

DINOSAUR WORLD LIVE



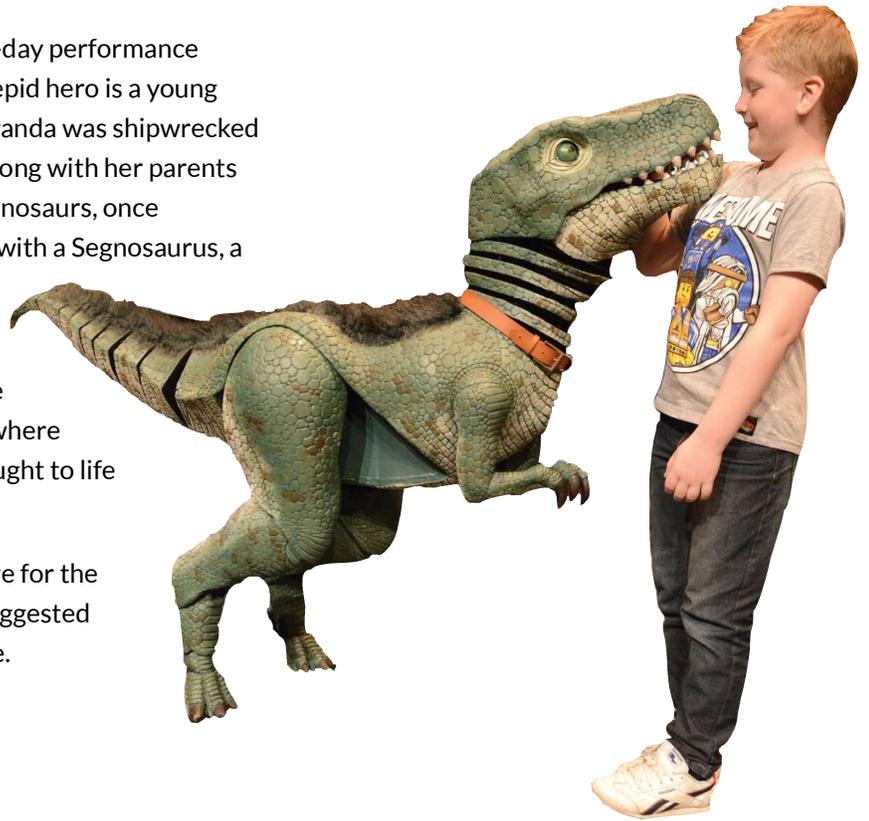
 **STATE** | THEATRE
NEW JERSEY

KEYNOTES

State Theatre New Jersey welcomes you to the school-day performance of *Dinosaur World Live*. In the show you'll meet our intrepid hero is a young woman named Miranda. When she was just a baby, Miranda was shipwrecked on an island called Mundo De Los Lagartos Terribles, along with her parents and a team of palaeontologists. The island was full of dinosaurs, once thought to be extinct, and as a result Miranda grew up with a Segnosaurus, a Triceratops, a Giraffatitan (or two), a Microraptor, and some Tyrannosaurus Rex for a family.

Miranda will bring her favorite prehistoric pals onstage one by one to talk about what they eat, how they live, where they are found, and much more. The dinosaurs are brought to life through amazingly lifelike, full-sized puppets.

These *Keynotes* provide information to help you prepare for the performance. Included are discussion questions and suggested activities to help you make the most of your experience.



CONTENTS

- Welcome!2
- Meet the Carnivores!3
- Meet the Herbivores! 4-5
- What Is a Dinosaur?.....6
- New Jersey Dinosaurs.....7
- The Age of Dinosaurs.....8
- Scales, Spikes, Feathers, or Fur?9
- Where Did They Go? 10
- The Dinosaur Hunters..... 11
- Fossils..... 12
- At the Show..... 13



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Dinosaur World Live production photos by Robert Day



