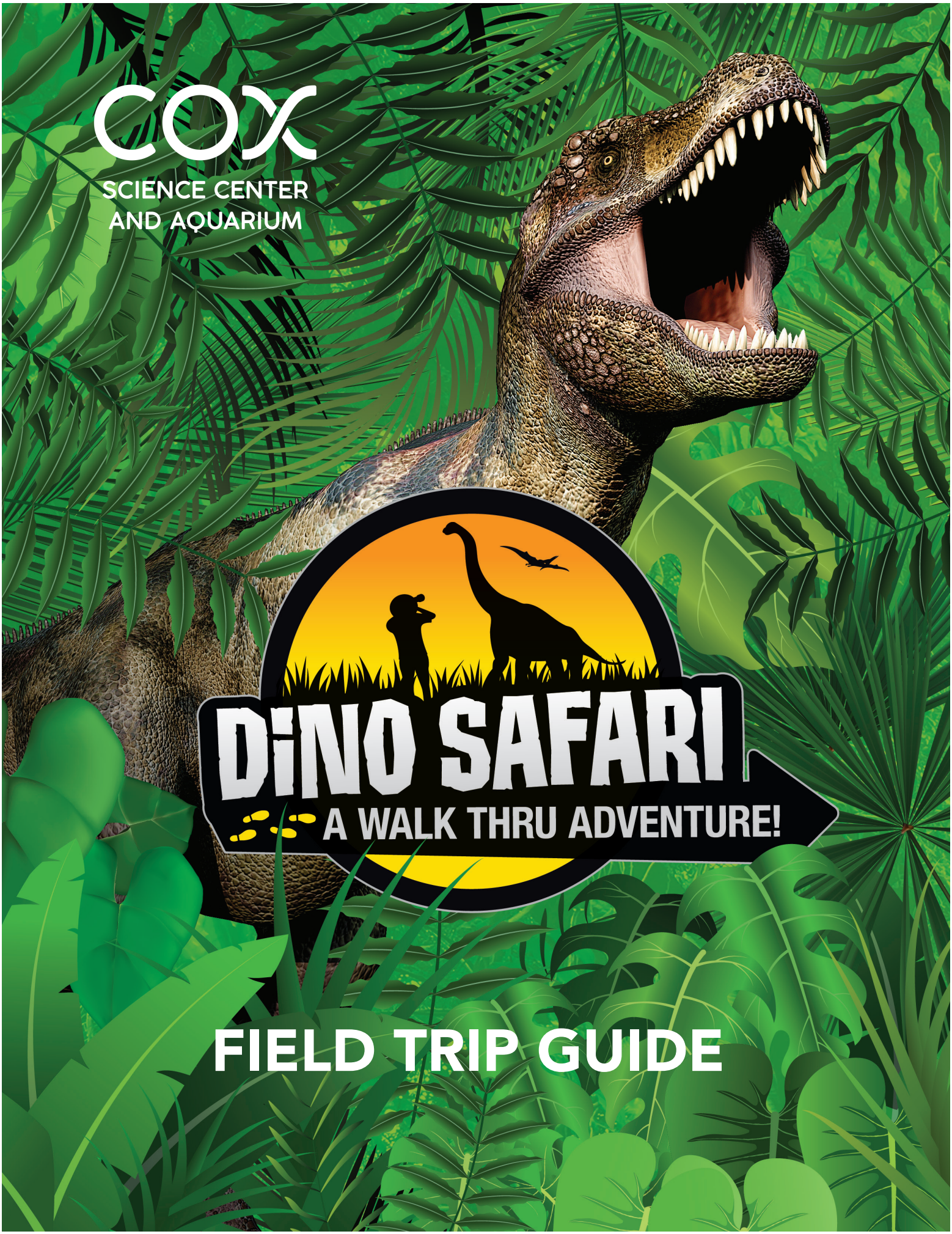

COX
SCIENCE CENTER
AND AQUARIUM
DINO SAFARI
A WALK THRU ADVENTURE!
FIELD TRIP GUIDE

Fellow Educators,

Thank you for your interest in the Cox Science Center and Aquarium (CSCA). We look forward to meeting with you and your classes while you explore our exciting new exhibit, Dino Safari.

This Field Trip Guide is designed to enhance your Science Center experience by helping you and your students prepare for your visit. This guide will answer questions such as: how long you can expect to spend at the Science Center and where you can eat your lunch. As you know, by preparing students in advance for their trip, they will better focus on the science content. Additionally, this guide includes some quick and fun activities to further enhance the educational experiences offered by the exhibit.

Have additional questions? Please call our Group Sales Coordinator at (561) 832-2026. It is our sincere hope that your experience embodies our mission to "Open Every Mind to Science." We'll see you at the Science Center!

Sincerely,

The Education Team

Cox Science Center and Aquarium

COX SCIENCE CENTER AND AQUARIUM

Table of Contents

Pricing and Policies

Pricing

Pricing for groups scheduled in advance

Self-guided visit admission per student……..……..$12

Visit plus a planetarium show per student…….....$17

Visit plus a demonstration per student…….....$19

Visit plus a laboratory program per student……..……..…..$20-$27

*One chaperone is required per 10 students at $10 per chaperone up to a maximum of one chaperone per 5 students. Extar chaperones will be charged the Adult Group admission rate of $23. Chaperone admissions must be paid as part of the group booking; they will not be allowed to pay separately.

Policies

- Reservations must be made at least 14 days in advance.
- A 20% deposit is required 14 days before your visit.
- Final payment must be made by the day of your scheduled visit.
- If final payment has not been received by the day of your visit, reservations are subject to cancellation. NO REFUNDS WILL BE GRANTED.
- On the day of your scheduled visit, check in your group at the Front Desk under your group/ contact name. Additional tickets may be purchased at the group rate on the day of your scheduled visit, if space is available.
- Increase in headcount should be called in as soon as possible to ensure availability.
- Acceptable forms of payment are check, money order, or credit card (Visa and Master Card).
- Please make checks payable to the *Cox Science Center and Aquarium* and mail to:

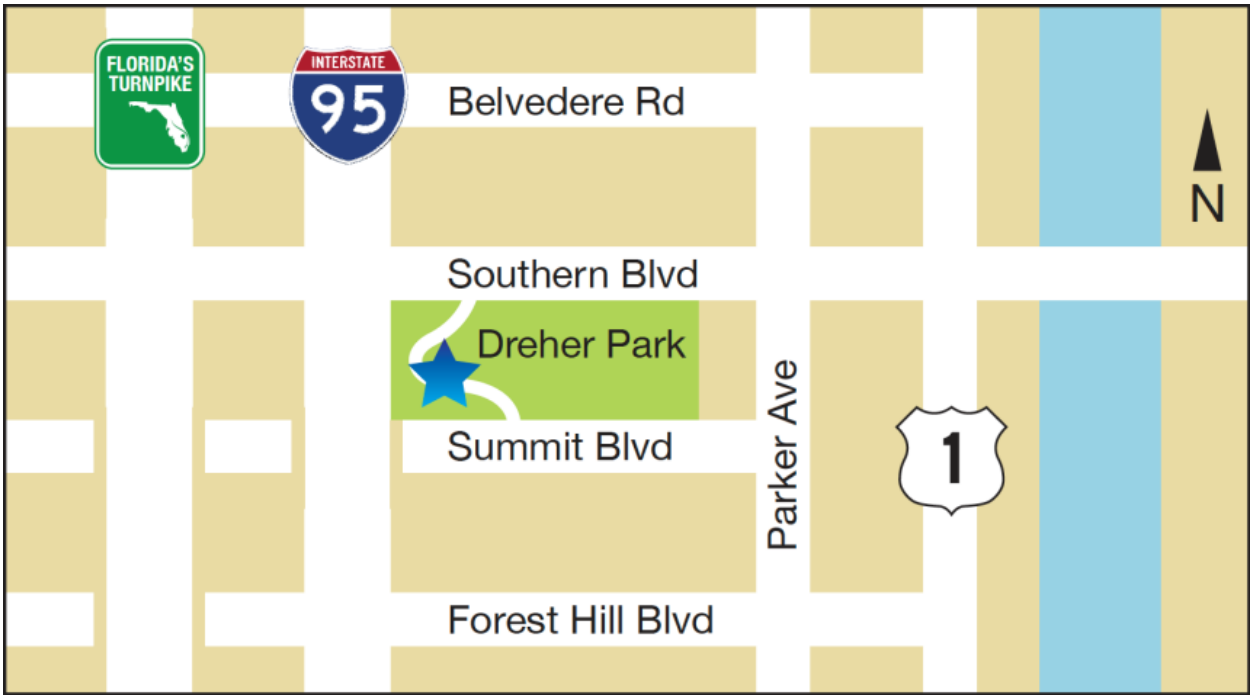
  Cox Science Center and Aquarium
  Attention: Group Sales
  4801 Dreher Trail North
  West Palm Beach, FL 33405

- Surcharges may apply for special event days and holidays.
- Science center memberships, coupons and other discounts are not applicable with school group rates.
- Teacher Members receive $25.00 off first program booked only

Directions and Map

The Cox Science Center and Aquarium is located at:

4801 Dreher Trail North,
West Palm Beach, FL 33405.
Phone: (561) 832-1988



From the Florida Turnpike:

Take the Southern Boulevard exit 97 east, and continue just past I-95. Make a right into Dreher Park. Follow Dreher Trail to the Cox Science Center.

From I-95, heading south:

Take exit 68, Southern Boulevard and head east. Immediately over the I-95 bridge, make a right into Dreher Park. Follow Dreher Trail to the Cox Science Center.

From I-95, heading north:

Take exit 68, Forest Hill Boulevard east to Parker Avenue. Turn left on Parker Avenue (north) to Summit Boulevard. Turn right on Summit (west). At the first light (Dreher Trail North), turn right and continue around to the Cox Science Center.

Science Center Manners

PLEASE REVIEW THESE GUIDELINES WITH YOUR STUDENTS BEFORE YOU ARRIVE AT THE SCIENCE CENTER.

- Please walk, do not run, while in the Science Center. This is for your safety, as well as the safety of others.
- Please do not touch the glass on any exhibits, including the aquarium.
- Please enjoy yourselves and the hands-on exhibits, but leave them the way you found them.
- Please keep eating and drinking to the patio and picnic areas outdoors.
- Please have students remain with their chaperone at all times.
- Chaperones, please refrain from using your phones while supervising students at the Science Center.
- Violation of the rules could result in your group being asked to leave the Science Center.
- No refunds will be given.
- Groups are not allowed in the Engineers on a Roll area

Science Center Store Rules

- Students must be accompanied by a chaperone while in the gift shop. Please do not allow more than 5 children per chaperone in the store at one time.
- All sales are final, so please choose carefully.

What to Do at the Science Center

Arrival

Welcome! Once you arrive at the Science Center, have students either remain on the bus or line up on the patio space leading up to the front doors. Have your group leader check in at the front desk and get directions on where to go first. One of our CSCA staff members will welcome and orient your group as a whole.

Programs

Favorite programs such as planetarium shows, labs, and demonstrations can be scheduled for a small fee to be added in with your field trip. Call (561) 832-2026 in advance to schedule.

Lunch

Picnic tables are available on the Science Trail or you can eat within Dreher Park, surrounding the Science Center. Snacks are available for purchase at the snack bar located in the main exhibit hall.

Exhibits

There are many exciting exhibits to explore at the CSCA:

Aquariums of the Atlantic

See marine life from around the world in over 10,000 gallons of salt and fresh water aquariums. A living coral reef, sharks, eels, the invasive lion fish and a "touch tank" create this wonderful undersea exhibit hall.

