyrann tyrant

uni one

vertebrae the bones that make up the spinal column, or backbone, of an animal

vertebrate a group of animals with backbones; includes fish, amphibians, mammals, birds, and reptiles

vor(e) eat

Western Interior Sea (Seaway) a large, inland sea that split the continent of what is now North America into two parts during most of the early and late Cretaceous period; also called the Cretaceous Seaway, the Niobrara Sea, and the North American Inland Sea

Student Handout

MEET A PALEONTOLOGIST

While on a fossil dig in Africa, paleontologist Paul Sereno uncovered the skeleton of a very old, very large crocodile. In this interview he talks about this important discovery.

Interviewer, Peter Laufer: This is National Geographic World Talk. I'm Peter Laufer, along with paleontologist Paul Sereno. Is there any kid, anywhere, who's not fascinated by dinosaurs? Why is it so important that we learn where dinosaurs came from, when the first dinosaurs appeared, and why they died out?

Paleontologist, Paul Sereno: We're curious about our history. We're curious about deep time. Dinosaurs speak about a time that we can only dream about and think about scientifically.

Peter Laufer: Tell us about SuperCroc, who he was, and how you found him.

Paul Sereno: Well, [in Africa] we came upon an incredibly huge skull—six feet long. It was just astonishing that it was a crocodile with a skull that long. Then we found enough of the skeleton to get a good idea of what it looked like. You're talking about an animal 40 feet long, twice as long as the largest living crocodiles today and many times as heavy.

Peter Laufer: You are finding things that have never been seen before. They are related to animals that live with us today.

Paul Sereno: That's the great thrill of working in paleontology.

Peter Laufer: Despite the fact that you're studying these [animals] who lived so long ago, there's constantly new material. Isn't that correct?

Paul Sereno: Yes. That's my great understanding of science. In college, I started out as an artist. Science seemed like a pile of facts that I could never remember. As I got interested in paleontology I began to understand that it's about discovery and creativity. It's about thinking of a question or trying to answer a question that nobody else has before you.

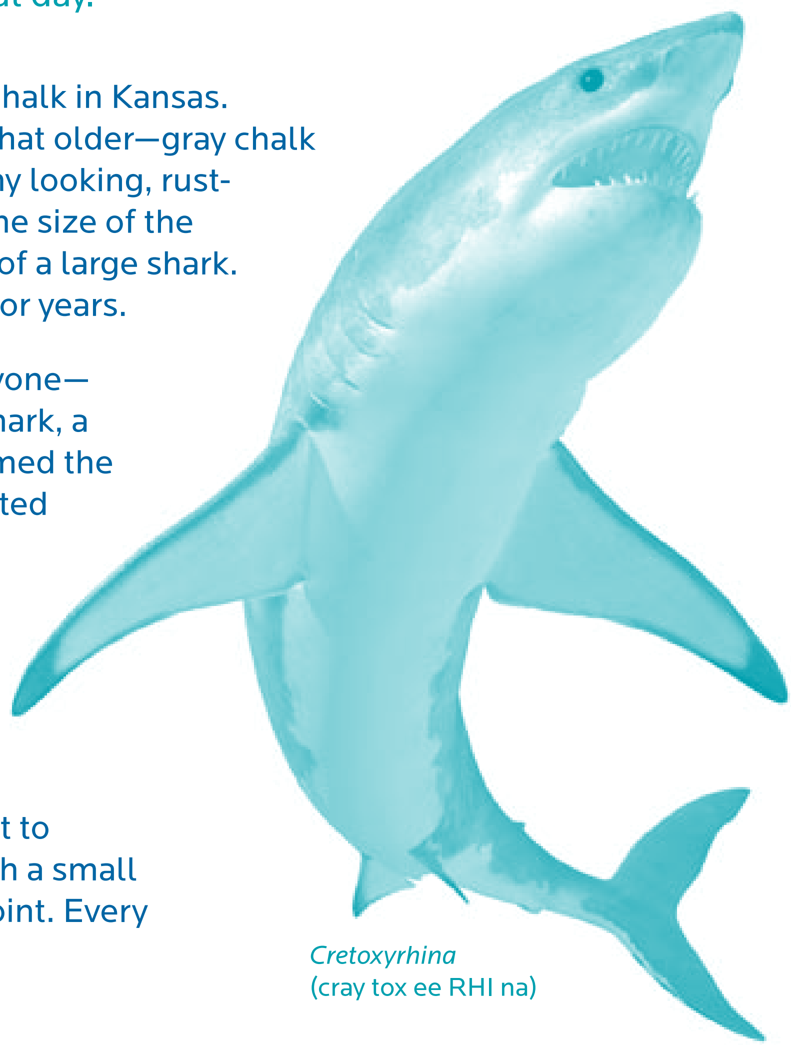
That's what I love. We're always going to be finding out new things.

