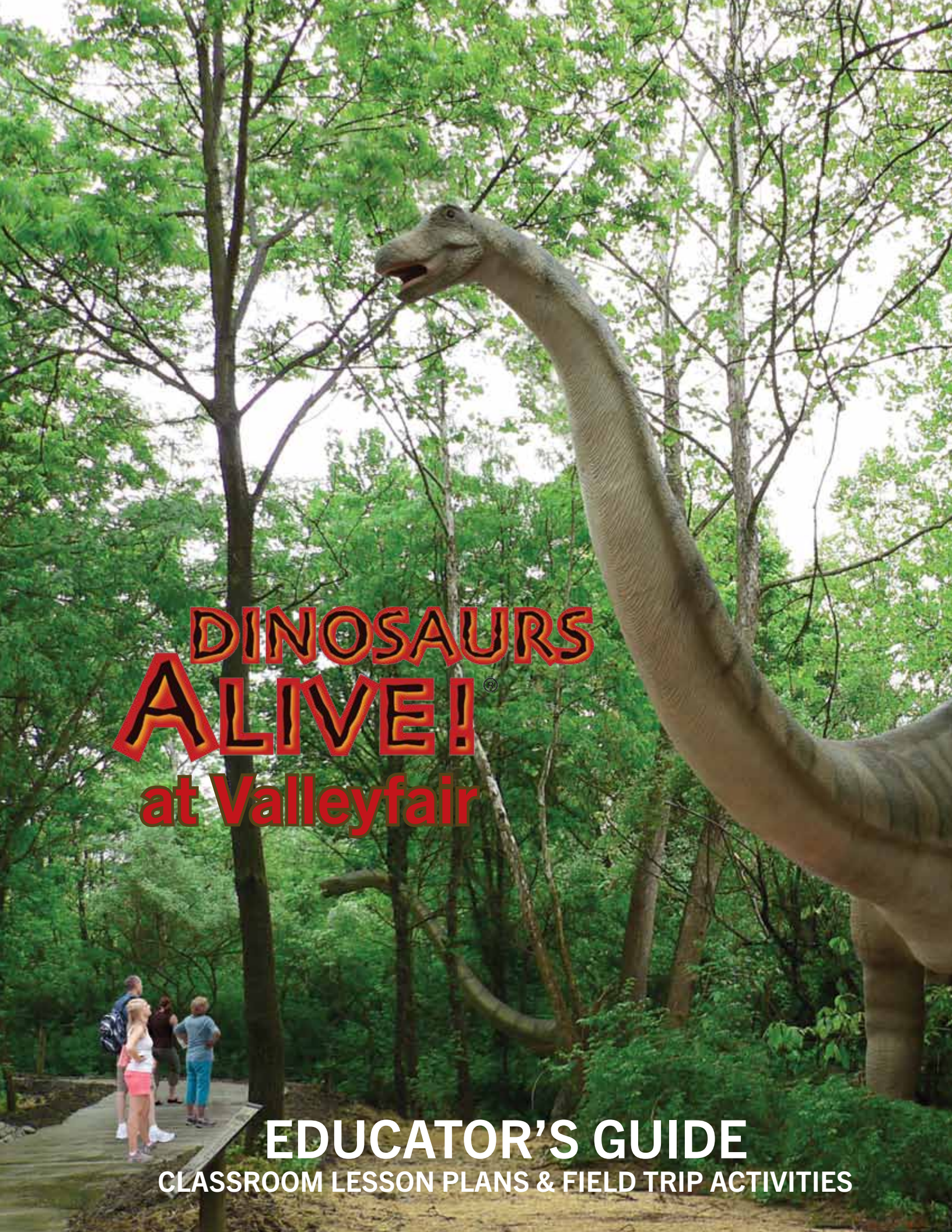

EDUCATOR'S GUIDE

CLASSROOM LESSON PLANS & FIELD TRIP ACTIVITIES

DINOSAURS ALIVE!®
at Valleyfair

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Content co-created by TurnKey Education, Inc. and Dinosaurs Unearthed, 2012

www.turnkeyeducation.net
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INTRODUCTION

The Field Trip

From the time of the first exhibition unveiled in 1854 at the Crystal Palace, dinosaurs have captured the imagination and fascination of the public. Step back in time to the beginning of the "Age of the Dinosaurs" at DINOSAURS ALIVE! – the most immersive and comprehensive Mesozoic experience – and encounter the beasts that dominated the planet for over 180 million years. This multi-sensory and interactive experience brings not only insight into the new scientific discoveries concerning the appearance and behaviors of dinosaurs, but also features some of the latest finds including *Mojoceratops* and *Kosmoceratops*, both of whom were discovered in 2010. Art and technology, two disparate disciplines, are also explored in order for students and teachers to hear the sounds, see the movements and observe the beauty of full-sized animatronic creations that replicate nearly every feature of the dinosaurs.

Imagine not passively learning but actively comparing not only the immense size of each dinosaur to the others but also being able to witness how they may have looked and moved in their own environments. DINOSAURS ALIVE! is presented in a spectacular outdoor setting, in order to feature the full life-sized majesty of gigantic sauropods such as *Mamenchisaurus* and the over 40-foot tall *Ruyangosaurus giganteous*.

This outdoor exhibition presents scenes and stories based on real fossil evidence, such as the predator trap at Cleveland-Lloyd in Utah and the *Pachyrhinosaurus* flash flood episode from Pipestone Creek in Alberta, Canada. Students can create a written or oral history of these events detailing what happened before, during and after what they see depicted so vividly at the exhibition. Other key scenes depicting behaviors and diversity include an attack by a pack of *Deinonychus* on a lone *Tenontosaurus*, and an adult *Tyrannosaurus rex* stalking a *Triceratops*. Art students are invited to

bring their sketch pads to document these magnificent creatures as they really lived.

The exhibition is laid out in such a way that students can easily compare dinosaurs from different locations and observe their physical similarities. Fish eaters discovered in Africa are compared with creatures from South America and England who share their same penchant for fish. The iconic North American *Parasaurolophus* is grouped with the lesser known *Olorotitan*, originally discovered in the Far East.

The opportunity to observe the size of these massive hadrosaurs, as shown in the life-sized animatronics at DINOSAURS ALIVE!, and understand that they lived in herds numbering in the hundreds and thousands, all the while sharing the same ecological environment with giant predators, becomes a moment of awe and understanding of a world long since extinct. Yet the comparison and contrast does not end with similar species.

Illustrating not only the range of species found in one paleontological excavation but also the similarities in physicality from other locations, the dinosaurs represented from the Dashanpu Quarry site recall the creatures discovered at Cleveland-Lloyd. In both instances the accompanying content tells the dynamic story of Jurassic prehistoric life and presents the facts in an engaging and rich educational manner which will capture the attention of any grade level.

Combining finely detailed, hand-crafted animatronics, interactive consoles, a lush setting and educational content that reflects the latest scientific theories DINOSAURS ALIVE! offers not only the excitement of a tail thrashing, clawing, and roaring exhibition but the opportunity to actively engage in a unique learning experience. The educational package which accompanies the field trip was developed by an award winning educational consultant to meet curriculum standards and specifically references facts and species from DINOSAURS ALIVE!

The Educator's Guide

This Educator's Guide has been created to help educators and students make the most of their field trip to DINOSAURS ALIVE! The guide begins with an on-site field trip activity to keep your students engaged and focused while at DINOSAURS ALIVE! Next, you will find four Classroom Lesson Plans centered on key topics highlighted in the exhibition and designed to correlate closely with your STEM curriculum standards.

These plans contain dynamic activities and assignments for elementary school students as well as adaptations and advanced lessons for older grades. The guide is created to be flexible; use it to best fit the needs and capabilities of your class. You know your students better than anyone else. You may select some of the lower level activities for use with your eighth graders or you might pull from some of the more advanced activities for use with your most curious and sophisticated young paleontologists.

Lesson 1 is called Form and Function. At the exhibition you will see how dinosaurs evolved and adapted based on their needs, environments and diets. In the classroom, your students will learn about some of the anatomical differences between predators and prey while doing a hands-on science experiment on depth perception. In Lesson 2, Dinosaur Detectives, students research key paleontologists and their discoveries and learn first-hand that science is a dynamic and ever-changing world. While at the exhibition, your students will see the culmination of over a hundred years of paleontology.

Lesson 3 is Mesozoic Math. Students work with measurements, proportions and scale models of the true-to-life-sized dinosaurs they see on their field trip. The final lesson, Lesson 4, is Fossil Stories. At DINOSAURS ALIVE!, you will be introduced to three stories of dinosaur discoveries, theories of how mass death may have occurred and the connection between dragons and dinosaurs.

The guide also contains recommended reading lists to expand your students' knowledge of the world of dinosaurs, plus dinosaur-themed games and puzzles for both younger and older students and dinosaur fun facts that you can adapt for trivia contests, Jeopardy and Bingo games or a Fact of the Day calendar.

We know how important it is to be able to justify field trips and document how instructional time is spent outside of your classroom. To that end, the Educator's Guide correlates to national curriculum standards.

These resources can be used before your visit to help prepare students for the teachable moments found throughout the exhibition as well as when you return to school to further explore the connections between the educational themes of the exhibition and your classroom instruction. Take advantage of this unique opportunity to literally bring science to life for your students. We look forward to seeing you at DINOSAURS ALIVE!

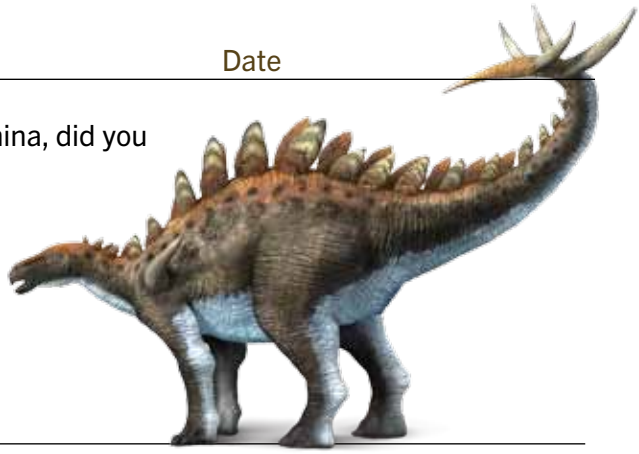
WHO AM I?

Read the clues and look for these creatures on your field trip to DINOSAURS ALIVE! Fill in the first column with the dinosaurs' names as you encounter them; then answer the questions following the chart.

	WHO AM I?	MY UNIQUE FACT	I LIVED IN THE	THE AREA I LIVED IN WAS	HINT
1.		My name comes from the fact that paleontologists were frustrated when trying to remove the plaster around my skull	Early Cretaceous 110 Mya	South America: Brazil	I am grouped with other fish eaters
2.		My lower jaw could deliver 10,000 newtons of force – the equivalent of being able to lift a semi-trailer	Late Cretaceous 65 Mya	North America: USA – Colorado, Montana, South Dakota and Wyoming; Canada – Alberta	As the "King of the Lizards" I may be the best known dinosaur
3.		My duck-like beak holds hundreds of tiny teeth	Late Cretaceous 72 Mya	North America: USA – New Mexico, Utah; Canada – Alberta	I am one of the dinosaurs whose movements can be controlled
4.		My name comes from an early 20th-century African-American term meaning a magic charm or talisman	Late Cretaceous 75 – 74 Mya	North America: Canada – Alberta and Saskatchewan	I have a distinctive heart-shaped frill
5.		I first appeared in a time when dinosaurs were not yet dominant and competed against larger, more powerful animals for food	Mid-Triassic 231.4 Mya	South America: Argentina	I am grouped with some other Mesozoic Predators
6.		I was the largest North American predator of the Jurassic Period	Late Jurassic 150 Mya	North America: USA – Montana, North Dakota, South Dakota, Nebraska, Kansas, Wyoming and Colorado; Europe: Portugal	I was the victim of a "Predator Trap" which was later named the Cleveland-Lloyd Quarry
7.		I have the most ornate skull of any known dinosaur	Late Cretaceous 76.4 – 75.5 Mya	North America: USA – Utah	I have 10 hooks and 15 horn-like structures on my frill
8.		I was the largest Cretaceous sauropod in Asia	Late Cretaceous 99.6 – 89.3 Mya	Asia: China – Henan Province	I am the largest dinosaur in this park
9.		Unlike other horned-face dinosaurs I have a thick bony facial pad	Late Cretaceous 73.5 – 71 Mya	North America: USA – Alaska; Canada – Alberta	At Dinosaurs Alive! I can be found near or in a creek

Name Class Date

10. What animal, pictured here, from the Mid-Jurassic Period in China, did you see at the exhibition that was an early stegosaurid?



11. Which time period has the most dinosaurs on the chart?

12. Which three US states would be the best for fossil hunting? (Hint: Which three states are on the chart the most?)

13. Which province in Canada would be best for fossil hunting?

14. Once you complete the Field Trip Activity "Who Am I?" chart, place the dinosaurs in chronological order starting from the earliest (Triassic) to the latest (Cretaceous) showing the name, time period and date.

LESSON 1: FORM AND FUNCTION

How do the scientists and engineers behind the scenes at DINOSAURS ALIVE! know how to accurately create the moving, roaring, life-sized beasts you see on your field trip? They study and learn from the evidence the real dinosaurs left behind, like fossilized bones.

For example, during your field trip to DINOSAURS ALIVE!, take a close look at the head of *Omeisaurus*, one of the large, herbivorous sauropods, and compare it to that of a predator like *Tyrannosaurus rex* or *Yangchuanosaurus*. Where are their eyes positioned on their skulls?

Prey animals (like *Mamenchisaurus*) usually have eyes spaced far apart and on the sides of their heads, while the eyes of a predator (like *Tyrannosaurus rex* or *Yangchuanosaurus*) face forward so they can focus on what's in front of them – a tasty dinner!

Animals that are prey, meaning that they are hunted by other animals, need eyes that can see all around them in order to be able to watch out for danger. Predators are animals that hunt, kill and eat other animals. They need eyes that give them good depth perception and the best chance of catching their prey.

Activity 1: Elementary School (Grades K - 5)

How are mice and cats like dinosaurs? It's all in the eyes! Animals that hunt for food need to have good aim, good hand-eye (or hand-claw!) skills and good depth perception. When our brain tells us what we are seeing, it needs information from both eyes. For depth perception, the brain uses the differences between the picture from the left eye and the picture from the right to figure out how far away something is.

When only one eye sends information, the picture is not complete and depth perception is lost. Imagine how hard it would be to hit a baseball if you couldn't tell whether the pitcher stood 16 feet away or 60 feet!

The biggest carnivorous hunters were the theropods, like T. rex*, with forward-facing eyes.*

Name Class Date

When the eyes are close together on the front of the head, an animal has what is called "binocular vision" and better depth perception. This means it is easier for them to tell how far something – like their dinner – is from them. This activity will show you how animals with binocular vision, including humans and dinosaurs, have better depth perception when both eyes are looking at the same object at the same time.

Materials

- Partner
- Pencil or pipe cleaner
- Washer with a hole larger than pencil/pipe cleaner diameter
- Modeling clay
- Eye patch

Procedure

1. Stand the washer up on the clay.
2. Turn the clay and washer so that you are looking at the side of the washer – not the hole.
3. Hold the clay and washer in one hand with that arm stretched out in front of you.
4. Put the eye patch on one eye.
5. Try to put the pencil or pipe cleaner through the washer, like threading a needle.
6. Repeat the experiment so that you make 10 tries with the right eye covered, 10 tries with the left eye covered, and 10 tries with both eyes open.
7. Your partner will count your tries and record your results in this chart.

