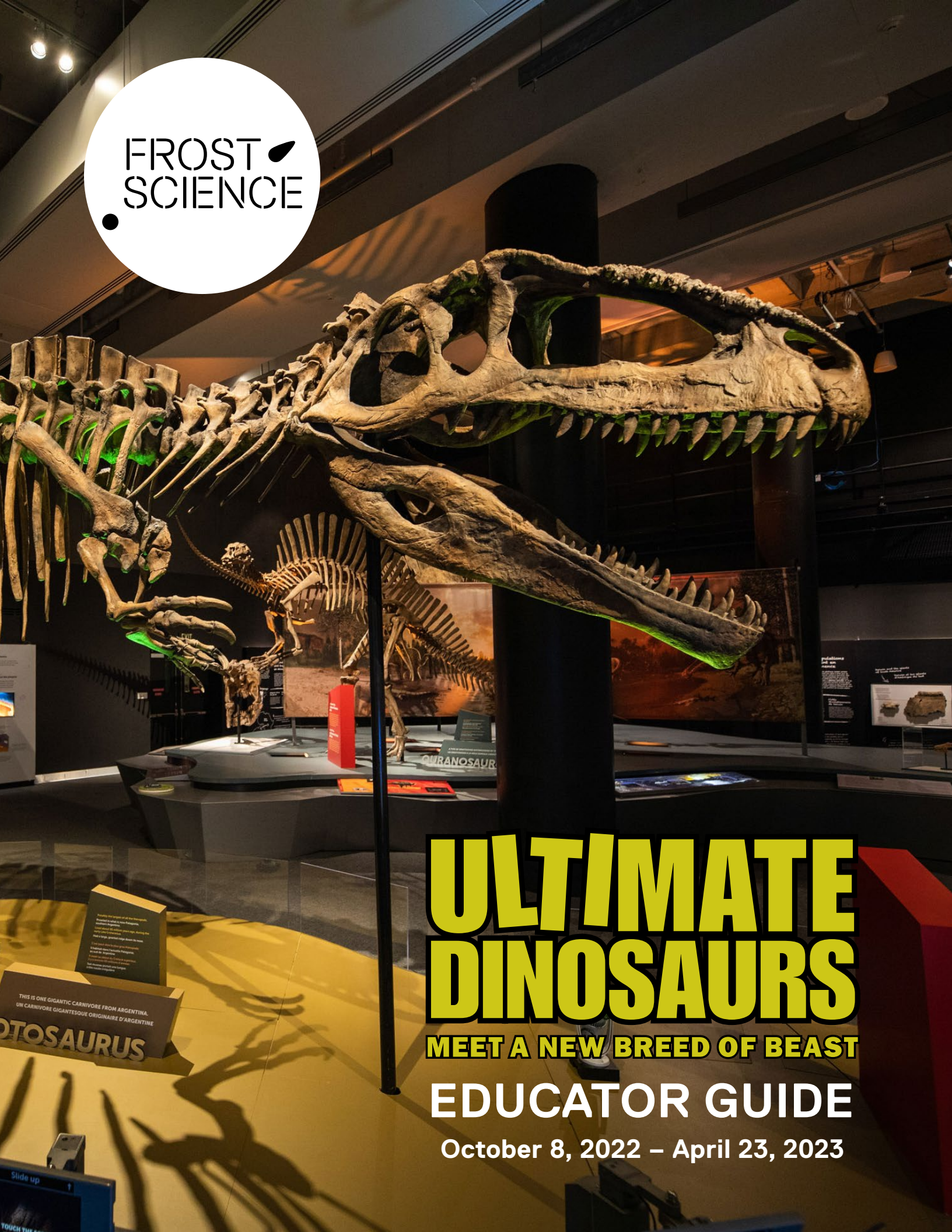

ULTIMATE DINOSAURS

MEET A NEW BREED OF BEAST

EDUCATOR GUIDE

October 8, 2022 – April 23, 2023

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Not your typical dinosaur exhibit, *Ultimate Dinosaurs* introduces your students to new and unique dinosaurs that evolved in isolation in South America, Africa and Madagascar and are unfamiliar to most North Americans. The exhibition combines rarely-seen specimens with interactive stations to highlight scientific study of fossils and includes examples of augmented reality technology that transforms full-scale dinosaurs into flesh-covered moving critters right before your eyes.

Students will be introduced to dozens of dinosaurs. They will learn about the break-up of supercontinent Pangaea into the continents that we know today and how plate tectonics and the way changing continents affected the evolution of dinosaurs during the Mesozoic Era. *Ultimate Dinosaurs* features groundbreaking research from scientists around the world, including current Macalester College professor, Kristi Curry Rogers.

Your students will have the opportunity to:

- See actual dinosaur fossils and casts made from unique, rare fossil finds in a colorful, immersive environment.
- Use new technology to layer virtual "skins" over dinosaur skeletons to see what they may have looked like when they were alive.
- Engage in hands-on explorations of real dinosaur fossil specimens, learning how fossils form, sifting for microfossils, interacting with mini dioramas, and more.
- Link direct experiences with fossil evidence to develop conclusions about prehistoric creatures, change over time, and the process of science.
- Take part in the process of discovery to learn how paleontologists do their work.

Portions of this educator guide were adapted from guides developed by the Royal Ontario Museum, the Cincinnati Museum Center and the Science Museum of Minnesota.

Presented by Science Museum of Minnesota

Created and Produced by ROM Royal Ontario Museum

Field Trip Information

Ultimate Dinosaurs: Meet a New Breed of Beast,
plus access to all of our interactive exhibitions:

August 16 – December 22: $12.95

January 9 - April 23: $14.95

Plan your trip today! Visit frostscience.org/field-trips
or email fieldtrips@frostscience.org.

Before you visit the *Ultimate Dinosaurs* exhibition:

- Do some preparation activities before your visit. Use suggestions in this guide and the resource list for more ideas.
- Review this guide for connections to your curriculum. Choose the activities that best meet your needs. Jigsaw groups to provide fewer questions for each student, but still cover topics you need.
- Add your own page(s). Use journals or composition notebooks if you use these in classroom work. Bring sturdy cardboard to write on if you plan to use single pages during your field trip.
- Share expectations, plans and schedules for the visit with students and chaperones. Give chaperones copies of any activities students will do.
- Encourage students to spend time in *Ultimate Dinosaurs* beyond simply answering questions.

During your visit to the *Ultimate Dinosaurs* exhibition:

- Ask students to add their own questions and observations that arise during their exhibit explorations.
- Photographs are permitted and encouraged.
- Students must be with their chaperones to enter the exhibition, and should stay with the chaperone throughout.
- Divide your class into small groups to work together in the exhibition.

Don't miss these complimentary programs throughout the exhibit!

Sauropod vs. Theropod
Participate in a fun game of dinosaur categories. Discover what dinosaurs are Sauropods v. Theropods and what makes them special. Using fossils and casts, learn more about the Mesozoic Era. Do you think you have what it takes to get them all correct? Come test out your knowledge with us at Ultimate Dinosaurs: Meet a New Breed of Beast.

Pterosaur Launch
Fly like a Pterosaur and check out the adaptations that made them such individuals. Use our constructed gliders and test out different crest and wing shapes. Watch how the pterosaur glides through the air and make changes to improve their flights.

