# Dinosaurs
# Teacher's Guide

**Dinosaurs** presents full-sized giant robot dinosaurs arranged in behavioral scenes along a trail that follows the course of dinosaur evolution.

**IN THIS GUIDE**

Activities from this guide for your classroom and in the exhibition will help students understand new scientific research that may provide an answer to the mystery of how the biggest dinosaurs grew so large.

**TABLE OF CONTENTS**



**HOW TO USE THIS GUIDE**

How to Use This Guide

- Give chaperones copies of student pages

- Add your own activities. Connect with your own special unit. Some questions may leave students with more questions. Use these as the basis for after-trip discussions or group research.
- Provide extensions of museum experiences back at school. The *Connecting with the Classroom* section (pg. 18) gives suggestions for integrating the museum visit with classroom lessons.

## ABOUT THIS TOPIC

### How Did Some Dinosaurs Grow So Large?

The largest animals to ever walk the Earth were the **sauropod** dinosaurs – the huge four-legged plant-eating dinosaurs such as the 30 foot-high *Brachiosaurus*, which children know as "long-necks."

**Growth** – As youngsters, these dinosaurs could double their weight in a week. They grew all their lives but fastest when they were about to reach maturity at an age similar to the onset of human fertility. Growth rings in bone cells examined under a microscope indicate that a giant dinosaur lived more than 70 years.

**Reproduction** – These dinosaurs probably laid several sets of eggs a year in shallow, unguarded nests. As many as 24 eggs were laid at a time, none bigger than a large grapefruit.

**Metabolism** – Rapid growth, and the kind of bone cells found in sauropods indicates they were very warm-blooded. Their prosauropod ancestor, *Plateosaurus*, appears to have experimented with different metabolic strategies. Some individuals appear to have grown all their lives. Other *Plateosaurus* grew only half as long and stopped growing as adults.

**Diet** – Sauropods ate coarse evergreen, non-flowering plants and trees. They had small heads and few teeth, so they didn't chew their food. Rather they swallowed it down their long necks to a giant gut where they broke down the food into useful nutrients with the help of bacteria over four or five days. A simulation done by the researchers with relatives of ancient plants digested by enzymes in a cow's stomach established this theory. And contrary to past theories, sauropods did not swallow rocks called **gastroliths** to help digest their food. By feeding stones to ostriches (birds are living dinosaurs) and then examining their stomachs months later, the scientists noticed that the stones did wear down as they would have if they helped the animals digest.

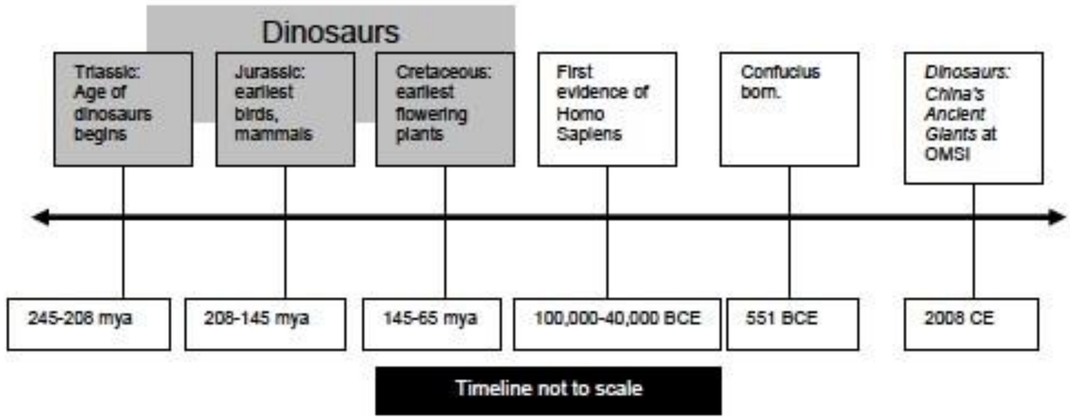
**Posture** – Except for the high-necked *Brachiosaurus*, sauropod dinosaurs carried their necks level to the ground, like their tails. They browsed for plants by sweeping their necks across the land and low trees like a giant vacuum cleaner hose. Again except for the towering *Brachiosaurus*, sauropods appear to have been able to rear up on their hind legs for a short while to feed on high plants.

**Bones-** Sauropods had bones like hard sponges, with many holes. The holes did not make the bone weaker, only lighter. With lightweight bones, sauropods could grow to enormous size without becoming too heavy to move.

**The Big Answer: How Sauropods Grew So Big**
Sauropods grew to ten times the size of all animals on land before or since because they did NOT chew their food. The dinosaurs that did chew, whether T. rex and other giant predators, or plant-chewing duckbilled dinosaurs, never grew larger than 50 feet, half the length and 10 tons, $1/10^{th}$ the weight of the biggest sauropods. If chewing dinosaurs were as big as sauropods they would have needed huge muscles, which would have made their heads too heavy to be supported. But since sauropods had tiny heads, which shoveled food down to their enormous stomachs for digestion, they had no need of an enormous head full of chewing muscles.