Travel through Florida's diverse ecosystems of Everglades, Coral Reefs, Gulf Stream, and Open Ocean, home to the most beautiful native fish such as queen angels, lookdowns, moray eels, stingrays, seahorses and many more.

The Hidden World of the Everglades

Experience the Florida Everglades ecosystem and listen to sounds of Florida's wildlife in their natural habitat in this interactive exhibit about America's only sub-tropical wilderness.

River of Grass

Find out where our water comes from as you follow a drop of water from the Everglades to your faucet in this interactive display.

Florida Conservation Station

This learning station brings to life the immense variety of life in Florida and the complex relationships among living things. Visitors become real world biologists at these learning stations that include hands-on experiments and research activities.

Frozen Shadows

Lights, Action! 'Freeze' your shadow on the wall while you experience the effects of phosphorescence.

Marvin Dekelboum Planetarium

Palm Beach County's only public planetarium features a full-dome, newly renovated digital projection system. Sit back and be transported through the Universe with daily star shows, interactive astronomy presentations and other immersive science adventures. It's only $5 more per adult/child visitor to book as a group.

Nano Exhibit

Nano is an interactive exhibition that engages family audiences in nanoscale science, engineering, and technology. Visitors will be able to build a giant model of a carbon nanotube, explore progressively smaller magnetic materials, and explore the relative effects of static electricity and gravity using the Static vs. Gravity discs.

Hands and Minds on Science

Explore the basic principles of science with hands-on displays representing the states of matter, including solid, liquid, gas, and plasma displays. Continue through the gallery for more basic principles of electricity revealed through conversion machines and Jacob's Ladder.

Out of This World

Part of the Ambassadors of Space Exploration, the Science Center was honored by Apollo 14 Astronaut Dr. Edgar Mitchell with a long-term loan of an authentic Moon rock collected during the Fra Mauro expedition. This exhibit also features a Mars rock found in Nigeria in 1962, a 232 pound meteorite.

Mitchell was the Lunar Module Pilot on NASA's 3rd Moon expedition where Mitchell became the 6th man to walk on the Moon. Authentic mission footage accompanies this rare display.

Brain Teasers

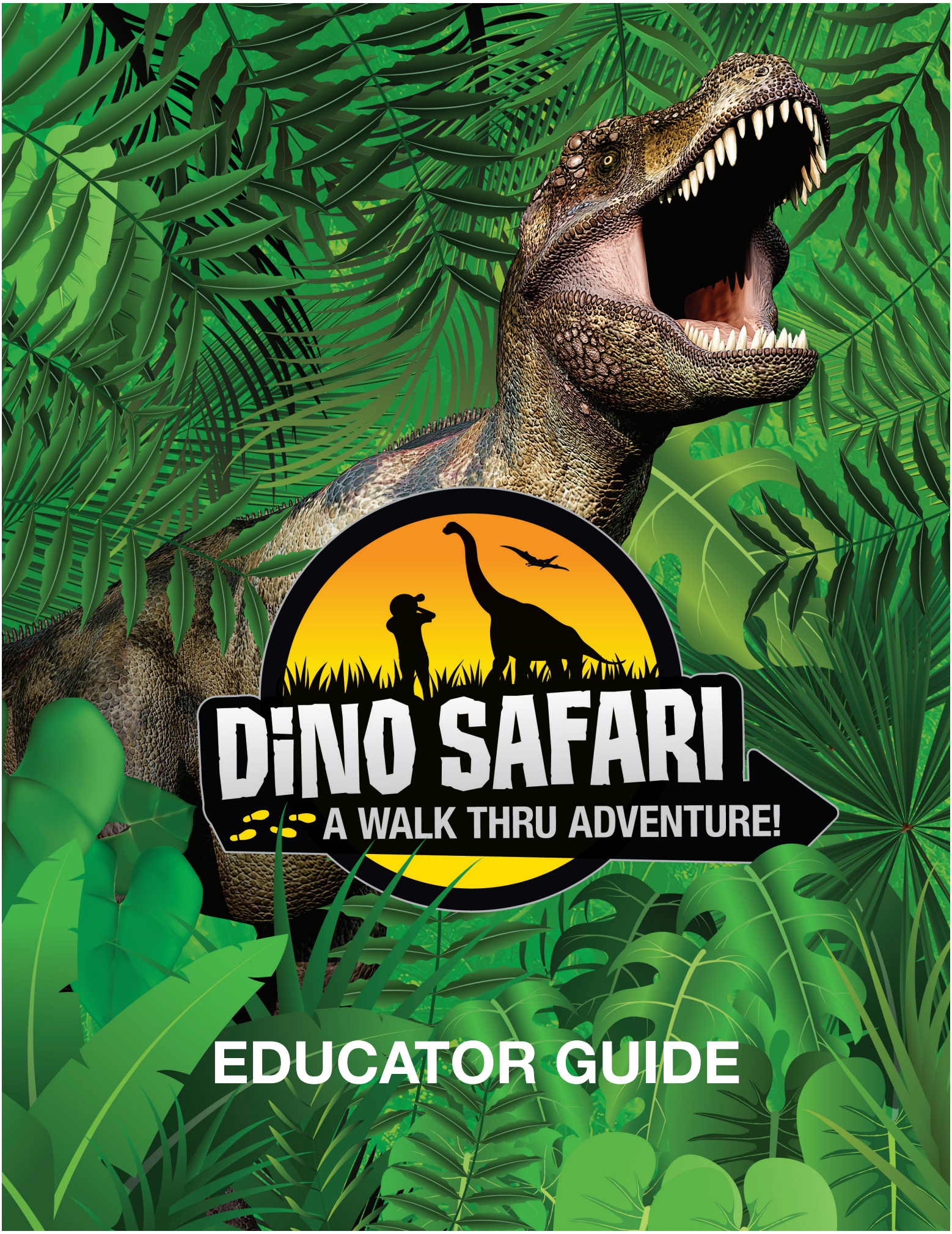
Exercise your mind with puzzling challenges for all ages!

Hurricane Simulator

Have you ever experienced hurricane force winds? In our Discovery Hall, dial up the winds of a Category 1 Hurricane and see the 78 mph wind make your skin crawl! Visitors can also learn how to better protect their lives and property, and what to do once the storm has passed. The booth uses video, audio and high wind speed to make you feel like you are right in the storm! .

Fisher Family Science Trail

Enjoy the outdoors while continuing your science exploration! The upgraded quarter-mile trail connects 15 new exhibits, including a Physics Forest, FPL *SolarScape*, splash pad, gem panning station, shark tooth dig pit, a dinosaur walk, picnic areas and much more! **School/group reservations may not use the splash pad*


DINO SAFARI
A WALK THRU ADVENTURE!
EDUCATOR GUIDE

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DINO SAFARI Educator Guide

Introduction to the Exhibition

Imagine yourself in a time when dinosaurs roamed the Earth and all seven continents were joined together to form one huge super landmass called Pangea. Then imagine you are on a 172 million year journey to witness the breakup of Pangea, the evolution of hundreds of species of dinosaurs, and the eventual downfall of the Age of Reptiles. This is DINO SAFARI. .

DINO SAFARI is not just a showcase of dinosaurs but an educational tool for teaching students about geology, evolution, ecology and much more. Visit the DINO SAFARI website for more information

.

Included in This Guide

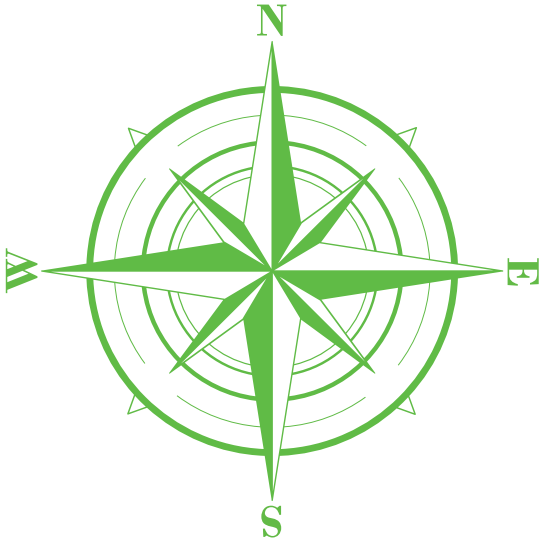
To engage with the exhibition, teachers can choose what will best fit students' needs and interests.
This guide contains:

- A brief overview of each continent gallery
- Essential questions to ask students while touring the exhibition.
- Eleven lesson plans with hands-on activities, many of which can be completed at school or while visiting the exhibition, including:
    - Debriefing questions to help students reflect on the lessons
    - Grade level adaptations for more or less complex lessons that allow teachers to modify activities to all levels.

Stem

In Class

At Venue



Next Generation Science Standards

Next Generation Science Standards (NGSS) were used to structure this guide. DINO SAFARI and NGSS both embrace the concepts of 21st century skills and integration. Each activity in this guide in based on NGSS Cross Cutting Concepts. The NGSS outlines seven Cross Cutting Concepts present at all levels of science. Each of these concepts is clearly reflected within DINO SAFARI.

NGSS Cross Cutting Concepts

1. **Patterns**
   - Do you see any similarities among the dinosaurs in this exhibition?
   - Do dinosaurs from different continents have similar characteristics?

2. **Cause and effect: Mechanism and explanation**
   - What caused Pangea to break apart? What was the effect?
   - What caused the dinosaurs to go extinct? What was the effect?

3. **Scale, proportion, and quantity**
   - In terms of the life of the Earth, how long were dinosaurs alive on Earth?
   - Are all dinosaurs giant? If not, why are some big and some small?

4. **Systems and system models**
   - Do the adaptations of the dinosaurs in this exhibition relate to the adaptations we see in animals today? If so, how do they relate?
   - What is the connection between the size and climate of a continent and the type of dinosaurs that evolved on it?

5. **Energy and matter: Flows, cycles, and conservation**
   - How did a disruption of the flow of energy through the dinosaur's food chain cause their extinction?
   - How did the size of the dinosaurs affect their diet? Does a dinosaur's diet affect it's size?

6. **Structure and function**
   - What new adaptations did dinosaurs develop to survive on different continents?
   - What were the specific functions of these new adaptions?

7. **Stability and change**
   - How did geology affect the evolution of dinosaurs?
   - Would dinosaurs be able to survive in today's climate?
   - Why are Earth's specida constantly evolving?

The Exhibition

There are nine galleries in DINO SAFARI, each highlighting the characteristics of the dinosaurs on each of today's seven different continents. This guide provides an overview of each gallery with an accompanying lesson plan for each.

PANGEA: The Original Super Continent

Overview

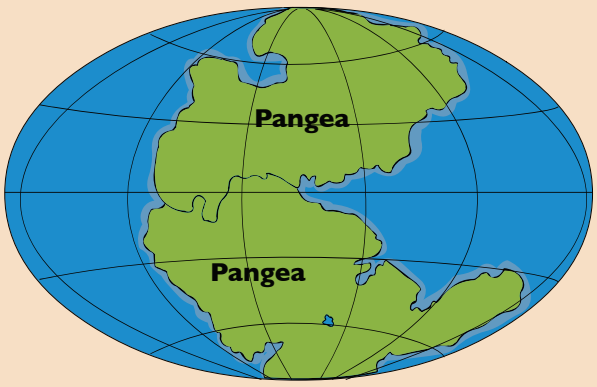
270 million years ago, our planet looked very different than it does today. It was more like an alien landscape with a different climate, plants, and animals. At that time, all seven of Earth's continents as we know them today (North America, South America, Asia, Europe, Africa, Australia, and Antarctica) were part of a single giant landmass—a supercontinent called Pangea. On Pangea, everything was interconnected. If it happened on Pangea, it really stayed on Pangea.

