

DINOSPHERE

A 3 – 5 UNIT OF STUDY

The Children's Museum of Indianapolis



DINOSPHERE



NOW YOU'RE IN THEIR WORLD.

Acknowledgments

The Children’s Museum of Indianapolis wishes to acknowledge the assistance of the following people in the preparation of this unit of study:

Rick Crosslin, teacher, writer
Mary Fortney, educator
Dinosphere Exhibit Development Team

The Children’s Museum of Indianapolis

The Children’s Museum of Indianapolis is a nonprofit institution dedicated to providing extraordinary learning experiences for children and families. It is one of the largest children’s museums in the world and serves people across Indiana as well as visitors from other states and countries. In addition to special exhibits and programs, the museum provides the **infoZone**, a partnership between The Children’s Museum of Indianapolis and The Indianapolis-Marion County Public Library. The **infoZone** combines the resources of a museum with the services of a library where students can read, search for information and find the answers to their questions. Other museum services include the **Teacher Resource Link** that lends books, learning kits, artifacts and other materials to Indiana educators. Items may be checked out for minimal fees. For a complete catalog, call **(317) 334-4001** or fax **(317) 921-4019**. Field trips to the museum can be arranged by calling **(317) 334-4000** or **(800) 820-6214**. Visit **Just for Teachers** at The Children’s Museum Web site: www.ChildrensMuseum.org

Dinosphere

A 3 – 5
Unit of Study

Enduring Idea:
Fossils are clues
that help us learn
about dinosaurs.



Table of Contents

Introduction	4
Lesson 1: Dinosaurs — Fascinating Animals From the Past	7
Experience 1 — How a Dinosaur Fossil Forms	8
Experience 2 — Fossils: Observing, Making and Learning	11
Experience 3 — Fossilized Dinosaur Teeth Adaptation	14
Lesson 2: Many Types From Different Times and Places	19
Experience 1 — What's in a Dinosaur Name?	20
Experience 2 — Size, Scale and Models	28
Lesson 3: Some Dinosaurs Lived Together	33
Experience 1 — Why Do Animals Live in Groups?	34
Experience 2 — Dinosaur Interaction	37
Lesson 4: Dinosaurs Are Not Alive Today — or Are They?	40
Experience 1 — What Happened to the Dinosaurs?	41
Experience 2 — Paleontologists	44
Culminating Experience:	
Dinosphere — Now You're in Their World!	47
Experience 1 — Classroom Dinosaur Dig	48
Experience 2 — Cretaceous Treat	51
Resource Materials: Dinosphere Dinosaurs	53



Introduction

Enduring Idea

Fossils are clues that help us learn about dinosaurs.

Why study fossils? Fossils are clues to the past. They are nature's records written in rock. A fossil is the remains, imprint or trace of an organism preserved in the earth's crust. To some people fossils are just curious natural oddities of little value. To scientists, fossils are a window into past geologic ages — the physical evidence and data used to test hypotheses and build theories that lead to better understanding of ancient life. When children hold fossils their imagination instantly transports them to a world where dinosaurs walked the earth. Fossils are powerful learning tools that motivate children to "read" the clues they offer about prehistoric plants and animals.



The Children's Museum of Indianapolis

A fossil is a window into the past that offers students unparalleled learning opportunities.

A Unit of Study for Grades 3 – 5

This unit of study is designed for teachers of Grades 3 – 5. A companion unit of study with different lessons and activities is available for Kindergarten and Grades 1 and 2. Lessons are designed to build upon each other. The lessons and activities can be completed with classroom resources and library books and by visiting **The Children's Museum Dinosphere** Web site. The best way to promote science learning in your class is to take a field trip to **Dinosphere** and complete the unit of study.

What will students learn?

In this unit students will learn much about life in the Cretaceous Period. Each lesson has specific objectives designed to increase understanding of dinosaurs through the study of fossils. The unit of study is divided into five parts. Each lesson is a separate set of activities that build upon the enduring idea that fossils are clues that help us learn about dinosaurs. The culminating experience builds upon the topics explored in the lessons.