**When Did Dinosaurs Live:**
Dinosaurs were an extremely successful group of reptiles that inhabited the Earth during the period of time known as the Mesozoic Era, dominating the land for more than 100 million years. The Mesozoic Era is divided into three periods: the Triassic, Jurassic, and Cretaceous. The reign of the dinosaurs did not start until close to the end of the Triassic Period, so of the more than 1,000 kinds of dinosaurs known, there are comparatively few dinosaurs known from that time period. *Dinosaurs* contains some fossils from the Triassic Period, but most of the

dinosaurs in this exhibit are from the Jurassic Period (200 -145 million years ago) or the Cretaceous Period (145 million – 65 million years ago).




**How do we learn about dinosaurs and other ancient life?**
Scientists called **paleontologists** study ancient life by examining fossils and the rock layers in which they are found. A **fossil** is any remain or trace of ancient life. It can be a bone or plant part that has been filled in with minerals, an insect trapped in amber, a dinosaur egg or even a footprint. Fossils are most commonly preserved in sedimentary rocks (rocks that are formed from the eroded grains of older rocks or minerals). Some of the most common sedimentary rocks are sandstone, shale and limestone.

**What is a dinosaur?**
Dinosaurs are a group of reptiles that lived during the Mesozoic Era. Dinosaurs have certain features in their skeletons, such as the number of holes in their skulls and the way their teeth fit into their jaws that make them different from other reptiles such as lizards or turtles.
Dinosaurs also differed from other reptiles in the way that they stood. Other reptiles have sprawling or semi-erect postures where the elbows and knees pointed out to the sides. Dinosaurs had an erect posture—their legs were directly underneath their bodies. In that way, the legs more efficiently supported the weight of the body. Mammals also have an erect posture.

Dinosaurs lived only on land. The flying reptiles, called pterosaurs, were not dinosaurs. Large prehistoric swimming reptiles such as plesiosaurs and mosasaurs were not dinosaurs either.

Birds are living dinosaurs. They are descended from feathered dinosaurs, although dinosaurs did not fly.

**How does a dinosaur become a fossil?**

Only a tiny fraction of all the animals that have ever lived are preserved as fossils. There are many things that happen to a dead animal that make fossilization unlikely. The body decomposes; scavengers pull the body apart and devour it. Wind and rain can destroy the body. But in rare, special circumstances, a dead animal is buried rapidly before any of these things can start to destroy the body. An animal that dies in or near water is more likely to be buried quickly by sediments in the water. Over thousands, even millions, of years, minerals contained in groundwater can be deposited within the animals' bones. The minerals make the bone heavier and it feels like rock. This is what people mean when they call something "petrified." Paleontologists call this process **permineralization and replacement**.

**Climate and dinosaurs:**

Dinosaurs lived in many environments, from forest to desert. While it never snowed in dinosaur time they experienced cool weather and dark Arctic winters.

When dinosaurs first appeared, the weather was moist and warm across the single world-continent, Pangaea. By the time the shape of the modern continents developed near the end of dinosaur time, dinosaurs were living in a wide variety of conditions and habitats. The smaller dinosaurs in the exhibit come largely from the end of dinosaur time in the near-desert environment of the modern Gobi Desert of Mongolia and China. Scientists speculate that an absence of abundant food resources led to smaller dinosaurs in this region near the end of dinosaur time.

# Featured Dinosaurs

*Brachiosaurus*
(BRACK-ee-oh-SORE-us)
Plant-eater
65 feet long, 35 feet high
Western North America, East Africa
Late Jurassic, 145 million years ago

*Brachiosaurus* was the tallest animal that ever lived. It fed off leaves from high in the tree canopy and its fossil remains have been found in both East Africa and Western America. As you know, there were no buildings 145 million years ago. But if there had been, a *Brachiosaurus* could have looked in a fourth-floor window!

*Deinonychus*
(DIE-non-e-cuss)
Meat-eater
10 feet long
Early Cretaceous, 115 million years ago
Western North America

*Deinonychus* was a man-sized "raptor." It had sharp teeth but probably killed with the single big claw on each of its hands and feet. *Deinonychus* should have been the real bad guy in ***Jurassic Park***. He It was the same size. *Velociraptor* in real life was the size of a poodle.

*Kosmoceratops*
KOZ-mow-SERR-a-tops
Plant-eater
15 feet long
Late Cretaceous, 75 million years ago
Western North America

*Kosmoceratops* was only half the size of Triceratops, the largest horned dinosaur. But *Kosmoceratops* had the fanciest head decorations of any dinosaur. An adult *Kosmoceratops* had 15 horns on its head. But it probably had few when it was young as the horns would have been used to impress other adults.

*Maiasaura*
(MY-ah-SORE-ah)
Plant-eater
25 feet long
Late Cretaceous, 75 million years ago
North American West

*Maiasaura* means “good mother reptile.” This duckbilled dinosaur earned that name because it was found next to nests of its eggs and embryos, and youngsters. *Maiasaura* took care of its young. Its hatchlings grew fast – up to seven feet long in just one year!