238 million years ago, a new type of creature emerged on Pangea, one that would forever change the makeup of animal communities on the planet—the dinosaurs! Although initially few in number and small by dinosaur standards (no more than 15 feet in length), these early carnivores and herbivores possessed a unique set of attributes that would aid in their domination of nearly all terrestrial ecosystems for more than 170 million years!

Dinosaur Spotlight

One of the earliest dinosaurs, *Herrerasaurus* was a bipedal predator with a long, stiff tail, three main fingers, and sharp, serrated teeth. Its flexible lower jaw helped it to grasp prey. Its long legs and hollow bones suggest it was a fast runner. Bite marks on the skulls of these animals show that they often battled one another, presumably over food or mates. The earliest forms were small, about 10-feet long, later growing up to 20-feet in length. The rare *Herrerasaurus* was discovered in 1991 in the Ischigualasto Formation of Argentina.

PANGEA ESSENTIAL QUESTIONS



What is a dinosaur? How are they similar or different than animals alive today?

How did having all the continents together in one huge landmass change the environment?

How do continents move? What causes them to move and what are the effects?

Pangea Activity 1: Puzzle Pangea

Cross Cutting Concept: Stability and Change

In Class **Stem**

Overview

Before dinosaurs evolved, all of the landmasses on Earth came together to create the super continent called Pangea. The word Pangea comes from the Greek words Pan meaning "entire" and Gaia meaning "Mother Earth." Pangea had enormous impacts on Earth's environment and the subsequent evolution of animals. In this activity, students will use cutouts of Earth's current continents and arrange them to form Pangea. They will then compare the characteristics of Pangea with the alignment of today's continents. Students will measure the lengths of coastlines and the latitudes of the landmasses to identify some of the differences between Pangea and Earth today. This activity helps students visualize how the continents came together and split apart, as well as the impact the moving continents had on climate and life forms.

Exhibit Connection

The Pangea gallery explains the mechanism of plate tectonics and discusses the type of environment that existed 270 million years ago.

Materials

Puzzle Pangea Handout, ruler, scissors, marker, string

Procedure

- ✔ Give students materials and explain that they will be examining some of the differences between Earth 270 million years ago and Earth today.
- ✔ Ask students to review the handout and discuss what they notice. Explain that they are looking at Pangea—the super continent that existed 270 million years ago. Ask students to explain what might be different if the Earth was like this today.
- ✔ Using a ruler, have students put a dot on their string every ½ centimeter.
- ✔ Have students place the string on the map so that it traces Pangea's shoreline. Measure the total length of the shoreline and record findings on the handout.
- ✔ Have students estimate the percent of Pangea that is above the Tropic of Cancer, below the Tropic of Capricorn and between the Tropic of Cancer and the Tropic of Capricorn. Record findings on the handout.
- ✔ Have students cut out each of the colored landmasses of Pangea. Using the image of modern Earth as a guide, have students place the continents close to where they currently are on the blank map of Earth.
- ✔ Have students measure the total coastline of all the continents and record on the handout.

(Continued on page 7)

Pangea Activity 1: Puzzle Pangea

Procedure (continued from page 6)

- ✔ Have students estimate the percent of the total landmass that is above the Tropic of Cancer, below the Tropic of Capricorn and between the Tropic of Cancer and Tropic of Capricorn. Ask students to record their findings on the handout.
- ✔ Have students review their data table—what do they notice? Are the numbers very different? If so—what does that mean? How would this effect climate? Ask students to discuss with partners.

Debrief

Have students share their findings with the entire class. Discuss what they think was different on Earth 270 million years ago compared to now. What are the implications of having more or less coastlines? Why does it matter what latitude land is on? Ask students to explain how we know that the Earth once featured the landmass of Pangea and ask how we know that the continents move. Ask students to explain their understanding of *how* and *why* the continents are still moving today.

Grade Level Adaptations

More Advanced

Have students accurately measure the percent of land above and below the Tropics. Have students create new "puzzle" pieces with accurately shaped pieces of the current continents.

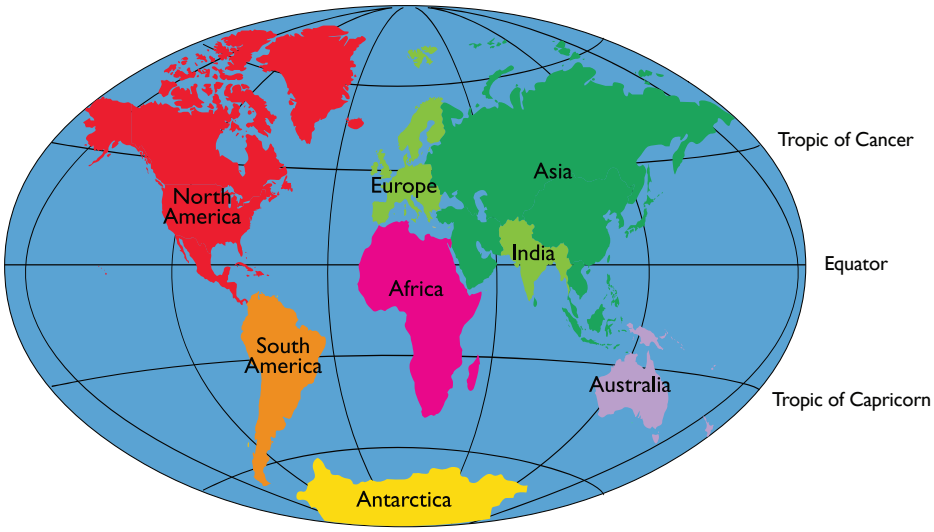
Less Advanced

Do not have students record precise measurements. To discuss shoreline lengths, have students use one string to measure Pangea and another to measure the modern continents to compare their lengths.

PUZZLE PANGEA HANDOUT

Procedure:

- ✔ Using your ruler and a marker, put a dot on the string every ½ centimeter.
- ✔ Place the string on the map so that it traces Pangea's shoreline. Measure the total length of the shoreline and record your findings on the table.
- ✔ Estimate the percent of Pangea that is above the Tropic of Cancer. Estimate the percentage of Pangea that is below the Tropic of Capricorn, and estimate the distance between the Tropic of Cancer and the Tropic of Capricorn. Record your findings on table.
- ✔ Cut out each of the colored landmasses on Pangea. Using the illustration of the modern Earth to the right as a guide, place the continents where they currently are on the blank map of Earth.

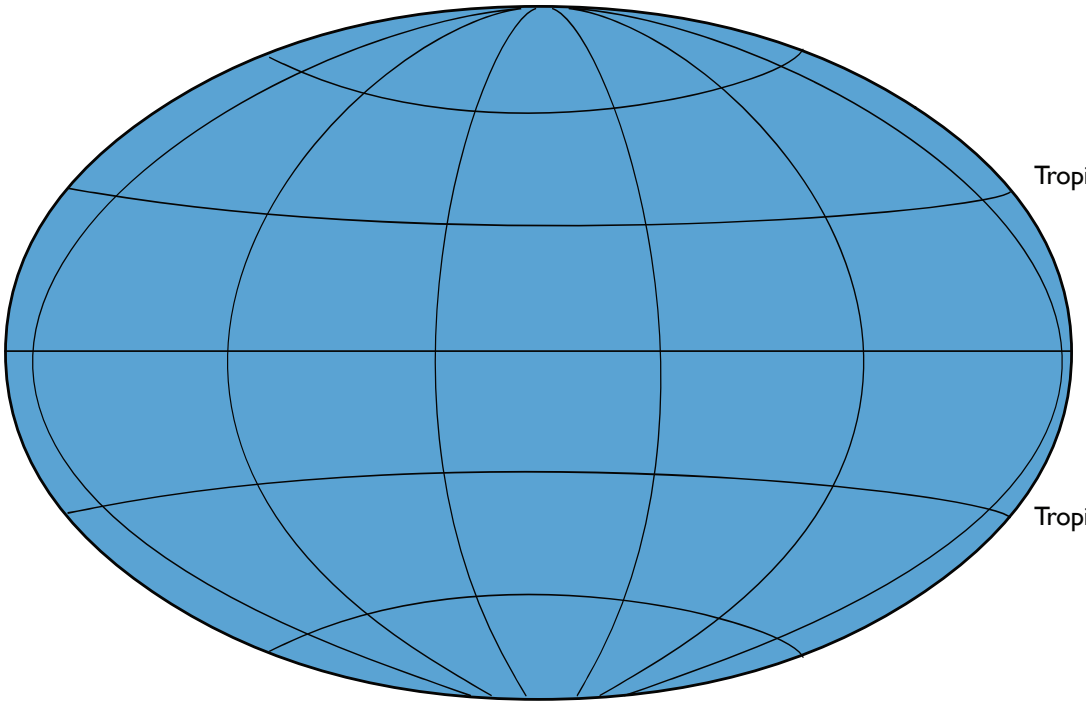


- ✔ Using your string, measure the total coastline of all the continents where they are today and record that measurement in the table.
- ✔ Estimate the percent of the total landmass that is above the Tropic of Cancer, below the Tropic of Capricorn and between the Tropic of Cancer and Tropic of Capricorn. Record your findings in the table.
- ✔ Review your data table—what do you notice? Are the numbers very different? If so—what does that mean? How would this affect the climate? Turn to a partner and discuss.

	Total Coastline	Percent of land that is above and below the Tropics of Cancer and Capricorn	Percent of land that is between the Tropics of Cancer and Capricorn
Pangea			
Modern Earth			
Difference			

PUZZLE PANGEA HANDOUT

EARTH



PANGEA
270 Million Years Ago

Pangea Activity 2: What is a Dinosaur?

Cross Cutting Concept: Patterns

Stem **At Venue**

Overview

Are dinosaurs extinct? It all depends on what a dinosaur actually is. Is it a reptile? Is it a bird or a mammal or something different? For this activity, students will use their prior knowledge to answer questions about some key characteristics of animals they already know. Then, while exploring the exhibition, they will answer the same questions about dinosaurs to help them better understand what dinosaurs are.

Exhibit Connection

Throughout the exhibition, and particularly in the Pangea gallery, the concept of "dinosaurs" is explained. The evolution of dinosaurs, how they cross-populated, and the similarities and differences in regards to the animals of today is explored.

Materials

What is a Dinosaur? Handout

Procedure

- ✔ Tell students that they will soon visit the DINO SAFARI exhibition but must first answer the question "What is a Dinosaur?"
- ✔ As a class, have students explain what they think a dinosaur is. During this discussion, be sure to ask if dinosaurs are reptiles, or birds, or neither. Are they warm blooded? Do they lay eggs?
- ✔ Pass out the "What is a Dinosaur?" handout and have students answer the questions about mammals, birds and reptiles in groups.
- ✔ Review each group's answers as a class and ensure that students record the correct answers on their handouts.
- ✔ Either individually or in groups, have students make predictions about the same questions regarding dinosaurs, and record the students' predictions on their handouts.
- ✔ While touring the exhibition, have students search for the correct answers to the questions about dinosaurs and have them record their answers on their handouts.

Pangea Activity 2: What is a Dinosaur?

Debrief

After returning to school, ask students to share their findings and ask them what answers, if any, were a surprise. Discuss what they learned and conclude by asking the students, "After all of our research, what is a dinosaur?" Discuss that the answer to this question is complex and not universally agreed upon. However, the point of this activity is not to find the answer, but for students to start asking questions to make sense of what they've learned.