Dino Dig
Activate your inner paleontologist by participating in an ongoing dig. Learn about the whole process of finding and collecting dinosaur bones. Discover the paleontological advancements being done at Frost Science with a sneak peek into our new paleontology initiatives.

Find that Dino
Let's test your dinosaur knowledge! Help us match a dinosaur description to one of the dinosaurs in our exhibition.

Exhibition Overview

Surrounded by life-like environmental murals, the exhibition features real fossils and 13 full-scale skeletal casts, many of which have never been seen before in the U.S. You'll see *Giganotosaurus*, possibly the largest land predator to have ever lived, as well as the crocodile-faced spinosaur *Suchomimus*, the horned meat-eater *Carnotaurus*, and many more.

Section Overview

INTRODUCTION:

The Supercontinent of Pangaea and the Earliest Dinosaurs

Dinosaurs originated during the time early in the Mesozoic Era (which lasted around 135,000,000 years, approximately 252 million years ago (mya)–65 mya) when all the continents were joined together to form Pangaea. Early dinosaur communities were globally distributed throughout the Triassic Period and the early Jurassic Period. *Eoraptor* and *Herrerasaurus* are just two of the early dinosaurs that populated Pangaea during the Triassic Period.

Continental Drift and Evolution in Isolation

Plate tectonics and evolution shaped the history of dinosaurs. Fossils found in both South America and Africa spurred the revolutionary idea of continental drift. Investigate examples of fossils that inspired these theories.

The North-South Divide: the Formation of Laurasia and Gondwana

In the first stage of continental break-up, the supercontinent of Pangaea divided near the equator to form a northern land mass (Laurasia) and a southern land mass (Gondwana). This section describes the initial stages of the break-up, a process that accelerates into Cretaceous time and sets the stage for the evolution of the dinosaurs of Gondwana.

SECTION 2:

The Great Gondwana Dinosaurs

The largest section of the exhibition focuses on the fragmenting of Gondwana. Organized along geographic lines into three major sub-sections—Africa, Madagascar, and South America—this part of the exhibition profiles southern dinosaurs. The fragmentation of Gondwana began in the early Cretaceous Period, after the southern continents had become largely isolated from those in the north. As Gondwana broke into the individual landmasses of South America, Africa and Madagascar (along with Australia, Antarctica and India), animal groups began to evolve in their own unique directions. During this time, each of the continents became completely separated from each other. This splendid isolation resulted in some of the most bizarre-looking and gigantic dinosaurs known today.

The Dinosaurs of Africa
This section features dinosaurs from Gadoufaoua, a rich fossil locality in Niger, Africa that dates back 130 million years. Thanks to the discoveries by Dr. Paul Sereno and his team in the last fifteen years, the 75-million-year-old fauna includes some of the best-preserved dinosaurs from Africa as well as crocodiles, birds and amphibians. Dinosaur specimens include *Ouranosaurus*, *Malawisaurus*, *Nigersaurus* (skull only), *Suchomimus* and *Carcharodontosaurus* (skull only).

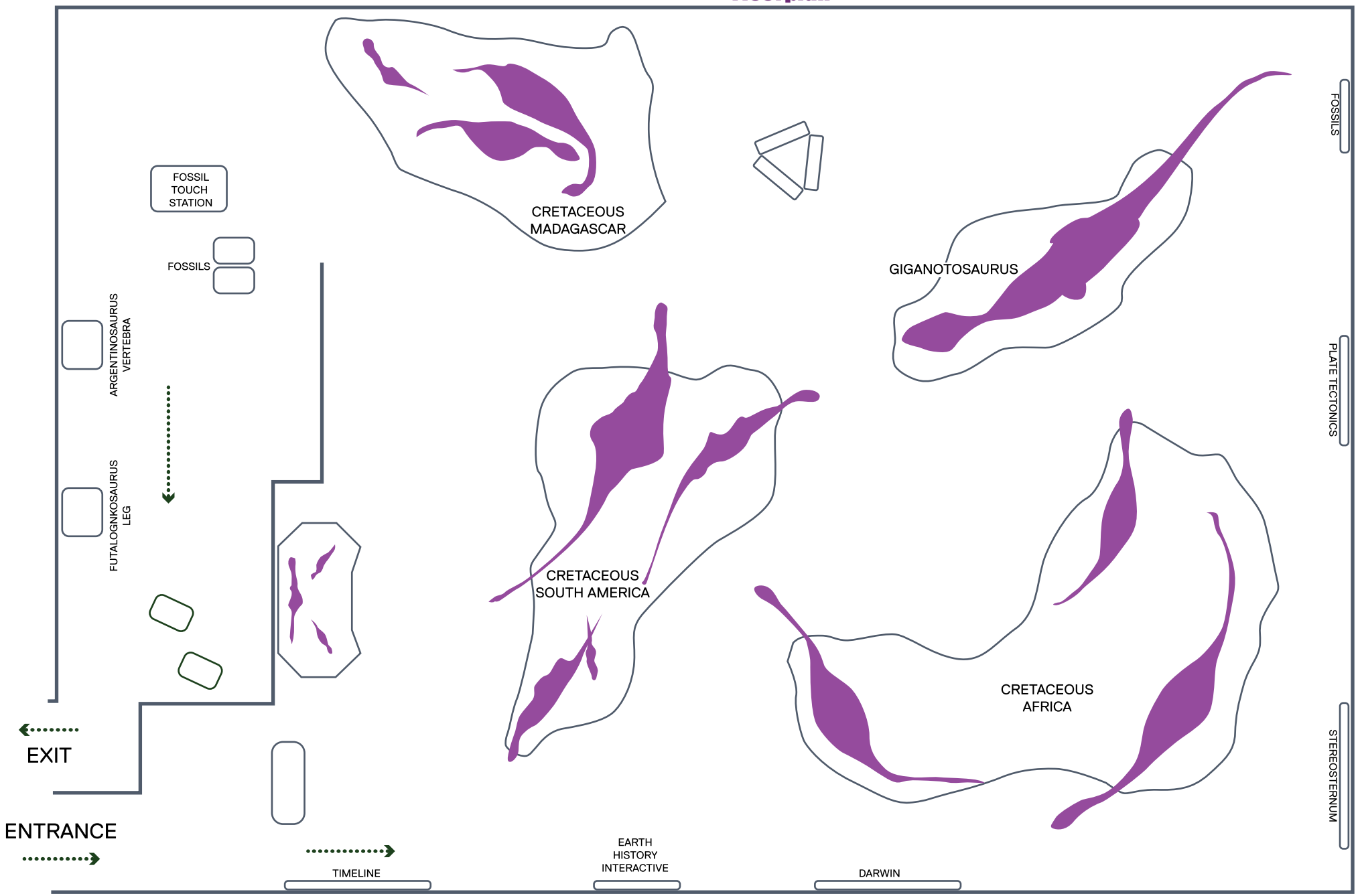
Madagascar: Late Cretaceous Island Wonders
Unlike South America and continental Africa, which have reconnected to other continents since the break-up of Gondwana, Madagascar has remained isolated to the present day. The lemur-dominated fauna of Madagascar today evolved under the same evolutionary conditions of biotic isolation as the strange dinosaurs millions of years before. This section includes wonderful specimens from the Late Cretaceous including complete skeletal casts of *Majungasaurus*, *Masiakasaurus* and *Rapetosaurus*, two of which were discovered within the last 15 years by Dr. David Krause and a team that included Dr. Kristi Curry Rogers.