*Pachycephalosaurus*
(PACK-ee-SEFF-a-low-sore-us)
Plant-eater
15 feet long
Late Cretaceous, 65 million years ago
Western North America

*Pachycephalosaurus* was the largest of the dome-headed dinosaurs. They probably used their thick skulls to butt each other as rams do today with their horns. This dinosaur’s name means “thick-headed” reptile. Pretty accurate for an animal with forehead as thick as a bowling ball.

*Parasaurolophus*
(PAIR-ah-sore-oll-OH-fuss)
Plant-eater
30 feet long
Late Cretaceous, 65 million years ago
Western North America

*Parasaurolophus* had the fanciest crest of any duckbilled dinosaur. It could blow low notes through its trumpet just as an elephant does today. Long ago, some scientists thought *Parasaurolophus* lived in the water and used its horn as a snorkel. Boy, were they wrong!

Pterodactylus
(TER-oh-DACK-till-us)
Meat-eater
1 meter to 4 meters wide
Late Jurassic, 145 million years ago to Late Cretaceous 65 million years ago
Western Europe and North America

Pterodactyls were first identified in Bavaria. They belong to a wide-ranging and long-lived but now extinct group of flying reptiles. They are named "winged finger" because their leathery wings extended from elongated fourth fingers. Pterodactyls featured fleshy crests and short tails. They dived in oceans to catch fish with their narrow jaws and as many as 90 sharp, small teeth.

The Italian scientists who found the first fossils of a pterodactyl in 1784 thought it was a marine creature which used its wings to paddle.

*Quetzalcoatlus*
(ket-zel-KWAT-a-lus)
Meat-eater
35 feet wide
Late Cretaceous, 65 million years ago
Western North America, Montana

*Quetzalcoatlus* was the largest animal that ever flew. It was as wide as a fighter jet. Like many other pterosaurs it was lightly built, with a thin body, long jaw, and sharp small teeth used to catch fish. *Quetzalcoatlus* is also the name for a feathered flying god worshiped by the Aztec civilization of Mexico.

*Triceratops*
(TRI-serr-oh-tops)
Plant-eater
30 feet long
Late Jurassic, 145 million years ago
Western North America, Montana

*Triceratops* is named for its three long horns. Though the horns look scary, they were thin and not a good defense against *T. rex*. So, what did *Triceratops* use their horns for? Maybe they just scraped them against the horns of other *Triceratops* in contests for mates.

*Tyrannosaurus rex*
(TIE-ran-oh-SORE-us rex)
Meat-eater
40 feet long
Late Cretaceous, 65 million years ago
Western North America, Montana

*T. rex* was the smartest and most powerful of all giant meat-eating dinosaurs. It had the most powerful bite of any animal ever. *T. rex* had 50 sharp teeth the size of bananas. It could chomp 500 pounds of dinosaur meat in one bite.

*Utahraptor*
(YOU-tah-RAP-tore)
Meat-eater
20 feet long
Early Cretaceous, 125 million years ago
North American West

*Utahraptor* is one of the largest and the earliest of the raptor dinosaurs. Like all "raptors," it had a single large claw on each hand and foot. Many dinosaurs are named after the place their fossils were discovered. Can you guess which state *Utahraptor's* bones were found in?

**Bird-Dinosaur Relationships**
Paleontologists have recently discovered several new dinosaurs with feathers or feather-like structures. These new specimens are further evidence for the evolutionary relationship between dinosaurs and birds and demonstrate that feathers evolved initially among non-flying dinosaurs for some other purpose. New specimens continue to be found that will no doubt raise more questions about bird evolution. The Liaoning fossil beds in China are home to more specimens relevant to bird origins than anywhere else in the world.

**Dinosaur Eggs**
Some of the most famous fossils in the world come from the Gobi desert in Mongolia, a neighbor to China. American Museum of Natural History expeditions to the Gobi desert in the 1920s yielded fascinating new dinosaurs and the first dinosaur eggs ever discovered. China is a virtual treasure trove for dinosaur eggs. In fact, dinosaur eggs have been discovered in at least 41 different places in China. A huge dinosaur nest site was recently found in Argentina, along with the skeleton of a midsized meat-eating dinosaur, which preyed up on them. In France, the first dinosaur eggs, from a sauropod plant-eater, were discovered in the 1830's.

Sculpted representation of a duckbilled dinosaur nest.

## CONNECTING WITH THE CLASSROOM: Before Your Visit

### K-4

- Brainstorm as a class: What do we know about dinosaurs? What is a fossil? Add to this list of ideas or change things after your visit to *Dinosaurs.*
- Though there are few bones in *Dinosaurs,* students may become more aware of their own skeletons and those of dinosaurs. Using chicken bones or drawings of bones from other animals can help children locate their own similar bones and visualize that living animals have muscle and skin over their skeletons.

### Grades 5 and up

**Odds are…**
What are the odds of becoming a fossil? Not good!

Have students brainstorm all the things that can happen to an animal after it dies. Ask students if they have ever observed road kill. Was it in good condition? What things would make a dead squirrel in the road unlikely to become a good fossil?
*(Hints: It is unlikely to be buried, it is exposed to the elements, it has been mangled by the car, birds eat it, flies lay their eggs in it and it becomes food for maggots, etc.)*

If all those things work against fossilization, what are some of the things that favor fossilization?