Grade Level Adaptations

More Advanced

Have students create and investigate more questions on the back of their handout. For example, they can either add new types of animals (fish, amphibians) or new questions (do they care for their young, do they have the same mate for life?)

Less Advanced

Answer questions and make predictions as a group.

WHAT IS A DINOSAUR? HANDOUT

Procedure:

✔ Answer the following questions about reptiles, mammals, and birds by marking yes (Y), no (N) or I don't know (IDK)

QUESTIONS	REPTILE	MAMMAL	BIRD	DINOSAUR	
				PREDICTION	ACTUAL
Does this animal have scales?					
Does this animal have feathers?					
Does this animal have fur?					
Does this animal lay eggs?					
Does this animal give live birth?					
Is this animal warm blooded?					
Is this animal cold blooded?					
Does this animal have a tail?					
Does this animal walk on 2 legs?					
Other: Create your own questions on the back of this sheet!					

SOUTH AMERICA: The Birthplace of the Fearfully-Great Reptiles and Land of the Super-Giants

Overview

During the late Triassic Period, South America was part of the supercontinent of Pangea. Near the lush tropical shores of the supercontinent, a new form of life appeared—dinosaurs! The first dinosaurs were small by dinosaur standards. They were between 3 and 15 feet in length and included bipedal carnivores such as *Herrerasaurus*, bipedal omnivores such as *Eoraptor* and *Pisanosaurus*, and long-necked, bipedal (two-legged) herbivores such as *Saturnalia*. These relatively small dinosaurs, born in what would later become South America, gave rise to all other dinosaurs, many of which grew to tremendous sizes.

Dinosaur Spotlight

Amargasaurus was one of the smallest sauropod dinosaurs at just 33 feet (its relatives could reach 140 feet!). It had a quadrupedal (four-legged) stance. Using its neck, it could feed on plants low to the ground and high in trees. Its most notable features were tall spines along its neck. These spines were most likely for display to fellow *Amargasaurus*, much like crests seen on the backs of reptiles today. It is unclear if there was skin between the spines; this remains a topic of debate among paleontologists. Like most dinosaurs, *Amargasaurus* is known from a single specimen discovered in Argentina.

SOUTH AMERICA ESSENTIAL QUESTIONS

What were the main factors that led to the evolution of dinosaurs?

What was unique about the South American environment and what was unique about its dinosaurs?

How did volcanoes and geology influence dinosaur evolution?

South America Activity 1: Build It and They Will Come

Cross Cutting Concept: Cause and effect: Mechanism and explanation

In Class **Stem**

Overview

Genetic diversity is the key to any species' ability to survive and flourish. During the late Triassic period, dinosaurs where "born" in modern day South America and they were able to quickly evolve into many different species. This was, in part, because of the land bridge that existed at the time between North America and South America that allowed animals from both continents to mix. In this activity, students will model how the formation of a land bridge can help to increase genetic diversity and how increasing genetic diversity helps populations survive.

Exhibit Connection

Many of the exhibition's galleries explore how increasing or decreasing isolation affected various dinosaurs' evolution. This activity will help students understand the importance of genetic diversity and how the position of the continents impacts the way things evolve.

Materials

Genetic Diversity Cards and Color Gene (alleles) Cutouts

Procedure

- ✔ Cut out the Genetic Diversity Cards and Colored Gene (alleles) Cutouts. These cutouts represent alleles, but to simplify concepts for elementary school students, we call them "genes" in this activity.
- ✔ Ask students "What are genes?" Then ask students what diversity means and ask that they try to explain what genetic diversity is. Tell students that they are going to model the importance of genetic diversity by modeling the construction of the land bridge that existed between North America and South America from the late Triassic period.
- ✔ Separate the students into two groups and have them stand on separate sides of the room. Tell one group to represent the dinosaurs in South America and the other group to represent the dinosaurs of North America.
- ✔ Pass out the Genetic Diversity Cards to each student and explain that the cards will tell them the color of their skin. Explain that each of them will have 2 genes (alleles) and the color of those genes will determine their skin color (phenotype).
- ✔ Randomly give the North American group either blue or yellow genes (alleles) and the South American group either blue or red genes (alleles). Use an equal number for each.

(continued on page 15)

South America Activity 1: Build It and They Will Come

Procedure (contined from page 14)

- ✔ On the board, draw the chart below and mark how many students are in each group.

Outcome (phenotype)	Generation 1	Generation 2	Generation 3	Land bridge	Generation 4	Generation 5	Generation 6
Yellow							
Blue							
Red							
Green							
Orange							
Purple							

- ✔ Tell students that they will model a generation by "reproducing" with another student in class. Tell them to swap ONE of their genes (allele) with someone in their group. Record the results of the swap on the chart for generation 2.
- ✔ Tell students that there is a disease that has developed and anyone with a BLUE outcome dies. Tell the BLUE students to sit down. Highlight the numbers of BLUES on the chart and have the students "reproduce" one more time (remember they can only reproduce with students in their group).
- ✔ Ask students to talk about what they notice about the number of students who are BLUE.
- ✔ Now tell students that a huge volcano just formed and created a land bridge between North America and South America. Now that they are able to walk from one continent to another, they are free to "reproduce" with anyone in the class. Give students time to walk around the room and swap cards again.
- ✔ Have students model several more generations, recording the outcomes after each swap (now students can "reproduce" with anyone in the class). After each generation, be sure that students note the number of BLUES.

South America Activity 1: Build It and They Will Come

Debrief

As a class, look at the data and look for trends. The most important thing on which to focus is the number of BLUE dinosaurs. Note that the longer the students were able to "reproduce" with the entire class, the less chance they had that they would be BLUE (dead) dinosaurs. Discuss how this demonstrates that having a diverse gene pool helps the survival of a species.

Grade Level Adaptations

More Advanced

Have students graph the data and look for trends over time.

Less Advanced

Complete the activity as a presentation. Have 4-5 students in each group.

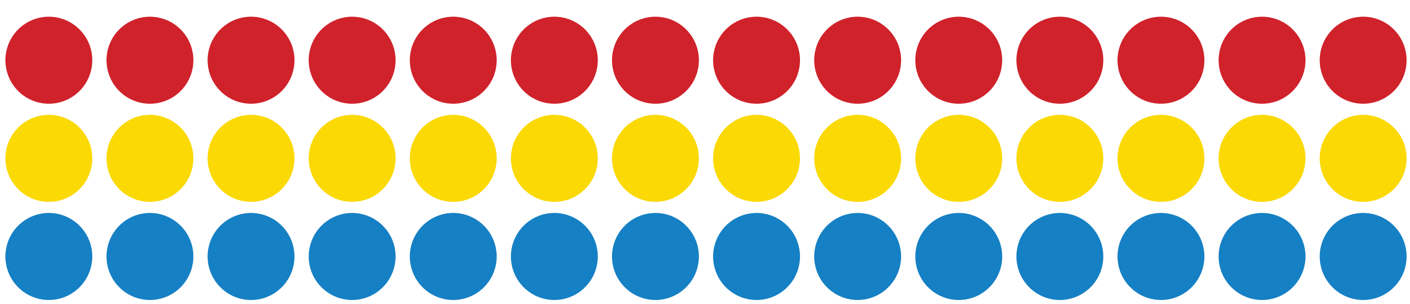
Genetic Diversity Cards

Gene (allele) 1	Gene (allele) 2	Outcome (phenotype) Gene 1 + Gene 2
Yellow	Yellow	Yellow
Blue	Blue	Blue
Red	Red	Red
Yellow	Blue	Green
Yellow	Red	Orange
Blue	Red	Purple

Gene (allele) 1	Gene (allele) 2	Outcome (phenotype) Gene 1 + Gene 2
Yellow	Yellow	Yellow
Blue	Blue	Blue
Red	Red	Red
Yellow	Blue	Green
Yellow	Red	Orange
Blue	Red	Purple

Gene (allele) 1	Gene (allele) 2	Outcome (phenotype) Gene 1 + Gene 2
Yellow	Yellow	Yellow
Blue	Blue	Blue
Red	Red	Red
Yellow	Blue	Green
Yellow	Red	Orange
Blue	Red	Purple

Gene (allele) 1	Gene (allele) 2	Outcome (phenotype) Gene 1 + Gene 2
Yellow	Yellow	Yellow
Blue	Blue	Blue
Red	Red	Red
Yellow	Blue	Green
Yellow	Red	Orange
Blue	Red	Purple



EUROPEAN ISLANDS: Home of Laurasia's Miniature Dinosaurs

Overview

When dinosaurs first appeared 238 million years ago, the world was much warmer and lacked extensive mountain ranges such as today's Rockies or Himalayas. There were no ice caps at the poles, which resulted in higher sea levels that often spread for miles inland, inundating lower lying continents.

Throughout the breakup of Pangea and Laurasia, Europe was a series of islands surrounded by warm shallow seas. Sea level fluctuations and continental collisions meant that the European Islands also connected with, and separated from, one another and the adjacent continents of North America and Asia during the Jurassic and Cretaceous Periods. Given this ever changing—and often disappearing—landscape, the dinosaurs that evolved in Europe are related to North American and Asian forms, but also include many that are unique to Europe.

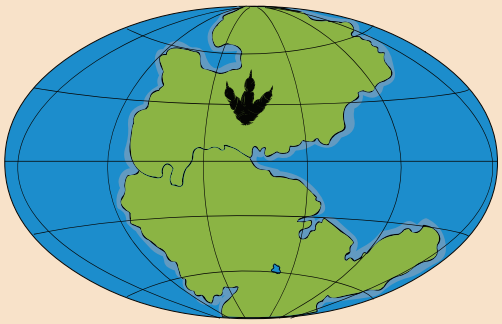
Dinosaur Spotlight

Neovenator was a very large, predatory dinosaur. Each hand and foot had three very sharp claws. Its teeth were thin, blade-like, and serrated like steak knives for cutting flesh. Short, horn-like projections above its eyes helped *Neovenator* to recognize others of the same species.

Neovenator was first discovered in 1978 on the Isle of Wight in the United Kingdom. The first and best-known specimen (70% complete) bears numerous injuries showing that these animals had violent lives. It is possible that such injuries occurred while hunting *Iguanodon* and other dinosaurs.

Iguanodon could either move all four limbs or stand up on its hind legs to reach higher plants. Its middle toes and fingers were hooved similarly to horse hooves. *Iguanodon's* hands had opposable small digits that were used like our thumbs to grasp branches. Its "thumbs" also had a horn-covered spike used for fighting other *Iguanodon* as well as for general defense. *Iguanodon's* teeth came together in a way that allowed it to effectively chew plants, which is very rare among reptiles today. Trackways, and discoveries of dozens of individuals together, suggest that they traveled in vast herds. *Iguanodon* was one of the first dinosaurs to be discovered and was originally thought to be a giant lizard.

EUROPEAN ISLAND ESSENTIAL QUESTIONS



What are the advantages and disadvantages of evolving in isolation (on an island)?

Is it better to evolve without competition?

How is it possible for some populations to not have genetic diversity?

European Island Activity: Founder Effect

Cross Cutting Concept: Stability and change

In Class **Stem**

Overview

On the European Islands, dinosaurs developed in unique ways due in part to the isolation of the islands. While some environmental factors, such as lack of resources, influenced how dinosaurs evolved here, another important factor was the islands' lack of genetic diversity and small populations. This activity demonstrates to students how a small population can quickly change when it lacks genetic diversity. Note: this activity works best when paired with the *Build It and They Will Come* activity.