	Right eye covered, left open		Left eye covered, right open		Both eyes open	
	yes	*no*	*yes*	*no*	*yes*	*no*
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

What happened?

One of the most intelligent dinosaurs was *Troodon*. It had a brain the same size as a mammal or bird of today, plus binocular vision and grasping hands.

1. How many times were you able to put the pencil or pipe cleaner through the washer with…

   only your left eye open? _____

   only your right eye open? _____

   both eyes open? _____

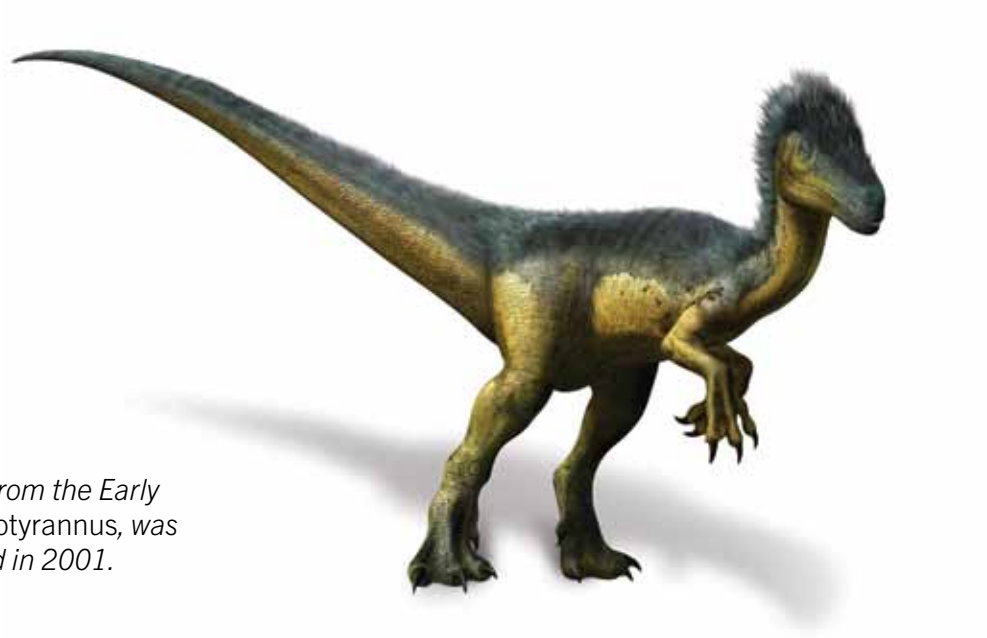
2. Would you be a good predator, like the *Eotyrannus* below, if you could only see with one eye at a time? Why or why not?

   _____

   _____

Try it!

- Calculate your success rates in number 1 above by dividing each total number by 10, then multiplying by 100 for a percentage. For example, if you were successful with only your left eye four times: 4 ÷ 10 X 100 = 40%.
- For your next science fair project, test your classmates and family to "see" if being right-handed or left-handed connects to whether they can thread the washer better with one eye or the other.
- Repeat the experiment on a larger scale. Have your partner toss you a bean bag or soft ball 10 times and see how well you can catch it with only one eye.



This small theropod from the Early Cretaceous Period, Eotyrannus*, was described and named in 2001.*

Activity 2: Middle and High School (Grades 6 - 12)

Eye position is only one of the things paleontologists study in order to learn more about a dinosaur. A dinosaur's teeth, if there are any left, can tell us if that creature was an herbivore or a carnivore. When we see armored plates we know that this was an animal that needed protection from neighbors with sharp teeth! What makes dinosaurs look so strange to us are exactly what helped the species survive, even if all those frills, knobs, crests, and horns were only there to make a dinosaur as handsome as possible to find a mate.

In this activity, match the features of a "mystery" dinosaur in the first list with the conclusions that can be made about that dinosaur's identity and life in the second list. The first one has been done for you.

Observations

1.	K	*Allosaurus* teeth marks on vertebra	7.		No tail marks found in trackways
2.		Eyes on the sides of its head	8.		No fossils in what would have been water
3.		Four large legs, footprints far apart	9.		About 150 million years old
4.		Gastroliths	10.		Dull, straight, rake-like teeth
5.		Hollow backbones	11.		Heart and brain separated by a long neck
6.		Long neck didn't lift above horizontal	12.		Long ribs and stout leg bones

Conclusions: This dinosaur...

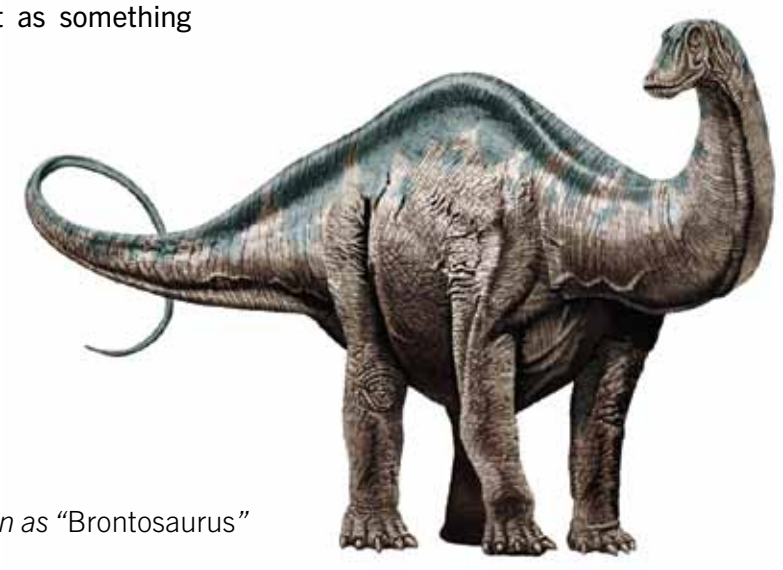
a. was an herbivore.
b. didn't live in a jungle or forest because it would constantly hit trees and get stuck.
c. needed light-weight bones.
d. held its tail up in the air, off the ground.
e. was not a predator.
f. lived in the Jurassic Period.
g. moved slowly.
h. needed a large, strong heart to keep enough blood pumping to the brain.
i. was a heavy animal with a large torso.
j. needed help digesting plant fibers.
k. was hunted by *Allosaurus*.
l. was not a swimmer.

13. Based on this information, what dinosaur do you think it is? _____

LESSON 2: DINOSAUR DETECTIVES

"Dinosaur detectives" (better known as paleontologists) are always learning new information about the prehistoric creatures you will see on your field trip to DINOSAURS ALIVE! Sometimes they even find mistakes in what we thought we knew about dinosaurs.

For example, when *Stegosaurus* was first discovered in the late 1800s, the famous paleontologist Othniel C. Marsh thought it might have had a second brain in a small space near its bottom! When a *Triceratops* was discovered, scientists first classified it as something similar to a buffalo, not a dinosaur. And, as you will learn at DINOSAURS ALIVE! the dinosaur once known as "*Brontosaurus*" no longer exists! That skeleton turned out to be an *Apatosaurus* with the skull of a *Camarasaurus* stuck on its neck!



Apatosaurus*, formerly known as* "Brontosaurus*"*

Activity 1: Elementary School (Grades K - 5)

The paleontologists listed in the chart on the next page are just 10 of the dozens of early scientists who first studied dinosaurs. Although they may have made a few mistakes along the way, their work is the beginning of scientific dinosaur paleontology.

In the chart, fill in the paleontologists' dates, nationalities, and the name of one of the dinosaurs they named. One has been done for you. Then, answer the questions that follow.

Name Class Date

Name	Birth-Death	Nationality	Dinosaur Named
Roy C. Andrews			
Barnum Brown			
William Buckland			
Edward D. Cope			
Lawrence M. Lambe			
Joseph Leidy			
Gideon Mantell			
Othniel C. Marsh			
Henry F. Osborn			
Hermann von Meyer	1801-1869	German	*Archaeopteryx*

The first dinosaur to be officially named was *Megalosaurus*, in 1824 by the Reverend William Buckland.

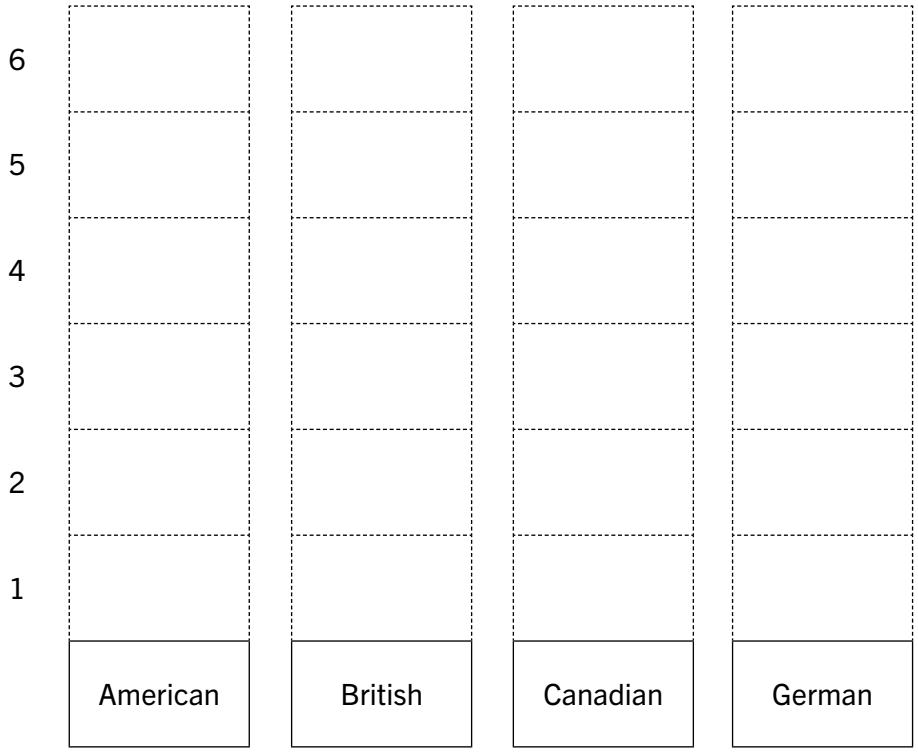
Name Class Date

1. Which paleontologist in the chart was born first? In what year? _____

2. Which nationality appears the most? _____

3. What reason do you think would explain this? _____

4. Color in the bar graph to show the number of paleontologists on the chart from each country.



Name Class Date

Activity 2: Elementary School (Grades K - 5)

Dinosaurs may be long gone, but new fossil discoveries and new theories from today's dinosaur detectives keep them in the spotlight! Working in groups and using the most recent dinosaur news found on the sites provided below, write, create and produce a "Breaking News" dinosaur newscast. Produce a YouTube video of your report and post it on your school website.

- Dinosaur News:
  http://www.dinosaurnews.org/

- *New York Times* Fossil News:
  http://topics.nytimes.com/topics/reference/timestopics/subjects/f/fossils/index.html

- *Smithsonian* Dinosaur Blog:
  http://blogs.smithsonianmag.com/dinosaur/

Activity 3: Middle and High School (Grades 6 - 12)

Not everyone who has a career working with dinosaurs is a paleontologist! Research these four people. Identify their careers and how they contributed to our knowledge of dinosaurs.

1. Luis Alvarez _____

2. Benjamin W. Hawkins _____

3. Arthur Holmes _____

4. Alfred L. Wegener _____

Creating intricate, life-sized dinosaurs requires teams of experts. Writers, robotics engineers, graphic designers, artists, landscapers, lighting experts and exhibition designers all helped create these animatronic masterpieces and the settings they inhabit. What other careers are part of discovering, studying, constructing, displaying and touring dinosaurs? Brainstorm a list of possibilities. Create a Dinosaur Job Fair in your class. Identify job titles, the education required, colleges and universities with the appropriate course of study, pay rate, duties and responsibilities. Could this be your future career?

LESSON 3: MESOZOIC MATH

Since humans were not alive that long ago, no one knows for sure exactly how long, tall, heavy or fast dinosaurs really were. Scientists make good guesses based on many pieces of information. For example, they study the size of fossils and then use the measurements to create the life-sized models you see on your field trip to DINOSAURS ALIVE!

But how do we know if a fossil came from a particularly small or big version of that kind of dinosaur? The more fossils that are discovered, the closer we get to figuring out the real lengths, heights and weights of these extinct creatures.

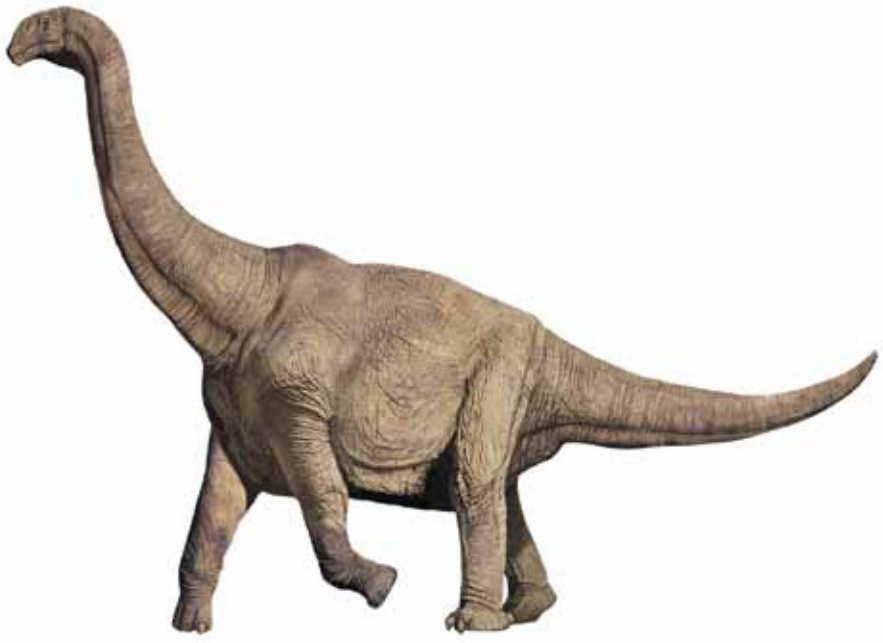
In this lesson, you will compare dinosaurs from different time periods, using average lengths from scientists' best guesses, and then use those measurements to create your own exhibition of dinosaurs!

One of the smallest dinosaurs to be discovered so far was only slightly larger than a modern-day chicken. *Compsognathus* grew to be about 3 feet long and weighed only about 6½ pounds.

Activity 1: Elementary School (Grades K - 5)

The dinosaur chart has information on 10 of the dinosaurs you will see during your field trip to DINOSAURS ALIVE!: name, time period and length. For each dinosaur, the length is listed in both meters (m) and feet (ft). Study the chart to answer the questions that follow.