**Rapid burial:** This could be with sediments in flowing water, an ash fall from a volcano, or even being buried by a collapsing sand dune, which is what probably happened to many of the Gobi Desert dinosaurs in *Dinosaurs*.

**Having hard parts:** Soft fleshy remains decompose very quickly. But hard parts of animals, like bones, teeth, and shell last a lot longer and are more likely to be preserved as a fossil.

**Dying in a place with very little oxygen:** Microorganisms that aid decomposition need oxygen. Therefore, a lack of oxygen delays or inhibits decay. Oxygen-deprived conditions can be found in waters with poor circulation, such as stagnant lake bottoms or bogs.

Paleontologists recognize that only a very tiny percentage of all species that have ever existed on the planet have made it in to the fossil record. There are many we will never know about.

**Fossilization Student Math Challenge**

Odds of any one species becoming a fossil are probably less than one in a million.

Now assume that each student represents a **species** (e.g. *T. rex* or a passenger pigeon) made up of thousands, maybe millions, of individuals. If we estimate that a species' chance of making it into the fossil record is 1 in 1,250,000, how many *classes* your size would you need to increase the odds that just *one* species (student) would ever be fossilized?

1 student = 1 species (Ask students to decide how many individuals they have in their species. There could be quite a range. Think how many dogs or African elephants there are in the world.)

If there are 1,250,000 species, how many might be fossilized? *(One or fewer)*

How many classes make up 1,250,000?

How likely is it that one of <u>your</u> students (one species) would become a fossil?

**Estimating length and height based on partial skeletons**

Very often paleontologists only find a few bones of an animal. How do they figure out how big the whole animal was based on a femur (thighbone) or just a few vertebrae? Estimates are usually based on measurements from similar animals whose skeletons are better known. Only a few bones of *Argentinosaurus*, the largest dinosaur, have been recovered. One of them is a back bone 5 feet wide and 5 feet high. These particular bones are clearly much bigger than corresponding bones on many other known dinosaurs. Based on that comparison, scientists have estimated that *Argentinosaurus* was 100 feet long. How reliable is that estimate?

**Measurement Challenge**

Imagine that you have just discovered an enormous femur (thighbone) that appears to be that of a sauropod dinosaur. But this femur is far bigger than any known sauropod femur. You have measured it as 6.5 feet. You have a femur in your lab from another dinosaur, very similar to the one you have just discovered. That femur belonged to *Apatosaurus* and is 5.8 feet tall. Fortunately, paleontologists have found enough specimens and bones of *Apatosaurus* to know that it was about 14 feet tall at the hip. The *Apatosaurus* is the most similar of all known femurs to your enormous specimen.

If you were to make an educated guess on how long your dinosaur might have been, what would it be?

- Use measuring tapes to look at 6.5 feet and 5.8 feet tall.
- Measure your own femur. How long is it? How tall are you?
- Compare class measurements. Are there relationships between height and femur length?
- Are there relationships between sauropod length and femur length?
- How would you defend your estimate?

*(Estimates should vary, since the initial comparisons are between the femur length and the height of the animal at the hip. There are other variables to be considered also, such as length of neck, size of head, length of tail, etc.).*
Text based on guide from Science Museum of Minnesota 9

**Averages**
For every species known from the fossil record (keep in mind that most never are known) there may be only one or two specimens ever recovered. There were probably hundreds of thousands or more that *weren't* preserved as fossils. In paleontology, we may have to make a generalization about a species that once had millions of individuals based on the remains of a few.

Randomly assign students to small groups of three or four. Have each group record their measurements and calculate the average height of their group. (If adults can be included, so much the better!) Assume each group is all that we know of the human species. Do the individual heights seem like a fair representation of what we KNOW to be true? What about the average?

- List all the averages and compare them.
- What is the tallest height and what is the shortest height in the room?
- How would you choose to describe the height of an *Xt*h grader?
- Does it make much sense to argue over which was bigger- the 42-foot dinosaur or the 44-foot dinosaur-when only a few incomplete skeletons have been found for either? Most kinds of dinosaurs are known from only a single tooth or bone. Only 2,500 complete skeletons of dinosaurs have ever been found. The incomplete fossil record makes it very difficult to estimate what an average size is for a dinosaur we know so little about.

**CONNECTING WITH THE CLASSROOM: Back in the Classroom**

**K-4**

Review student experiences in the exhibition.

Discuss answers to exhibit activities.

What dinosaurs did students find that looked like North American dinosaurs?

Discuss:

• What animals living today have feathers?
*Birds.* Why do birds have feathers? Some new discoveries in China show dinosaurs with feathers. What might that mean?

• What were the ancestors of the giant sauropod dinosaurs?
*Prosauropods.* What changes in anatomy are seen between prosauropods and sauropods that helped sauropods grow so large? *Larger bones, even leg length, large belly for digesting plants.*

• How much did a giant dinosaur like *Mamenchisaurus* eat in a day?
*Hundreds of pounds*. Is that more or less than you would have expected? Why?