Exhibit Connection

The role of the size and location of landmasses in relation to dinosaur evolution is a common theme throughout DINO SAFARI. this activity explores what happens evolutionarily when, instead of a super continent, there there are dozens of small isolated islands.

Materials

Genetic Diversity Cards and Color Gene Cutouts

Procedure

- ✔ Ask students to explain what isolation means. Ask what the difference is between living on an island and living on a continent.
- ✔ Ask students how they think isolation might effect how dinosaurs evolve. Would isolation be an advantage or disadvantage?
- ✔ Ask students what impact population size has on evolution. Do species evolve more quickly or more slowly when the population is smaller?
- ✔ Tell students that they are going to model something called the "Founder Effect." The Founder Effect occurs when a few members of the original population start a new colony. This small population size means that the colony may have reduced genetic variation which causes the new population to evolve differently than the original population.
- ✔ Pass out the Genetic Diversity Cards to each student and give each student two of the same colored genes [pass out an equal amount of yellow, blue and red genes (alleles)].
- ✔ Draw the table below on the board and write down how many students are in each group (color). (continued on page 20)

European Island Activity: Founder Effect

Procedure (continued from page 19)

✔ Draw the table below on the board and write down how many students are in each group (color).

Outcome (phenotype)	1	2	3	Island Seperates	4		5		6	
					Y	other	Y	other	Y	other
Yellow										
Blue										
Red										
Green										
Orange										
Purple										

✔ Tell students that they are going to model a generation by "reproducing" with another student in class. Tell them to swap ONE gene (allele) with one other person in the class. Record the number of each color for generation 2. Be sure to record the phenotype—the outcome of the 2 genes together—not the color of each gene.

✔ Repeat and record data for a total of 3 generations. Ask students to look at the data and explain what they see. Ask if diversity is increasing or decreasing. How do they know?

✔ Ask all the students with yellow genes raise their hands. Find the area of the room with the highest concentration of students with yellow genes and tell the class that the continent on which they were all living has now split and the group in the area with the high concentration of yellow genes is now on an island and can no longer reproduce with the rest of the group.

✔ Have the students swap genes to model "reproducing" several more times and record the population of the yellow group (Y column on the chart) and the population of the other group (marked other on the chart) on the chart each time.

European Island Activity: Founder Effect

Debrief

Ask students to look at the data and explain what they see. Ask what caused the difference between the yellow group and the rest of the class. Discuss what this would mean if the yellow gene caused a certain type of disease or if the yellow gene supported immunity. Explain to students that this type of random gene isolation is seen frequently in nature, particularly in humans. For example, the Afrikaner population of Dutch settlers in South Africa is descended mainly from a few colonists. Today, the Afrikaner population has an unusually high frequency of the gene that causes Huntington's disease, because those original Dutch colonists just happened to carry that gene.

Grade Level Adaptations

More Advanced

Have students graph the data and look for trends over time.

Ask students to explain current world implications of the Founder Effect.

Less Advanced

Do the activity as a presentation with 4-5 students in each group.

ANTARCTICA: A Temperate Dinosaur Vacation Spot

Overview

During the time of the dinosaurs, Antarctica was not a frozen continent like it is today. Along with the other landmasses of the time, Antarctica benefitted from Earth's warmer temperatures. It was a lush environment characterized by conifer forests with ginkgoes and ferns spotting the landscape. Long-necked herbivorous sauropods feasted on the continent's greenery.

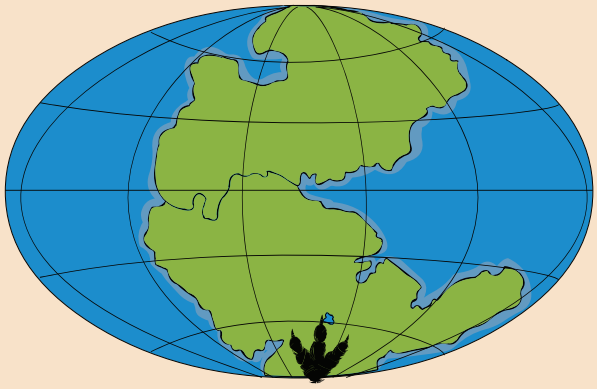
Discovered in 1991, *Cryolophosaurus* was one of the most spectacular dinosaurs to live in Antarctica and was found only there. It certainly benefitted from hunting the well-fed herbivores that enjoyed the lush forest buffet. Antarctica at this time was a much different place than the ice-covered plains that modern scientists and penguins experience now.

Dinosaur Spotlight

Hadrosaurs had up to 1,400 teeth that were continually replaced with wear. The file-like chewing surfaces of their teeth allowed for the grinding and slicing of tough and abrasive plant matter, similar to the way modern horse teeth work. Findings of hundreds of specimens and vast trackways show that they were herd animals. Hadrosaurs also appear to have cared for their young in the nest.

Hadrosaurs made their way to South America and then Antarctica via land bridges just before the demise of the dinosaurs.

ANTARCTICA ESSENTIAL QUESTIONS



How was Antarctica different 80 million years ago than it is now?

How do scientists know about Antarctica if it is now completely covered in ice?

Why is this gallery called "A Temperate Dinosaur Vacation Spot?"

Antarctica Activity: Exploring the Ice

Cross Cutting Concept: Stability and change

In Class **Stem**

Overview

Many people call Antarctica the Earth's final frontier because of its frigid, ice covered, unexplored terrain. However, during the time of the dinosaurs, this continent was a tropical paradise covered with lush flora and diverse fauna. Unfortunately, we still have much to learn about the history of Antarctica due to its current frozen state. In this activity, students will conduct an inquiry experiment using a block of ice to discover how exciting and difficult it is to identify what lies beneath the ice of Antarctica.

Exhibit Connection

The Antarctica Gallery showcases the few dinosaurs that have been discovered there. However, much of the focus of this gallery is on how much we don't yet know about ancient life on this continent.

Materials

Balloons, toothpicks, plastic utensils, miscellaneous art supplies

Procedure

- ✔ The day before the activity, fill 6 balloons with water and various art supplies (glitter, bits of tissue paper, pipe cleaners, etc.). Freeze the balloons. The following day, remove the balloons from the freezer and remove the balloons from the ice.
- ✔ Ask students to tell you what they know about Antarctica. Ask if they believe that it was once a lush tropical paradise where dinosaurs roamed.
- ✔ Ask students how scientists can tell what life was once like in Antarctica. Ask how scientists can find fossil evidence in a place covered in ice.
- ✔ Tell students that today they will conduct an inquiry activity in an attempt to identify what lies beneath the ice in Antarctica. Break the class into 6 groups.
- ✔ Tell students to make an "I notice" "I wonder" T-chart and give each group an ice ball.
- ✔ For 10-15 minutes, have students observe the frozen ball and write down what they notice and what they wonder on their chart.
- ✔ Have students share what they observed with the class.
- ✔ Give students toothpicks, plastic utensils and flashlights. Allow them to explore the ice for 10-15 more minutes. Have students continue to write down what they notice and what they wonder.

Antarctica Activity: Exploring the Ice

Debrief

Have students share their questions and findings with the class and record their "I noticed" and "I wonder" points on the board. Identify common themes and questions. Ask students to think about and explain how this process might be similar to how scientists try to understand what life was like 80 million years ago in Antarctica.

Grade Level Adaptations

More Advanced

Have each group choose one of their "I wonders" to further explore. Give students more time to design and test an experiment based on this "I wonder."

Less Advanced

Make observations and ask questions as an entire class. Create one master list of "I notice" "I wonder" for everyone in class.

AUSTRALIA: Way, Way, Way Down Under

Overview

Approximately 150 million years ago, Antarctica and Australia split from South America and Africa and drifted south. Because of the continents' latitude (the two connected continents were both close to the South Pole), they endured long stretches of darkness during the winter months—similar to the months of darkness that occur at the North and South Poles today.

The separation of Australia and Antarctica from Pangea led to the evolution of many unique dinosaurs. A land bridge that formed between 105 and 90 million years ago also allowed dinosaurs from South America to arrive on Australian soil.

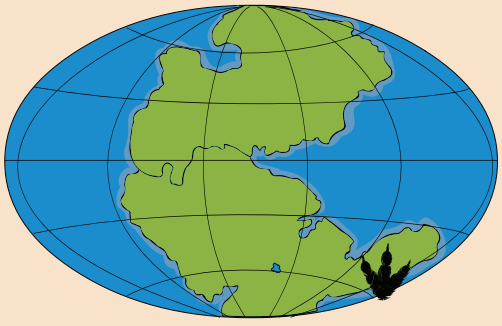
These new arrivals evolved over time into dinosaurs such as the small, herbivorous, bipedal dinosaur *Leaellynasaura*, and the armored *Minmi*. Both of these adapted for survival in the low light and cooler temperatures.

Dinosaur Spotlight

Minmi was a small, quadrupedal, armored, herbivorous dinosaur from Australia. Its head, neck, and body were covered by bony armor; very much like today's armadillos. Although it was slow and small-brained, its armor protected it from predators. Only one specimen has been found, but it had stomach contents that suggest that it ate leaves, fruits and seeds, and that it chewed the plants before it swallowed them.

Leaellynasaura was a small, bipedal, herbivorous dinosaur from Australia. Its teeth came together in a way that allowed it to chew plants well. It had a remarkably long tail, which contained over 70 vertebrae and made up as much as 75% of its total body length! It was once believed that *Leaellynasaura's* large eyes were used to see during the months of darkness in prehistoric Australia. Recent studies, however, show that all *Leaellynasaura* specimens discovered are juveniles. Much like puppies and kittens, juvenile *Leaellynasaura* had large eyes regardless of where they were found in the world because all found specimens were young at the time of their death.

AUSTRALIA ESSENTIAL QUESTIONS



How was the environment in Australia different during the time of dinosaurs than it is today?

Why are the days so much longer in the summer and so much shorter in the winter at Earth's poles?

How would animals need to adapt to survive the long winter nights and long summer days at the poles?

Australia Activity: Long Day, Long Night

Cross Cutting Concept: Systems and system models

In Class **Stem**

Overview

When Australia split from Pangea, it relocated near the South Pole. Because Earth's average temperature was warmer at that time, Australia had a lush environment. However, because Australia was located near the South Pole, it experienced long periods of darkness during the winter and long periods of daylight during the summer, leading plants and animals to evolve in ways unlike anything we see on Earth today. In this activity, students will investigate why the summer days are long and the winter days are short at the poles.

Exhibit Connection

The Australia Gallery explores some of the adaptations that occurred due to the long summer days and long winter nights in Australia.

Materials

Lamp, fist-sized Styrofoam balls, pencils

Procedure

- ✔ Ask students if they think that the sun sets later in the winter or in the summer. Ask them why they think the sun sets at different times throughout the year. Ask if the students believe that the sun sets at the same or different times across the world.
- ✔ Tell students that they are going to model how the Earth revolves around the sun. Give students a Styrofoam ball and tell them that this ball represents Earth. Ask students to drive a pencil through the middle of their Styrofoam ball. The pencil represents Earth's axis.
- ✔ Have students stand in a circle around a lamp. Turn the lamp on and turn off all the other lights in the classroom.
- ✔ Have students hold their Styrofoam balls straight out in front of them and ask students to use the pencil end to model how the Earth spins. Ask students if the entire ball is ever fully lit. Ask students to use this model to explain why there is night and day, and ask why the sun sets and rises every day. Ask again if the sun sets and rises at the same time everywhere on Earth.
- ✔ Explain to the students that they are not currently doing an accurate representation of how the Earth spins because the Earth is tilted at its axis.
- ✔ Now have students tilt the axis (pencil) about 25 degrees. Ensure that all the students tilt their axis in the same direction, regardless of where they are in the circle. The tips of each pencil should be pointed in the same direction.