The Giants of South America
Enormous sauropods (plant-eating, long-necked dinosaurs) were the dominant herbivores found in this region. These giant sauropods include the *Argentinosaurus*. The carnivores included *Amargasaurus*, *Buiteraptor*, *Carnotaurus* and *Austroraptor*.

SECTION 3:
Dinosaurs and Drifting Continents
The final section of the exhibition illustrates the difference between northern and southern dinosaurs. During the Late Cretaceous, the familiar *tyrannosaurs* were the dominant carnivores in North America, while the plant-eating hadrosaurs (duck-bills) and horned ceratopsians were the dominant herbivores. In Gondwana, the dominant carnivores were *Giganotosaurus* and its relatives, Carcharodontosaurids ("shark-toothed lizards"). Sauropods (long-necked, large herbivores) were the dominant plant-eaters.

This final section links the two narrative threads of continental drift and evolution that run through the exhibition and culminates in a dramatic face-off between the mega-predators *Tyrannosaurus rex* (from the north) and *Giganotosaurus* (from the south). Here, visitors determine for themselves which one was the biggest carnivorous dinosaur of all time.

ULTIMATE DINOSAURS
Floorplan



About this Topic

What is a dinosaur?

With new discoveries and scientific improvements, our understanding of dinosaurs is constantly changing, making it difficult for educators to stay current. Here's the most up-to-date information to help you stay ahead of the game.

Dinosaurs were a unique type of animal that:

- **lived during the Mesozoic Era from 245 to 65 million years ago.** Not all animals that lived during this time were dinosaurs. Many flying reptiles, marine animals, insects, mammals, etc. are often mistaken for dinosaurs.
- **were vertebrates.** All dinosaurs, regardless of their size, had backbones and shared similar skeletal features.
- **were terrestrial, meaning they lived on land.** While some dinosaurs may have been able to wade or paddle through water, they did not live in oceans, rivers or lakes like the swimming reptiles of the Mesozoic Era such as the mosasaurs and plesiosaurs. Dinosaurs also did not spend extended periods of time in flight like the flying reptiles such as the pterosaurs.
- **walked with their legs positioned directly under their bodies like birds and most mammals.** This adaptation made dinosaurs efficient walkers and runners. Modern reptiles walk with their legs splayed out, their knees always bent and their feet pointed out, rather than forward.
- **are now extinct, but their descendants are alive today as birds.** Through new discoveries and advancements in science, scientists have realized that dinosaurs of the past and modern birds have very similar features including three-toed feet, a wishbone, nests, brooding, feathers, hollow bones and hard shelled, oblong eggs just to name a few.

A few things to remember:

- Dinosaurs did not live with humans.
- Dinosaurs did not live in water.
- *Pterosaurs* (flying reptiles) were not dinosaurs.
- Dinosaurs did not drag their tails on the ground—footprints suggest that they walked with their tails held off the ground.
- Different types of dinosaurs lived at different times in different places. The "Age of Dinosaurs" lasted more than 140 million years. Not only were groups of dinosaurs separated by the different landmasses, but they continuously evolved and became extinct over that time.

Continental Drift

Alfred Lothar Wegener, a meteorologist in the early 20th century, noticed that the coasts of western Africa and eastern South America looked like the edges of interlocking pieces of a jigsaw puzzle.

He proposed the theory of continental drift:

- A protocontinent—which Wegener named Pangaea—began to split apart.
- Pangaea broke into two large continental landmasses, Laurasia and Gondwana, over millions of years.
- These two supercontinents then continued to break apart into the various smaller continents that exist today.

While continental drift explains similarities in the form of current continents, in fossils, rock formations and landforms found in widely separated areas, Wegener could not explain how continental drift happens. The theory of plate tectonics developed during the 1960's provided the explanation that had been lacking.

Cretaceous-Paleogene (K-Pg) Extinction Event

The most famous of all mass extinctions marks the end of the Cretaceous Period approximately 65 million years ago and is known as the Cretaceous-Paleogene (K-Pg) extinction event (formerly called the Cretaceous-Tertiary [K-T] extinction event). This mass extinction wiped out an estimated 71–81% of all species, including the non-avian dinosaurs. While all pterosaurs and giant marine reptiles, and many species of mammals, plants, fish, insects, and other organisms were victims of this mass extinction, other groups—horses, whales, bats, primates, birds, and more—found new evolutionary opportunities.

It's likely that a 6-mile-wide asteroid struck the Yucatan Peninsula in Mexico and triggered catastrophic effects on the global environment that caused the K-Pg extinction. These effects included a winter with lingering impact that made it impossible for plankton and plants to carry out photosynthesis. While most scientists now agree that the asteroid was involved, some maintain that the K-Pg extinction was caused or exacerbated by other factors, such as volcanic eruptions, climate change and a change in sea level.

Paleontology
The scientific study of ancient life includes the study of fossils. Fossils are physical evidence of former life from a period of time prior to recorded human history, usually defined as about 10,000 years ago or more.

Plate Tectonics
Plate tectonics is the scientific theory that Earth's outer layer is made up of plates, which have moved throughout Earth's history. The theory explains the how and why behind mountains, volcanoes, and earthquakes, as well as how, long ago, similar animals could have lived at the same time on what are now widely separated continents. It provides an explanation for "continental drift".

Supercontinents
The term supercontinent is usually used when referring to a large landmass that includes multiple continents. One such giant supercontinent, Pangaea, formed approximately 300 million years ago. Evidence of the first dinosaurs comes from this time period. Pangaea eventually broke apart about 150 million years ago and became the two smaller supercontinents of Laurasia (in the north) and Gondwana (in the south). Laurasia was comprised of present day North America, Europe and Asia. Gondwana was comprised of present day Africa, South America, Australia, Antarctica, Madagascar and India. *Ultimate Dinosaurs* features dinosaurs from Gondwana supercontinent.

The Earliest Dinosaurs
The earliest archosaurs (dinosaurs and their evolutionary relatives) are found in Permian rocks, formed before the Mesozoic Era began. In the beginning of the Mesozoic, when animal life was recovering from the worst mass extinction in the world's history, the archosaurs expanded and quickly spread. Crocodiles, dinosaurs, pterosaurs and birds all evolved from the same ancestor, an early archosaur, however not all archosaurs are dinosaurs. One characteristic scientists use for describing and categorizing dinosaurs is the structure of the pelvic bones. Dinosaurs can be categorized into ornithischians (bird-hipped), which include *Triceratops*, *Stegosaurus* and the duck-billed dinosaurs and saurischians (lizard-hipped), which include *Tyrannosaurus rex*, *Brachiosaurus* and modern day birds!

Two important evolutionary changes took place within the archosaur group. Sprawling, lizard-like animals evolved into animals that walked with their legs held directly under their bodies. And animals with cold-blooded, lizard-like metabolisms developed a warm-blooded, bird-like metabolism. These changes did not take place in all archosaurs, but they happened in the dinosaurs. Crocodilians are the only surviving example in which those changes did not occur; birds are the only surviving group in which they did.

The Cretaceous-Paleogene extinction event caused the extinction of all dinosaurs except the branch that had already given rise to the first birds.

For a list of dinosaurs and other specimens seen in *Ultimate Dinosaurs*, see page 24.