• What defenses did giant dinosaurs have? Some had armor and small tail clubs, but most had no body protection or weapons. So how did they protect themselves?
*Their size was so large that they were hard to defeat. Also they traveled in herds and kept youngsters in the center of the herd.*

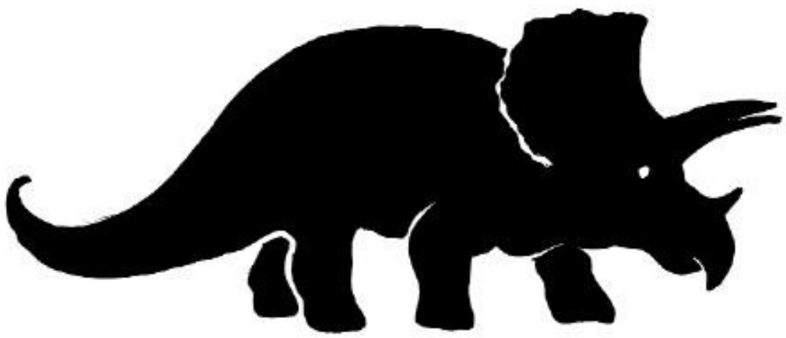
• Giant sauropods had tiny heads, no bigger than a horse's head, and very few teeth. How and where did they digest their food?
*Hind gut of belly*. What advantage did this way of eating give these animals that allowed them to grow so large? *Chewing requires big muscles. A head large enough to chew food for these giants could not stand up*.

• How do scientists know about dinosaur skin or muscles since we have mostly fossil bones?
*They interpret the size of muscles by the size of the bones, especially where muscles insert into them. Skin impressions can show the pattern of dinosaur skin.*

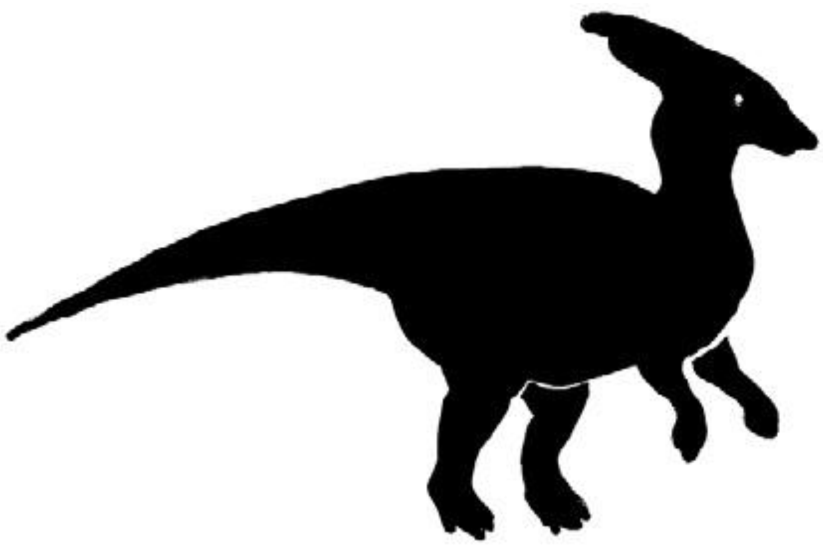
• Review your first discussion about fossils and dinosaurs. What new things can students add to the list? What questions do students still have after the visit?

**Grades 5-12**

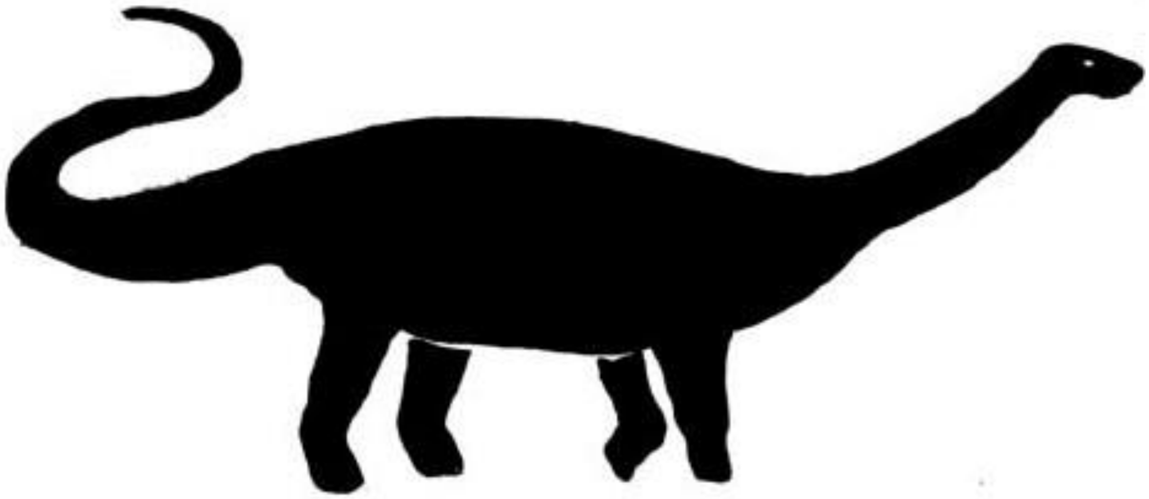
Teacher key/Museum pages
Below are silhouettes of well-known North American dinosaurs. What are they?