What's Ahead

Lesson One

Dinosaurs — Fascinating Animals From the Past

Students learn what fossils are and the special conditions needed to form them. They also make a fossil cast.

Lesson Two

Many Types From Different Times and Places

Students learn how the many different types of dinosaurs are named and classified.

Lesson Three

Some Dinosaurs Lived Together

Students analyze how animals live in groups and the ways dinosaurs may have interacted.

Lesson Four

Dinosaurs Are Not Alive Today — or Are They?

Students explore dinosaur theories and learn how paleontologists and other scientists make dinosaur discoveries.

Culminating Experience Dinosphere — Now You're in Their World!

Students use their knowledge to create a model dinosaur dig for the classroom.

Indiana's Academic Standards

This unit of study helps students achieve academic standards in:

- science ● language arts
- math ● social studies

Specific Academic Standards are listed with each experience. A complete list of the Indiana Science standards and indicators are included along with the National Science Standards in the resources section at the end of this unit.

Getting started

Children love dinosaurs because they are evidence that strange, fantastic worlds can exist. Imagination and reality come face to face when a child looks into the eyes and jaws of *Tyrannosaurus rex*. What did it eat? How did it move? Was it real? What does its name mean? How long ago did it live? It is these questions that make children and scientists alike want to find out more. The best reason for studying dinosaur fossils is to provide students, teachers and parents a unique opportunity to use science to answer questions and solve problems. Science can be used to make observations, collect data, test ideas and draw conclusions about the dinosaurs' world.



© Black Hills Institute of Geological Research, photograph by Neal L. Larson

Scientists use many different tools to help unlock the mysteries of a dinosaur fossil.



© Black Hills Institute of Geological Research, photograph by Peter L. Larson

A dig site is carefully excavated in layers to avoid damaging the fossils.

Dinosphere

Visitors to **Dinosphere** will be transported to the Cretaceous Period via the plants, animals, sights, sounds and smells of 65 million years ago, when the earth belonged to the dinosaurs. Students will meet the stars of the era — *T. rex*, *Triceratops*, *Hypacrosaurus*, *Gorgosaurus*, *Maiasaura* and many more unique creatures. The fossil clues left in the Cretaceous Period help to reconstruct the world of dinosaurs. Now

you're in their world!

Indiana dinosaurs?

Why aren't dinosaurs found in Indiana? Students often ask this question. Dinosaurs probably lived in Indiana long ago, but several major changes in climate have occurred in this state since the end of the Cretaceous. Large glaciers scoured, scraped and eroded the surface and bedrock of Indiana, where dinosaur bones may have been deposited. When the climate changed the melted glaciers produced tremendous quantities of water that moved sediments, soil, rocks and fossils out of the state. Fragile fossils cannot survive the strong natural forces that have shaped the Hoosier state. The youngest bedrock in Indiana, from the Carboniferous Period, 360 – 286 million years ago (mya), is much older than the Mesozoic Era fossil beds of the dinosaurs, 248 – 65 mya. Thus fossilized dinosaur bones have not been found in Indiana.

Focus questions

Science is driven by questions. This unit of study asks questions that encourage investigation and challenge students to learn more: What are dinosaurs? Are dinosaurs real? What were they like? How did they become fossils? How does someone

learn about dinosaurs? How are dinosaurs named? Why did they live in groups? What did they eat? What happened to them? Who discovered them? What is still not known? Who studies dinosaurs? How can a person share what he or she learns? Where can someone learn more? Students embark on an expedition of discovery by using fossil clues and indirect evidence.

Science class environment

In **Dinosphere** students explore dinosaurs and fossils from a scientific perspective. Instead of just learning words, ideas and facts, they use science to build understanding. In this unit students are encouraged not just to learn about what someone else has discovered but also to try that discovery on their own — to explore the world using tools with their own hands. Reading, writing and math are essential elements of this scientific method. Students ask questions, make hypotheses, construct plans, make observations, collect data, analyze results and draw conclusions. A good science program provides experiences that offer an opportunity to learn in a unique manner. This unit of study combines the scientific method with hands-on experience.