EDUCATION & COMMUNITY ENGAGEMENT SUPPORTERS

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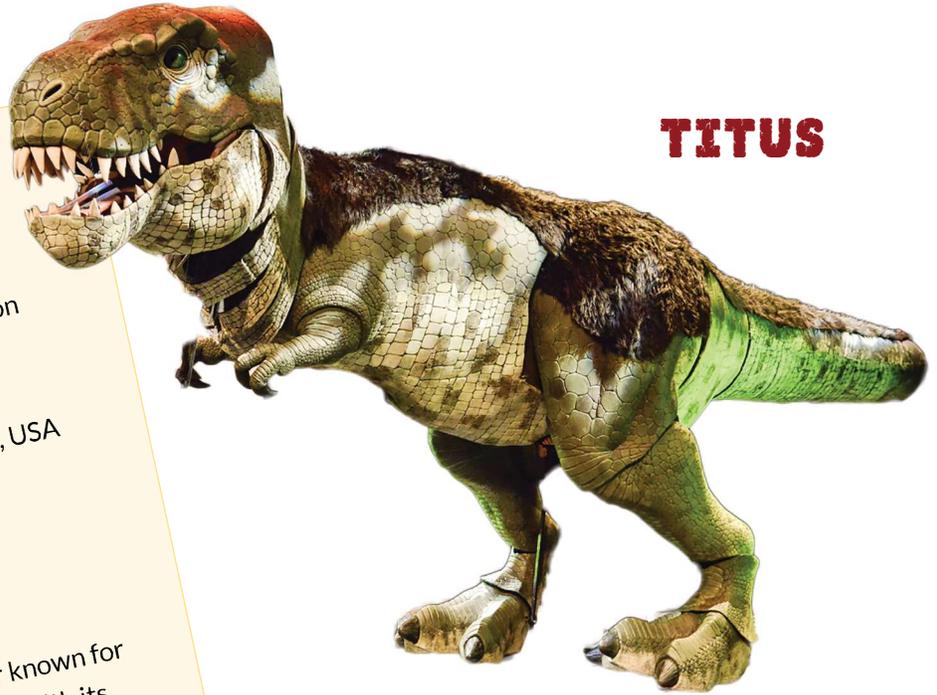
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TYRANNOSAURUS REX

Pronunciation: tye-RAN-uh-SAW-russ
Name means: "tyrant lizard king"
Period: Late Cretaceous, 65-75 million years ago
Where found: North America
Discovered: 1902, Hell Creek, Montana, USA
Height: 13 feet
Length: 46 feet
Weight: 9 tons
Food: other animals, insects

Tyrannosaurus rex was a giant predator known for its large, sharp teeth and powerful jaws. With its massive skull and four-foot-long jaw, it could easily crush the bones of the other dinosaurs (such as Triceratops and Edmontosaurus) that it liked to eat. Some scientists today believe that Tyrannosaurus rex had feathers on at least some parts of its body.



TITUS



BABY TAMORA

ORLANDO



MICRORAPTOR

Pronunciation: MY-cro-RAP-ter
Name means: "small animal that seizes"
Period: Early Cretaceous, 125 million years ago
Where found: China
Discovered: 2000, Liaoning province, China
Length: 31 inches
Weight: 2 pounds
Food: fish, lizards, small birds and mammals

Weighing only about two pounds, Microraptor is thought to be the world's smallest dinosaur. This birdlike creature had four wings, with long feathers on both its front and back limbs. Its tail was feathered, too. Microraptor probably couldn't fly, but it may have been able to "parachute" from tree branch to tree branch, gliding like a flying squirrel.

GIRAFFATITAN

Pronunciation: jer-AFF-ah-TIE-tan
Name means: "giant giraffe"
Period: Late Jurassic, 142-154 million years ago
Where found: Africa
Discovered: 1909, Tanzania
Height: 39 feet
Length: 75 feet
Weight: 40 tons
Food: plants

As its name suggests, Giraffatitan was shaped a lot like a giraffe, with long front legs, a short body, and a very long neck that allowed it to feed on the tall conifers that were the main trees in the Jurassic forests. Although scientists have identified dinosaurs that were more than twice as big, a Giraffatitan in Berlin's Natural History Museum holds the world record for the tallest mounted dinosaur skeleton in the world!



GERTRUDE

SEGNOSAURUS

Pronunciation: SEG-no-SAW-russ
Name means: "slow lizard"
Period: Late Cretaceous, 88-97 million years ago
Where found: Mongolia, China
Discovered: 1973, Gobi Desert, Mongolia
Length: 20-23 feet
Weight: 1.4 tons
Food: plants

It's hard to know what Segnosaurus was really like, because not many fossils have been found. Scientists believe it was bipedal (walked on two legs) and had a long slender neck, small head with a horny beak, and small fingers with huge claws. Fossils indicate that Segnosaurus was a feathered dinosaur.