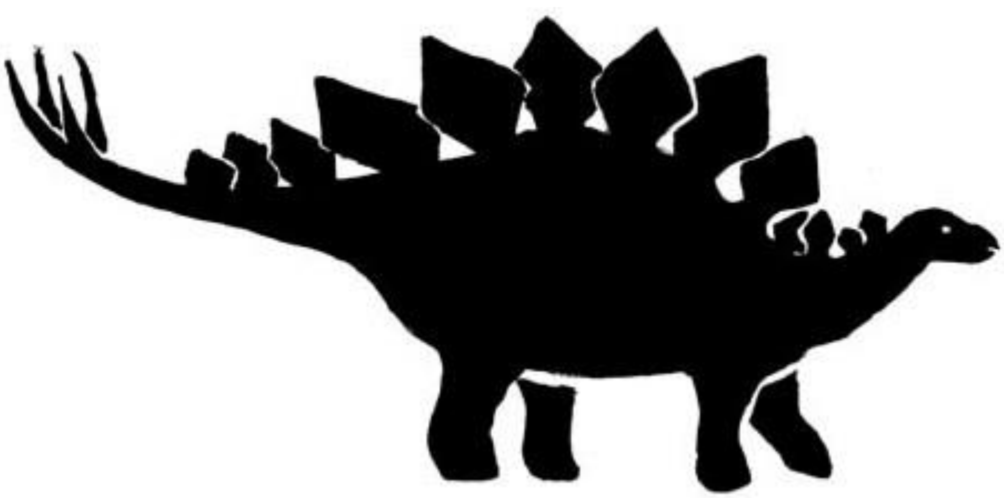
Drawing of: ***Triceratops***



Drawing of: *Parasaurolophus*



Drawing of *Diplodocus* answers: *Mamenchisaurus, Bellusaurus*

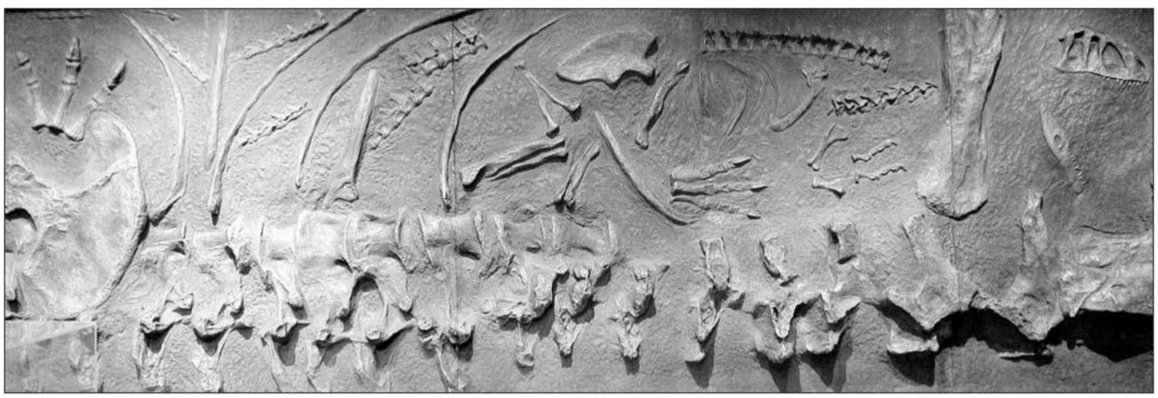


Drawing of *Stegosaurus*

Dinosaurs in China were similar to North American specimens. Why?
*The world was a single landmass when dinosaurs first appeared in the Late Triassic Period so dinosaurs roamed worldwide. A land bridge connected Asia to North America late in the Cretaceous period allowing dinosaurs to cross between continents.*

Reconstructing Ancient Life ***Mamenchisaurus***
Study the photograph below of a *bone wall of Mamenchisaurus* and *Gasosaurus fossils.*

As a paleontologist, you have been asked to find out more about dinosaurs living in Jurassic times. Look at the excavation of *Mamenchisaurus* fossil remains. Inspect this photos showing what these creatures may have looked like when they were alive.



Put different letters next to the bones that you are fairly certain belong to a particular part of *Mamenchisaurus.* On a piece of paper write what part of the dinosaur each letter matches up to. Don't worry if not all of the bones are circled—there will be some that you just can't be sure about.
*Most of the bones in this bone bed, but not all, belong to Mamenchisaurus. This is the same dinosaur as the two enormous long-necked specimens in the exhibit. Compare bones in the bone bed to those on the mounted skeletons if you need help. The other dinosaur bones in the bed belong to Gasosaurus, a small meat-eater.*

Describe the dinosaurs and what happened to create the excavated bone bed.