Connecting with the Classroom

Field trips are most effective when integrated with your curriculum. Below are activities that can be used as an introduction to topics included in the *Ultimate Dinosaurs* exhibition. Many can be used after your trip or as ongoing topic explorations.

Before Your Visit

There are many classroom activities that are linked to dinosaur topics. Below are a few suggestions.

ALL GRADES

Vocabulary Review

Review the activities to do at the museum to review any vocabulary that will be new to students. A suggested vocabulary list is below. Add other words that may be new to your students. Ask students to find the meaning of each word and make a drawing to help them remember its meaning. Discuss each as a class.

- ⇨ Carnivore
- ⇨ Fossil
- ⇨ Omnivore
- ⇨ Continental Drift
- ⇨ Geology
- ⇨ Paleontology
- ⇨ Dinosaur
- ⇨ Herbivore
- ⇨ Plate Tectonics
- ⇨ Evolution
- ⇨ Inference vs. Evidence
- ⇨ Supercontinents
- ⇨ Extinction
- ⇨ Mesozoic Era

Charting Dinosaur Knowledge

Discuss what students already know about dinosaurs and explore what they would like to learn further by creating a classroom Dinosaur Chart to keep track of classroom progress.

Gather class questions about the topic. What do students want to know? What do they think they will see and experience? What do they know or think about dinosaurs? Use their questions as a basis for your field trip guiding questions, or choose from questions in the Student Pages (pg.12-19).

Becoming a Paleontologist

As paleontologists, we are studying an extinct group of animals that we've never seen. Have the class discuss how we find out about dinosaurs.

Suggestions:

- How do we learn about and study dinosaurs?
- What evidence do we have about dinosaurs?
- Why is the study of paleontology important?
- Have any dinosaurs been found in Minnesota?

As the class discusses some of these answers, add them to your Dinosaur Chart.

Use images from the websites listed in the Resource section (pg. 23) to discuss what students will be seeing when they visit the exhibition.

Review the floorplan (page 6) of the exhibition with your students before your field trip. You can also provide floorplan copies to chaperones or individual students.

Review the schedule for the day with students, and share behavior expectations.

K-2

SORTING DINOSAURS

There are many ways to sort dinosaurs. Paleontologists divide dinosaurs into two main categories based on their hipbone structure. Some paleontologists specialize in certain aspects or attributes of dinosaurs, such as footprints or eggs. Their knowledge helps us fill in the details of these mysterious creatures. It can even help us understand the ancient environments dinosaurs once lived in. Classification or sorting helps to focus on patterns that may be helpful in identification or defining relationships of animal groups.

Materials:

- Dinosaur models or books with pictures of dinosaurs.
- Laminated pictures of dinosaurs obtained from old calendars or magazine articles.
- **EnchantedLearning.com/subjects/dinosaurs/dinotemplates/Templatelist.shtml** contains line drawings of dinosaurs, which could be printed out for this activity. It also has links to other dinosaur sites and other activities for your classroom.

Activity:

Show the class a dinosaur picture. Ask what they notice about the animal. List all the features mentioned. As a whole class, take the dinosaur pictures and model sorting by the number of legs the dinosaurs use for walking. Use think-pair-share to ask what other feature from the list could be used to sort.

Divide class into several teams and give each group a set of dinosaur pictures or models. Ask the groups to sort the pictures several times into as many categories as possible.

Bring teams together and list all the ideas. You can also mention some of the ways other people have sorted (classified) dinosaurs:

- Big/little
- Eggs/babies/juvenile/adult
- Slow/fast
- 2 legs/4 legs used for walking
- Teeth/no teeth
- Pointy teeth/flat teeth
- North American/not found in North America
- Herbivore/Carnivore
- Dinosaurs/non-dinosaurs

If your class has not done any sorting activity, start with some common objects to sort (e.g. with shells, buttons, pencils, coins, and so on). Give each group of students a box of objects and let them devise a sorting strategy.

Grades 3-5

IDENTIFY THAT CAST

Fossils form in many ways. Sometimes a plant or animal can leave an imprint (foot, skin, leaf) in soft earth, such as mud. When the imprint hardens, it forms a mold. Later mud or other material can fill the mold to make a cast, or a copy of the original. Have students make their own molds and casts of objects and ask them to match each of the casts to the original object.

Materials:

- Small objects
- Hardening clay material
- Plaster of Paris, mixing tools (bowl, spoon or stick)
- Spray vegetable oil

Have students bring in or supply small objects to mold and cast, e.g. a small toy, shell, coin, leaf, screw, etc. Give each student a small amount of clay, salt dough or other hardening clay material. Shape the clay into a small disk, slightly larger than the object. Place the disk on a flat, dry surface, and add a rim around the top edge that will allow for pouring plaster into the disk without spilling over. Students will then spray their disk with vegetable oil, and carefully push their object into the clay. Remove the object, leaving an imprint. You have created a mold.

Mix up Plaster of Paris and quickly pour the mixture onto the molds. Allow the plaster to dry until cool and hard. Carefully separate the cast from the mold.

Pass out the casts, and see if students are able to identify what their cast is from. You can place all of the original objects on a table and allow students to compare the casts with the objects.

Paleontologists may find molds of organism features (footprints, skin texture, cavities in the body) that would not have fossilized in other ways. They can make a cast from this mold to replicate what that feature may have looked like in real life. Molds and casts are also made from other types of fossils (bones, for example) to share with colleagues in other museums, provide specimens that people can touch (since they would not be able to touch the actual fossil specimen) or complete a skeleton that is missing parts for display.

Grades 3-8

DINOSAUR NAME MATCHING

Dinosaur names are usually made up of root words from the Latin or Greek languages. A dinosaur's name might describe what the dinosaur looked like, how it may have acted, or where its bones were found. For example, the word "dinosaur" itself can be split into two parts, "dino" and "saur." The Greek word "dino" means terrible while "saur" means lizard, so the word "dinosaur" means terrible lizard. Using the Latin/Greek Word Bank that shows word roots and their meanings, draw a line matching the dinosaur names below with their correct meanings.

Dinosaur name	Meaning
Tyrannosaurus Rex	massive vertebrae
Carcharodontosaurus	crocodile mimic
Eoraptor	dragon hunter
Carnotaurus	sharp-toothed lizard
Giganotosaurus	dawn robber
Cryolophosaurus	southern thief
Massospondylus	giant southern lizard
Austroraptor	cold crested lizard
Suchomimus	meat-eating bull
Dracovenator	tyrant lizard king

Latin/Greek Word Bank

austr = south
giga = giant
saur, saurus = lizard
carcharo = jagged, sharp
lopho, lophos = crest
spondylis = vertebae
carno = meat-eating
masso = massive
sucho, suchus = crocodile
don, dont = tooth
mimus = mimic
taur, taurus = bull
cryo = icy, cold
notos = south
tyrranos = tyrant
draco = dragon
raptor = thief, robber
venator = hunter
eo, eos = dawn
rex = king

MAKE UP A NEW NAME FOR A DINOSAUR

Using a dictionary with meanings of roots and affixes, ask students to look up several dinosaur names and compile a list of affixes with the English meaning. (e.g. dino = terrible) Compile a whole class list and each group can rename one dinosaur with a new combination of roots and prefixes and suffixes. Discoveries new to science are named by the person who first publishes a scientific description. They usually use the same kinds of roots and affixes to create new names.