JULIET

TRICERATOPS

- Pronunciation: try-SER-uh-tops
Name means: "three-horned face"
Period: Late Cretaceous: 66-70 million years ago
Where found: North America
Discovered: 1887, Denver, Colorado, USA
Height: 10 ft.
Length: 30 ft.
Weight: 6-12 tons
Food: plants

Triceratops, with its three horns and bony frill around the back of its head, is one of the more recognizable dinosaurs. This massive dinosaur had the largest skull of almost any land animal—almost a third of its entire length! It had a birdlike beak that it used to clip off hundreds of pounds of tough vegetation (including cycads, ginkgoes, and conifers) every day. Triceratops had anywhere from 432-800 teeth, but used only a few hundred at a time; as one set of teeth wore down, they would be replaced by the ones next to them.

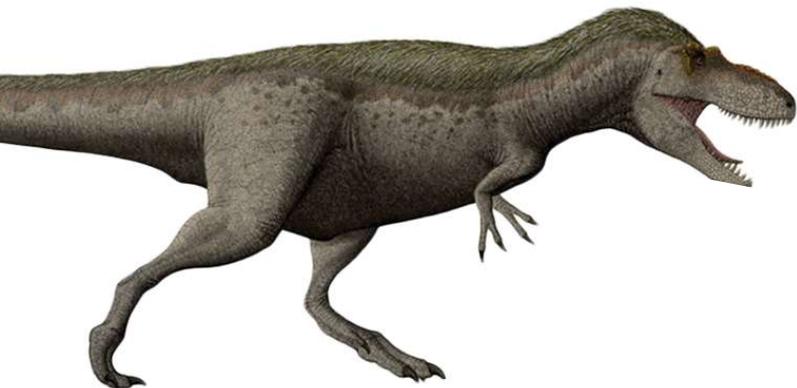


BRUTUS



**BABY
BEATRICE**

WHAT IS A DINOSAUR?



Dinosaurs are a large, yet very specific group of animals. The term “dinosaur” is often used incorrectly: many people lump together all of the ancient reptiles (including the flying reptiles and marine reptiles) and call them dinosaurs.

The word “dinosaur” was coined in 1842 by Sir Richard Owen, an English biologist and paleontologist. He was known for his skill as a comparative anatomist—a person who studies the bodies of different types of animals and compares their similarities and differences. Using his understanding of anatomy, he began to create a classification system for dinosaurs. He identified key common features and criteria which identified an animal as a dinosaur. His four main criteria were:

- It must have lived during the Mesozoic Era.
- It must be a reptile (but not all reptiles are dinosaurs; for example, lizards are reptiles, but they are not dinosaurs).
- Its legs must be below its body, as opposed to sticking out from the sides, like a crocodile’s legs. This allowed dinosaurs to run faster and farther than other reptiles of similar size.
- It must have lived on land, not in the water like swimming reptiles, or in the air like the pterosaurs. (However, the fossil record indicates that birds evolved from dinosaurs during the Jurassic period, and so birds are now considered a type of dinosaur in modern classification systems.)

As new fossils are discovered and scientists have increasingly advanced tools to examine them, it has become more and more difficult to define what makes a dinosaur a dinosaur. Some scientists have proposed the theory that dinosaurs were warm blooded. They have debated about dinosaurs’ skin color and whether or not some may have had feathers. In 2015, they were shocked by the discovery of what they believe is the first known amphibious dinosaur, which contradicts their belief that all dinosaurs were land-based animals. And of course, one of the biggest debates is what caused dinosaurs to go extinct.

VOCABULARY

BIPED (BYE-ped) - walks on two feet

CARNIVORE (CAR-nuh-vore) - meat eater

DINOSAUR - reptiles that lived millions of years ago but became extinct

EVOLVE - develop and change overtime

EXTINCT- does not exist anymore

FOSSIL - bones, footprints, or other remains of ancient animals or plants

HERBIVORE (ER-buh-vore) - plant eater

INVERTEBRATE - an animal that doesn’t have a backbone. Invertebrates include insects, spiders, shellfish, jellyfish, worms, sponges, and starfish.

OMNIVORE (ahm-NIH-vore) - eats everything

PALEONTOLOGIST (pail-ee-on-TAL-o-jist) - A scientist who studies fossils to learn about life in the past

PREDATOR - an animal that hunts and eats other animals

PREY (PRAY) - animals that are hunted by other animals

PREHISTORIC - the time before history was written down

REPTILE - an air-breathing vertebrate covered in scales and/or bony plates. Crocodiles, snakes, lizards, turtles, tortoises, and many dinosaurs are all reptiles.