Peter Laufer: Paleontologist Paul Sereno, thanks so much for joining us today on National Geographic World Talk. I'm Peter Laufer.

Student Handout

JOIN A DIG

In 2002, paleontologist Mike Everhart came across a wonderful discovery. Here is his story about what happened that day.



Cretoxyrhina
(cray tox ee RHI na)

We were on a field trip to the Smoky Hill Chalk in Kansas. I decided to search the lower—and somewhat older—gray chalk flats. When I looked down, I noticed a funny looking, rust-orange lump. Then I saw six teeth. From the size of the teeth, I could tell I had found the remains of a large shark. A shark like this had been on my wish list for years.

I got my camera out to take pictures. Everyone—including me—was in awe. It was a huge shark, a *Cretoxyrhina mantelli,* which I had nicknamed the “Ginsu” shark. I got out my field map, plotted the location, and checked it against the GPS data.

Time to start the excavation. First, I used a large pick and shovel. Then I got down on my hands and knees to work closer to the skeleton. I had to work very carefully because I didn’t want to damage the fossil. I removed the chalk with a small knife and an ice pick that has a very fine point. Every so often, I cleared away the bits of chalk with a small brush.

After a few hours, we had exposed the front 16 feet of a 20-foot shark. I made drawings in my notebook to show where each piece was found.

Now that the remains were exposed, we had to protect them. We used wet paper towels to pad the skull. Then we made a protective jacket for the skull out of burlap dipped in plaster. We waited for the plaster to dry and then loaded the jacket into my van. Then we covered the rest of the shark with plastic.

After a complicated but successful recovery, a plaster frame holding the body of the shark arrived at the Sternberg Museum three weeks later.

Student Handout

"FOSSILS ROCK!" RADIO PROGRAM

You have been asked to work on a radio program, "Fossils Rock!" Use your imagination to write a story or an interview for this program. Write about finding the fossil remains of a prehistoric animal.

Step 1: Think about ideas. What details can you include to make your story or interview interesting for listeners? For example:

- Where did you find the fossil?
- What did you notice first?
- What is the name of the prehistoric animal you found?
- What did you do to recover the fossil?
- What tools helped you?

Step 2: Write your story or interview. Use at least ten words from the Word Bank in your story or interview. If you do not know the meaning of a word, use a dictionary to look it up.

Word Bank

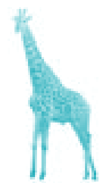
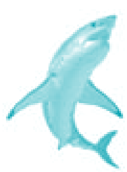
burlap	**jacket**	**plastic frame**
camera	**large pick**	**protect**
chalk	**locate**	**remains**
discovery	**location**	**scientific**
excavate (remove) dirt	**observation**	**shovel**
field map	**observe**	**skeleton**
fossil	**paleontologist**	**sketch**
GPS data	**paleontology**	**small brush**
ice pick	**photograph**	**small knife**
identify	**plaster**	**transport**

Student Handout

Student Name: ____________________

ANIMAL ADAPTATIONS

Use Internet or library research to complete the chart below. Use the giraffe as a model.

Animal	Animal Classification	Where it Lives	What it Eats	Body Part Adaptations	Behavior Adaptations	How Adaptations Help the Animal Survive
MODERN ANIMAL						
 GIRAFFE	Mammal	Grasslands of Africa	Leaves from shrubs and trees	Long legs, long neck, long tongue, good eyesight	Live in herds	Height and long tongue help it reach food; living in herds provides protection
PREHISTORIC ANIMALS						
 *TYLOSAURUS*						
 *STYXOSAURUS*						
 *CRETOXYRHINA*						

Student Name: ____________________

Student Handout

CRETACEOUS SEAS FACT SHEET

Use library or Internet resources to research the answers to the following questions. Your answers will be one of the prehistoric marine reptiles listed below.