The Earliest Dinosaurs

Choose one of these and describe this dinosaur by answering some questions.

Eoraptor *Herrerasaurus*

How many toes does this dinosaur have? _____

What do its teeth look like? Draw them here.

What do you think this dinosaur ate?

_____

What clues helped you answer this?

_____

_____

_____

The Great Gondwana Dinosaurs: Africa, Madagascar, South America

Paleontologists found these dinosaurs in different parts of the world. Find your favorite from one section. Draw the dinosaur and write its name on the bottom.

Label important parts of your dinosaur (for example, teeth, head, feet, toes).
Dinosaur Name:

Where was it found? Africa Madagascar South America
(Circle One)

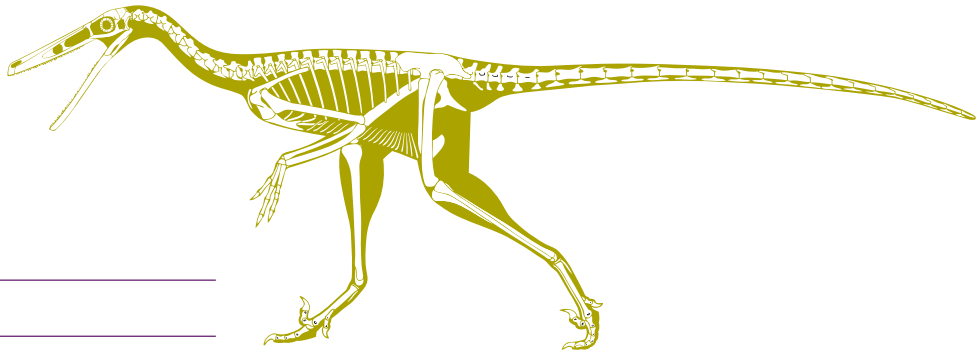
What tools in this exhibit help you know more about dinosaurs? Circle the ones you find.

microscope ruler magnifier bulldozer iPad headphones scales glasses

Draw a picture of something you were able to see through the microscope.

Which one is bigger?

T. rex *Giganotosaurus*



What did they eat?

_____

_____

What do you think—did they ever meet each other?

YES NO

Write your own question about anything you saw or did!

_____

_____

_____

The Earliest Dinosaurs

True or False? Circle true or false for each statement. Add evidence that gave you clues to answer the question.

True False *Eoraptor* was one of the largest dinosaurs ever found.

How do you know?

True False *Herrerasaurus* still lives in zoos today.

How do you know?

True False Dinosaur remains were found in South America and give us information about the earliest known dinosaurs.

How do you know?

Find 2 examples of fossils that you find interesting.

Draw them here.	What do YOU think: What can we learn from this fossil?

Dinosaur Skin

The murals on the wall show how dinosaurs might have looked when they were alive. Paleontologists need to have evidence about the dinosaur to show what it might have looked like.
Find some evidence in this area that would give some information about the skin of Carnotaurus.

What are we able to learn about the Carnotaurus by studying the skin impressions?

_____

_____

_____

What are we NOT able to determine?

_____

_____

_____

The Great Gondwana Dinosaurs

The supercontinent of Pangaea divided near the equator to form a northern land mass (Laurasia) and a southern land mass (Gondwana).

Circle the continents that were once part of Gondwana.

North America South America Europe Antarctica Asia Africa

Find an example of dinosaur fossils from one of these continents.				
Dinosaur	When did it live? (Circle One)	Paleontologist who Excavated It	Where did s/he go to excavate this fossil?	Another organism that lived during this time.
	Triassic Jurassic Cretaceous			

Dinosaurs and Drifting Continents

Could *T. rex* and *Giganotosaurus* have ever hunted each other? YES NO
Give evidence for your answer.

_____

_____

_____

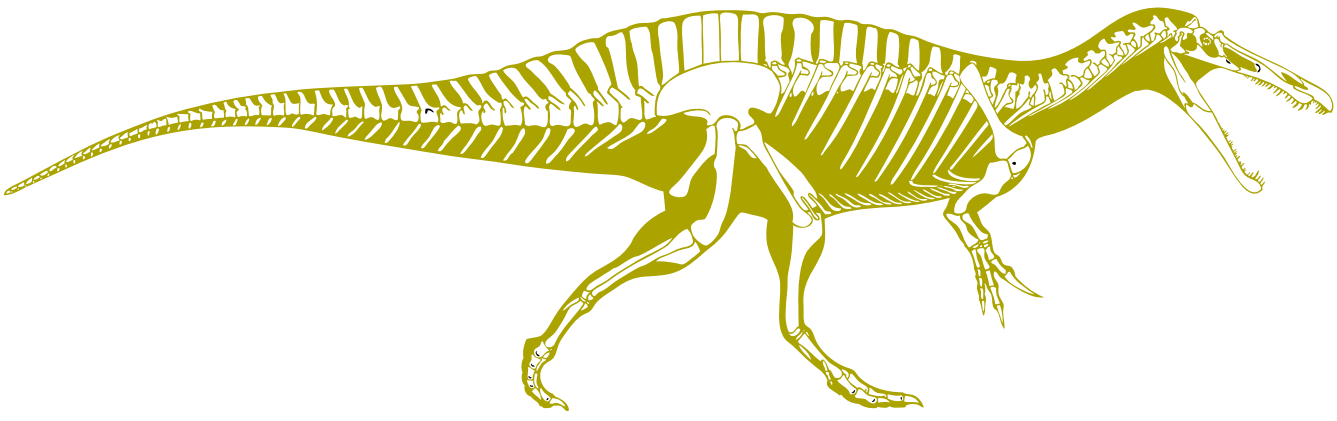
The Supercontinent of Pangaea and the Origin of Dinosaurs

Once dinosaurs all lived on one land mass (the supercontinent Pangaea). Today there are multiple continents and dinosaur fossils have been found on every continent. Some of these dinosaurs are similar, but many look very different from one another. Scientists in the past had ideas to explain these changes. Use the exhibits and your own ideas to complete the chart.

	Alfred Wegener	Charles Darwin	You
What is the claim?			
Evidence they used?			
Other possible explanation for this evidence			

Draw or describe one dinosaur shown here:

Name of dinosaur:	When did it live? Circle one: Triassic Jurassic Cretaceous Add and label one other organism that lived with this creature.



Try the **"extinction scavenger hunt!"** to find out more about extinction and what happened to creatures that are no longer living today.
Find information about a mass extinction event in *Ultimate Dinosaurs*.

When did it happen?

Who survived?

Who didn't?

How many mass extinction events can you find?

There are clues in the first section and you may find other clues in the rest of the exhibition.

The Pangaea North-South Divide: the Formation of Laurasia and Gondwana

What is Gondwana?

Find an example of a dinosaur who once lived in Gondwana, where the fossils were found and an interesting feature of that dinosaur that is different from the others in this section.

Dinosaur	When did it live?	Where was it found?	What creature living today does it remind you of?	Interesting feature
	Triassic Jurassic Cretaceous			

Dinosaurs and Drifting Continents

T. rex fossils have been found in North America. *Giganotosaurus* fossils are found in South America.

Compare the two examples shown here. What features do they have in common?

How are they different?

Are they related? Give an explanation, with evidence, for your answer.