SEDIMENT- dirt, decayed plants, and other material that settles to the bottom of a body of water

QUADRUPED (KWA-drew-ped) - walks on four feet

SKELETON - the bones that make up the body of an animal

TERRESTRIAL (teh-RES-tree-ul) - living on land

VERTEBRATE - an animal with a spinal cord and backbone, such as birds, fish, amphibians, reptiles, and mammals.

Southern New Jersey and Philadelphia hold an important place in the history of dinosaur research and discovery. In the late 19th century, some of the world's foremost paleontologists were drawn to the region by the incredible abundance and quality of the fossils being discovered in southern New Jersey. Among the prehistoric animals discovered in New Jersey are two dinosaurs, a giant crocodile and a number of prehistoric fish and sharks. Here are the two most famous New Jersey dinosaurs.

HADROSAURUS

Pronunciation: had-row-SAW-russ

Name means: "bulky lizard"

Period: Late Cretaceous: 65-75 million years ago

Where found: North America

Discovered: 1858, Haddonfield, NJ, USA

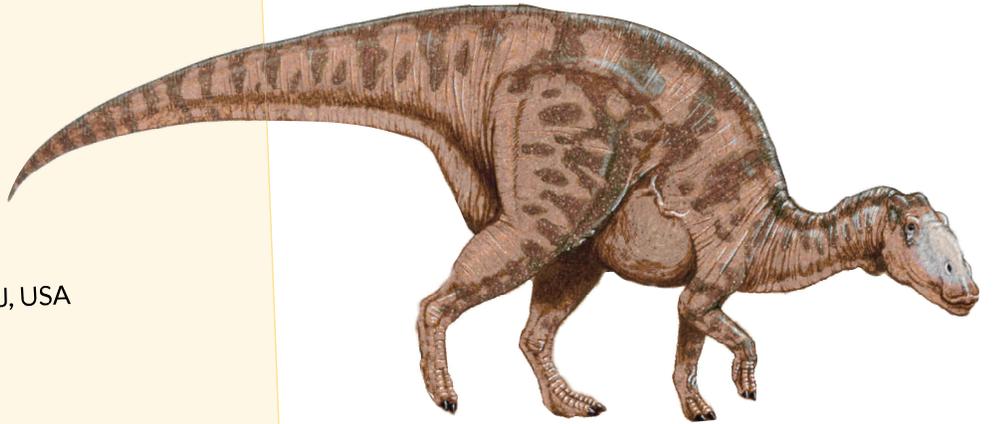
Length: 10-40 ft.

Weight: 5 tons

Food: plants

Did you know that the very first almost-complete dinosaur fossil was found in New Jersey? In 1858, William Parker Foulke dug up the remains of a dinosaur that had been discovered on a farm in Haddonfield. The dinosaur was named *Hadrosaurus foulkii*, or "Foulke's bulky lizard." The fossils he uncovered are now stored at the Academy of Natural Sciences in Philadelphia, but you can see a reproduction at the State Museum in Trenton. In 1991, *Hadrosaurus foulkii* was officially declared the state dinosaur.

If you look at a picture of a Hadrosaurus, you will see why they are known as the duck-billed dinosaurs. Their beak-shaped mouth was perfect for munching leaves and twigs.



DRYPTOSAURUS

Pronunciation: drip-toe-SORE-us

Name means: "tearing lizard"

Period: Late Cretaceous: about 67 million years ago

Where found: New Jersey, USA

Discovered: 1866, Barnsboro, NJ USA

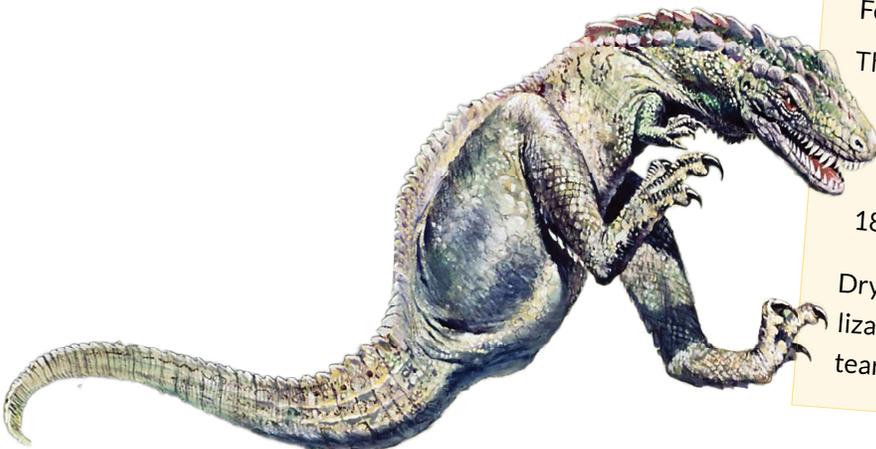
Length: up to 36 ft.