Although we may never have exact measurements, paleontologists are confident that the heaviest dinosaurs were sauropods, like this Ruyangosaurus giganteous, *or* "Giant Ruyang Lizard" *which is the largest animatronic model at the exhibition.*



Name Class Date

DINOSAUR CHART - TIME PERIOD AND LENGTH

Name	Period	Length	
Allosaurus	Late Jurassic	12 m	39.6 ft
Apatosaurus	Late Jurassic	23 m	75.9 ft
Baryonyx	Early Cretaceous	9 m	29.7 ft
Huayangosaurus	Mid-Jurassic	4 m	13.2 ft
Mamenchisaurus	Late Jurassic	24 m	79.2 ft
Omeisaurus	Late Jurassic	20 m	66.0 ft
Parasaurolophus	Late Cretaceous	9 m	29.7 ft
Stegosaurus	Late Jurassic	9 m	29.7 ft
Triceratops	Late Cretaceous	9 m	29.7 ft
Tyrannosaurus rex	Late Cretaceous	13 m	42.9 ft

Name Class Date

Mamenchisaurus
Late Jurassic, length: 24m (79.2ft)

Reading the Chart

1. Which dinosaur was from the Early Cretaceous period?

2. Which four dinosaurs had the same length?

3. Which dinosaur was longer, *Allosaurus* or *Tyrannosaurus rex*?

Length

4. If all these dinosaurs stood head-to-tail, how long would the line be?

   a. In meters: _____

   b. In feet: _____

Not every sauropod was a behemoth like *Argentinosaurus* (up to 36 meters/118 feet) or had an incredibly long neck like *Mamenchisaurus*. *Magyarosaurus*, which was discovered in Romania in 2005, was "small" and measured only 5.3 meters/17 feet long.

Name Class Date

5. *Huayangosaurus* (4 m/13.2 ft) is the shortest dinosaur on the chart and *Mamenchisaurus* (24 m/79.2 ft) is the longest. How many *Huayangosaurus* would fit in one *Mamenchisaurus*? Show your work.

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6. Here are two ways to see how the dinosaurs' sizes compared to each other and how they would have looked in real life!

   a. When we study something very large, like a dinosaur, it is easier to work on a smaller version called a scale model. In the chart above, let's pretend that the meters are actually centimeters. On a piece of paper, measure and draw a line for each dinosaur based on these new versions of their length. For example, *Apatosaurus* is 23 meters; draw a line on your paper that is 23 centimeters long and label it "*Apatosaurus*."

   b. Divide your class into 10 groups and assign a dinosaur from the chart to each group. Go outside, in the hallway, or into the gym with long ropes and measuring tapes or meter sticks. Each group measures and marks of the length of their dinosaurs using the rope to see how long that dinosaur would really be.

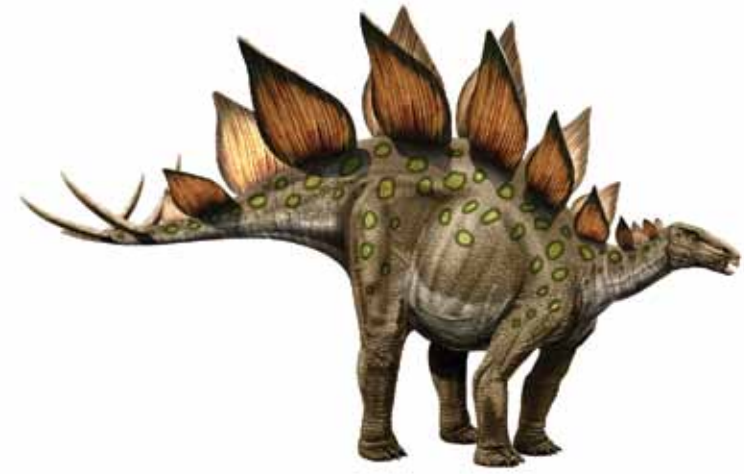
7. The longest school bus is about 14 meters. Match these dinosaurs' lengths to their size, in terms of school buses. (One answer will not be used.)

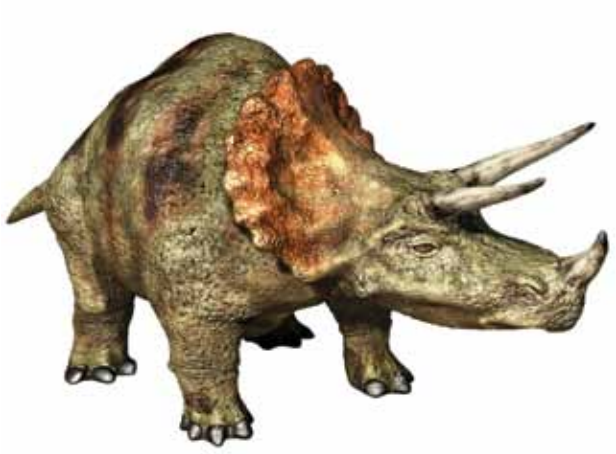
about ½ a school bus	about 1 ½ school buses
about 1 school bus	about 2 school buses

   a. *Mamenchisaurus* _____

   b. *Omeisaurus* _____

   c. *Tyrannosaurus rex* _____





Stegosaurus *(left) and* Triceratops *(right) were both shorter than a school bus.*

Name Class Date

8. Use the dinosaurs' lengths in feet to make a stem-and-leaf plot to help you answer these questions. Round your answer to the nearest tenth.

Stems	Leaves

a. What is the mean? _____

b. What is the mode? _____

c. What is the median? _____

Time Periods

9. Which two time periods have only one dinosaur on the chart?

_____

10. Count the number of dinosaurs in each of the time periods on the chart.

a. Which time period has the most dinosaurs on the chart?

_____

b. What percentage of the dinosaurs from the list is in that time period? Write your answer as a fraction, reduce the fraction, rewrite it as a decimal and then calculate the percentage. Remember, there are 10 dinosaurs, so 10 is the denominator for the fraction. To find the percentage, multiply the decimal by 100.

Fraction: _____ Decimal: _____

Reduced fraction: _____ Percent: _____

11. *Triceratops* and *Tyrannosaurus rex* are the two youngest dinosaurs on the chart. They both lived about 65 million years ago.

a. Write 65 million with all its zeros.

_____

b. BONUS! Write 65 million in scientific notation.

_____

Activity 2: Middle and High School (Grades 6 - 12)

Engineers use scale models to see how something will look or work before they begin building the full-sized versions. Architects, car manufacturers, toy makers, roller coaster designers, cartographers (map makers) and many other careers use scale models. All of the animatronic dinosaurs you see on your field trip began life as two dimensional drawings on paper. Next, they became scale models, which are the three-dimensional, miniature versions of themselves.

Scale Model

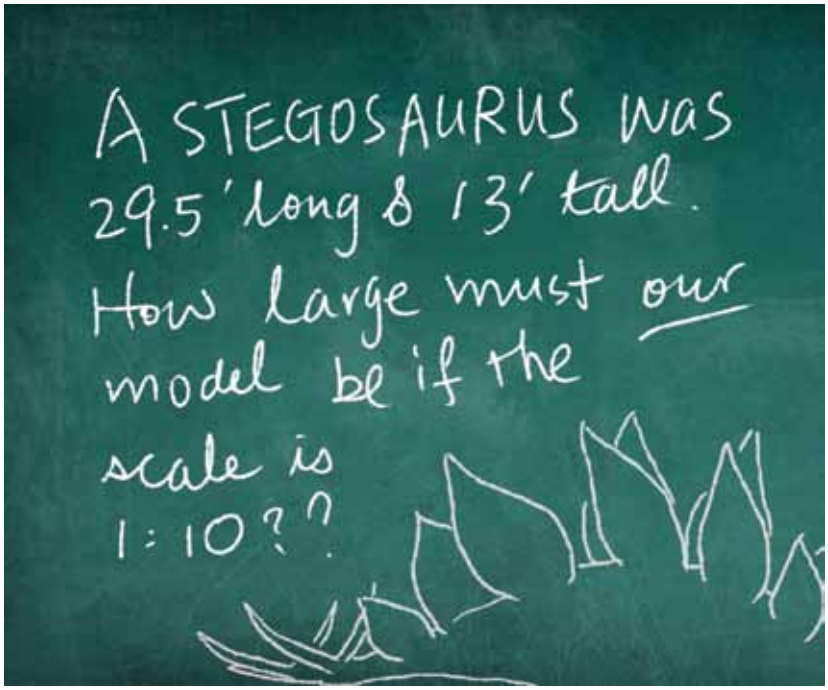
A scale model has the same proportions as the other object, just in a smaller size. For example, if a dinosaur's skull makes up half its entire body, then that needs to be true whether it is a 20-foot model with a 10-foot skull or a 20-inch model with a 10-inch skull. In these activities you will use fractions, ratios, multiplication and measurements to construct and compare scale models to their full-size counterparts.

Scale Factor

Scale factor is the ratio of the corresponding lengths on the scale model to the actual object, written as a fraction. This number tells us how many times bigger the real object is, or how many times smaller the model is. In the example above, of the 20-foot dinosaur with the 10 foot skull, the scale factor for the model is 1/12. The real skull is 12 times bigger than the model skull. The model skull is 1/12th the size of the real skull. (Remember, there are 12 inches in a foot, and we have to reduce the fraction.)

$$\text{scale factor} = \frac{\text{model size}}{\text{object size}} = \frac{10 \text{ in}}{10 \text{ ft}} = \frac{10 \text{ inches}}{10 \text{ ft X } 12 \text{ in}} = \frac{10 \text{ in}}{120 \text{ in}} = \frac{1 \text{ in}}{12 \text{ in}} = \frac{1}{12}$$

Name Class Date



1. A life-sized dinosaur statue is 50 times larger than its model. What is the scale factor for the model?

2. If the neck on a real *Mamenchisaurus* was 30 feet long, and the scale factor for its model is 1/10, how long is the neck of the scale model, in feet?

3. You have a model of a *Spinosaurus* that is 2 feet long and you know that it was made with a 1/20 scale factor. How long is the life-sized version of Spinosaurus? Would it fit in your classroom?

Name Class Date

4. You have been asked to select, design and engineer the newest life-sized animatronic dinosaur for the exhibition. Your first task is to present a scale model.

    a. Choose your favorite dinosaur. Research its length and height.

    My dinosaur: _____

    Length: _____ Height: _____

    b. Decide what scale factor would allow you to display your dinosaur model on your desk. (Hint: measuring your desk will help.)

    My scale factor: _____

c. Build the scale model of your dinosaur using arts and crafts supplies like modeling clay, rubber bands, craft sticks, cardboard, cotton balls, Styrofoam, aluminum foil, construction paper, toothpicks, tissue paper, florist wire, feathers, pipe cleaners, straws, hot glue gun, tape, spools, etc.

d. Display a miniature dinosaur exhibition in your classroom! Build a diorama to re-create the environment in which it lived. Was it a desert or a forest? Prepare a sign with your dinosaur name, pronunciation, brief history and at least one interesting fact. Stand by your display and be available to answer questions and explain how you created your scale model. Create an event and invite students, teachers and your principal.

LESSON 4: FOSSIL STORIES

There are three recent dinosaur fossil discovery sites – in the United States, Canada and China – that sound as though they could be part of an ancient crime scene investigation! At the Cleveland-Lloyd Quarry in Utah, the Pipestone Creek Bonebed in Alberta and in Ruyang County in the Chinese province of Henan, paleontologists are trying to unravel the mysteries behind how an unusual assortment of dinosaurs' bones came to be.

The ongoing discovery and recovery of the fossils from these three locations, along with ideas about how they got there, are rewriting dinosaur history.

At DINOSAURS ALIVE! you can become part of this new wave of scientific investigation! You will experience the thrill and mystery surrounding the discoveries of these three hotbeds of modern paleontology. Nowhere else can you see an *Allosaurus* and a *Stegosaurus* stuck moments before their death at the Predator Trap, recreated from the site in Utah. At Death by Drowning you will witness the creation of an unusual mass *Pachyrhinosaurus* grave in Canada. In the area of the Titans of the Ruyang you will encounter a 40-foot-tall replica of the heaviest and tallest Asian dinosaur, *Ruyangosaurus*.

Activity 1: Elementary School (Grades K – 5)

Read the information about the three dinosaur fossil sites you viewed at DINOSAURS ALIVE! and answer the questions that follow.

Cleveland-Lloyd Quarry, Utah, United States

In 1929, local ranchers discovered dinosaur bones in central Utah. Since then, thousands of fossils have been found in this one location. How did this happen? We know now that during the Jurassic Period, about 147 million years ago, a group of young *Allosaurus* were gathered together when something happened that caused these dinosaurs, along with several other species, to die quickly. Perhaps the group became stuck and they couldn't save themselves from becoming dinner for other predators (including some older *Allosaurus*!). These adult predators then became stuck themselves attracting more predators to the scene who then took advantage of both the dying and the dead.

Usually, dinosaur deathbeds contain more fossils from herbivore dinosaurs than from carnivores because there were more herbivore dinosaurs around. Paleontologists were not surprised to find herbivores at the Cleveland-Lloyd Quarry like *Camarasaurus*, *Barosaurus*, *Camptosaurus*, *Stegosaurus* and an unidentified sauropod. However, this site is unusual because it has many more fossils from carnivore dinosaurs than herbivore dinosaurs. Of the fossils discovered so far, two-thirds are from *Allosaurus* alone. The disproportionate number of predators to prey is the reason sites such as Cleveland-Lloyd are referred to as predator traps.

Pipestone Creek Bonebed, Alberta, Canada

A high school science teacher named Al Lakusta found the first fossils from the Pipestone Creek Bonebed in the early 1970s. Since then, thousands of bones and over a dozen skulls have been identified from a *Pachyrhinosaurus* herd that died in a river 73 million years ago, during the Late Cretaceous Period. It is one of the densest bonebeds in the world and is called "monogeneric" because the fossils are almost entirely from one species – *Pachyrhinosaurus* – although fossils from some predators were found nearby.

The *Pachyrhinosaurus* fossils found in the Pipestone Creek Bonebed were from dinosaurs of all ages, so scientists can learn a lot about this specific dinosaur. *Pachyrhinosaurus* was a ceratopsian. It was an herbivore that lived in herds and was related to *Triceratops*. Its name means "thick-nosed lizard" because it had a thick nose bone, or boss. Paleontologists aren't sure yet what kind of horn, or whether a horn even grew from the boss. They do know this dinosaur had a bony neck frill with horns on it and a beak-like mouth. Adults could grow to over 20 feet long. A new species of *Pachyrhinosaurus* was found recently in Alaska and has been named *P. perotorum*.

Ruyang County, Henan Province, China

Henan Province was known for its dinosaur fossils before the huge *Ruyangosaurus* was discovered in 2006 and named in 2009, but the earlier fossils were from eggs and not bones. In fact, Henan has the most dinosaur eggs of any site in the world! The area is also known for the "dragon bones" that can be found buried in the ground, especially in Ruyang County. Over the centuries, these bones were used for many purposes and especially as medicine to treat diseases and injuries. Today, paleontologists wonder how many species of "dragons" will never be discovered since the fossils have been transformed into traditional remedies and medicines.

These dragon bones, of course, were dinosaur fossils – and some gigantic ones at that! The two species that have been identified so far are humongous sauropods. One of them, *Ruyangosaurus giganteus*, is the biggest dinosaur ever found in Asia! This dinosaur lived in the beginning of the Late Cretaceous Period, almost 100 million years ago. Paleontologists estimate that it was over 90 feet long and was close to 40 feet tall. Its neck and tail were shorter in relation to the rest of its huge body, when compared to earlier large sauropods.