Introduction

Dinosaur classroom

You can enhance the study of dinosaurs by creating a “Cretaceous Classroom.” **The Children’s Museum Store** is a great place to find dinosaur books, puzzles, posters, puppets and models to outfit your learning space. Bookmark the listed Web sites on classroom computers. Create different areas in the room for exploration. Use plastic tablecloths for clay or play dough work areas. Locate a sand table or a plastic wading pool filled with sand in an area where student paleontologists can dig up dinosaur models. Provide students with vests, pith helmets and goggles to role-play dinosaur hunters. Ask students to create artwork to show where dinosaurs lived. Create a space where students can add to a dinosaur mural as they learn more about these fascinating creatures. Post in your room a **Vocabulosaurus** section for new words to learn. Provide families with a list of dinosaur videos that students can check out overnight. Other great sources for turning your classroom into a prehistoric adventure area can be found at *The Dinosaur Farm* (<http://www.dinosaurfarm.com/>) and *The Dinosaur Nest* (<http://www.the.dinosaurnest.com/>).

Literature connection

Many outstanding dinosaur big books, magazines, paperback books, videos and models are listed in the resources at the end of this unit. Two separate book lists are included: those specifically about plants and animals of the Cretaceous Period, and titles appropriate for a classroom library. In addition, annotated books are listed with each lesson.

Dino Diary

Students use a Dino Diary to write words and sentences, take notes, make drawings and record the data they collect during the lessons. At the end of each activity students are asked to respond to the following **Dino Diary** writing prompt, “**Today I discov-**



© Black Hills Institute of Geological Research, photograph by Neal L. Larson

Bucky Derflinger is the young cowboy who found the first toe bone of Bucky, the T. rex.

ered ...” Each experience ends with a writing component in the science journal. Two styles of templates are provided in the resource section of this unit.

Family connection

This unit is intended for classrooms, families and individual learners. Let families know that your class will be studying dinosaurs. Some families may have visited museums or dig sites featuring dinosaurs or may be interested in planning such a trip in the future. They can learn a lot by working together to explore the Web sites and books recommended in this unit of study. Share the **Dinosphere** Web site with your students’ families and encourage them to visit **Dinosphere** at **The Children’s Museum**. The activities are set up for group discussion appropriate for working and learning in a family setting, so that families can explore the world of dinosaurs very much like the Linster family did. The Linsters spent each summer vacation on a family quest to find dinosaurs. They found and helped excavate the *Gorgosaurus*, *Maiasaura* and *Bambiraptor* featured in **Dinosphere**. The Zerbst family found and excavated Kelsey the *Triceratops*, one of the museum’s star attractions. Kelsey was named after the Zerbsts’ granddaughter. A family that uses this unit of study to start their own expedition of discovery might find a treasure that ends up in **Dinosphere!**

Dinosphere museum link

Plan a field trip or get more information via the Web site, www.childrensmuseum.org.

A museum visit provides extraordinary learning opportunities for students to explore the world of dinosaurs. Museums serve as field trip sites where fossils and immersive environments help motivate visitors to learn more about the world. **The Children’s Museum Dinosphere** provides a doorway into the Cretaceous Period, where visitors come face to face with dinosaurs. Visitors will see real dinosaur fossils in life-like exhibits, discover how fossils tell stories about the past and learn the latest findings from the world’s top paleontologists. More information, including Webquests, can be found at **The Children’s Museum** Web site. In addition, many of the print selections listed in the unit are available through **infoZone**, a branch of the Indianapolis-Marion County Public Library located at **The Children’s Museum**. For teaching kits and other hands-on classroom resources, see the **Teacher Resource Link** at www.childrensmuseum.org.

Lesson 1

Fascinating Animals From the Past

Get ready to dig

In this lesson students learn what fossils are and how they form. They explore how fossilized bones are assembled to form skeletons. They also learn that by studying fossils they can learn clues about the lives of dinosaurs.