Weight: up to 6 tons

Food: meat

The first tyrannosaur fossil to be dug up in the U.S. wasn't a T-Rex—it was *Dryptosaurus*. A nearly-complete *Dryptosaurus* fossil skeleton was discovered in Barnsboro, New Jersey in 1866 by paleontologist Edward Drinker Cope.

Dryptosaurus got its name (which means "tearing lizard") because of the long, sharp claws it used to tear apart its prey.



Between 230 and 65 million years ago, our planet was inhabited by some of the most amazing creatures ever to have existed. The most successful were a group of reptiles called dinosaurs. No other group of animals has been dominant on Earth for such a long period of time—over 165 million years. Compare that to humans, who began to evolve about 2.4 million years ago, and modern humans (*Homo sapiens*), who originated only about 200,000 years ago.

Different dinosaurs lived during different periods of time and in different parts of the world. They existed during a period of the Earth’s history called the Mesozoic Era. The Mesozoic Era spans roughly 185 million years and is divided into three time periods:

- The Triassic Period - 252-201 million years ago
- The Jurassic Period - 201-145 million years ago
- The Cretaceous Period - 145-66 million years ago

The first dinosaurs appeared during the late Triassic Period. They were very small—on the average, about 3-6 feet long. The Triassic ended with a major extinction event that killed off about 75 percent of the planet’s animal species. The mass extinction created ecological niches that led to dinosaurs becoming dominant in the Jurassic Period.

The Jurassic saw the arrival of larger dinosaurs, including *Allosaurus*, *Apatosaurus*, *Brachiosaurus*, *Diplodocus*, and *Stegosaurus*. The very largest dinosaurs did not emerge until the Cretaceous Period, which began more than 100 million years after the start of the “age of dinosaurs.” Cretaceous dinosaurs included *Tyrannosaurus Rex*, *Triceratops*, *Velociraptor*, and the titanosaurs.



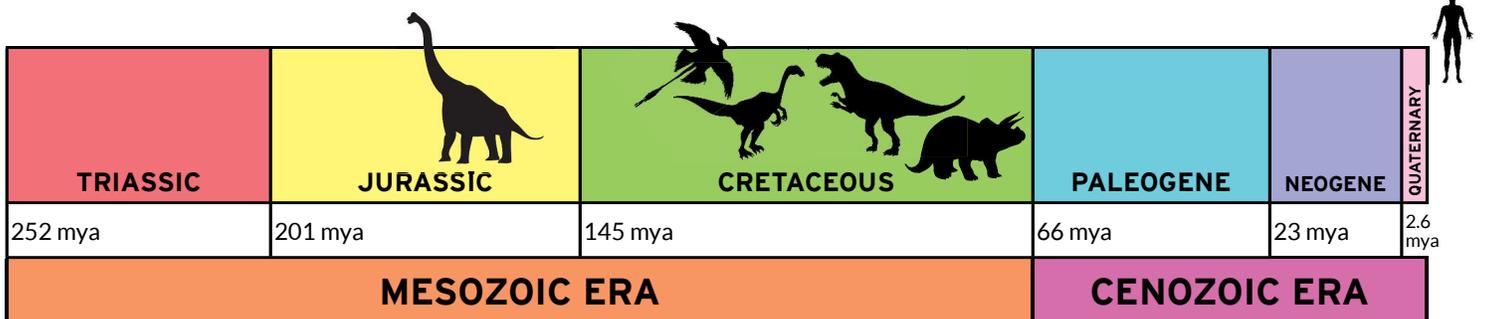
FYI

Some of the best-known dinosaurs in the “Jurassic Park” films— including Triceratops, T-Rex, Velociraptor—did not exist during the Jurassic Period!

EARTH IN THE AGE OF DINOSAURS

The world the dinosaurs inhabited looked incredibly different from the Earth today. During the Triassic period, all of the continents were grouped together in one huge “supercontinent” called Pangaea (pan JEE-uh, meaning “all Earth”). The continents we recognize today did not exist, or were not in the locations they are now.