(continued on page 27)

Australia Activity: Long Day, Long Night

Procedure (continued from page 26)

- ✔ Have students spin their balls again and ask if they notice anything different. Point out that the part of Earth that is now lit is different than it was before.
- ✔ Ask students to focus on their South Pole. As students spin their balls, ask them to notice how much light is on the South Pole. Is the South Pole always lit? Is it never lit? Is it lit some of the time but not others?
- ✔ Depending on where students are in the circle, they will have different answers. Explain how this activity displays why winter at the poles has long periods of darkness and summer at the poles has long periods of light.

Debrief

Have students explain why winter days at the poles are so short and summer days are so long. Ask students if this also explains the seasons and ask if the length of days ever changes at the Equator. Ask students how plants and animals must adapt differently because of the long winter nights and long summer days.

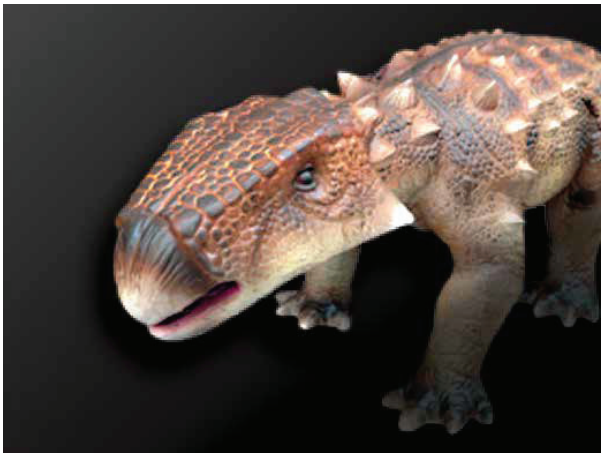
Grade Level Adaptations

More Advanced

Challenge students to think about how they would see the sun differently at the poles. Have them imagine that they are standing on their Styrofoam balls and ask them what they would see as they spin around. Help students understand why the sun is never directly overhead and always stays low in the sky at the poles

Less Advanced

Instead of using Styrofoam balls, have students use their bodies to model the Earth. As they spin, they can see the sun rise and set. When their back is to the lamp it is nighttime. To model Earth's tilted axis, have students bend 45 degrees at the waist and try to spin without changing shape. They should do this at various points around the circle. This will model the amount of sunlight seen at the North Pole.



AFRICA: Home of the World's Meanest Dinosaurs

Overview

When the continent of Africa was still a part of Pangea, its dinosaurs were similar to those in other parts of the world. Dinosaurs such as the predatory *Coelophysis*, found in Early Jurassic sediments in Zimbabwe, have been found in other parts of the world as well.

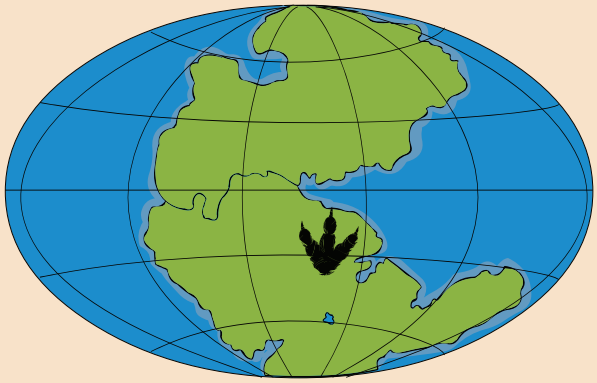
When Pangea broke up about 150 million years ago, Africa began to drift southward as part of a grouping of continents including Australia, South America, and Antarctica. This landmass, known as Gondwana, or Gondwanaland, began to develop its own distinct dinosaurs. African dinosaurs that developed during this period were some of the largest to ever walk the Earth. These giants included the monstrous sauropod *Giraffatitan*, one of the tallest dinosaurs, which stood at a height of more than 40 feet! The finned and spike-tailed stegosaurus *Kentrosaurus* also dominated Africa; skeletons of this massive dinosaur have been discovered in great numbers in the country known today as Tanzania.

Dinosaur Spotlight

Spinosaurus was the world's largest carnivorous dinosaur, even larger than the mighty Tyrannosaurus rex! It is named for the giant fin on its back. The fin was probably a display feature, rather than a heating and cooling device as was once believed. *Spinosaurus* stalked fish at the water's edge as well as small prey, such as infant dinosaurs.

The first *Spinosaurus* skeleton was found in Egypt by German researchers in 1912. It was destroyed during World War II when the museum in which it was housed was accidentally hit during a night bombing raid. Fortunately, scientists have recently found new specimens near where the original was found.

AFRICA ESSENTIAL QUESTIONS



Why do dinosaurs evolve differently when the continents break up?

Are there common adaptations that all dinosaurs have even when they have evolved in different environments?

What are some adaptations that all dinosaurs should have to better help them survive?

Africa Activity: African Adaptation

Cross Cutting Concept: Structure and Function

Stem **At Venue**

Overview

One phenomenon clearly on display throughout DINO SAFARI is the wide variety of adaptations dinosaurs developed on different continents. The age of the dinosaurs began during the time of the super landmass Pangea and, as the landmass broke apart, environments changed and dinosaurs evolved differently to survive in their new surroundings. This activity looks at some of the adaptations of dinosaurs in Africa and challenges students to predict what these specific adaptations are for.

Exhibit Connection

This activity challenges students to look closely at the details of the dinosaurs displayed in the Africa Gallery to identify the purposes of specific adaptations.

Materials

African Adaptations Handout

Procedure

- ✔ Ask students to describe what an adaptation is and identify adaptations on their own body. For example, we developed opposable thumbs so we can grab things.
- ✔ Tell students that one of the most interesting things to observe in the DINO SAFARI exhibition is how dinosaurs evolved differently on different continents. Tell students that, as they walk through the exhibition, they should try to identify different adaptations on the dinosaurs they see.
- ✔ When the class arrives in the Africa gallery, pass out the African Adaptations Handout.
- ✔ Have students look for the adaptations listed on their handouts, identify the dinosaur that has that adaptation and make predictions about what that adaptation is for.

Debrief

Ask students to share the results on their handout and compare their predictions with a peer. As a class, discuss why they did or did not have similar answers. Discuss if it's possible for more than one species of dinosaur to have developed specific features.

Grade Level Adaptations

More Advanced

As students travel through the exhibition, have them look for adaptations in each gallery. In addition to predicting the purposes of the dinosaur adaptations in the Africa Gallery, have students discuss and predict the purposes of adaptations they notice in other galleries.

Less Advanced

When you arrive in the Africa Gallery, split your class into groups and assign each group one or two questions from the handout. Bring the class back together and share results.

AFRICA ADAPTATIONS HANDOUT

Procedure:

✔ When you arrive in the Africa Gallery, look for the adaptations listed on this handout. Indicate the name of the dinosaur and explain what you think the adaptation is for.

Adaptation	Name of Dinosaur	What is the adaptation used for?
Huge height! This dinosaur grew to be over 40 feet tall.		
Spiked tail—Ouch!		
Hardened, spiked brow		
Semiaquatic—able to hunt on land or sea		
Does this animal give live birth?		
Long delicate snout		
Fin on back		
Razor-sharp teeth		
Long neck		

ASIA: Home of the First Dinosaur Fashion Show

Overview

In the time of the dinosaurs, Asia was warm and lush with marine environments, like that of modern Liaoning, China. It was here that paleontologists in the 1990s found remarkably well-preserved remains of small predatory dinosaurs such as the *Sinosauropteryx* from the early Cretaceous Period. Amazingly, scientists believe that this dinosaur had feathers, making it the first discovery of a dinosaur that was not entirely covered with scales! This discovery helped scientists to understand that birds are not only close relatives of dinosaurs, but are in fact, **living dinosaurs!** It is now understood that these feathers were initially for display, and were later used for insulation, camouflage, gliding and, ultimately, flight in birds.

Dinosaur Spotlight

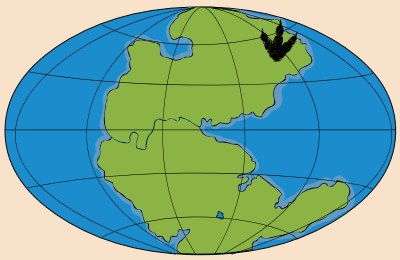
Therizinosaurus was a peculiar dinosaur, with a small head, tiny teeth, a fat body and a short tail. Its most notable feature was its hand claws that were scythe-like—flattened side to side and up to three feet long. These represent the longest claws known for any animal. When first discovered it was though that the claws belonged to a turtle-like animal and were used to harvest seaweed. Later it was discovered that it is a theropod dinosaur. Theropods are typically carnivorous but the teeth of *Therizinosaurus* show it ate plants. What it used its claws for is a mystery.

Velociraptor was a small, carnivorous dinosaur from Mongolia. It had sharp, serrated teeth, clawed hands and feet, and a stiff, bony tail. It stood on just two of its toes, making it quite agile while its remaining toe sported a very large, retractable cat-like claw. Marks on the arm bones of fossils show that they also had feathered wing-like features.

A specimen of *Velociraptor* found in 1971 showed that it had died while attacking a small herbivorous dinosaur known as *Protoceratops*. This famous fossil, known as the "fighting dinosaur," shows that the *Velociraptor* killed the *Protoceratops* with one of its sharp foot claws, but perished itself during the attack from having its arm caught in the mouth of the *Protoceratops*.

Protoceratops was a very common, small, herbivorous dinosaur from Mongolia. It had a parrot-like beak and a bony frill over its neck that was likely for displaying to others of the same species, much like the crests of chameleon lizards today. Various fossils provide evidence of two forms of the frill, suggesting that there were differences between males and females. Unlike most reptiles, the teeth of *Protoceratops* contacted one another during feeding; this allowed it to easily slice through tough plant matter. Recently, a nest of *Protoceratops* was found containing hatched-out individuals, suggesting that *Protoceratops* cared for their young.

ASIA ESSENTIAL QUESTIONS



What are feathers for? Why did dinosaurs develop feathers?

Are dinosaurs still alive today?

What are some advantages and disadvantages of being a bird over being a dinosaur?

Asia Activity: Dinosaur or bird? Or both?

Cross Cutting Concept: Structure and function

In Class **Stem**

Overview

In the Asia Gallery, students learn that dinosaurs are not all extinct. In fact- some evolved into modern birds! In this activity, students will draw bird features onto dinosaurs to explain the similarities and better visualize how dinosaurs evolved into birds. Students will also compare their images to mythological creatures and discuss how those creatures could have been based on ancient memories of dinosaurs.

Exhibit Connection

The Asia Gallery explains the evidence of dinosaurs evolving into birds and explores some of the root ideas of mythological creatures.

Materials

Dino-Bird Handout

Procedure

- ✔ Discuss with students the difference between birds and dinosaurs.
- ✔ After visiting the DINO SAFARI exhibition, discuss how it explains that some dinosaurs did not go extinct but evolved into birds .
- ✔ Discuss the similarities between birds and dinosaurs. If you have already completed the *What is a Dinosaur Handout*, review and reflect upon that activity.
- ✔ Pass out the *Dino-Bird Handout* and tell students that they are going to try to transform two dinosaurs into birds. The goal is for students to make the dinosaurs as bird-like as possible by drawing beaks, wings, feathers and claws onto the dinosaurs.
- ✔ After completing the *Dino-Bird Handout*, have students leave their drawings on their desks and walk around the classroom to see the drawings done by their peers.
- ✔ Ask students to compare their drawings with the image of a Griffin—a mythical creature. Do any of the drawings look similar to the Griffin? Is it possible that the Griffin could have been a type of dinosaur?