*Mamenchisaurus*
Herbivore or carnivore?

Interesting facts about this dinosaur:

One question I have about this dinosaur:

How did the bones end up all together in the “bone bed”?

Does it look like the bones of the *Mamenchisaurus* are in the same places they would have been when the animal was alive? Do you think some of them might have moved after it died?

> *Answers can vary. The Mamenchisaurus is pretty complete and not badly disarticulated- as big skeletons go. But by no means are all the bones where they would have been in life. They have shifted around and some were not preserved. Most likely both dinosaurs died near water and the current carried their bodies to a place where they piled up and were buried. This question asks students to look at evidence and make hypotheses based on the evidence.*

**RESOURCES**
Google the many articles and websites available by listing “Martin Sander sauropod” which will refer to the exciting research now underway by Dr. Sander’s team of scientists.

*Dinopedia* by Don Lessem, National Geographic Books. This colorful new reference for young readers is the first to contain all known dinosaurs. It was written by the exhibition's creator.

*Dino Don, Inc.* – A colorful website full of information, contests, games, and videos.

*Zoom Dinosaurs*—information, definitions, activities, links to other dinosaur sites – very thorough; useful for K-12
*http://www.enchantedlearning.com/subjects/dinosaurs/index.html*

University of California Museum of Paleontology
*http://www.ucmp.berkeley.edu/exhibits/index.php*

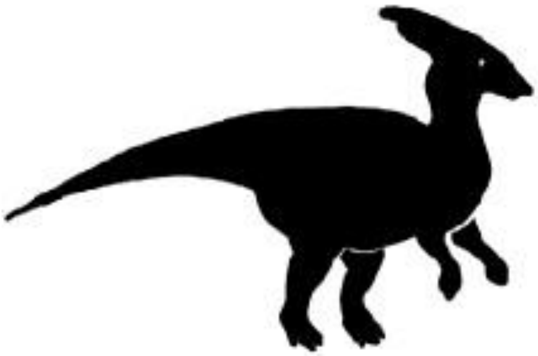
The National History Museum in London
*http://www.nhm.ac.uk/nature-online/life/dinosaurs-other-extinct-creatures/*

*The Evolution of Flight in Birds* contains excellent background information, online and classroom activities regarding the structures and functions necessary for flight present in living, flying birds and ancient, non-flying reptiles.
*http://www.ucmp.berkeley.edu/education/explorations/reslab/flight/main.htm*

**Student Pages**
Here are pictures of dinosaurs.
Find ones that look like the pictures.
Circle the ones you find in the exhibit.
Write the name of the Chinese one next to the American example.

Looks like *Triceratops*.

Chinese dinosaur:



Looks like *Parasaurolophus*.

Chinese dinosaur:

Looks like *Stegosaurus*.

Chinese dinosaur:

Why are dinosaurs in China so similar to North American specimens?

**What does the word "Pangaea" mean?**

Look at the map showing the world during the <u>Cretaceous</u> Period. Describe two things you notice that are different from the world of today.

*1.*

*2.*

**Reconstructing Ancient Life:** *Mamenchisaurus* and *Gasosaurus*

Find: *bone bed mural of Jurassic times*

As a paleontologist, you have been asked to find out more about two dinosaurs living in Jurassic times. Look at the excavation of *Mamenchisaurus* and *Gasosaurus* fossil remains. Inspect the mural showing what these creatures may have looked like when they were alive.

Identify bones you see by drawing a line from the name to the bone:

Ribs Skull Vertebra Toe bone Tail bone Leg bone

Circle the bones that you think belong to *Mamenchisaurus* and write "M."

Circle the bones you think belong to *Gasosaurus* and label them with a "G."

Don't worry if not all of the bones are circled- there will be some that you just can't be sure about.

Describe the dinosaurs and what happened to create the excavated bone bed.

*Mamenchisaurus*
Circle one: Herbivore or carnivore

Interesting facts about this dinosaur:

One question I have about this dinosaur

*Gasosaurus*
Circle one: Herbivore or carnivore

Interesting facts about this dinosaur:

One question I have about this dinosaur:

How did the bones end up all together in the “bone bed”?

**ACTIVE LEARNING LOG**

Teacher Pages

The Process of Paleontology

The study of ancient life (paleontology) involves a combination of making observations, forming and revising testable questions (hypotheses), evaluating evidence and synthesizing conclusions.

Fossils provide invaluable information gathered through direct measurement and inferences derived from many supporting sources.

Expert Investigations

Assign specific specimens or types to each student/group to investigate thoroughly during their visit and report their findings to the class.

Have each student/group develop a hypothesis and gather information from the specimen skeletons in the exhibit.

• What information about dinosaurs can be inferred from skeletons?
Vital statistics, such as estimated height, length, weight? Skin color? Behavior?

• What evidence would be needed to support or contradict your hypotheses?