The Triassic dinosaurs spread throughout Pangaea. During the Jurassic Period, the supercontinent began to break apart. Over millions of years, Pangaea split into smaller continents, each with different climates, plants, and dinosaurs. Plants and animals evolved into new species as they adapted to the environments.



SCALES, SPIKES, FEATHERS, OR FUR?

No one knows exactly what dinosaurs really looked like: the colors, patterns, and texture of their skin, and whether they were covered in scales, plates, or even feathers. Fossilized skin impressions have been found for only a small fraction of the known dinosaurs. Not much is known about dinosaur skin and there is some debate among paleontologists on this topic. Most skin fossils show bumpy skin; only the huge plant-eaters appear to have had scaly skin. Some of the bird-like dinosaurs even had feathers. Other dinosaurs developed feathers but were flightless, like several types of bird known today: ostriches, emus, and kiwis, to name just a few.

Through the process of evolution, animals develop special features to help them survive. Some dinosaurs were likely camouflaged in order to hide from predators or to sneak up on prey. Some may have been colored in a particular way to attract mates, and some may even have been brightly colored to ward off predators. Different colors are also important for temperature regulation because different colors absorb or reflect sunlight in different ways.



MICRORAPTOR FEATHERS

Microraptor was among the first non-avian dinosaurs discovered whose fossils show impressions of feathers and wings. A team of American and Chinese researchers sampled the feathers from a Microraptor fossil and looked at the **MELANOSOMES**—pigment-bearing organelles that partially produce feather color. Comparing the melanosomes to those of modern birds, they concluded that Microraptor feathers were iridescent blue-black, similar to a grackle, magpie, or crow.



Feathers can be clearly seen in this Microraptor fossil from the Paleozoological Museum of China.

WHERE DID THEY GO?



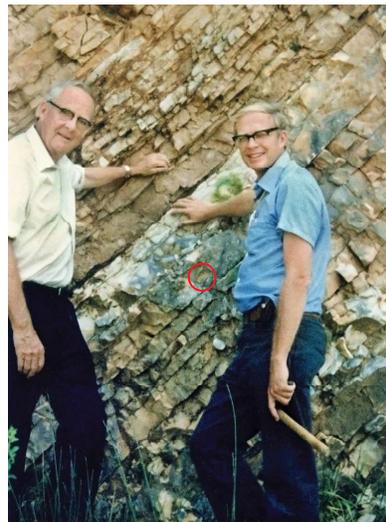
66 million years ago, all of the dinosaurs (except for some bird ancestors) ceased to exist. Along with them, between 60 and 80 percent of all living things on Earth suddenly became extinct. Huge marine reptiles such as the mosasaurs, ichthyosaurs, and plesiosaurs were gone, as well as all the flying reptiles known as pterosaurs. While some mammals, birds, small reptiles, fish, and amphibians survived, life on Earth became much less diverse. This mass extinction marked the end of the Cretaceous Period.

What killed off all these life forms? As yet, no one has come up with a definitive answer. Because the extinctions happened all at once, it seems likely that they were caused by a sudden, catastrophic event.

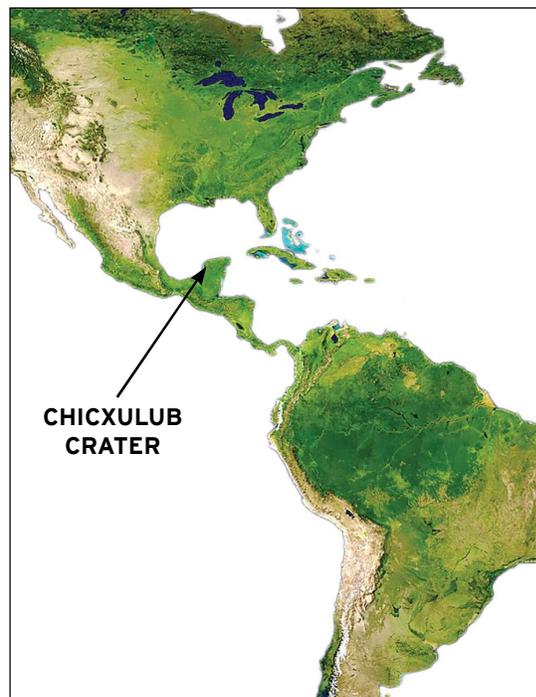
In 1980, a team of scientists, led by Luis Alvarez and his son Walter Alvarez, proposed a hypothesis that Earth was struck by a massive comet or asteroid—possibly even more than one. They reasoned that the impact would have sent a massive cloud of hot dust, steam, ash, and sulfur gas into the atmosphere. The dust cloud would have completely blocked out sunlight for as long as ten years, killing off plants on land and plankton in the oceans by making photosynthesis impossible. As plants and plankton died, extinctions would have expanded up the food chain from herbivores to carnivores.