Debrief

Ask students if their finished drawings look more like dinosaurs or more like birds. Discuss with students the similarities they see between dinosaurs and birds.

Grade Level Adaptations

More Advanced

Have students sketch one of the dinosaurs at the exhibit. Upon returning to school, add bird features to the sketches.

Less Advanced

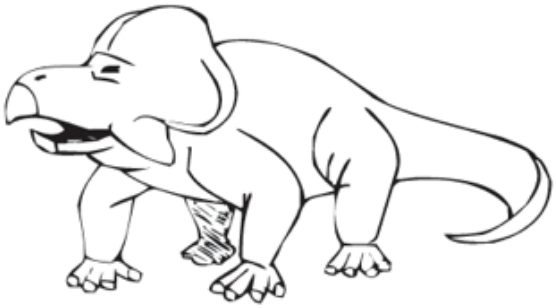
Have students only draw feathers on the dinosaur drawings.

DINO-BIRD HANDOUT

Procedure:

✔ After visiting the DINO SAFARI exhibition, you learned that dinosaurs evolved into modern birds! Now that you know that some dinosaurs evolved into birds, can you see the similarities between the two?

✔ Turn the drawings of the *Velociraptor* and *Protoceratops* below into birds. Draw a beak, feathers, wings, and claws on the dinosaurs, along with anything else you imagine that would make them look more like birds.



✔ Now, compare your drawings with this image of a Griffin—a creature who, according to Greek mythology, came from Asia. Do your drawings look similar to the Griffin? Do you think the Griffin could have been a type of dinosaur?

NORTH AMERICA: Home of the Dinosaur Melting Pot

Overview

At the beginning of the Age of Reptiles, North America remained part of the Pangean supercontinent. In the North American regions near the modern states of Arizona and New Mexico, paleontologists have discovered hundreds of skeletons of some of the earliest dinosaurs such as the 10-foot long, long-necked predatory dinosaur, *Coelophysis*.

North America remained connected to the Gondwanan continents (South America, Africa, Australia and Antarctica) and Europe via island chains until the Late Jurassic Period. At that time, about 150 million years ago, North America temporarily separated from all other continents. During this period, North America was dry and savanna-like, with most plants growing near water sources. These plants included ginkgoes, cycads, tree ferns, and horsetails. Common dinosaurs found at this time in North America were closely related to those found elsewhere in the world at the time, including the plated herbivore, *Stegosaurus*, giant long-necked sauropods like *Brachiosaurus, Apatosaurus, Sauroposeidon* (the tallest dinosaur at 56 feet!) and *Supersaurus* (the longest dinosaur at 140 feet!) Large predators such as *Allosaurus*, also roamed the land.

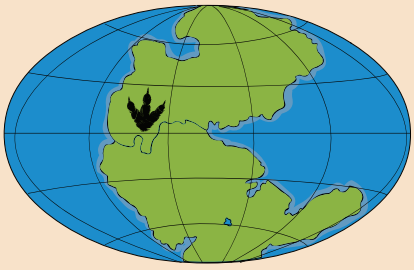
Dinosaur Spotlight

Triceratops was one of the last dinosaurs to walk the Earth. It is known for its large skull and neck frill with three horns. Evidence shows that its head could grow to be over 8 feet long—almost a third of its body length. It was an extremely common dinosaur, and hundreds of specimens have been recovered.

When first discovered, *Triceratops* was mistaken for a giant extinct bison! Wounds on the heads of these animals indicate that they commonly engaged in head-to-head fighting. Bite marks also indicate that *Tyrannosaurus rex* often ate them.

Tyrannosaurus rex is the most famous of all dinosaurs and was among the largest carnivorous animals ever to walk the planet. These dinosaurs had enormous skulls lined with up to 60, 7-inch-long, serrated teeth, and they could generate bite forces as great as 35,000 pounds! This allowed the *Tyrannosaurus rex* to easily bite through both flesh and bone. They ate duck-billed dinosaurs, horned dinosaurs, and even one another! Discoveries of multiple individual fossils in the same location suggest that they formed herds and a recent study suggests that they lived to just thirty years of age.

NORTH AMERICA ESSENTIAL QUESTIONS



How did dinosaurs interact? Did some of them travel in herds or hunt in packs? How do we know?

What are some similar characteristics that the dinosaurs in this gallery exhibit compared to modern day animals?

North America Activity: Descriptive Scene

Cross Cutting Concept: System and System Models

In Class **Stem** **At Venue**

Overview

The North America Gallery is the last continent students will visit in DINO SAFARI. By this time, students have seen a wide variety of dinosaurs and the wide variety of environments in which they lived. In this activity students will use the descriptive text found in the North America Gallery and their imagination to draw a scene from prehistoric North America.

Exhibit Connection

Students will use the text found in the North America Gallery to help them visualize and draw the landscape of North America during the time of the dinosaurs.

Materials

Descriptive Scene Handout

Procedure

- ✔ Either at school after visiting or while visiting DINO SAFARI, pass out the *Descriptive Scene Handout.*
- ✔ Explain to students that they have seen many different dinosaurs and have experienced a wide variety of environments, however, there is no way for an exhibition to display everything that occurred in prehistoric times. Therefore, it is important to read the exhibition text to create a full mental image of prehistoric Earth.
- ✔ Tell students that they need to use the descriptive text found on their handout, and any additional text they can find in the gallery, to imagine and draw what North America looked like during the Age of Reptiles.
- ✔ After drawing, have students share their scenes with a partner and discuss.

Debrief

How are your peers' pictures similar and different? What were the terms that were most helpful in drawing your pictures? How would your picture change if you were to draw the same scene on another continent? If you were to describe a different scene, what are some key terms you would use?

Grade Level Adaptations

More Advanced

Have students draw the scene without giving them the handout. They need to find and identify the key text from the gallery.

Less Advanced

Go through each quote as a class and explain what each means. For example, describe what a savanna is and explain what it means for animals to travel in packs. Have students draw their scenes as you describe them.

DESCRIPTIVE SCENE HANDOUT

Procedure:

- ✔ Using the descriptive text below and any additional text found in the North America Gallery, imagine and draw what you think North America looked like when dinosaurs roamed Earth.
- ✔ Label your drawing with the descriptive words in **bold**.

North America Descriptive Text

"At this time North America was dry and **savanna-like**, and **most plants were found near water**. These included ginkgoes, cycads, tree ferns, and horsetails."

"Wounds on the heads of ***Triceratops*** indicate that they **commonly engaged in head-to-head fighting**. Bite marks also indicate ***Tyrannosaurus rex*** often ate them."

"The ***Triceratops*** was an extremely common dinosaur, and hundreds of specimens have been recovered."

"***Tyrannosaurus rex*** had enormous skulls lined with up to 60, 7-inch-long, serrated teeth and could generate bite forces as great as 35,000 pounds! This allowed them to easily bite through both flesh and bone. They **ate duck-billed dinosaurs, horned dinosaurs, and even one another**! Findings of multiple individuals in the same location suggest they **formed herds**."

Scene

END OF THE DINOSAURS

Overview

65.6 million years ago, the remarkable 172-million-year reign of the dinosaurs came to an end. The end of many other life forms, including the sea monsters of the shallow seas, the pterosaurs of the air, many types of marine plants, some mammals and other reptiles accompanied their disappearance. In fact, nearly 75% of all life forms on the planet perished. This type of event is known as a mass extinction. There have been five mass extinctions during Earth's 4.54-billion-year history.

Most scientists believe that this mass extinction occurred when a six-mile-wide asteroid crashed into the Gulf of Mexico. Following the impact, the vaporized asteroid's wake blocked the sun's rays and caused major environmental changes, leading to a rapid cooling of the planet. As the heat from the sun diminished, many land plants died, as did the algae and plankton in the seas. The death of the most basic elements at the bottom of the food chain led to a major collapse, leading all the way up to the mighty dinosaurs.

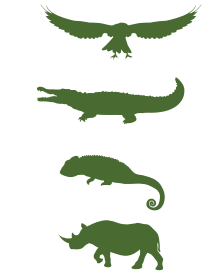
Dinosaur Spotlight
Who survived and evolved after the mass extinction?

Dinosaur Success Story

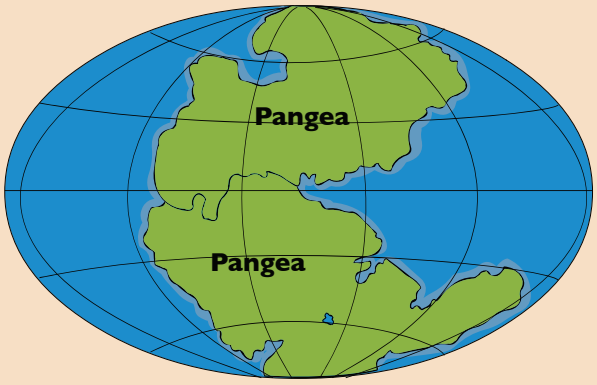
Number of Species Alive Today*

Birds	10,000
Reptiles	8,200
Amphibians	6,200
Mammals	5,400

*approximate



END OF DINOSAURS ESSENTIAL QUESTIONS



What evidence do we have that an asteroid caused the extinction of the dinosaurs?

Why does a lack of sunlight cause animals to die?

Was it just the dinosaurs that went extinct during that time or did other species die as well? Why?

End of Dinosaurs Activity: Disrupting the Food Chain—A Cartoon

Cross Cutting Concept: Energy and Matter: Flows, Cycles and Conservation

In Class **Stem**

Overview

Most people have heard that an asteroid killed the dinosaurs, but students often don't understand how the asteroid killed the dinosaurs. It wasn't the direct impact of the asteroid that caused the mass extinction, but the impact's widespread and powerful effects that caused ejecta (debris) to cloud the atmosphere and block the sun. Without sunlight, Earth quickly cooled, causing plants, algae, and plankton—the foundation of the food chain—to die. Without these basic forms of food and energy, animals higher on the food chain slowly began to die. In this activity, students will see how losing one piece of the food chain affects all other organisms within it. Students will create a cartoon demonstrating their understanding of this topic.

Exhibit Connection

The exhibition closes with an explanation of how dinosaurs became extinct. This activity further explains how this extinction was a delayed reaction to the asteroid impact and was not a quick or immediate event.

Materials

Disrupting the Food Chain Handout

Procedure

- ✔ Ask students to explain why dinosaurs became extinct. Ask if they think the asteroid impact was the direct cause or if the asteroid caused something else to happen which led to dinosaurs becoming extinct.
- ✔ Ask students to explain a food chain. Tell students that a food chain describes the flow of energy throughout a system. It is basically a chart of who eats whom.
- ✔ Distribute the *Dinosaur Food Chain Handout*. Have students cut out the images and put them in food chain order using the arrows. The arrows go in the direction of the energy flow. In this case, the sun points to the plants, the plants point to the *Triceratops* and the *Triceratops* points to the *Tyrannosaurus rex*.
- ✔ Now, tell students to imagine a huge asteroid smashing into Earth. The asteroid is six miles long, and when it hits Earth, it causes so much dirt and debris (called ejecta) to fly into the air that the sun's heat and light are temporarily blocked.
- ✔ Have students remove the sun from their food chain and ask what they think the impact of removing the sun will be. Students should indicate that the plants could not survive without the sun. Have students remove the plants from their food chain. Ask them what would happen without the plants and have them remove the *Triceratops* from the food chain. Finally, ask what would happen without the *Triceratops* and have them remove the *Tyrannosaurus rex* from the food chain. This is how the extinction of the non-avian (non-flying) dinosaurs—and 75% of all plants and animals—occurred.