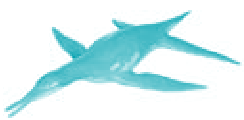
Dolichorhynchops (dolly ko RING cops)
Protostega (pro toe STAY ga)
Tusoteuthis (two so TOOTH is)
Ammonite (AM mon ite)
Henodus (HEN o dus)
Xiphactinus (zi FAC tin us)
Tylosaurus (TIE lo sore us)
Cretoxyrhina (cray tox ee RHI na)
Hesperornis (hes per OR nis)
Styxosaurus (STIK-so-SAWR-uhs)

1. This animal had tentacles and lacked an external shell. It is identified by the fossilized 'pen' that was inside its body. ____________________
2. This bird-like marine reptile swam but could not fly. ____________________
3. This fast-swimming reptile looks like a dolphin but is not related. ____________________
4. This immense bony fish had a powerful tail that allowed it to swim very fast. ____________________
5. This top predator with a keen sense of smell had large, sharp teeth that when lost were replaced by the teeth behind it. ____________________
6. This marine reptile was wider than it was long, and has distant relatives swimming the seas and lakes today. ____________________
7. This giant reptile had a hard shell covered in leather and needed to come ashore to lay eggs. ____________________
8. This invertebrate had tentacles and a hard shell. ____________________
9. Name the snake-like marine reptile at the top of the food chain in the Cretaceous seas. ____________________
10. This distant cousin of the *Dolichorhynchops* had a super-sized neck that equaled more than half its length. ____________________

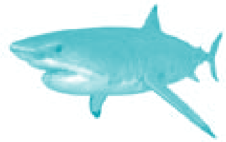
Student Handout

CRETACEOUS SEAS BINGO PICTURES

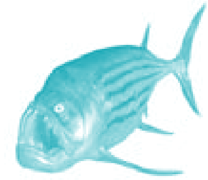
Use scissors to cut out the animal picture squares below. Mix them up and select 25.


DOLICHORHYNCHOPS


TYLOSAURUS

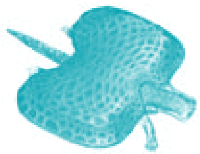

CRETOXYRHINA

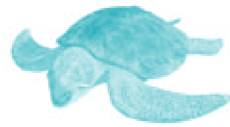

AMMONITE


XIPHACTINUS

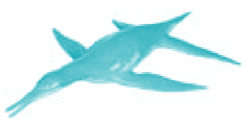

TUSOTEUTHIS


HESPERORNIS

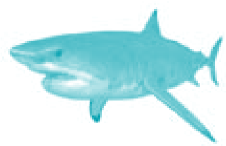

HENODUS


PROTOSTEGA

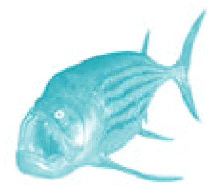

STYXOSAURUS


DOLICHORHYNCHOPS


TYLOSAURUS

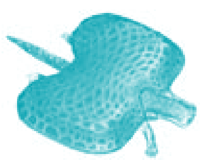

CRETOXYRHINA


AMMONITE


XIPHACTINUS


TUSOTEUTHIS


HESPERORNIS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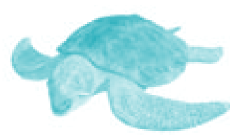
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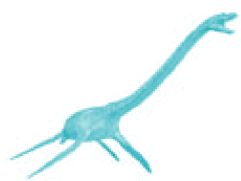
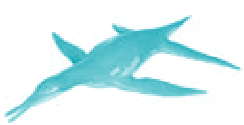
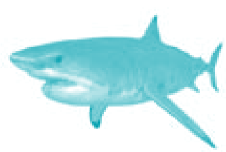
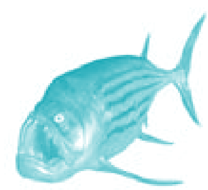