In situ measurement of Ruyangosaurus *fossil before "jacketing" and transport to research lab*

Workers exposing the Ruyangosaurus *fossils in Henan Province, China. Note the stratification in the rock wall.*

Name Class Date

1. Which of the three places has the oldest dinosaur fossils? Which has the youngest?

2. When were the fossils first found at the Cleveland-Lloyd Quarry in Utah?

3. Why is the Cleveland-Lloyd Quarry an unusual fossil site?

4. Were *Camarasaurus* and *Camptosaurus* herbivores or carnivores?

5. What dinosaur has the most fossils at the Cleveland-Lloyd Quarry?

6. Who first found the fossils at Pipestone Creek in Alberta? What was his job?

7. What dinosaur has the most fossils in the Pipestone Creek Bonebed?

8. What does “monogeneric” mean?

Name Class Date

9. What does “boss” mean when it is used to describe a dinosaur?

10. What kinds of fossils were first found in China’s Henan Province?

11. From what kind of creature did the “dragon bones” really come?

12. Why might we never learn about some of the dinosaurs from Ruyang?

13. How was *Ruyangosaurus* different from earlier large sauropods?

Name Class Date

Activity 2: Middle School and High School (Grades 6 – 12)

Important questions remain about the dramatic fossil stories you saw first-hand at DINOSAURS ALIVE!. For example, how many different kinds of dinosaurs are at each location? What were the dinosaurs doing right before they died? What happened next? Why are there are so many fossils in one place?

Let's investigate! While most people turn to Annual Paleontology Review (APR) as their trusted source for dinosaur news, a few other "news stations" have picked up on the latest fossil stories – especially those from Utah and Alberta. The Journal of Dinosaur Discoveries (JDD), Earth Sciences News (ESN) and Paleontology Press International (PPI) are presenting alternative hypotheses as to what could have happened at those sites, based on the same sets of evidence.

At the Cleveland-Lloyd Quarry...

The APR claims that it was a muddy, sticky bog that became a predator trap.
The JDD purports that it was a riverbed where carcasses slowly washed up over time.
The ESN states that the animals were drinking from a poisonous water hole.
The PPI argues that the site was a waterhole that dried up during a drought.

At the Pipestone Creek Bonebed...

The APR believes that a *Pachyrhinosaurus* herd was migrating to better feeding grounds when they were caught in a flash flood after a rain storm.
The JDD declares that the herd was chased into a rushing river by a predator.
The ESN alleges that once in the water, the herd was swept away, drowned and the bodies collected in one area downstream.
The PPI asserts that once in the water, the animals panicked and trampled each other while trying to climb out.

How can the same facts be used to support so many different theories? Divide your class into four teams, each representing an investigative team at one of the four news stations. Research the sites in Utah and Alberta in greater detail in order to find information to support the theories stated above for your station.

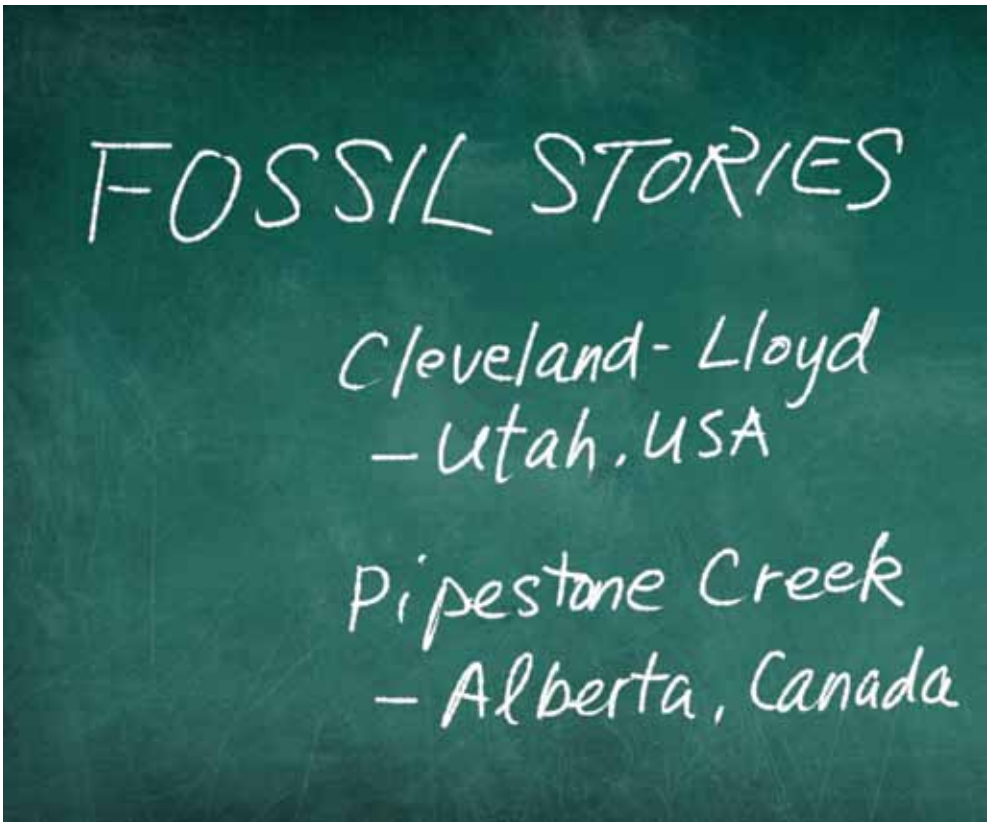
While collecting evidence to support your theory behind how these fossil sites were formed, keep these questions in mind:

- Are there more carnivores than herbivores?
- Are there more young dinosaurs than adults?
- Is there a thin layer of fossils?
- Are there several layers of fossils?

Name Class Date

- Are some bones crushed and fractured?
- Are there both large and small bones present, or are only the larger ones left?
- Are most of the bones scattered?
- Are there complete skeletons?
- Do any of the bones have tooth marks?
- What kinds of sediment surround the fossils?

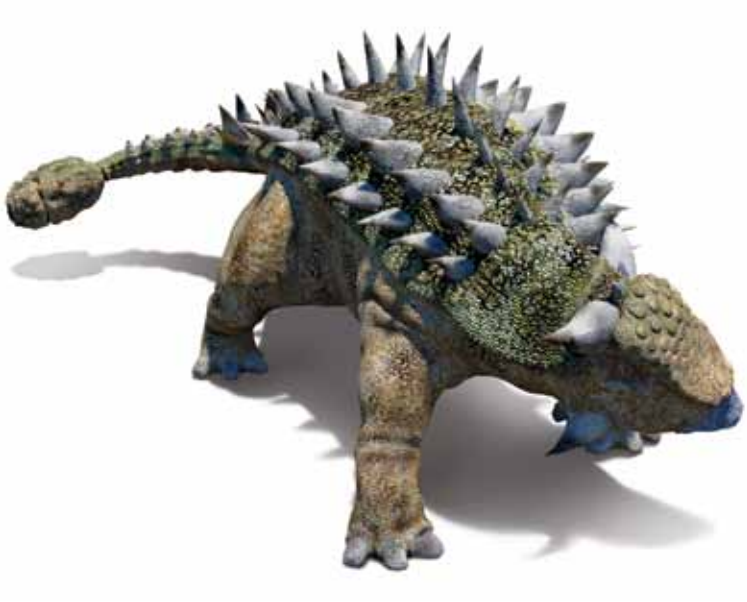
Present your coverage in the form of a skit in front of the class. Which investigative team – APR, JDD, ESN, PPI – presented the most credible report? Did you identify an "approved" theory or did you raise even more questions about these fossil sites? If so, welcome to the ever-changing world of paleontology!



CROSSWORD PUZZLES

Name that Dinosaur!

Dinosaurs' names are often made of words from other languages. The name can describe the dinosaur's body, the place where it was found, or even the person who found it. For example, *Acrocanthosaurus* is Greek for "high-spined lizard" which is an accurate description of what it looked like. *Gobisaurus* was named for the Gobi Desert where the fossil was found. *Lambeosaurus* was named for paleontologist Lawrence Lambe. Read the clues for these puzzles and find the dinosaur whose name has that meaning. A word bank is provided for the first puzzle.



This is Dyplosaurus*, whose name means "double-crested lizard"*

Gasosaurus was named for the gas company under construction when the dinosaur was discovered!

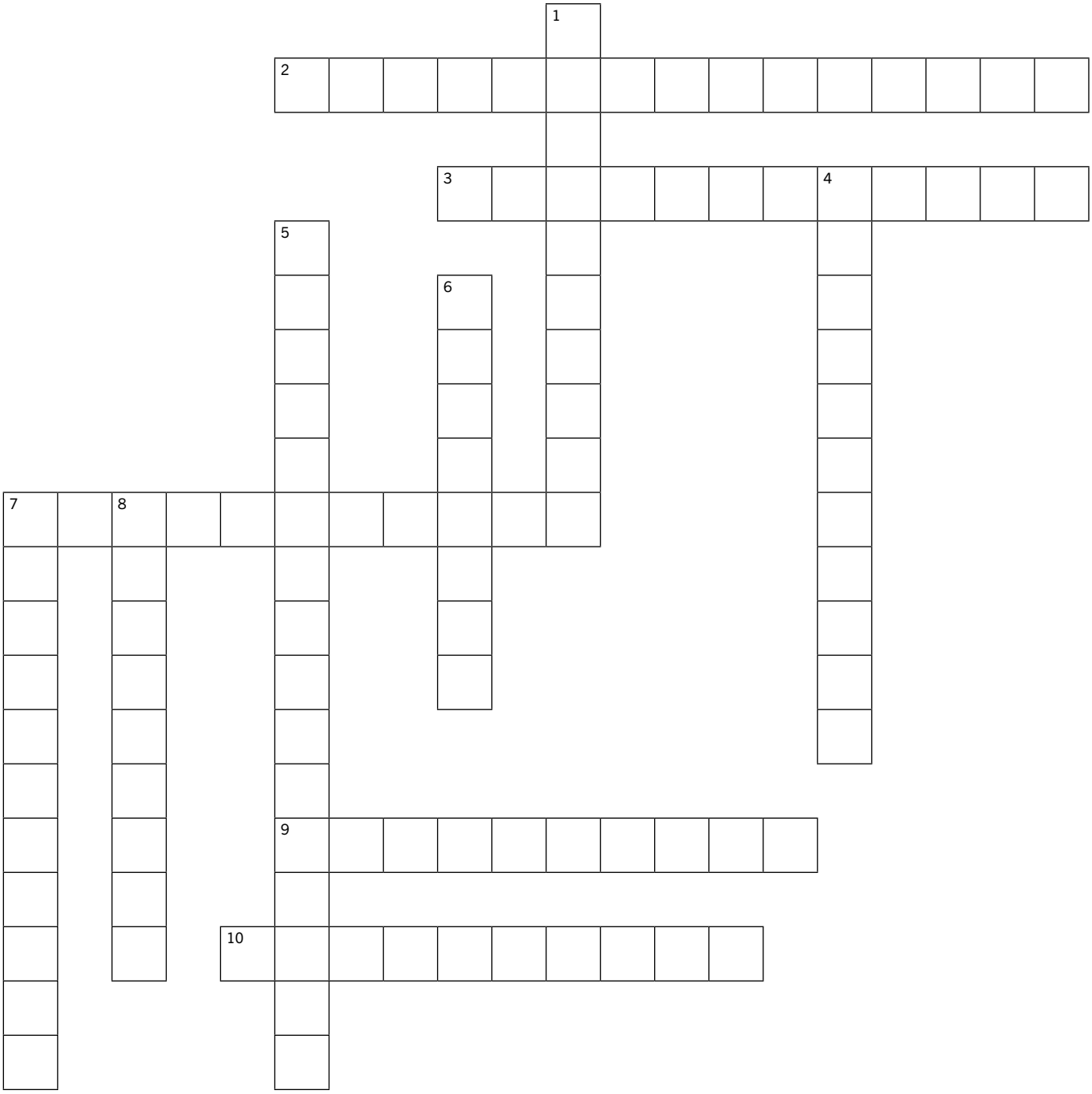
The longest dinosaur name is _Micropachycephalosaurus_, which means "tiny, thick-headed lizard."

Level 1:

Across	Down
2. Strange-ankled lizard	1. Chicken mimic
3. Fast thief	4. Agile lizard
7. Three-horned face	5. Thick-nosed lizard
9. Different lizard	6. Heavy claw
10. Slow leg	7. Swollen head
	8. Iguana tooth

Name Class Date

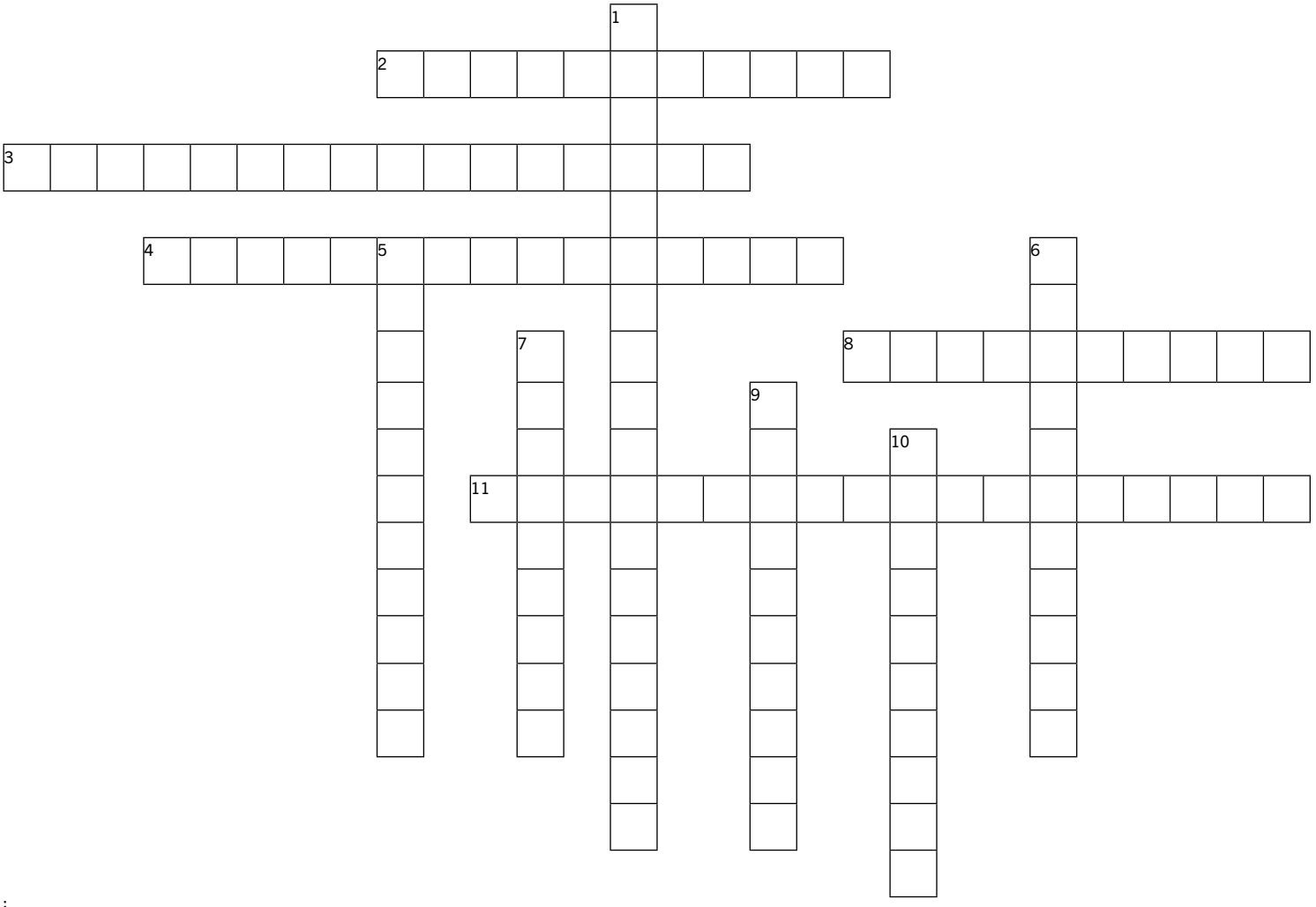
Agilisaurus	*Gallimimus*	*Tylocephale*
Allosaurus	*Iguanodon*	*Velociraptor*
Baryonyx	*Pachyrhinosaurus*	*Xenotarsosaurus*
Bradycneme	*Triceratops*	