(continued on page 39)

End of Dinosaurs Activity: Disrupting the Food Chain—A Cartoon

Procedure (continued from page 38)

- ✔ Tell students that, instead of discussing what just happened, they are going to create a cartoon strip that describes their understanding of the extinction event. Tell students to create a cartoon strip (minimum of 5 panels) that describes how dinosaurs went extinct. Students should include at least 5 panels and must include all of the images from the food chain handout.

Debrief

Have students share their cartoons with each other. Discuss the idea of direct versus indirect effects. Discuss the importance all living things have in the food chain.

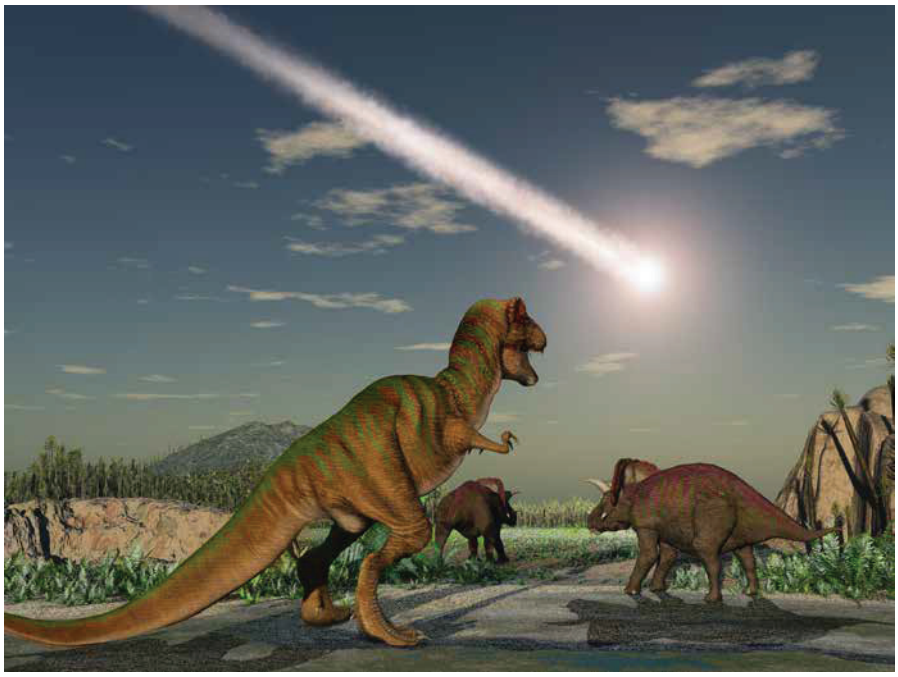
Grade Level Adaptations

More Advanced

Have students create a food web instead of a food chain. They can use plants and animals of today or can use the plants and animals they learned about when visiting DINO SAFARI.

Less Advanced

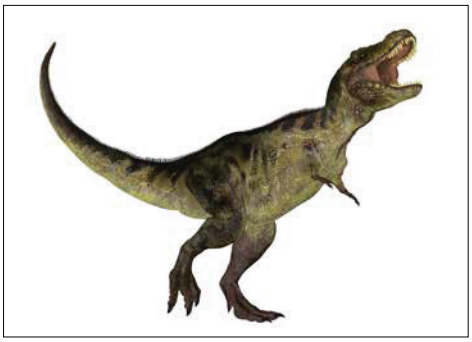
Have students work in groups to create their food chains and cartoons.

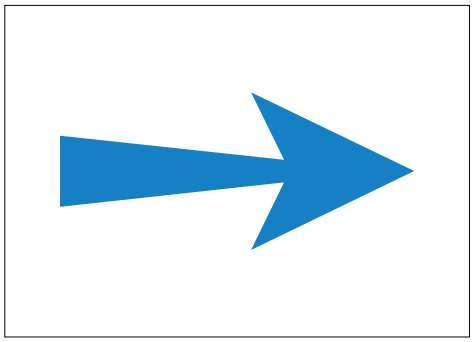


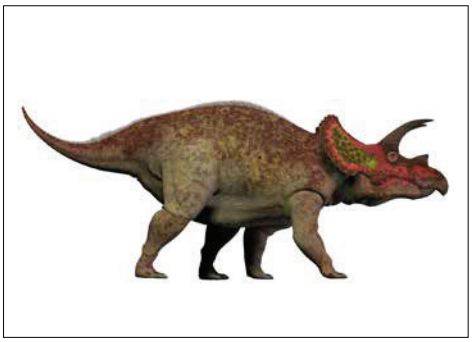
FOOD CHAIN HANDOUT

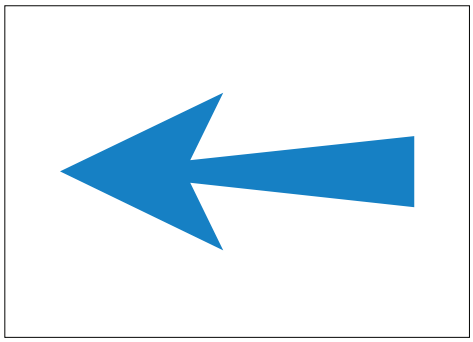
Procedure:

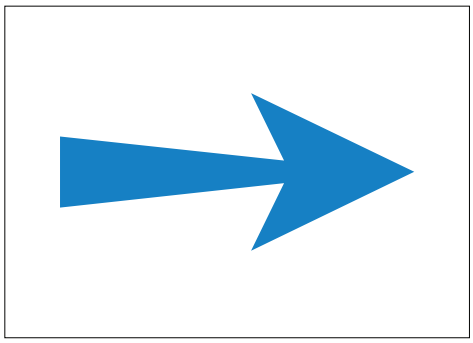
✔ Cut out each image and put them in food chain order. Use the arrows to indicate the direction of the energy flow.

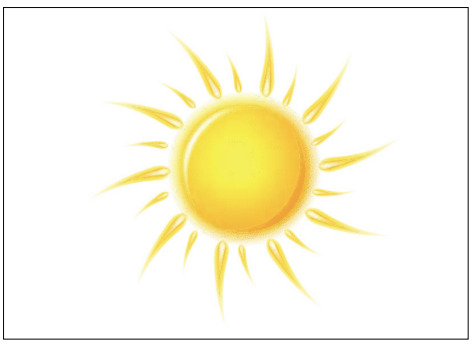


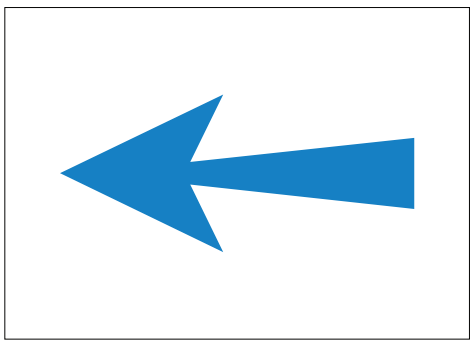










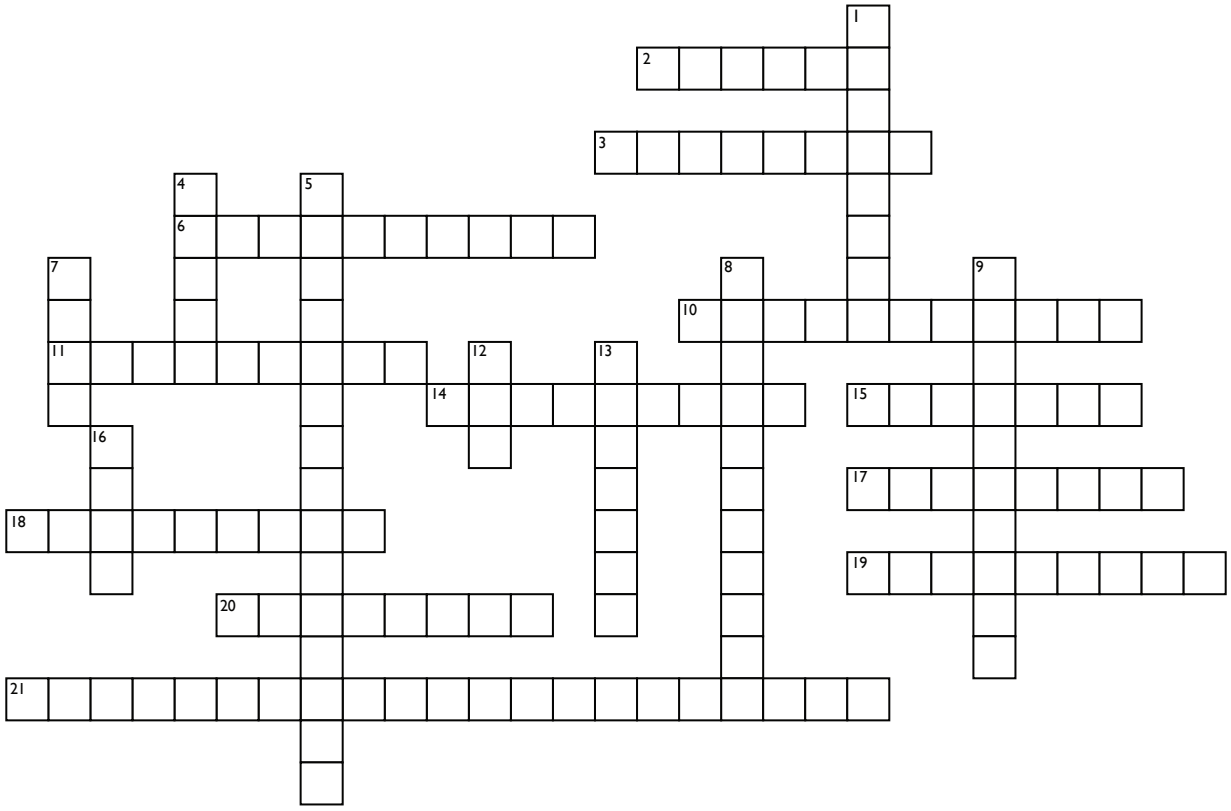


SCAVENGER HUNT CROSSWORD PUZZLE

Procedure:

✔ Before entering DINO SAFARI, take 15 minutes to try to complete the crossword puzzle below.

✔ While exploring the exhibition, look for the answers you were not able to complete to finish the puzzle. Each answer can be found somewhere in the exhibition. Good luck hunting!



Across

2. The material shot upward into the sky from an explosion or impact
3. A rock from space
6. Flowering plants
10. An animal with backbones
11. Much of modern-day Australia's eastern regions were covered by a massive inland sea. A large amount of amount of marine animal fossils can still be found in a region called the Great Artesian _____ _____ .
14. Meat-eating animal
15. A rare mineral from space
18. Egg stealer
19. A hierarchy of organisms each dependent on the next as a source of food
20. Catalyst
21. (warm blooded) Generating one's own internal heat from food rather than relying on the sun

Down

1. A geographic coordinate that specifies the north south position of a point on Earth's surface
4. Animal Life
5. Chinese Dinosaur Wing
7. Greek for "Mother Earth"
8. On land
9. A connecting tract of land between two continents, enabling animals to pass from one continent to another
12. Greek for "entire"
13. Walking on hind legs only
16. Dry, having little rain

CROSSWORD ANSWER KEY