STYXOSAURUS


DOLICHORHYNCHOPS

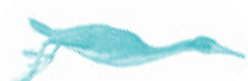

TYLOSAURUS

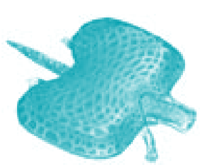

CRETOXYRHINA

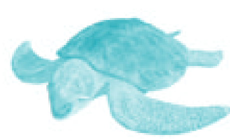

AMMONITE

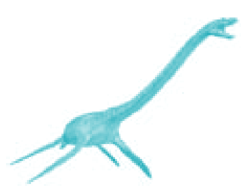

XIPHACTINUS


TUSOTEUTHIS


HESPERORNIS


HENODUS


PROTOSTEGA


STYXOSAURUS

Student Handout

CRETACEOUS SEAS BINGO CARD

Glue or tape an animal picture in each square of the grid below. Place them in random order so that your card is unique.

CRETACEOUS	SEA	PREHISTORIC	CREATURE	BINGO

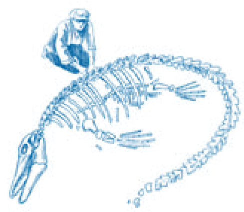
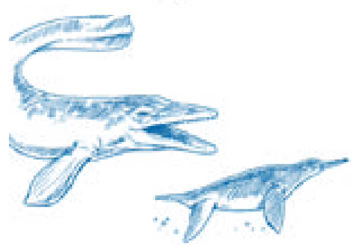
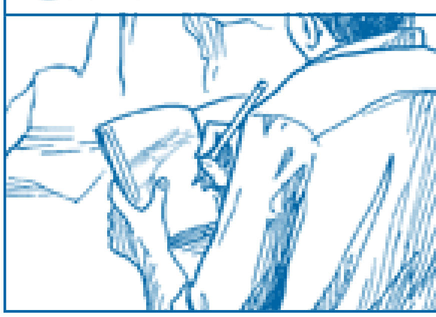
Student Handout

BEHIND THE SCENE: SCIENCE NOTES

During the making of the film *Sea Monsters: A Prehistoric Adventure,* scientific advisors reviewed storyboards to ensure the film was science-based. Below is a storyboard with scripted voiceover (VO) and notes from Dr. Ken Carpenter, a paleontologist with the Denver Museum of Nature & Science.

Step 1: Review the scientific notes. Which are examples of evidence? Which are inferences based on the evidence?

Step 2: On a separate piece of paper, make a chart with two columns labeled "Evidence" and "Inference." List examples of evidence from the notes. Across from each example of evidence, write the inferences based on it (sometimes there is more than one). Hint: there are seven examples of evidence and ten examples of inference.

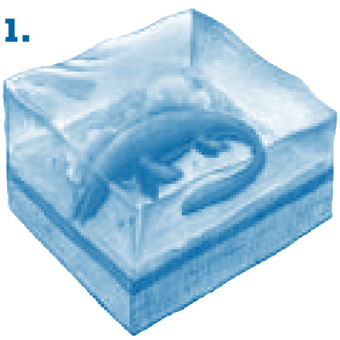
	**VO:** They had found a monster's last meal – entombed within its ribs. **Notes:** *Based on Sternberg find in 1918 – a Dolichorhynchops (nicknamed "Dolly") within the ribs of a Tylosaurus (we'll call "Tylo"). Since only the skeleton of the Tylo remains, we assume the region is where the stomach was, but can't say for sure.*
	**VO:** The *Tylosaurus* can open its mouth wide enough to swallow prey whole, like a snake. **Notes:** *Tylo lacked hands to hold prey. Thus, it had to either bite and shake large chunks out of prey, or swallow prey whole. Like snakes, Tylo had two rows of teeth way back on the roof of the mouth. Like snakes, we believe it used these teeth to help swallow prey.*
	**VO:** Because Dollies are fast, a *Tylosaurus'* best bet is to catch one by surprise. **Notes:** *Dolly had a short, rigid body and long flippers. Flippers may have worked like wings to help it "fly" under water—similar to a penguin. Tylo had a long body and tail. It probably swam with an eel-like movement. Thus we suppose it was a much slower swimmer than Dolly.*
	**VO:** The female escapes…but her brother doesn't see the danger coming. **Notes:** *Because Tylo was a slower swimmer there were probably two ways it might have caught Dolly to eat it: either Dolly was dead (and Tylo scavenged) or Tylo made a surprise attack. We can see from Dolly skeletons that its blind spot was immediately behind and below its body. We can assume that could have been the direction of a surprise attack.*
	**VO:** The Sternbergs had discovered a life-and-death moment…a story locked in time of two ancient lives intersecting. **Notes:** *Fossil skin impressions show Tylo had very small, overlapping, lizard-like scales. Unfortunately, these impressions do not indicate skin color. We don't know the true color of any marine reptiles. Since most large marine animals are drab and/or dark, we assume the same might have been true for Dolly and Tylo.*