Name Class Date

Level 2

Across	Down
2. swollen head	1. medium-spined lizard
3. lizard from Yang-Ch'uan	5. deceptive lizard
4. lizard with strange ankles	6. agile lizard
8. chicken mimic	7. iguana tooth
11. lizard with a thick head	9. lizard from Mount Emei
	10. dwarf lizard



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LOGIC PUZZLES

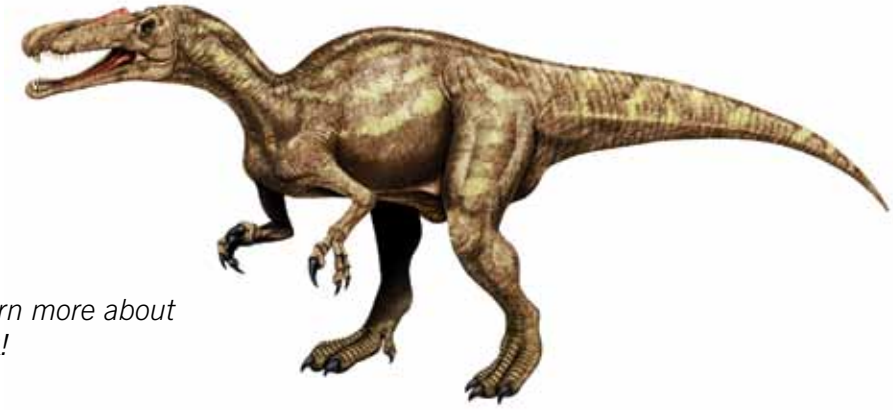
Logic puzzles are a fun way to practice critical thinking skills and key math concepts, while also learning more about some of the dinosaurs you may encounter during your field trip! The trick to solving a logic puzzle is to narrow down your options and use your deductive reasoning skills.

Start eliminating options by following the clues in the logic puzzle that clearly state if something is not true and placing an "X" in the appropriate box. Slowly but surely, you will begin narrowing down the possibilities. When you finish all the clues and still haven't completed the logic puzzle, read through the clues one at a time again. Once you make some basic deductions, you will be able to learn new things and come closer to solving the puzzle. Select Level 1 or Level 2 (or both!) and start thinking logically! Some clues have been marked to help you get started.

The remains of a "new" species of ceratopsia dinosaur, called* Mojoceratops*, were recently found mixed together in a collection with the fossils from a similar-looking dinosaur at the American Museum of Natural History in New York City!

Sorting Fossils

You are the newest intern at the local natural history and science museum. Your first task is to organize a storage room with fossils from different dinosaurs. Unfortunately, the paleontologists who recovered the fossils did not take very good field notes. The only facts you have about these fossils are listed below. Use the logic puzzle charts to help you identify and describe each dinosaur.



Solve the logic puzzles to learn more about the fossils from this Baryonyx*!*

Name Class Date

LEVEL 1

Clues:

1. *Parasaurolophus* did not come from China.

2. *Mamenchisaurus* is not from the Late Cretaceous Period.

3. The dinosaur from the Late Jurassic Period was from China.

4. The *Baryonyx* fossil was found in Europe.

5. The dinosaur that came from North America is not from the Early Cretaceous Period.

Chart:

	Late Jurassic	Late Cretaceous	Early Cretaceous	Europe	China	North America
Parasaurolophus					X	
Baryonyx						
Mamenchisaurus						
Europe						
China						
North America						

Name Class Date

LEVEL 2

Read this list of hints and tips to help you solve this advanced logic puzzle. Remember to narrow down your options using your critical thinking skills. Two clues have been marked on the puzzle to get you started. Good luck sorting through these fossils!

1. Read through the entire list of clues at least once before making any marks on your chart.

2. Eliminate options by following the clues, one by one, and looking for definitive statements. If a connection is stated explicitly in the clues, then mark it on the chart. For example, the first clue states that the dinosaur that is 4 feet long lived before *Apatosaurus*. Therefore, *Apatosaurus* cannot be the dinosaur that IS 4 feet long. Place an X in the box where the column for "*Apatosaurus*" intersects the row for "4 feet."

3. Mark all the obvious questions stated in the rest of the clues, the same way you did in the step above. For example, based on the information in clue #4, we can place an X in the box where the column for "30 feet" intersects the row for "Mongolia." We can also place Xs in the boxes where the columns for both "*Baryonyx*" and "*Agilisaurus*" intersect the row for "Mongolia."

4. Slowly but surely, you will begin narrowing down your fields. Some answers will become apparent as other options are eliminated. For example, after marking the obvious information from the clues the first time through, you will have all the pieces of information you need to identify "*Apatosaurus.*"

5. After all the clear connections have been made, re-read the list of clues, keeping in mind what you know now. For example, since we now know the name, length, location, and time period for "*Apatosaurus*," they become equivalent terms and are interchangeable within the wording of the clues. Any time one of them appears in a clue, you can replace it with one of the other aspects for the *Apatosaurus*.

6. Read back through the clues and use the substitution method from hint #5 every time you correctly connect two or more pieces of information. Replacing a term with one of its "equivalents" will reveal more information. For example, based on clue #9, you can substitute "Late Jurassic" in any clue where "70-foot dinosaur" is mentioned. Using that information in clue #5 tells us that the fossils from the Late Jurassic Period were found either in the US & Mexico or in Mongolia. Now, you also know you can place an "X" in the boxes where the column for "Late Jurassic" intersects the columns of the other two locations, China and Europe.

7. You will need to read through your clues many times. Be diligent! If you get stuck, check your chart to see if any connections have revealed themselves "accidentally" as you worked through the process of elimination. Look for tricky language in the clues, too, like "either/or" and "neither/nor."

Name Class Date

Clues:

1. The 4-foot dinosaur lived before *Apatosaurus*.

2. The 70-foot dinosaur lived before *Protoceratops*.

3. Of *Apatosaurus* and *Baryonyx*, one lived in the Late Jurassic Period and the other was 30 feet long.

4. The fossils found in Mongolia are not from a 30-foot dinosaur and are neither a *Baryonyx* nor *Agilisaurus*.

5. The 70-foot dinosaur is either from the US and Mexico or Mongolia.

6. *Apatosaurus* is neither 5 – 8 feet nor 30 feet long.

7. The dinosaur from the Early Cretaceous Period was found in Europe.

8. The fossils found in the US and Mexico do not belong to *Protoceratops*.

9. The dinosaur from the Late Jurassic Period is 70 feet long.

10. The fossils found in Mongolia are not from a 70-foot dinosaur.

Name Class Date

Chart:

	Apatosaurus	*Baryonyx*	*Protoceratops*	*Agilisaurus*	70 ft	30 ft	4 ft	5 – 8 ft	US and Mexico	Mongolia	China	Europe
Mid-Jurassic												
Late Jurassic												
Early Cretaceous												
Late Cretaceous												
US and Mexico												
Mongolia						X						
China												
Europe												
70 ft.												
30 ft.												
4 ft.	X											
5 – 8 ft.												

Name Class Date

WORD SEARCH

Dinosaur Vocabulary

Search vertically, horizontally and diagonally for dinosaur and paleontology terms in the puzzles. BONUS! Define each word in the puzzle. Hint: There is a glossary at the end of this Educator's Guide.

Lower Level:

ALXASAURUS	FEATHERS	MESOZOIC	TRACKWAY
CRETACEOUS	*GIGANTORAPTOR*	PALEONTOLOGIST	TRIASSIC
DINOSAUR	JURASSIC	PANGAEA	*VELOCIRAPTOR*

T	N	F	U	C	A	D	Z	X	C	H	R	K	R
S	S	G	C	R	E	T	A	C	E	O	U	S	O
A	Q	I	P	W	H	B	M	V	T	Y	W	G	T
P	L	H	G	Q	C	E	W	P	I	A	T	O	P
P	M	X	K	O	S	I	A	V	N	W	D	D	A
R	A	B	A	O	L	R	S	Q	M	K	N	B	R
A	N	N	Z	S	I	O	D	S	J	C	H	O	O
S	U	O	G	C	A	K	T	A	A	A	X	O	T
L	I	D	O	A	G	U	R	N	Z	R	I	O	N
C	Q	L	Y	E	E	Z	R	P	O	T	U	M	A
Q	E	V	O	C	I	A	H	U	Y	E	G	J	G
V	C	I	S	S	A	I	R	T	S	G	L	J	I
E	A	Q	N	F	E	A	T	H	E	R	S	A	G
A	D	I	N	O	S	A	U	R	P	D	H	D	P

Name Class Date

Level 2:

ALXASAURUS	JURASSIC	SAUROPOD
COPROLITE	MESOZOIC	*STEGOSAURUS*
CRETACEOUS	*MICRORAPTOR*	THEROPOD
DILOPHOSAURUS	ORNITHOPOD	TRACKWAY
FOSSILS	OVIPAROUS	TRIASSIC
GIGANTORAPTOR	*PARASAUROLOPHUS*	*TYRANNOSAURUS*

K	R	Q	F	B	D	X	K	C	L	R	R	D	G	M	O	C	T	T	T	Y	G
N	Z	O	G	O	E	P	D	I	L	O	P	H	O	S	A	U	R	U	S	C	S
O	O	I	T	S	S	H	S	U	H	P	O	L	O	R	U	A	S	A	R	A	P
R	B	S	O	P	E	S	A	F	Y	Y	F	T	A	L	C	F	J	H	B	I	S
E	E	U	A	R	A	D	I	O	O	G	N	P	G	K	R	Z	Z	F	E	H	U
I	R	E	A	U	F	R	C	L	O	I	T	R	W	P	J	P	T	D	H	J	R
U	O	V	I	P	A	R	O	U	S	O	U	A	V	L	R	N	G	B	O	D	U
H	B	W	A	D	I	U	P	R	R	S	Y	R	L	A	M	I	N	M	O	R	A
X	O	U	N	X	R	P	S	P	C	J	U	R	A	S	S	I	C	P	O	G	S
E	T	A	O	O	C	S	Q	I	D	I	O	G	F	R	U	T	O	T	C	T	O
C	I	S	S	A	I	R	T	S	O	V	M	N	Z	T	M	R	P	D	A	J	G
R	V	D	I	M	O	V	Y	Z	P	F	M	O	M	A	E	A	R	I	T	Z	E
E	C	M	A	Z	Z	Q	R	F	O	G	D	V	W	H	R	G	O	D	D	F	T
T	Z	Q	S	P	O	I	A	E	R	N	J	I	T	O	E	S	L	O	Y	N	S
A	C	E	X	S	S	Q	N	M	U	P	R	W	T	Q	V	U	I	P	E	K	B
C	B	T	P	L	E	I	N	Y	A	E	O	N	M	C	F	D	T	O	F	V	U
E	T	O	I	A	M	Q	O	A	S	K	A	Z	S	W	N	C	E	H	N	S	D
O	T	Q	E	X	A	S	S	G	Q	G	Z	H	J	E	G	B	T	T	H	B	Z
U	B	K	Q	N	Q	B	A	G	I	B	A	J	G	M	V	D	Q	I	O	T	M
S	N	D	M	C	F	N	U	G	T	R	T	Y	L	R	R	L	W	N	E	T	G
O	A	S	A	V	Y	K	R	V	H	M	V	R	J	W	B	D	T	R	F	J	C
X	E	I	T	O	G	A	U	Y	F	Q	R	W	M	G	X	Y	N	O	Y	D	A
H	A	L	A	L	X	A	S	A	U	R	U	S	A	E	I	Q	L	B	N	V	S

ANSWER KEYS

Field Trip Activity

1. *Irritator*
2 *Tyrannosaurus rex*
3. *Parasaurolophus*
4. *Mojoceratops*
5. *Herrerasaurus*
6. *Allosaurus*
7. *Kosmoceratops*
8. *Ruyangosaurus*
9. *Pachyrhinosaurus*
10. *Huayangosaurus*
11. Late Cretaceous
12. Colorado, Wyoming, Utah
13. Alberta
14. (in chronological order)

Herrerasaurus	Mid-Triassic	231.4 Mya
Allosaurus	Late Jurassic	150 Mya
Irritator	Early Cretaceous	110 Mya
Ruyangosaurus	Late Cretaceous	99.6 - 83.9 Mya
Kosmoceratops	Late Cretaceous	76.4 - 75.5 Mya
Mojoceratops	Late Cretaceous	75 - 74 Mya
Pachyrhinosaurus	Late Cretaceous	73.5 - 71 Mya
Parasaurolophus	Late Cretaceous	72 Mya
Tyrannosaurus rex	Late Cretaceous	65 Mya

Lesson 1: Form and Function

Activity 1: Elementary School (Grades K - 5)

1. Answers will vary 2. No

Activity 2: Middle and High School (Grades 6 - 12)

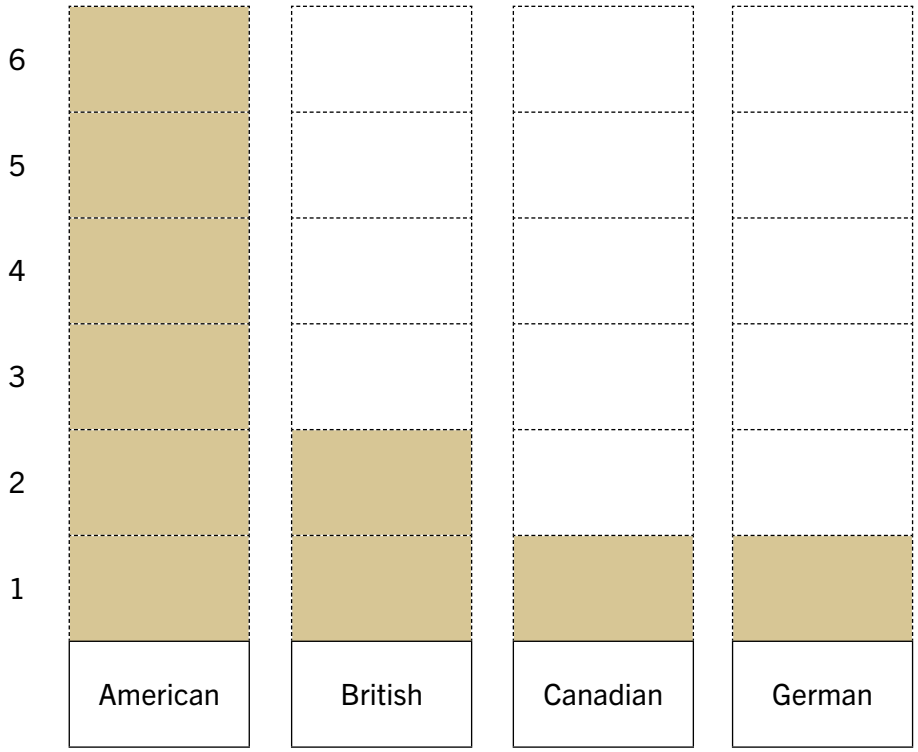
1. k 2. e 3. g 4. j 5. c 6. b 7. d 8. l 9. f 10. a 11. h 12. i 13. A large sauropod: *Apatosaurus*

Lesson 2: Dinosaur Detectives

Activity 1: Elementary School (Grades K - 5)

Name	Birth-Death	Nationality	Answers may vary: dinosaur names may include…
Roy C. Andrews	1884-1960	American	*Oviraptor, Velociraptor, Saurornithoides*
Barnum Brown	1873-1963	American	*Ankylosaurus, Corythosaurus, Leptoceratops, Saurolophus*
William Buckland	1784-1856	British	*Megalosaurus*
Edward D. Cope	1840-1897	American	*Camarasaurus, Coelophysis, Dimetrodon*
Lawrence M. Lambe	1849-1934	Canadian	*Chasmosaurus, Edmontosaurus, Euoplocephalus, Styracosaurus*
Joseph Leidy	1823-1891	American	*Hadrosaurus*
Gideon Mantell	1790-1852	British	*Iguanodon, Hylaeosaurus*
Othniel C. Marsh	1831-1899	American	*Allosaurus, Apatosaurus, Diplodocus, Stegosaurus, Triceratops*
Henry F. Osborn	1857-1935	American	*T. rex, Pentaceratops, Ornitholestes, Velociraptor*
Hermann von Meyer	1801-1869	German	*Archaeopteryx, Rhamphorhynchus, Plateosaurus*

1. William Buckland, 1784.
2. American.
3. Answers may vary. Best answers should suggest that more dinosaurs were found in America at that time than anywhere else.
4. Bar graph:



Activity 3: Middle and High School (Grades 6 - 12)

1. Physicist: described how an asteroid striking the Earth led to the dinosaurs' extinction.
2. Sculptor/artist: created the first dinosaur models and statues.
3. Geologist: proposed a geologic time scale, estimated the age of the Earth as old enough to include millions of years of dinosaurs.
4. Meteorologist/geologist: proposed the theory of continental drift (plate tectonics), which explains how the same dinosaurs are found on different continents.