There is evidence in the geological record that supports the Alvarez's hypothesis. On land and in oceans throughout the planet, there is a thin layer of rock, called the K-Pg boundary, which was laid down at the same time as the mass extinction. The rock contains high amounts of iridium, a metal that is rare in the Earth's crust, but plentiful in asteroids.

The asteroid impact hypothesis gained even more support in the early 1990s when a huge crater—about 93 miles in diameter and 12 miles deep—was discovered buried under the Yucatán Peninsula in the Gulf of Mexico. It was named the Chicxulub [pronounced *CHEEK-shoo-loob*] crater, after a nearby city. Core samples taken from the crater show it was formed at the exact same time as the iridium-rich rock layer of the K-Pg boundary.



Luis Alvarez and his son Walter show the K-Pg boundary in a rock formation in Gubbio, Italy.



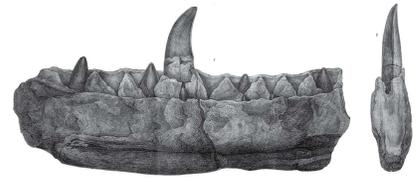
Humans have been finding dinosaur fossils for thousands of years. Most people in ancient times did not understand what fossils were, and explained them through their stories and myths. The Sioux believed they were the bones of giant serpents that were hunted and killed by the Great Spirit. Ancient Chinese people thought dinosaur skeletons were the remains of flying dragons. In ancient Greece and Rome, fossils of dwarf elephants were considered the remains of the Cyclops, a mythical one-eyed giant.

Some ancient scientists did understand what fossils were, and formulated complex hypotheses based on fossil evidence. Around the sixth century BC, Greek biologist Xenophanes discovered seashells on land, and deduced that the land was once a sea floor. In the 11th century, Chinese scientist Shen Kuo formulated a theory of climate change based on fossilized bamboo.

The science of **PALEONTOLOGY**—fossil collection and description—began in the late 1700s, when scientists began to describe and map rock formations and classify fossils. The Frenchman Georges Cuvier, one of the pioneers of paleontology, compared ancient fossil bones to bones of living animals to prove the existence of past life forms that became extinct, including giant reptiles that roamed the earth before humans existed.

During the 1800s, Great Britain became a center of dinosaur science. Amateur fossil collector Mary Anning became the first person to collect, display, and correctly identify the fossils of dinosaurs such as ichthyosaurs, plesiosaurs, and pterosaurs. In 1824, paleontologist William Buckland announced the discovery of *Megalosaurus* (“giant lizard”), the first dinosaur fossil to be described and named. Around the same time, scientist Richard Owen was examining bones from three different creatures—*Megalosaurus*, *Iguanodon*, and *Hylaeosaurus*. Each of them lived on land, was larger than any living reptile, walked with their legs directly beneath their bodies instead of out to the sides, and had three more vertebrae in their hips than other known reptiles. Using this information, Owen determined that the three formed a special group of reptiles, which he named *Dinosauria*. The word comes from the ancient Greek word *deinos* (“terrible”) and *sauros* (“lizard” or “reptile”).

Paleontology expanded rapidly in North America in the second half of the 19th century. In 1858, in Haddonfield, NJ, miners discovered the first nearly-complete fossilized skeleton of a dinosaur ever recovered. As America expanded westward, major fossil discoveries were made in the Midwest, including primitive birds and horses, and many new dinosaurs, including *Allosaurus*, *Stegosaurus*, and *Triceratops*.



portion of a *Megalosaurus* jawbone, identified by William Buckland

THE “BATTLE OF THE BONES”

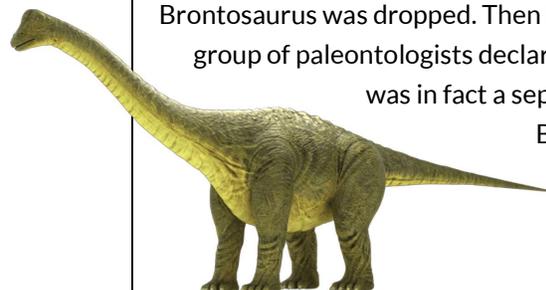
The discovery of dinosaur fossils in the Midwest triggered an intense competition, known as the “Great Dinosaur Rush,” or the “Bone Wars,” between two rival fossil hunters, Othniel Charles Marsh (top) and Edward Drinker Cope (bottom). During their 20-year feud, they resorted to bribery, theft, and even destroyed fossils to outdo each other. The intense competition, however, resulted in hundreds of important new dinosaur finds.