Student Handout

A FOSSIL FORMS

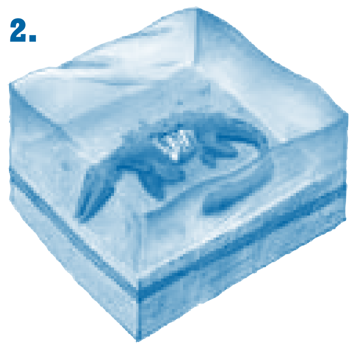
Only a small percentage of all living plants and animals become fossils. Plants and animals that die and are quickly buried by mud, sand, volcanic ash, or other sediments are most likely to become fossilized. Once the sediment has hardened, other factors—including oxygen, sunlight, microorganisms, and geologic forces—play an important role. Even with millions of years to form, a fossil is the result of a rare and unique process, and it must be found and analyzed in order to become part of the fossil record.

1.



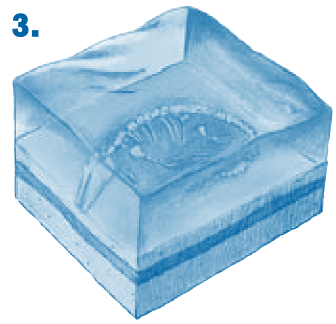
A *Tylosaurus* dies and sinks to the seabed.

2.



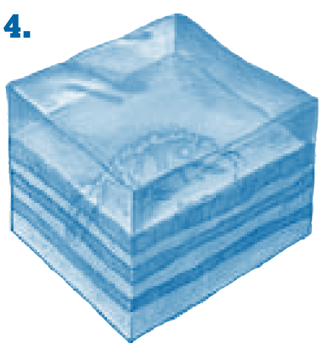
Animals and bacteria remove its flesh.

3.



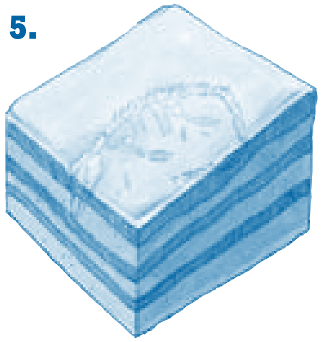
Over time, layers of sediment bury the remains.

4.



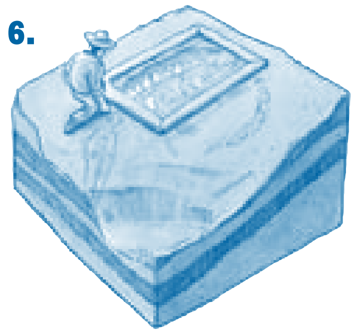
Slowly, the sediments turn into rock and preserve the remains as a fossil.

5.



Millions of years pass. Earth's plates shift and the ocean floor is uplifted. Waters retreat and seabeds become dry land.

6.



More time passes. Natural forces like wind and water erode layers of sedimentary rock, exposing the fossil.

Student Handout

"IMPOSSIBLE FOSSIL" SITE MAP

Use the site map below to answer the following questions. Write your answers on a separate piece of paper.

1. Where was the discovery made?
2. What is preserved?
3. When did these animals live?
4. What evidence shows a possible animal interaction?
5. What type of animal interaction is suggested by the physical evidence?
6. What do you think might have happened the day these animals died?
7. This fish ate another fish almost half its length. If you were to scale this to the meal of a six-foot-tall person, how long of a sandwich would the person have to eat?