Lesson 3: Mesozoic Math

Activity 1 : Elementary School (Grades K - 5)

1. *Baryonyx*
2. *Baryonyx, Parasaurolophus, Stegosaurus, Triceratops*
3. *Tyrannosaurus rex*

4. a) 132 m b) 435.6 ft
5. 24 ÷ 4 = 6
7 a) about 2 b) about 1½ c) about 1
8 a) 43.6 ft b) 29.7 ft c) 34.7 ft

9. Early Cretaceous, Mid-Jurassic
10 a) Late Jurassic b) 5/10 = ½ = 0.5 = 50%
11 a) 65,000,000 b) 6.5×10^7

Activity 2: Middle and High School (Grades 6 - 12)

1. 1/50
2. 3 feet
3. 40 feet, probably not

Lesson 4: Fossil Stories

Activity 1 : Elementary School (Grades K - 5)

1. Oldest is the Cleveland-Lloyd/Utah. Youngest is Pipestone Creek/Alberta.
2. 1929
3. Because it has many more fossils from carnivore dinosaurs than herbivore dinosaurs
4. Herbivores
5. *Allosaurus*
6. Al Lakusta, science teacher
7. *Pachyrhinosaurus*
8. The fossils are almost entirely from one species
9. A thick nose bone
10. Eggs
11. Dinosaurs
12. The fossils are gone because they were used by local people for medicine
13. Its neck and tail were shorter in relation to the rest of its huge body, when compared to earlier large sauropods.

Crossword Puzzles

Lower level

Across: 2. *Xenotarsosaurus* 3. *Velociraptor* 7. *Triceratops* 9. *Allosaurus* 10. *Bradycneme*
Down: 1. *Gallimimus* 4. *Agilisaurus* 5. *Pachyrhinosaurus* 6. *Baryonyx* 7. *Tylocephale* 8. *Iguanodon*

Upper Level

Across: 2. *Tylocephale* 3. *Yangchuanosaurus* 4. *Xenotarsosaurus* 8. *Gallimimus* 11. *Pachycephalosaurus*
Down: 1. *Metriacanthosaurus* 5. *Apatosaurus* 6. *Agilisaurus* 7. *Iguanadon* 9. *Omeisaurus* 10. *Nanosaurus*

Logic Puzzles

Lower level

Parasaurolophus – Late Cretaceous – North America
Baryonyx – Early Cretaceous – Europe
Mamenchisaurus – Late Jurassic – China

Upper level

Mid-Jurassic – *Agilisaurus* – 4 feet – China
Late Jurassic – *Apatosaurus* – 70 feet – US & Mexico
Early Cretaceous – *Baryonyx* – 30 feet – Europe
Late Cretaceous – *Protoceratops* – 5 - 8 feet – Mongolia

Word Searches

Lower Level

T	N	F	U	C	A	D	Z	X	C	H	R	K	R
S	S	G	C	R	E	T	A	C	E	O	U	S	O
A	Q	I	P	W	H	B	M	V	T	Y	W	G	T
P	L	H	G	Q	C	E	W	P	I	A	T	O	P
P	M	X	K	O	S	I	A	V	N	W	D	D	A
R	A	B	A	O	L	R	S	Q	M	K	N	B	R
A	N	N	Z	S	I	O	D	S	J	C	H	O	O
S	U	O	G	C	A	K	T	A	A	A	X	O	T
L	I	D	O	A	G	U	R	N	Z	R	I	O	N
C	Q	L	Y	E	E	Z	R	P	O	T	U	M	A
Q	E	V	O	C	I	A	H	U	Y	E	G	J	G
V	C	I	S	S	A	I	R	T	S	G	L	J	I
E	A	Q	N	F	E	A	T	H	E	R	S	A	G
A	D	I	N	O	S	A	U	R	P	D	H	D	P

Upper Level

K	R	Q	F	B	D	X	K	C	L	R	R	D	G	M	O	C	T	T	T	Y	G
N	Z	O	G	O	E	P	D	I	L	O	P	H	O	S	A	U	R	U	S	C	S
O	O	I	T	S	S	H	S	U	H	P	O	L	O	R	U	A	S	A	R	A	P
R	B	S	O	P	E	S	A	F	Y	Y	F	T	A	L	C	F	J	H	B	I	S
E	E	U	A	R	A	D	I	O	O	G	N	P	G	K	R	Z	Z	F	E	H	U
I	R	E	A	U	F	R	C	L	O	I	T	R	W	P	J	P	T	D	H	J	R
U	O	V	I	P	A	R	O	U	S	O	U	A	V	L	R	N	G	B	O	D	U
H	B	W	A	D	I	U	P	R	R	S	Y	R	L	A	M	I	N	M	O	R	A
X	O	U	N	X	R	P	S	P	C	J	U	R	A	S	S	I	C	P	O	G	S
E	T	A	O	O	C	S	Q	I	D	I	O	G	F	R	U	T	O	T	C	T	O
C	I	S	S	A	I	R	T	S	O	V	M	N	Z	T	M	R	P	D	A	J	G
R	V	D	I	M	O	V	Y	Z	P	F	M	O	M	A	E	A	R	I	T	Z	E
E	C	M	A	Z	Z	Q	R	F	O	G	D	V	W	H	R	G	O	D	D	F	T
T	Z	Q	S	P	O	I	A	E	R	N	J	I	T	O	E	S	L	O	Y	N	S
A	C	E	X	S	S	Q	N	M	U	P	R	W	T	Q	V	U	I	P	E	K	B
C	B	T	P	L	E	I	N	Y	A	E	O	N	M	C	F	D	T	O	F	V	U
E	T	O	I	A	M	Q	O	A	S	K	A	Z	S	W	N	C	E	H	N	S	D
O	T	Q	E	X	A	S	S	G	Q	G	Z	H	J	E	G	B	T	T	H	B	Z
U	B	K	Q	N	Q	B	A	G	I	B	A	J	G	M	V	D	Q	I	O	T	M
S	N	D	M	C	F	N	U	G	T	R	T	Y	L	R	R	L	W	N	E	T	G
O	A	S	A	V	Y	K	R	V	H	M	V	R	J	W	B	D	T	R	F	J	C
X	E	I	T	O	G	A	U	Y	F	Q	R	W	M	G	X	Y	N	O	Y	D	A
H	A	L	A	L	X	A	S	A	U	R	U	S	A	E	I	Q	L	B	N	V	S

RECOMMENDED READING

Consult these books to learn more about your favorite dinosaurs. Build your own dinosaur library to follow-up on what you learned during your field trip and explore the latest discoveries and theories in dinosaur research!

Ages 4 – 8

Hughes, Catherine D. *National Geographic Little Kids First Big Book of Dinosaurs*. National Geographic Children's Books, 2011.

Judge, Lita. *Born to be Giants: How Baby Dinosaurs Grew to Rule the World*. Flash Point, 2010.

Kudlinski, Kathleen V. *Boy, Were We Wrong About Dinosaurs!* Puffin, 2008.

Priddy, Roger. *My Big Dinosaur World*. Priddy Books, 2008.

Theodorou, Rod. *I Wonder Why Triceratops Had Horns*. Kingfisher, 2011.

Zoehfeld, Kathleen Wiedner. *Where did Dinosaurs Come From?* Collins, 2010.

Zoehfeld, Kathleen Wiedner. *Did Dinosaurs Have Feathers?* Collins, 2003.

Zoehfeld, Kathleen Wiedner. *National Geographic Readers: Dinosaurs*. National Geographic Children's Books, 2011.

Ages 9 – 12

Barrett, Paul. *National Geographic Dinosaurs*. National Geographic Children's Books, 2001.

Bishop, Nic. *Digging for Bird Dinosaurs: An Expedition to Madagascar (Scientists in the Field Series)*. Sandpiper, 2002.

Holmes, Thom. *Feathered Dinosaurs: The Origins of Birds*. Enslow, 2002.

Lambert, David. *Dinosaur (DK Eyewitness Books)*. DK Children, 2010.

Lessem, Don. *National Geographic Kids Ultimate Dinopedia: The Most Complete Dinosaur Reference Ever*. National Geographic Children's Books, 2010.

Manning Phillip. *Dinomummy*. Kingfisher, 2007.

Parker, Steve. *Age of Dinosaurs*. Natural History Museum, 2011.

Williams, Judith. *The Discovery and Mystery of a Dinosaur Named Jane*. Enslow, 2007.

Young Adult & Above

Brusatte, Steve & Michael Benton. *Dinosaurs*. Quercus, 2010.

Chen, Pei-ji, Yuan-ging Wang, & Mee-Mann Chang (eds). *The Jehol Fossils: The Emergence of Feathered Dinosaurs, Beaked Birds & Flowering Plants*. Academic Press, 2008.

Currie, Philip J. & Josh Long. *Dino Gangs*. Collins, 2011.

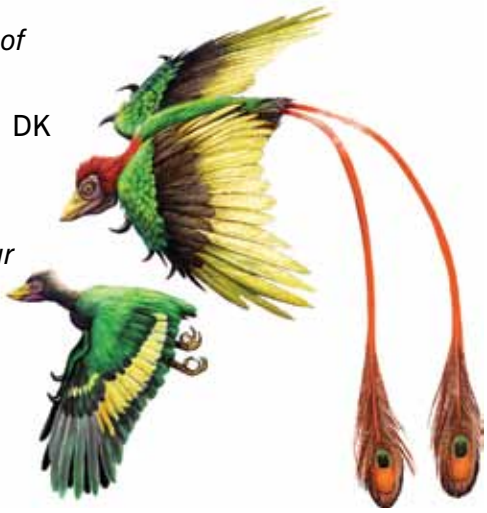
Haines, Tim & Paul Chambers. *The Complete Guide to Prehistoric Life*. Firefly Books, 2007.

Holtz, Thomas R. *Dinosaurs: The Most Complete, Up-to-Date Encyclopedia for Dinosaur Lovers of All Ages*. Random House Books for Young Readers, 2007.

Long, John. *Feathered Dinosaurs: The Origin of Birds*. Oxford University Press USA, 2008.

Nash, Darren. *The Great Dinosaur Discoveries*. University of California Press, 2009.

Sampson, Scott D. *Dinosaur Odyssey: Fossil Threads in the Web of Life*. University of California Press, 2011.



With the increase in new discoveries and theories about feathered dinosaurs, like Confuciusornis, *the transition between dinosaurs and birds is often discussed in recent dinosaur literature.*

DINOSAUR DATA

Do you want a crash course in paleontology? Here is what you need to know about some of the dinosaurs you will encounter on your field trip. Impress your friends and family as you rattle off these fascinating facts and figures!

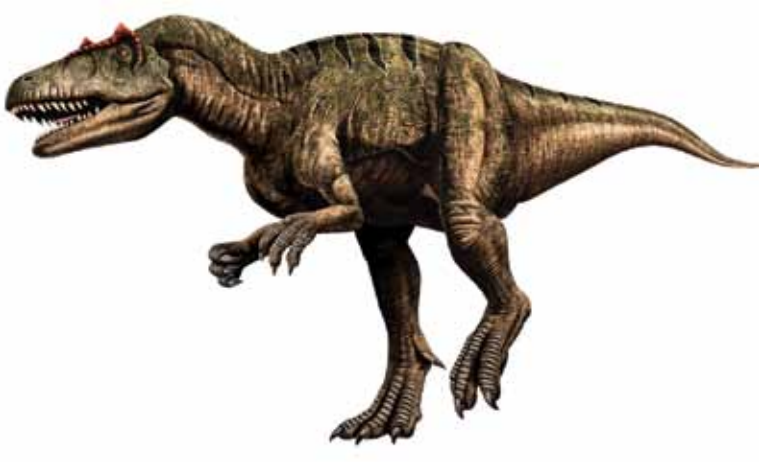
For each dinosaur, you will find the order, suborder, meaning of the name, how to pronounce the name, the period in which it lived, the locations where fossils have been found, the estimated length and height and the year in which that dinosaur was officially named. Each dinosaur also has three really great Quick Facts that you definitely want to check out.

Educators! Dinosaur Data can also be used as reference material in your classroom. Dig around and use this information for math and statistics exercises as well as additional lessons in geography (map the locations) and history (create a timeline of the years).