The Supercontinent of Pangaea and the Origin of Dinosaurs

Once dinosaurs all lived on one land mass (Pangaea). Today scientists find dinosaur fossils on many continents and they all look different from each other. Scientists in the past had ideas to explain these changes.

	Alfred Wegener	Charles Darwin
What is the claim?		
Evidence they used?		

Try the **"extinction scavenger hunt!"** to find out more about extinction and what happened to creatures that are no longer living today.
Find information about a mass extinction event in *Ultimate Dinosaurs*.

When did it happen?

Who survived?

Who didn't?

How many mass extinction events can you find?

There are clues in the first section and you may find other clues in the rest of the exhibition.

Flooded with fossils

What do you think: why don't we find piles of dinosaur remains everywhere?

What are some conditions that are necessary for fossil formation?

What is Gondwana?

Where do paleontologists go to find dinosaurs who once lived in Gondwana?

Observe all of the dinosaur specimens. Give three examples of features that are common to all that might suggest a common ancestor.

Does dinosaur skin really look like that?

The murals could be considered a model. What would a scientist need to develop a model of living dinosaurs like the ones in the murals, complete with flesh, skin and full color?

What might be a drawback to using this model?

Dinosaurs and Drifting Continents
Battle of the Giants

Could *T. rex* and *Giganotosaurus* have ever hunted each other? YES NO

Give evidence for your answer.

Chaperone Page

° Encourage students to look closely at the exhibits, try the activities, share their discoveries and ideas with the rest of the group.

° Enjoy the exhibits with your group! Share your own discoveries, questions, and "I wonder..."

° Allow time for student exploration. The suggestions below encourage exploration in the exhibition. Check with the teacher for their expectations.

°Teachers may have provided students with guiding questions or question sheets to use. Check with the teacher for your own copy.

° Please stay with your group throughout the exhibition.

° If you have questions, please ask any of the staff in the exhibition.

Here are some questions to share with your group. Develop your own exploration questions too!

⇨ Have the group try out one or more of the activities. Share what you each learned from that activity.

⇨ Ask students to find a dinosaur they find interesting, then describe it to the rest of the group, so that other students can find their dinosaur.

For example: My dinosaur has 3 toes on each foot, is running on two legs and has a head bigger than a watermelon. Or, partner students to work together. Each partner should use 3 words or phrases that are different from their partner's.

⇨ What body parts do the dinosaurs have that humans also have?
What do they have that humans do not?

⇨ Talk about the environment the dinosaurs lived in. Look at the murals or read the labels. What would they have heard if they were there? Would it be hot? Warm? Cold? What would they smell? What clues do they use to decide? Talk about: Since people were not around yet, why do scientists think it might have looked like this? Where did these animals get food? What clues helped you decide?

⇨ Round robin questions – ask each student to finish this statement.
"I wonder..."

⇨ In the last section of the exhibition you will see two very large meat-eaters
Which one is bigger?
T. rex *Giganotosaurus*
What do you think—did they ever meet each other? Try to find the answer by reading some of the labels.

AFTER YOUR VISIT

K-2

Discuss questions from the student pages. Use drawings for murals, newsletters to families or classroom display.
Compare the drawings in class, discuss or ask students where "their" dinosaur was discovered, then find the continent (Africa or South America) or island (Madagascar) on a world map.

Did T. rex and Giganotosaurus ever meet? Yes (No)
They lived on different continents and at different time periods. Not all dinosaurs lived at the same place or time. Some lived very early and became extinct long before all dinosaurs became extinct.

What questions did students have about the exhibit? Discuss how they could find answers to their questions.

Grades 3-5

Discuss student pages. What choices did students make for their dinosaurs?
The final question about *T. rex* and *Giganotosaurus* meeting is to reinforce the main point of the exhibition: the landmass of Pangaea divided into Laurasia (which eventually became most of the Northern Hemisphere) and Gondwana, highlighting the dinosaurs that evolved in Gondwana, unfamiliar to many students. The dinosaurs from each of these supercontinents would not have encountered each other. Dinosaurs in each of the supercontinents evolved differently, because of this isolation.

These questions all ask students to provide evidence for their answers.

True (False) *Eoraptor* was one of the largest dinosaurs ever found.
How do you know? *Eoraptor is quite small (about 1 meter). Students should be able to compare it with other, much larger specimens.*

True (False) *Herrerasaurus* still lives in zoos today.
How do you know? *Dinosaurs are all extinct (except for the branch that we know today as birds).*

(True) False Dinosaur remains were found in South America and give us information about the earliest known dinosaurs.
How do you know? *The exhibition has examples of these early dinosaurs. Students can found information on where they were found on the accompanying label.*

The questions about learning from fossils are designed to provide students with an opportunity to do some direct observation and reasoning to put together evidence, previous knowledge, written information from the exhibit and their own ideas.

Grades 6-8

Ask students to write a complete response to the *At The Museum* questions, based on their notes. Review their answers as appropriate. Discuss in class to share insights, reactions and perceptions.

Once dinosaurs all lived on one land mass (Pangaea). Today there are multiple continents and scientists have found dinosaur fossils on every continent. Some of these dinosaurs are similar, but many look very different from one another.
Scientists in the past had ideas to explain these changes.

	Alfred Wegener	Charles Darwin	You
What is the claim?	*Continental Drift*	*Descent with modifications (or evolution)*	*Will vary*
Evidence they used?	*Similarities in coastline appearance of S. America and Africa*	*Similarities of extinct animals and current forms*	*Will vary*
Other possible explanation for this evidence	*Will vary*	*Will vary*	*Will vary*

Given the theory of plate tectonics with continental drift, what will the Earth look like in 200 million years if plates and continents keep moving?

Draw or describe one dinosaur shown here:
Will vary. Opportunity for student observations of specimens and to consider the environment

Are dinosaurs still alive today? **Extinction scavenger hunt!**
Find information about a mass extinction event in *Ultimate Dinosaurs.*
Discuss extinction events students found—what does extinction mean? What are some causes of extinction?
Is extinction going on today? Did all dinosaurs become extinct? At the same time?

The Pangaea North-South Divide: the Formation of Laurasia and Gondwana
What is Gondwana?
Discuss the separation of the supercontinent Pangaea into Laurasia and Gondwana and the isolation of evolving organisms on the separated continents.

Dinosaurs and Drifting Continents
***T. rex* fossils are found in North America. *Giganotosaurus* fossils are found in South America.**
Are they related? Give an explanation, with evidence, for your answer.
All dinosaurs have a common ancestor and have features in common that define them as dinosaurs. With the separation into smaller continents, evolution resulted in differing forms and adaptations. T. rex and Giganotosaurus are also both categorized as theropods, but in different families.

Discuss: Think-Pair-Share: As a paleontologist working to understand more about the prehistoric past, what question would you pursue next? What parts of the exhibit would be most valuable for you to revisit?

High School
Ask students to write a complete response to the At The Museum questions, based on their notes. Review their answers as appropriate. Discuss in class to share insights, reactions and perceptions.

	Alfred Wegener	Charles Darwin
What is the claim?	*Continental Drift*	*Descent with modifications (or evolution)*
Evidence they used?	*Similarities in coastline appearance of S. America and Africa*	*Similarities of extinct animals and current forms*

Discuss: How have ideas about continental drift and evolution changed from what Wegener and Darwin first proposed? What further evidence supports their theories or has modified the theories?