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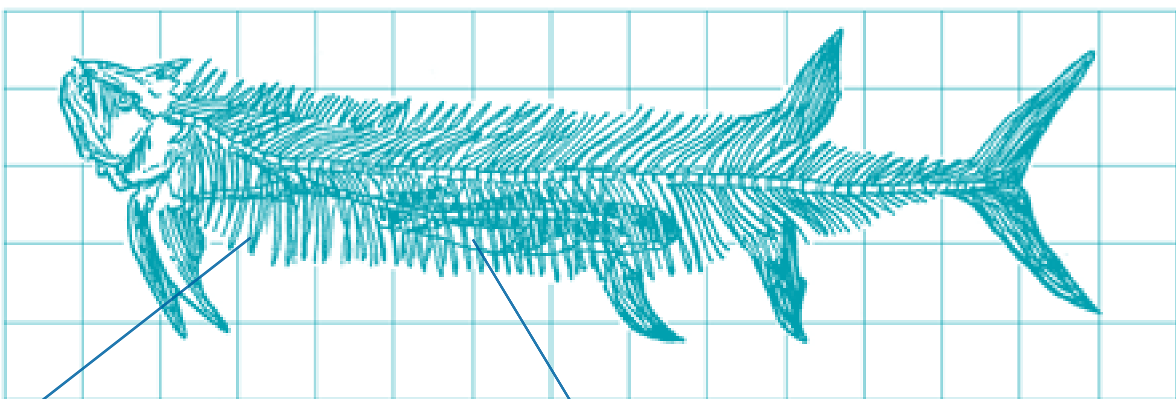
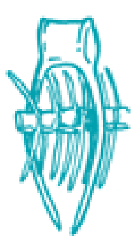


Scale 1 square = 1 ft^2

Observation: *Ribs of large fish around smaller fish*



Observation: *No evidence of acid etching on bones of small fish. Therefore, large fish must have died shortly after ingesting small fish. (No time for stomach acids to disolve bones.)*

Specimen: *Large fish – Xiphactinus*
Small fish – Gillicus

Collected by: *G.F. Sternberg*
Fort Hays State University

Date of find: *1952*

Age: *87–82 mya (during Cretaceous)*

Location: *Smoky Hill Chalk, Gove County, Kansas*

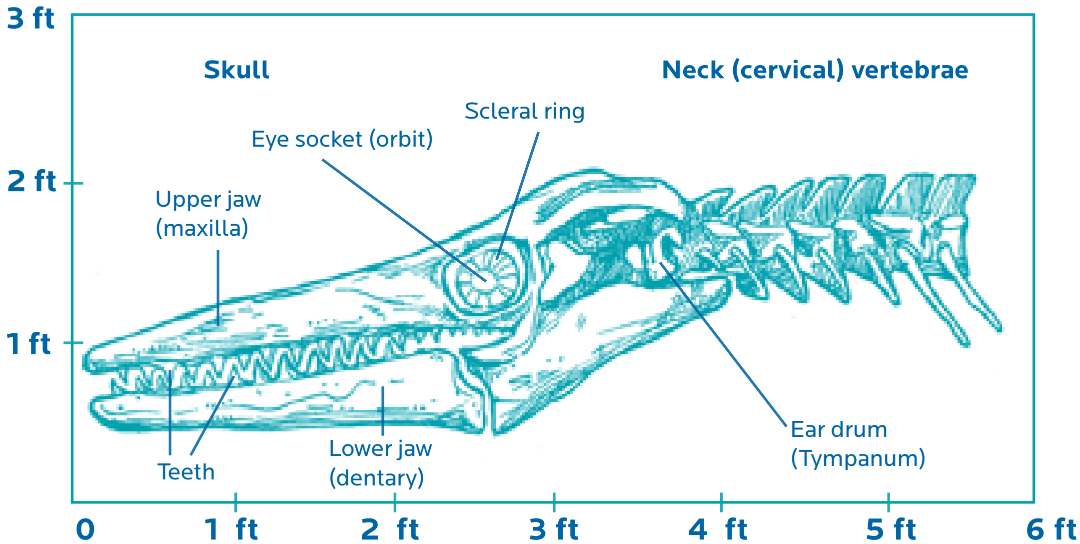
Student Handout

CREATE A SITE MAP: PART 1

Review the words in the Word Bank, the sketch, and the notes below.
Use this information to complete a site map on "Create a Site Map: Part 2."