Come face-to-teeth with the life-sized Tyrannosaurus rex *at DINOSAURS ALIVE! exhibition designers hand-carve the models and the installation crew hand sews the separate pieces together using suture needles.*

ALLOSAURUS

Order: Saurischia
Suborder: Theropoda



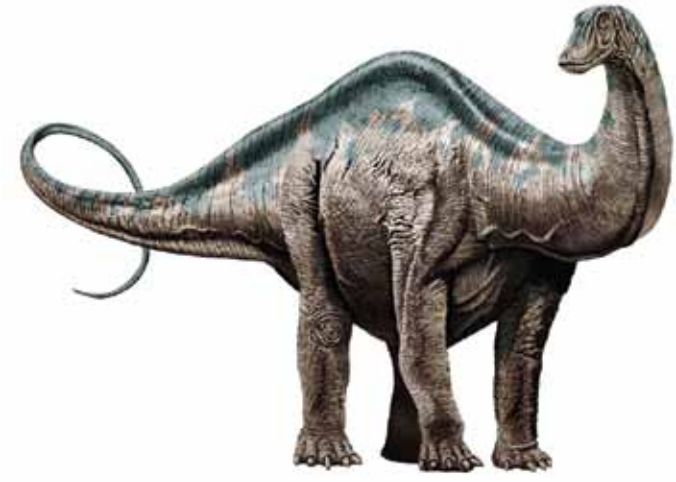
Means	Different lizard
Pronunciation	AL –uh-SOR-us
Period	Late Jurassic
Where	North America: USA – Montana, North Dakota, South Dakota, Nebraska, Kansas, Wyoming and Colorado; Europe: Portugal
Length	Up to 12 meters (39 feet)
Height	5 meters (16 feet)
Named in	1877

Quick Facts:

- A two-legged meat-eater, *Allosaurus* could open its jaws extra wide, like some modern snakes, to swallow huge chunks of meat.
- A fierce carnivore, *Allosaurus* used sharp, serrated teeth to slice through flesh.
- In the 1920s, the remains of 44 *Allosaurus* and several other dinosaurs were found together at the Cleveland-Lloyd Quarry in Utah.

APATOSAURUS

Order: Saurischia
Suborder: Sauropodomorpha



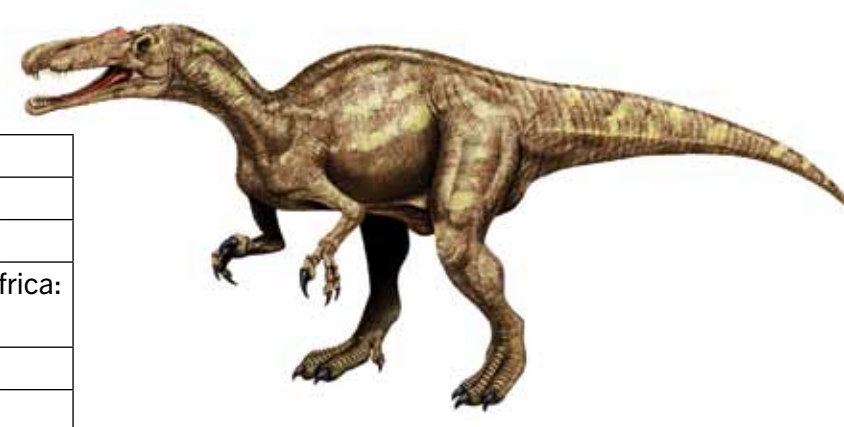
Means	Deceptive lizard
Pronunciation	uh-PAT-uh-SOAR-us
Period	Late Jurassic
Where	North America: USA – Wyoming, Utah, Colorado and Oklahoma
Length	23 meters (75 feet)
Height	4.5 meters (15 feet)
Named in	1877

Quick Facts:

- *Apatosaurus* ate huge amounts of plants each day: 200 kg or 440 lbs, which is the same as eating about 22 car tires every day.
- A young *Apatosaurus* grew quickly and could gain as much as 6 lbs per day.
- We used to think that because this animal was so huge, it must have spent most of its life in water just to support its weight. However, it is now believed to have lived mostly on land.

BARYONYX

Order: Saurischia
Suborder: Theropoda



Means	Heavy claw
Pronunciation	BEAR-ee-ON-ix
Period	Early Cretaceous
Where	Europe: England, Northern Spain; Africa: Morocco
Length	9 meters (30 feet)
Height	2 meters (6 feet)
Named in	1987

Quick Facts:

- Although *Baryonyx* was a true dinosaur, it was also very similar to crocodiles.
- *Baryonyx* was one of the few dinosaurs that fished. A fossil was found with a fossilized fish in its stomach.
- *Baryonyx*, with 64 teeth in its lower jaw and 32 larger teeth in its upper jaw, had about twice as many teeth as *Tyrannosaurus rex*.

DILOPHOSAURUS

Order: Saurischia
Suborder: Theropoda

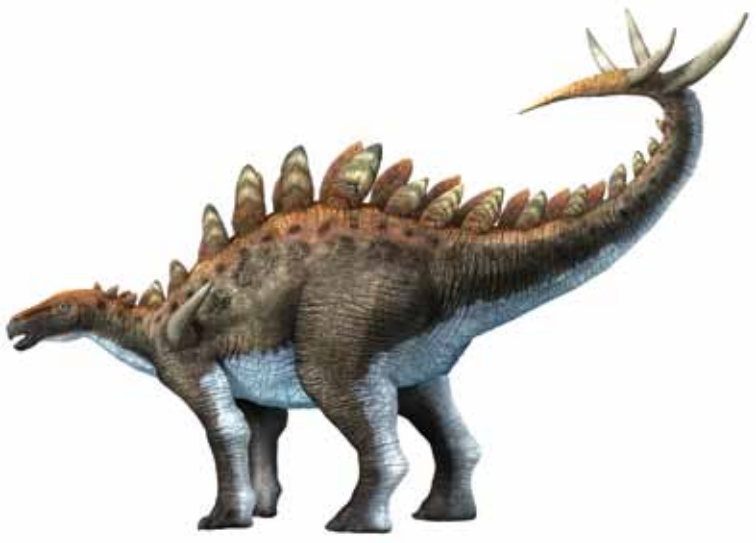
Means	Two-crested lizard
Pronunciation	die-LOF-uh-SOAR-us
Period	Early Jurassic
Where	North America: USA – Arizona; Asia: China
Length	6 meters (20 feet)
Height	2.4 meters (8 feet)
Named in	1.5 meters (5 feet)
Named in	1970

Quick Facts:

- In 1942, the first *Dilophosaurus* fossils were discovered by Sam Welles in Arizona.
- Other carnivorous dinosaurs living in the same time period included *Coelophysis* and *Syntarsus*, which were both smaller than *Dilophosaurus*.
- It had a dewclaw – a functionless, shorter digit or claw – on its back legs, similar to what you can see on some dogs, birds and reptiles today.

HUAYANGOSAURUS

Order: Ornithischia
Suborder: Thyreophora



Means	Huayang lizard
Pronunciation	hoi-YANG-uh-SAUR-us
Period	Mid - Jurassic
Where	Asia: China – Sichuan Province
Length	4 meters (13 feet)
Height	1.8 meters (6 feet)
Named in	1982

Quick Facts:

- The spiky plates on its back may have been for protection or to look attractive for a mate.
- Those large, spiny projections would have helped to regulate body temperature, by both collecting and dumping excess heat.
- "Huayang" is another name for Sichuan, the place in China where the *Huayangosaurus* was discovered.

MAMENCHISAURUS

Order: Saurischia
Suborder: Sauropodomorpha

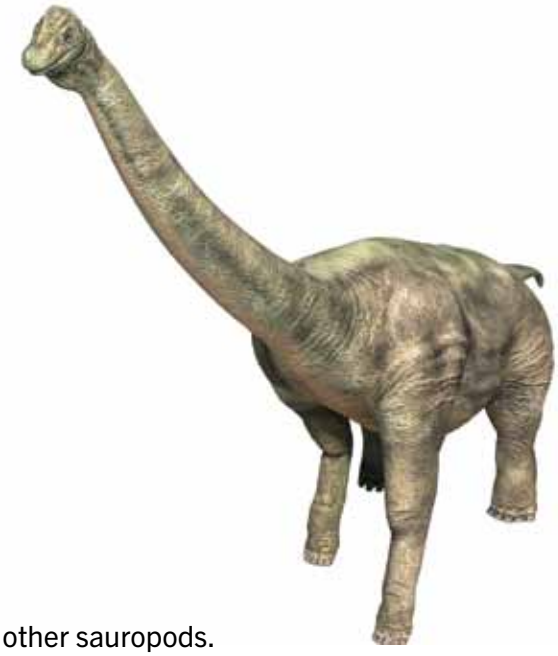
Means	Mamenchi lizard
Pronunciation	ma-MEN-chee-SOR-us
Period	Late Jurassic
Where	Asia: China – Sichuan Province
Length	Up to 24 meters (80 feet)
Height	3.3 meters (11 feet)
Named in	1954

Quick Facts:

- Scientists used to think *Mamenchisaurus* lived mainly in the water, floating its tiny head on top of the water and breathing through the nostrils on top of its snout. However, it is now believed to have lived on land.
- *Mamenchisaurus* was an herbivore and lived during a time when the Earth was very warm and wet – a great environment for growing plants.
- *Mamenchisaurus* was discovered by workers during construction on a highway bridge in 1954.

OMEISAURUS

Order: Saurischia
Suborder: Sauropodomorpha



Means	Mount Emei lizard
Pronunciation	oh-MY-ee-SOAR-us
Period	Late Jurassic
Where	Asia: China – Sichuan Province
Length	Up to 20 meters (66 feet)
Height	4 meters (13 feet)
Named in	1939

Quick Facts:

- *Omeisaurus's* nostrils were closer to the front of its snout than on other sauropods.
- Many models and pictures still show *Omeisaurus* the way paleontologists thought it looked before we learned it couldn't raise its neck and head that far up.
- The large, cervical (neck) vertebrae had a honeycomb structure – a little like the way bridges are built today – to keep them light but strong.

PARASAUROLOPHUS

Order: Ornithischia
Suborder: Ornithopoda

Means	Close-to-crested lizard
Pronunciation	PAIR-uh-so-ROL-uh-PHUS
Period	Late Cretaceous
Where	North America: USA – New Mexico, Utah; Canada – Alberta
Length	9 meters (30 feet)
Height	3 meters (10 feet)
Named in	1922

Quick Facts:

- At first, paleontologists thought this dinosaur may have lived in the water and used its crest like a snorkel!
- *Parasaurolophus* are known as the "cows of the Cretaceous" because there were so many of them and they lived in herds.
- *Parasaurolophus* seems to have had rough, bumpy, pebbly-textured skin.

STEGOSAURUS

Order: Ornithischia
Suborder: Thyreophora

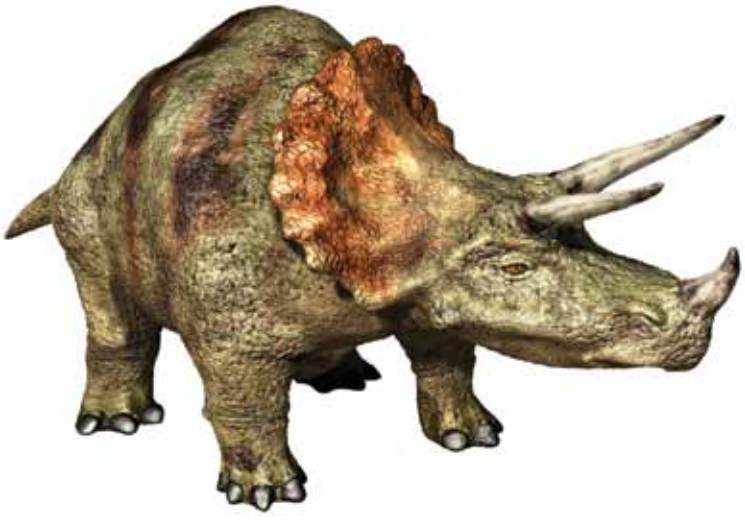
Means	Roof lizard
Pronunciation	STEG-o-sawr-us
Period	Late Jurassic
Where	North America: USA – Montana, North Dakota, South Dakota, Nebraska, Kansas, Wyoming and Colorado; Europe: Portugal
Length	9 meters (30 feet)
Height	4 meters (13 feet)
Named in	1877

Quick Facts:

- The plates on its back made the *Stegosaurus* look larger to its enemy and may have also discouraged attack by predators.
- *Stegosaurus* had five toes on its front feet, but only three on its back feet.
- Because its brain was so tiny, *Stegosaurus* was probably one of the least intelligent dinosaurs.

TRICERATOPS

Order: Ornithischia
Suborder: Marginocephalia



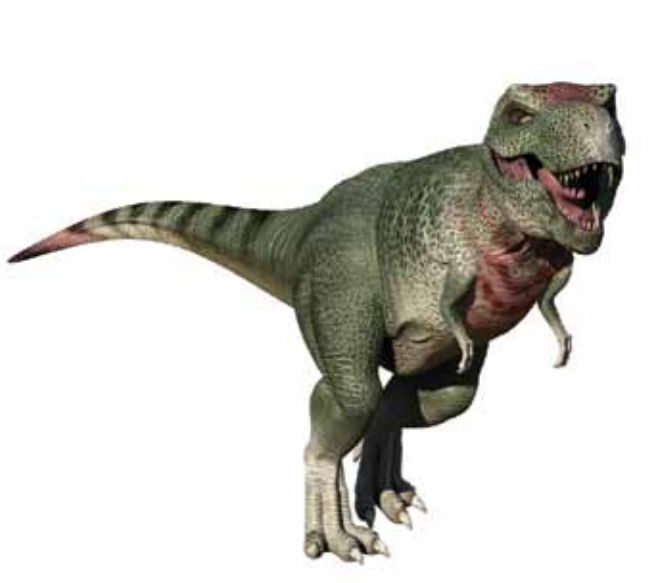
Means	Three-horned face
Pronunciation	try-SER-uh-TOPS
Period	Late Cretaceous
Where	North America: USA – Colorado, Montana, South Dakota and Wyoming; Canada – Alberta and Saskatchewan
Length	9 meters (30 feet)
Height	3 meters (10 feet)
Named in	1889

Quick Facts:

- The large neck frill on *Triceratops* probably helped keep its body temperature normal and protected it from predators like *Tyrannosaurus rex*.
- One *Triceratops* survived after a *Tyrannosaurus rex* bit off half of a horn!
- It's easy to look at *Triceratops* and see its resemblance to a modern rhinoceros, but they are not related. Rhinos are mammals.

TYRANNOSAURUS REX

Order: Saurischia
Suborder: Theropoda



Means	King of the tyrant lizards
Pronunciation	tuh-RAN-uh-SOR-us recks
Period	Late Cretaceous
Where	North America: USA – Colorado, Montana, South Dakota and Wyoming; Canada – Alberta
Length	Up to 13 meters (43 feet)
Height	4 meters (13 feet)
Named in	1905

Quick Facts:

- Usually it is impossible to know if a fossil came from a male or female, but one *Tyrannosaurus rex* was definitely a girl; a leg bone contained a special inner layer only found in female birds.
- A *Tyrannosaurus rex's* lower jaw could deliver 10,000 newtons of force – which is like being able to lift a semi-trailer with your mouth!
- *T. rex* of all ages have been found together, which means this dinosaur was possibly not the solitary predator living alone, as is often shown.

YANGCHUANOSAURUS

Order: Ornithischia
Suborder: Marginocephalia

Means	Yang-chuan lizard
Pronunciation	yang-chew ON-uh-SOR-us
Period	Late Jurassic
Where	Asia: China – Sichuan Province
Length	10 meters (33 feet)
Height	4.5 meters (15 feet)
Named in	1978

Quick Facts:

- *Yangchuanosaurus* is the largest Late Jurassic predator ever found in China so far.
- By comparing the size of its brain to the weight of its body, *Yangchuanosaurus* seems to have been fairly intelligent for a dinosaur.
- This dinosaur lived in the same time and place as the giant sauropods *Omeisaurus* and *Mamenchisaurus*.