Are dinosaurs still alive today? **Extinction scavenger hunt!**
Find information about a mass extinction event in *Ultimate Dinosaurs.*
Discuss extinction events students found—what does extinction mean? What are some causes of extinction? Is extinction going on today? Did all dinosaurs become extinct? At the same time?

Scientists now theorize that birds are descendants of dinosaurs. What structures or evidence show relationships? If Ms. Skeptik challenged this thinking, what evidence or idea might she bring up? How would you counter this? Or what further evidence would you need to provide?

Flooded with fossils
What do you think? Why don't we find piles of dinosaur remains everywhere? What are some conditions that are necessary for fossil formation?
The exhibition has two interactive components about conditions that foster fossilization. Most organisms decay or get scavenged long before they can become fossils.

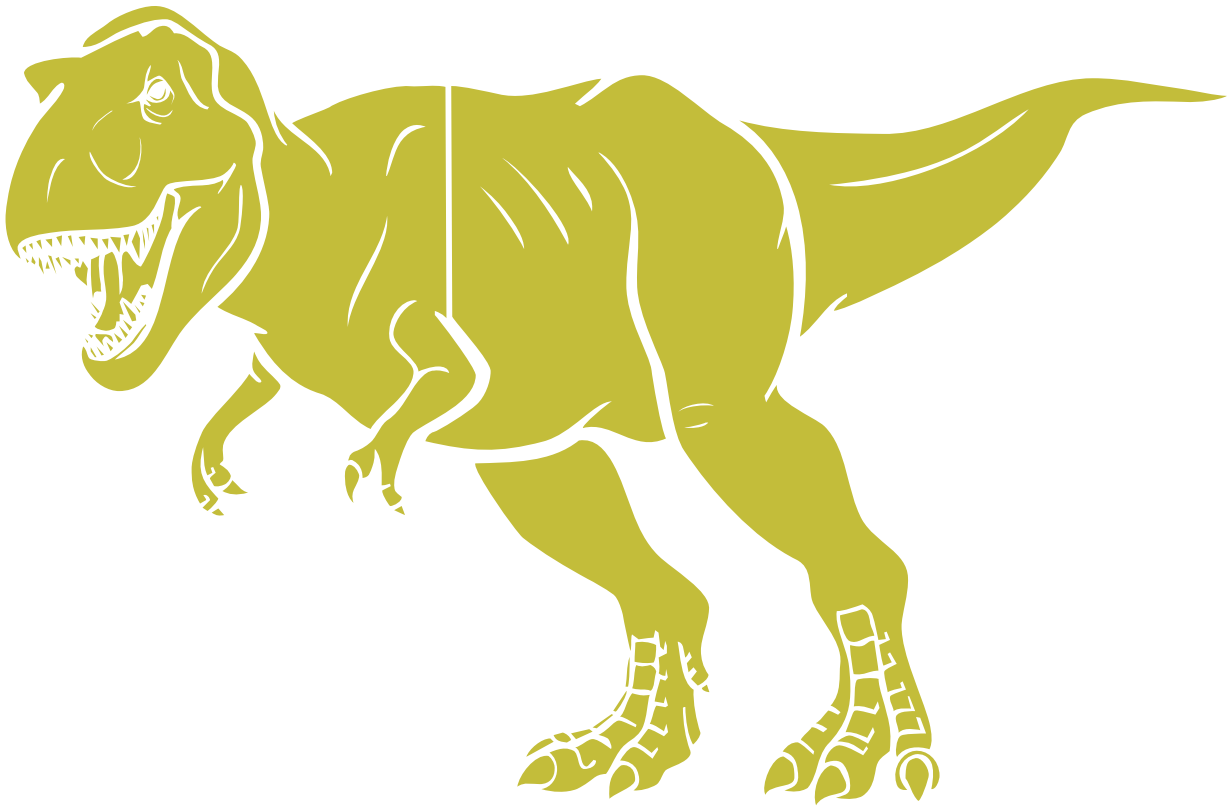
What is Gondwana? Where do paleontologists go to find dinosaurs that once lived in Gondwana?
Discuss the separation of the supercontinent Pangaea into Laurasia and Gondwana and the isolation of evolving organisms in the separated continents. Use research resources to identify areas of the world today and how they may have looked throughout time as continents changed.

Given the theory of plate tectonics with continental drift, what will the Earth look like in 200 million years?
Discuss—how will continents change?
Observe all of the specimens. Give 3 examples of features that are common to all that might suggest a common ancestor.
All dinosaurs have a common ancestor and have features in common that define them as dinosaurs. With the separation into smaller continents, evolution resulted in differing forms and adaptations.

Does dinosaur skin really look like that?
What would a scientist need to develop a model like the ones in the murals, complete with flesh, skin and full color?
Scientists would need evidence with actual fossils (e.g. skin impressions), and comparisons with living creatures to understand muscle attachment and structure. Color might be based on the function of skin color in animals living today.
What might be a drawback to using this model?
Will vary.

Battle of the Giants
Could T. rex and Giganotosaurus have ever hunted each other? Yes (No)
Give evidence for your answer.
They lived on different continents and at different time periods.

Think-Pair-Share: As a paleontologist working to understand more—what question would you pursue next? What parts of the exhibit would be most valuable for you to revisit?



TEACHER AND STUDENT RESOURCES

Websites

EnchantedLearning.com/subjects/dinosaurs/dinotemplates/Templatelist.shtml
Contains line drawings of dinosaurs that can be printed out. It also has links to other dinosaur sites and other classroom activities.

nhm.ac.uk/nature-online/life/dinosaurs-other-extinct-creatures/dino-directory/index.html
From the Natural History Museum in London, includes quizzes, games, information on hundreds of dinosaurs from all over the world.

sciencebuzz.org/blog/what-name
Find answers to questions like: "Who gets to name Dinosaurs?" "What is this dinosaur named after?" and "What does this name mean?"

Books

Dinosaurs!: The Biggest Baddest Strangest Fastest
by Howard Zimmerman
2000: Atheneum Books for Young Readers
ISBN 0689832761
Zimmerman categorizes dinosaurs mostly by physical characteristics. Includes information about each one, 75 illustrations, and pronunciation guides for names. The book often offers several artists' takes on the same animal, showing how appearance, color, and anatomy are still open to interpretation.
(Grades K-5)

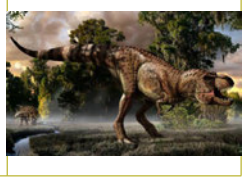
Dinosaurs and other Prehistoric Creatures
Consulting editor: Carl Mehling
2009: Amber Books
ISBN-10: 1906626677
ISBN-13: 978-1906626679

Handy visual guide to prehistoric creatures found worldwide, primarily dinosaurs. Each specimen includes one or more illustrations of the dinosaur as it may have appeared in life, maps showing where the fossils were found, what kind of fossil evidence exists, vital statistics of each one, including estimated size, pronunciation of the name, and other items. It also includes a timeline of when this species was alive and a size comparison with humans.
(All ages)