*Evidence based on direct measurement of the bones and similar results from many specimens can provide reliable support for inferences. Generally, bones do not provide enough specific information to support inferences about skin color or behavior while the animal was alive. Occasionally, however, there are exceptional finds – bits of pigmentation preserved in rock, feather impressions, or an undisturbed site where the position of the bones indicates something about the last moments of the animal's life. Sometimes bones from other animals are needed to support specific conclusions.*

**Dinosaurs, Birds and Pterosaurs (other flying reptiles)**
*The Evolution of Flight in Birds* contains excellent background information, online, and classroom activities regarding the structures and functions necessary for flight present in living, flying birds and ancient, non-flying reptiles.
http://www.ucmp.berkeley.edu/education/explorations/reslab/flight/main.htm

**Structural Features of Dinosaurs:**
Teeth
Vertebrae
Feet

Compare the structure in photographs and sketches of several fossil specimens.

Teeth
What words would you use to describe the teeth? *(Long, pointy, sharp, ridges, grinding surface, etc.)* How do you think the form affected their function? / How do you think they were used?

What type of food did they eat? What evidence supports your answer? *Generally, long, pointy, sharp teeth are signs of carnivores and short, blocky, teeth with ridges and grinding surfaces are signs of herbivores. However, some herbivores had long teeth with spaces between them in order to strip leaves from plants. (And those sauropods ate a lot of leaves!)*

Vertebrae
What features do you notice about the neck vertebrae of *Brachiosaurus*?

How do you think the structure of the neck affected its function? What other organ adaptations do you think it had? Neural projections are present on the neck vertebrae. They point backward and interlink, supporting the weight of the long neck, similar to a cantilever bridge. Although it is not possible to tell from skeletal evidence, Brachiosaurus could have had a large heart and accessory muscles for pumping blood throughout the body.

Feet
Some dinosaurs had 3 toes; others had 4-5 toes. From observing the skeleton, what do you think the dinosaur's footprint looked like? How long, wide, and/or deep would you expect it to be? How do you think the number and arrangement of toes affected the way the dinosaur moved? Do you think the number of toes related to the weight of the dinosaur? The speed the dinosaur could travel? What observable evidence at the exhibit supports your hypothesis? What other evidence do you think would help answer your questions?

ACTIVE LEARNING LOG

***Mesozoic Era*** – Triassic Period and Jurassic Period

__245 - 205__ *Ma* _205 - 140_ *Ma**

***Earth Science Hall, 2nd Floor*** ***(*Ma – mega annum)***

Note: Dates differ depending on the reference chart used. Accept approximate answers.

*Paleontology Notes*

***Select a dinosaur to research.***

***Make a sketch and record the following information:***

***Name:***
***Location:***
***Time Period:***
***Habitat:***

***Circle one: Herbivore/Carnivore***

***Adaptations for Habitat:***
***(What physical characteristics do you think helped it to get food, protect itself, etc.?)***

***Questions I have about this dinosaur:***

***Mesozoic Era*** – Cretaceous Period

__*140 - 65*__ ***Ma***

***Featured Exhibit Hall, Main Floor***

## *Velociraptor*

How does the height of the *Velociraptor* compare to you?
(Estimate its height – measured at the hip.
Sketch the comparison.)

Did this surprise you? Why or why not?

After seeing the size of a *Velociraptor* skeleton, what do you think it would be like to meet one face to face?

## Dinosaur Eggs

Observe the dinosaur eggs.
What can you tell about a dinosaur from looking at its eggs (the size, shape and/or texture)?
What information do you think is necessary to identify the species of the dinosaur?

*Even extremely large dinosaurs started out as small eggs (roughly the size of softballs or melons). Herbivores tended to have round eggs; carnivores, elongated eggs. Pores give the shell texture and provide openings for gas exchange. Skeletons are necessary in order to identify the species of dinosaur.*

## Feathers

Examine the feathers on different fossil specimens.
*(Look for fossils such as Sinosauropteryx, Confuciusornis, Caudipteryx, Sapeornis and others.)*

Sketch of feather:

Specimen:

Circle one: dinosaur early bird

Sketch your favorite example.
What purpose do you think these feathers served? (Insulation, flight, display)

What evidence supports your answer?

A full description of feathers and function is not detailed in the text. However, students should be able to use prior knowledge to describe the feathers and infer their function.

Short, fluffy, fine feathers – insulation
Long, stiff, defined feathers on appendages – flight
Long feathers on tail – display

***Mesozoic Era*** – Triassic Period and Jurassic Period

*_____-_____ Ma* *_____-_____ Ma**

*Earth Science Hall, 2nd Floor* *(*Ma – mega annum)*

*Paleontology Notes*

***Select a dinosaur to research.***
***Make a sketch and record the following information:***

*Name:*
*Location:*
*Time Period:*
*Habitat:*

*Circle one: Herbivore/Carnivore*

*Adaptations for Habitat:*
*(What physical characteristics do you think helped it to get food, protect itself, etc.?)*

*Questions I have about this dinosaur:*

| | | | |
|---|---|---|---|
| **Hypothesis** (testable question): | | | |
| **Fossil Information:**<br>Name<br><br>Type<br><br>Carnivore/ Herbivore | | | |
| **Observations, Sketches, Questions, Conclusions and other useful information:** | | | |