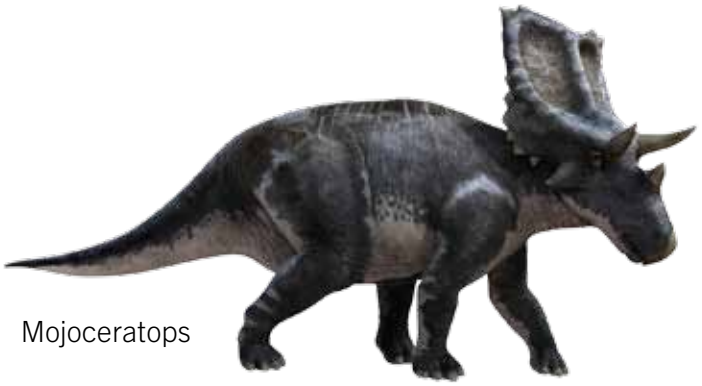
DISCOVERING DINOSAURS

Fascinating Facts

You can adapt these fun facts about dinosaurs for trivia contests, Jeopardy and Bingo games or a Dinosaur Fact-of-the-Day calendar. They are divided into three categories. "Species Specifics" contains information about particular kinds of dinosaurs. "Finding Fossils" lists interesting facts about finding and studying fossils. Finally, "Dinosaur Domain" describes fascinating details about dinosaurs living and adapting in their world for millions of years.

Species Specifics

- Although *Stegosaurus* was about the size of a bus, it had a small head (the size of a horse's head) and a brain that was only the size of a walnut!
- *Ankylosaurus* was one of the last dinosaurs to go extinct, probably because of its heavy armor and slow metabolism.
- In 1925, *Allosaurus* was featured in the movie The Lost World, the first full-length dinosaur movie – making it the first movie-star dinosaur.
- Not all sauropods were gigantic behemoths like *Argentinosaurus* (30 - 36 meters, or 98 - 118 feet) or had incredibly long necks like *Mamenchisaurus*. Some, like *Magyarosaurus*, found in Romania in 2005, were "small" at only 5.3 meters (17 feet) long.
- One of the largest complete dinosaurs ever discovered was *Brachiosaurus* ("arm lizard") which was 82 feet (two large school buses) long and 42 feet (a 4 story building) tall.
- One of the most intelligent dinosaurs was *Troodon*. It had a brain the size of a mammal or bird of today, plus stereoscopic (binocular) vision and grasping hands.
- One of the smaller dinosaurs was only slightly larger than a chicken. *Compsognathus* ("pretty jaw") was 3 feet long and weighed about 6.5 pounds.
- The biggest carnivores were theropods from the Cretaceous Period, such as *Tyrannosaurus rex*.
- The dinosaur *Gasosaurus* was named for the gas company under construction in the area when it was discovered in the Dashanpu Quarry.
- The dinosaur once known as "*Brontosaurus*" no longer exists! It was actually the sauropod *Apatosaurus* with a *Camarasaurus* skull incorrectly attached to the skeleton.
- The dinosaur with the longest name is *Micropachycephalosaurus*, which means "tiny, thick-headed lizard".
- The fierce *T. rex* began life as a fuzzy, feathered baby.
- The first dinosaur to be named was *Megalosaurus*, in 1824 by Reverend William Buckland.
- When the first *Triceratops* was discovered, scientists classified it as something similar to a buffalo, not a dinosaur.
- The remains of a "new" species of ceratopsia (horned-face) dinosaur, *Mojoceratops*, were recently found mixed in with a collection of fossils from a similar-looking dinosaur at the American Museum of Natural History in New York City.



Mojoceratops

Finding Fossils

- Ancient traditional Chinese medicines that called for "dragon bones" were actually using the fossilized bones of a titanosaur sauropod from the early Late Cretaceous Period!
- In the 1970s, a fossil was found in the Gobi desert of a *Protoceratops* and a *Velociraptor* fighting.
- Over 700 different species of dinosaurs have been identified and named based on fossil evidence. However, paleontologists believe that there are many more new and different dinosaur species still to be discovered.

Velociraptor

- At the Dashanpu Quarry in China, scientists are working in an area that may contain the single greatest concentration of dinosaur fossils ever.
- Dinosaur fossils have been found in 35 US states and on every continent.
- In the 1800s, coprolite (fossilized dinosaur dung) was mined in England for fertilizer. During WWI, coprolite was used in the making of munitions.
- More *Allosaurus* fossils have been found than for any other dinosaurs so far.
- The first decade of the 21st century has seen rogue fossil hunters steal everything from a set of 30 theropod footprints in England to hundreds of eggs from China and Mongolia.
- The term dinosaur ("terrible lizard") was created by the English anatomist Sir Richard Owen in the early 1840's when fossil hunting was growing in popularity.
- The only dinosaurs we can know about are the ones that leave fossils, but fossilization is a very rare process.
- When the first dinosaurs lived, the Earth's land was formed into one big super continent called Pangaea, which is why we find fossils from the same dinosaurs on more than one continent.
- The first entire dinosaur skeleton fossil was found in New Jersey in 1858.
- Only about 3% of dinosaur fossils found are from carnivores.

Dinosaur Domain

- Before dinosaurs first evolved about 230 million years ago, the dominant land reptiles were archosaurs ("ruling lizards") and therapsids ("mammal-like reptiles"). For the next 20 million years after the first dinosaurs appeared, the most fearsome reptiles were crocodiles, not dinosaurs.
- Dinosaurs and modern birds share over 90 anatomical features, including the neck, wrist bones and breastbone.
- *Hadrosaur* nests have been found complete with fossils of babies. The babies have slightly worn teeth, suggesting that they were probably fed by their parents.
- *Hadrosaurs*, often called duck-billed dinosaurs, were the only dinosaurs to develop cheeks and they also had more teeth than any other dinosaurs.
- Most dinosaurs were herbivores, meaning that they ate plants.
- Sauropods had more phalanges (digits, like fingers or toes) on their "feet" than on their "hands."
- Some ankylosaurid dinosaurs were so heavily covered with armored plates that they even had armored eyelids.
- Some dinosaurs had replaceable teeth; when a tooth was lost or broken, another one grew in to take its place.
- Some scientists think that the growth rates of theropods show a pattern much closer to other animals that are warm-blooded, not cold-blooded.
- The biggest dinosaurs were sauropods – gigantic, slow-moving, small-headed herbivores from the Late Jurassic and Cretaceous Periods.
- Various dinosaurs lived on Earth for about 165 million years. Humans have only been around for about 1 million years.

GLOSSARY

animatronics	Using technology to animate motorized models.
apex	Top-most, highest-ranking.
Appalachia	During the Cretaceous Period, the eastern area of the landmass that would become the continent of North America.
archosaurs	The "ruling reptiles" group including dinosaurs, crocodiles and pterosaurs.
avian	Bird-like.
binocular vision	The ability to maintain focus on an object with both eyes, creating a single visual image and indicating depth perception.
bi-pedalism	Walking on two feet; a form of terrestrial locomotion where an organism moves on its two rear limbs, or legs. An animal that usually moves in a bi-pedal manner is known as a biped, meaning "two feet."
bonebed	A layer of rock with a very large number of fossils often formed when floods or volcanic eruptions quickly overwhelmed groups of dinosaurs.
Bone Wars	A period of intense rivalry between two paleontologists (Edward Drinker Cope and Othniel Charles Marsh) at the end of the 19th century to see who could collect the most fossils and identify the most new species of dinosaurs.
carcass	Dead body of an animal.
carnivore	An animal that feeds on the flesh of other animals.
cervical	Pertaining to the neck.
Chicxulub Crater	Ancient impact crater beneath the Yucatan Peninsula in Mexico created approximately 65 million years ago, believed to have begun a series of global events and climate changes leading to the dinosaurs' extinction.
cladistic analysis	Biological systematics that classify organisms into hierarchical groups, based on the branchings of different groups from a common ancestor.
Cleveland-Lloyd Quarry	A National Natural Landmark in the San Rafael Swell near Cleveland, Utah. It contains the densest concentration of Jurassic dinosaur fossils found thus far.
cold-blooded	Animals that rely upon the outside temperature to regulate their body temperature.
convergent evolution	When unrelated species develop similar biological traits; for example, wings in bats and birds, or facial horns in a *Rhinoceros* and *Triceratops*.
coprolite	Fossilized dinosaur dung.
Cretaceous Era	145 to 65 million years ago.
Dashanpu Quarry	A site in the Sichuan Province of China where many dinosaur fossils, including seven species of theropods, ten species of sauropods, four stegosaurs, and a pterosaur, have been found.
digit	Finger or toe.
dinosaur	Literal meaning is "terrible lizard". Dinosaurs, which lived millions of years ago, were one of several kinds of prehistoric reptiles that lived during the Mesozoic Era.

evolution	Change in the genetic composition of a population during successive generations, as a result of natural selection of the genetic variation among individuals, and resulting in the development of new species.
excavate	To dig in the earth carefully in order to find buried objects, such as skeletons.
extant	Still alive, not extinct.
extinct	The ceasing to exist of a species, such as a plant or animal, whose numbers declined to the point where the last member of the species died and no new members of the species could ever again be born. Species become extinct when they are unable to adapt to changes in the environment or compete effectively with other organisms.
field gear	Equipment needed by dinosaur hunters ranging from simple hand tools such as hammers, chisels and shovels to earth-moving equipment such as bulldozers and trucks.
field jackets	Plaster-soaked burlap "bandages" — much like a cast which protects a broken arm — that keep fragile fossil pieces together and stable during transport to the laboratory.
fossil	"Having been dug up." The remains of a living thing which has been buried in the ground, replaced by minerals and turned to stone.
furcula	The "wishbone" found in birds, formed by the fusing of the two clavicles, which has also been found in theropods.
gastroliths	Stomach stones that aided with digestion in some herbivores; gizzard stones.
Gondwana	Large landmass formed from the continents that would become South America, Africa, Australia, and Antarctica.
herbivore	An animal that eats plants.
holotype	The specimen or sample used in the original description of a species.
ichnite	Fossilized footprint.
Jurassic Era	200 to 145 million years ago.
juvenile	Young, not fully grown.
Laramadia	During the Cretaceous Period, the western area of the landmass that would become the continent of North America.
Laurasia	Large landmass formed from the continents that would become North America, Europe and Asia.
mammal	Any of a class of warm-blooded higher vertebrates that nourish their young with milk, secreted by mammary glands, have the skin usually more or less covered with hair, and includes humans.
mass extinction	The process in which huge numbers of species die out suddenly. The dinosaurs (and many other species) became extinct, possibly because of an asteroid that hit the earth.
medullary bone	A type of soft tissue found in the leg bones of present-day female birds only during ovulation.
Mesozoic Era	This era ("The Age of Reptiles") occurred from 250 to 65 million years ago. It is divided into the Triassic, Jurassic and Cretaceous Periods, when dinosaurs, mammals and flowering plants evolved.
Mya	Million years ago. Also can be written as "mya".

natural selection	A process whereby helpful traits (those that increase the chance of survival and reproduction) become more common in a population while harmful traits become increasingly rare. Individuals with advantageous traits are more likely to survive and reproduce, resulting in more individuals of the next generation inheriting those traits.
nostrils	The holes in the nose through which air passes during breathing.
omnivore	An animal that feeds on everything.
ornithopod	Bird-hipped dinosaurs. All these dinosaurs were herbivores.
oviparous	Reproduction by producing eggs that hatch outside of the body.
paleontologist	A scientist who deals with the life of past geological periods as known by fossil remains.
Pangea	The global supercontinent formed during the Paleozoic Era, which eventually separated and formed the continents we recognize today.
permineralization	When mineral-rich groundwater permeates a cell or plant wall and deposits minerals in the spaces that once held gas or liquid in the living organism.
predator	An animal that hunts, catches and eats other animals (the prey).
prehistoric	The time before humans began to record events.
preparators	Lab workers who prepare fossils for future examination and use.
prey	An animal that is hunted and eaten by other animals.
protofeathers	"First feathers" or the filament-like precursors to feathers that some dinosaurs had.
pterosaur	"Winged lizards" who had an elongated fourth finger that supported a membranous wing. First evolved in the latter third of the Triassic Period and survived until the end of the Cretaceous. These animals were not dinosaurs but were closely related to both dinosaurs and crocodiles.
quadrupedalism	A form of animal locomotion with four limbs or legs. An animal that usually moves this way is known as a quadruped, meaning "four feet".
reptiles	A class of air-breathing scaly bodied vertebrates including alligators and crocodiles, lizards, snakes, turtles and extinct related forms (like dinosaurs and pterosaurs) that lay eggs which are fertilized internally.
sauropod	Lizard-hipped/footed, quadruped dinosaurs, such as diplodocids, brachiosaurids and titanosaurs. These dinosaurs were herbivores and were some of the largest animals ever to live on land.
scute	A bony plate embedded in the skin, found on armored dinosaurs and on the legs of modern birds; made of the same keratin protein found in feathers.
sedimentary rock	Rock formed from layers of sediment like mud, silt and sand carried by water, ice and wind; it is a kind of rock where fossils are found.
serrated	Sharp and jagged, notched, or saw-like.
snout	The nose, jaw and front part of the face on an animal's head.
theropod	Beast-footed dinosaurs, including allosaurs, tyrannosaurs and oviraptors. All of these dinosaurs were carnivores.
trace fossils	Fossils of footprints, eggshells, nests and droppings.
trackways	Paths of footprint fossils.

Triassic Period	250 to 200 million years ago.
vertebrae	The bone segments in the spine.
Western Interior Seaway	During the Cretaceous Period, the shallow, inland sea dividing the continent that would become North America.

NATIONAL CURRICULUM STANDARDS

Science

K-4

Science As Inquiry: Abilities necessary to do scientific inquiry

Life Science: Life cycles of organisms

Earth And Space Science: Changes in earth and sky

Science And Technology: Abilities of technological design; Understanding about science and technology

History Of Nature And Science: Science as a human endeavor

5-8

Science As Inquiry: Abilities necessary to do scientific inquiry

Life Science: Diversity and adaptations of organisms

Earth And Space Science: Earth's history

Science And Technology: Abilities of technological design; Understanding about science and technology

History And Nature Of Science: Science as a human endeavor; History of science

9-12

Science As Inquiry: Abilities necessary to do scientific inquiry

Life Science: Behavior of organisms

Earth And Space Science: Origin and evolution of the earth system

Science And Technology: Abilities of technological design; Understanding about science and technology

History And Nature Of Science: Science as a human endeavor; Historical perspectives

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Technology

1. Creativity and Innovation

c. use models and simulations to explore complex systems and issues.

3. Research and Information Fluency

b. locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.

d. process data and report results.

4. Critical Thinking, Problem Solving, and Decision Making

b. plan and manage activities to develop a solution or complete a project.

c. collect and analyze data to identify solutions and/or make informed decisions.

Mathematics

Number and Operations

- Understand numbers, ways of representing numbers, relationships among numbers, and number systems
- Understand meanings of operations and how they relate to one another
- Compute fluently and make reasonable estimates

Algebra

- Use mathematical models to represent and understand quantitative relationships

Geometry

- Apply transformations and use symmetry to analyze mathematical situations
- Use visualization, spatial reasoning, and geometric modeling to solve problems

Measurement

- Understand measurable attributes of objects and the units, systems, and processes of measurement
- Apply appropriate techniques, tools, and formulas to determine measurements.

Data Analysis and Probability

- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them
- Select and use appropriate statistical methods to analyze data

Process

- Reasoning and proof
- Connections

Geography

Physical Systems: Understand the physical processes that shape the patterns of Earth's surface.

The Uses of Geography: Understand how to apply geography to interpret the past.