Word Bank

- cartilage
- conical
- intact
- late Cretaceous
- mosasaur
- *Tylosaurus proriger*
- vertebrae



This sketch and notes are based on a large fossil found in 1996, in Gove County, Kansas. Based on the location of the find in the sedimentary layers, scientist Mike Everhart estimates the fossil is 85 million years old, dating to the time of the **late Cretaceous.**

Found a four-foot skull and seven ***vertebrae*** *(one foot, eight inches) of a very large (30 foot)* ***mosasaur*** *in Horsethief Canyon in the Smoky Hill Chalk, Gove County, Kansas. Identified the specimen as a* ***Tylosaurus proriger****. Length of skull is a key identifying factor since no other mosasaur of this time was as large.*

The left eye socket is ***intact****. This is the first time this feature has been observed in a Tylosaurus.*

There seems to be some ***cartilage*** *where the ear drum would have been.*

Although one tooth is missing in the upper jaw, all other teeth are present in the upper and lower jaw. There are 15 teeth in each upper jaw and 13 in each lower jaw. The teeth are ***conical*** *in shape. The largest are about two inches high with a base that is about 1.5 inches across.*

Student Name: ____________________

Student Handout

CREATE A SITE MAP: PART 2

Create a site map based on the information in Part 1.

1. **Make a grid over the illustration and label.** Use a ruler to draw a 6 X 3 grid over the illustration in Part 1.
2. **Label the site map.** In the grid below, label the y-axis (0 to 3 ft) and the x-axis (0 to 6 ft).
3. **Label scale.** Label the scale on your site map. Hint: If six squares across equals six feet, how much does one square equal?
4. **Copy the illustration.** Use the grid lines to copy the illustration in Part 1 to the grid below.
5. **Add notes and observations.** Use the notes in Part 1 to complete the site map.

Scale: 1 Square = __________

Specimen: __________

Collected by: __________

Date of find: __________

Age: __________

Location: __________

Observations: __________

Student Name: ______________________

Student Handout

MAPPING THE CRETACEOUS

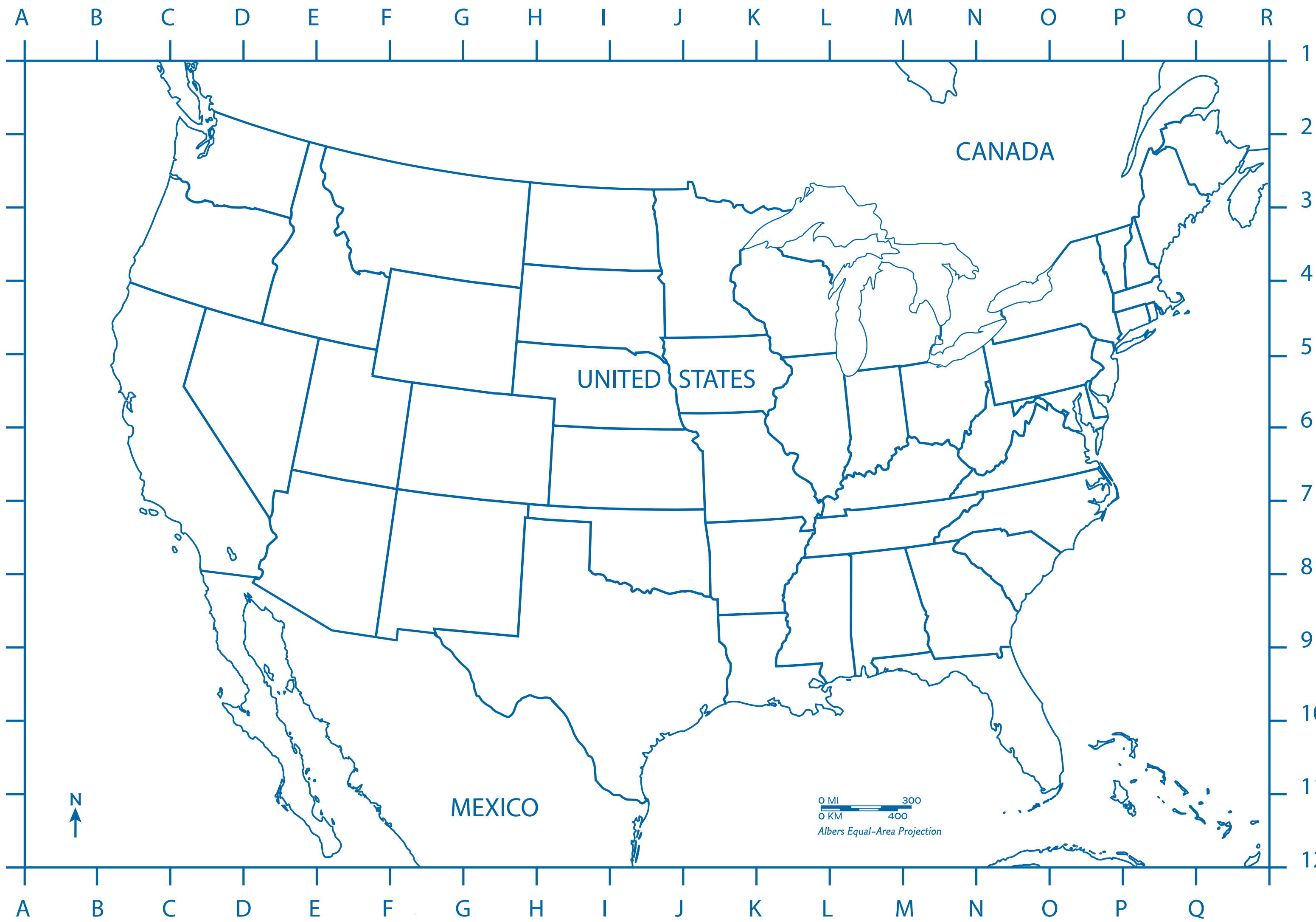
Directions:

1. Plot the points below.

Western landmass	Eastern landmass
(C, 1)	(K, 1)
(E, 1)	(L, 1)
(E, 2)	(M, 2)
(H, 3)	(N, 1)
(I, 3)	(Q, 1)
(G, 5)	(R, 2)
(F, 5)	(R, 3)
(G, 6)	(O, 6)
(G, 7)	(O, 7)
(H, 8)	(N, 9)
(H, 9)	(M, 9)
(G, 10)	(L, 7)
(H, 11)	(K, 8)
(H, 12)	(I, 8)
(F, 12)	(K, 6)
(C, 7)	(K, 5)
(B, 4)	(J, 4)
(C, 3)	(J, 3)
(C, 1)	(K, 1)

2. Join the points to outline the western and eastern landmasses.
3. Color these two landmasses green to represent land. Color remaining areas in blue to represent sea.
4. Label the "Western Interior Seaway" between the two landmasses.

What did the land of the United States look like duing the late Cretaceous?



ACKNOWLEDGEMENTS

This companion piece to the film *Sea Monsters: A Prehistoric Adventure* was created by National Geographic Education & Children's Programs.

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Special Thanks: Eduardo Abreu, Kevin Allen, Hannah Bloch, Dierdre Bevington-Attardi, Allen Carroll, Richard Easby, Mary Fortney, Jeanne Fink, Susan White Frazier, Jackie Hollister, Melissa Jordan, Tricia Kane, Eric Lindstrom, Cindy Olson, Gilberto Pilmentel, Susan Poulton, Susan Reeve, Jodi Vender, Bill Warren

Picture Credits: Front cover (inside), 2, 26 Globes by Christopher R. Scotese, PALEOMAP Project; **2, 3, 8, back cover (inside)** Photographs by Mark Thiessen/ National Geographic Giant Screen Films; **47** © National Geographic Society; *Sea Monsters: A Prehistoric Adventure*Movie Stills © 2007 NGHT, Inc.; Illustrations by Mike Carina

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This material is based in part upon work supported by the National Science Foundation under Grant No. ESI-0514981. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the National Science Foundation.

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Funded in part by the National Science Foundation

Published by the National Geographic Society, 1145 17th Street N.W., Washington, D.C., 20036-4688