WHAT IS IT?

It can take a long time for scientists and paleontologists to classify dinosaurs. Sometimes, new dinosaurs are discovered and named, but paleontologists later change their minds about how they should be classified. In 1879, a large dinosaur skeleton was discovered in Wyoming. It was identified as a new genus, given the name *Brontosaurus*. In 1903, scientists decided that it was actually a species of *Apatosaurus*, and the name *Brontosaurus* was dropped. Then in 2015, a group of paleontologists declared that it

was in fact a separate family; *Brontosaurus* was back—at least for now!



We know that dinosaurs and other extinct animals and plants existed because of the fossils they left behind. Fossils are physical evidence of life prior to human history. They include the remains of living organisms, prints and molds of their physical form, and marks/traces created in the sediment by their activities. Fossils of single-celled organisms have been recovered from rocks as old as 3.5 billion years. Animal fossils first appear in rocks dating back about one billion years.

Dinosaur fossils come in many types, including preserved bones, teeth, and tracks. Some well-preserved fossils show impressions of skin and other soft tissues. Most fossils are found in sedimentary rocks. These rocks were formed when wind and other weather events washed sediment (such as sand or mud) from the land and deposited it in bodies of water. The layers of sediment piled up and over time became rocks. Because these rocks were formed in bodies of water, fossils of sea creatures are more common than those of land creatures. Land animals and plants that have been preserved are found mostly in sediments in calm lakes, rivers, and estuaries.

The chance that any living organism will become a fossil is quite low. The path from the organic, living world to the world of rock and mineral is long and indirect. In the best conditions, fossilization will occur if an animal or plant dies and is quickly covered over with moist sediment. This prevents the animal or plant from being eaten by other organisms or from undergoing natural decay through exposure to oxygen and bacteria. The soft parts of an animal or plant decay more quickly than its hard parts. Teeth and bones are therefore more likely to be preserved than skin, tissues, and organs. Because of this fact, most fossils come from the time period dating back almost 600 million years ago, when organisms began to develop skeletons and hard parts.

Scientists use fossil remains to recreate the skeletons of dinosaurs and other extinct life forms, and create pictures of what they might have looked like. There is still so much to learn about dinosaurs and new fossil discoveries are being made all the time. It is estimated that there may have been more than 2,000 dinosaur species that existed in the Mesozoic Era. At the present time, only about 700 have been discovered. On average, the discovery of a new dinosaur is reported about every six weeks, but there are still lots of new exciting discoveries to be made!



Scientists recently dated this *Nyasasaurus* fossil to 240 million years ago—the earliest known dinosaur to date. It shows that dinosaurs were roaming the planet about 10 to 15 million years earlier than scientists had previously thought.



A fossilized *Amphistium*, a 50-million-year-old flatfish discovered in 2008



This fossilized T-Rex tooth is more than three-and-a-half inches long!



This fossil footprint, found in New Jersey, belongs to a *Grallator*, a late Triassic Period dinosaur.

BE A GOOD AUDIENCE MEMBER.

Going to see a show at the theater is not the same as going to a movie or watching TV. The performers will be right there with you and the rest of the audience, which makes it very exciting! It also means you have a special responsibility to respect the performers and the rest of the audience so that everyone can enjoy the show. Make sure to follow these rules:

- **If you have a phone, make sure to turn it off before the show starts. Keep it off until the show is over.**
- **During the show, give the performers all your attention. Stay in your seat and don't talk.**
- **Taking pictures or recording the show is not allowed.**
- **Don't eat or drink in the theater. And no chewing gum, please!**

BE A GOOD OBSERVER.

During the performance, pay attention to everything that's going on onstage—not only the words, but the lighting, the way the performers move around on stage, how they're dressed, and how they interact with the audience. Notice how all of these elements come together to create a unique experience.

Also try to observe how the performers interact with each other. What are some of the ways you see them working together as a team?



photo: Jason Paddock