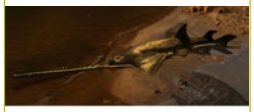
Who's Who in Ultimate Dinosaurs

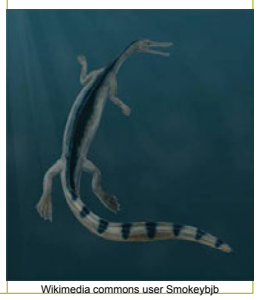
Name	Date	Diet	Stance	Approx. Size (max)	Where Fossils Have Been Found	Image
Amargasaurus cazaui "Amarga lizard" (after the rock formation where it was found) Saurischia: Sauropod: Diplodocid	125 mya	Herbivore	Quadruped	9 m	Argentina	
Austroraptor cabazai "Southern thief" Saurischia: Theropod: Dromaeosaur	70 mya	Carnivore	Biped	5 m 170 kg (375 lbs)	Argentina	
Buitreraptor gonzalezorum "Vulture thief" Saurischia: Theropod: Dromaeosaur	95 mya	Carnivore	Biped	1.5 m 3 kg (6.6 lbs)	Argentina	
Carcharodontosaurus saharicus "Jagged-toothed lizard" or "shark teeth lizard" Saurischia: Theropod: Carcharodontosaur	95 mya	Carnivore	Biped	13 m 2700 kg (6000 lbs)	Morocco	 Nobu Tamura (http://spinops.blogspot.com)
Carnotaurus sastrei "Meat-eating bull" Saurischia: Theropod: Carnotaur	75 mya	Carnivore	Biped	7 m 1500 kg (3300 lbs)	Argentina	
Cryolophosaurus ellioti "Frozen crested lizard" Saurischia: Theropod: Dilophosaur	190 mya	Carnivore	Biped	6.5 m 450 kg (990 lbs)	Antarctica	
Eoraptor lunensis "Early thief from the Valley of the Moon" Saurischia: Prosauropod	230 mya	Omnivore	Biped	1 m 10 kg (22 lbs)	Argentina	

Futalognkosaurus dukei "Giant chief lizard" Saurischia: Sauropod: Titanosaur	85 mya	Herbivore	Quadruped	34 m 68,000 kg (150,000 lbs)	Argentina	
Giganotosaurus carolinii "Giant south wind lizard" Saurischia: Theropod: Carcharodontosaur	95 mya	Carnivore	Biped	13 m 6000 kg (13,200 lbs)	Argentina	
Herrerasaurus ischigualastensis "Herrera's lizard" after the rancher who discovered the first fossil. Saurischia: Theropod: Herrerasaur	230 mya	Carnivore	Biped	4-5 m 150-250 kg (330-550 lbs)	Argentina	
Majungasaurus crenatissimus "Mahajanga lizard" Saurischia: Theropod: Carnotaur	70 mya	Carnivore	Biped	8 m 2000 kg (4400 lbs)	Madagascar	
Malawisaurus dixeyi "Malawi lizard" Saurischia: Sauropod: Titanosaur	120 mya	Herbivore	Quadruped	16 m 5000 kg (11,000 lbs)	Malawi	
Masiakasaurus knopfleri "Knopfler's vicious lizard" Saurischia: Theropod: Noasaurid (Named after musician Mark Knopfler)	70 mya	Carnivore	Biped	2 m 20 kg (44 lbs)	Madagascar	
Massospondylus carinatus "Longer vertebra" Saurischia: Prosauropod	190 mya	Herbivore	Biped (adult), quadruped (young)	4-6 m 500 kg (1100 lbs)	South Africa	
Nigersaurus taqueti "Niger lizard" Saurischia: Sauropod: Rebbachisaur	112 mya	Herbivore	Quadruped	9 m 4500 kg (9900 lbs)	Niger	

Ouranosaurus nigeriensis "Brave (monitor) lizard" Ornithischia: Ornithopod: Iguanodont	110 mya	Herbivore	Quadruped/ Biped	7 m 3000 kg (6600 lbs)	Niger	
Pisanosaurus mertii "Pisano lizard" Ornithischia	228 mya	Herbivore	Biped	1 m 4-6 kg (9-14 lbs)	Argentina	
Rahonavis ostromi "Cloud bird" Saurischia: Theropod: Dromaeosaur	71 mya	Carnivore/ Insectivore	Biped	0.7 m 0.5 kg (1 lb)	Madagascar	
Rapetosaurus krausei "Mischievous giant lizard" Saurischia: Sauropod: Titanosaur	70 mya	Herbivore	Quadruped	15 m 9000 kg (19,840 lbs) Madagascar	Madagascar	
Spinosaurus aegyptiacus "Spine lizard" Saurischia: Theropoda: Spinosaur	112 mya	Carnivore	Biped	15 m 6300 kg (13,860 lbs)	North Africa	 Bogdanov, modified by Matt Martyniuk
Suchomimus tenerensis "Crocodile mimic" Saurischia: Theropoda: Spinosaur	110 mya	Carnivore (piscivore)	Biped	11 m 3000 kg (6600 lbs)	North Africa	
Tyrannosaurus rex "Tyrant lizard king" Saurischia: Theropod: Tyrannosaur	65 mya	Carnivore	Biped	12.8 m 7000 kg (15,400 lbs)	North America	

Other Reptiles, Amphibians & Fish

Name	Date	Diet	Stance	Approx. Size (max)	Where Fossils Have Been Found	Image
Aegisuchus witmeri "Shield crocodile" Crocodylian	95 mya	Carnivore	Quadruped	15 m 9000 kg (19,800 lbs)	Morocco	 Henry P. Tsai, University of Missouri.
Ceratodus latissimus Fish: Lobe-finned	230 mya	Carnivore	Swimmer	0.6 m 0.4 kg (2 lbs)	Global	 Nobu Tamura (http://spinops.blogspot.com)
Elosuchus cherifiensis "Swamp Crocodile" Crocodylian	95 mya	Carnivore	Quadruped	3 m	Morocco	 Nobu Tamura (http://spinops.blogspot.com)
Hamadasuchus rebouli "Rocky desert crocodile" Crocodylian	95 mya	Carnivore	Quadruped		Morocco	
Lepidotes gigas Fish: Ray-finned	160 mya	Carnivore	Swimmer	2 m 11 kg (25 lbs)	Northern Hemi-sphere	 Nobu Tamura (http://spinops.blogspot.com)
Lystrosaurus "Shovel lizard" Therapsid reptile	240 mya	Herbivore	Quadruped	0.9 m 90 kg (200 lbs)	South Africa	 Nobu Tamura (http://spinops.blogspot.com)
Mesosaurus tenuidens "Middle lizard" Mesosaur (marine reptile)	280 mya	Carnivore	Swimmer	1 m 9 kg (20 lbs)	South Africa/ South America	
Onchopristis Fish: Sawfish	97 mya	Carnivore	Swimmer	8 m 900 kg (2000 lbs)	Africa	
Prestosuchus chiniquensis "Quick crocodile" Rauisuchian ("Rau's croco-diles") reptile	230 mya	Carnivore	Quadruped	5 m 90 kg (200 lbs)	Brazil	

Simosuchus clarki "Pug-nosed crocodile" Crocodylian	70 mya	Herbivore	Quadruped	0.75 m 9 kg (20 lbs)	Madagascar	
Stereosternum tumidum "Double sternum" Mesosaur	280 mya	Carnivore	Swimmer	0.3 m 1 kg (2 lbs)	Brazil	 Wikimedia commons user Smokeybjb

Plants

Name	Date	Diet	Stance	Approx. Size (max)	Where Fossils Have Been Found	Image
Glossopteris "Tongue fern" Fern: Seed fern	299 mya			30 m	South America, Africa, India, Antarctica, Australia