Students can learn more when they understand the unique conditions that must occur in order for a fossil to form. It is amazing to realize that the fossilized neck bone of the *Malasaura* was once part of a living, breathing dinosaur millions of years ago. By understanding how fossils form, students learn about the Cretaceous Period and how a living dinosaur became a fossil. Visit **The Children's Museum** Web site to learn how specific dinosaur fossils became part of **Dinosphere**. Look at the **Dino Institute Teacher Dig** to see Indiana teachers explore, dig and discover real dinosaur fossils.

How do fossils form?

Only a small number of living plants and animals become fossils. Most dead plants and animals are eaten by other animals. Some, however, are shrouded in mud or sand. Those covered over many millions of years ago hardened and turned to stone. More recently, wind, water and sun have slowly eroded the rock, exposing the hidden fossilized remains. Specific conditions are required for fossils to form. Plants and animals in areas of mud, sand, ash or other sediments are most likely to become fossilized. Once the plant or animal is



© Black Hills Institute of Geological Research, photograph by Neal L. Larson

Fossils must be found and preserved quickly before natural forces of erosion — wind, water and sun — destroy them.

buried and the sediment has hardened, other factors play important roles in fossil formation — oxygen, sunlight, microorganisms, permineralization and other geologic forces. Even with millions of years to form, a fossil is still the result of a rare and unique process.

Where do people find fossils?

Fossils can be found the world over, but some of the best dinosaur fossils are found in dry climates where the land has eroded to expose sedimentary rock. Western North America is a great place to look. Many dinosaur fossils (including *Tyrannosaurus rex*) have been found there.

Who digs fossils?

Paleontologists are scientists who study fossils and ancient life. They need help from volunteers and students to excavate or dig up fossils. In fact, one of the best-



The Children's Museum of Indianapolis

At the 2003 Dino Institute Dig, teachers uncovered dinosaur fossils at the Ruth Mason Quarry near Faith, S.D.

known fossil sites is the Ruth Mason Dinosaur Quarry in South Dakota. Ruth Mason picked up fossils on her ranch when she was a girl, yet it took years to convince others of her amazing discovery — a bone bed filled with thousands of fossilized dinosaur bones! Many of the bones prepared in the **Dinosphere Paleo Prep Lab** came from the Ruth Mason Quarry.

EXPERIENCE 1

How a Dinosaur Fossil Forms

Indiana Academic Standards

Science — 3.1.2, 3.1.3, 3.2.3, 3.2.6, 3.3.5, 3.4.5, 3.6.3, 3.6.5, 4.1.3, 4.1.4, 4.1.5, 4.2.5, 4.3.5, 4.4.6, 4.6.3, 5.1.3, 5.2.6, 5.2.7, 5.4.4, 5.4.8, 5.5.7

Language Arts — 3.4.4, 3.5.2, 3.6, 4.4.1, 4.4.7, 4.5.4, 4.6, 4.7.12, 5.4.5, 5.6, 5.7.10

Social Studies — 3.3.5, 4.3.6, 4.3.7, 5.3.5

Focus Questions

- How does a fossil form?
- Can fossils be made today?
- What are bones and skeletons?
- Are the most deeply buried fossils the oldest or the youngest?
- What can be learned by comparing fossils?
- What can be learned about a dinosaur fossil?

Objectives

Students will:

- List some conditions that are needed for fossils to form.
- List, observe and examine different types of fossils.
- Compare and contrast, make drawings and write about fossils.
- Write about and draw the necessary steps for a fossil to form.

Vocabulosaurus

- **fossil** — Latin for “dug up,” evidence of past life, the remains or traces of plants and animals that have turned to stone or rock.
- **adaptation** — a body part or behavior that produces an advantage for the animal. This could be feathers, fur, scales, teeth or beaks, or migration and hibernation.
- **model** — a representation that is both like and different from the real thing.
- **erosion**
- **expose**
- **sediments**
- **life**
- **death**
- **extinct**
- **mold**
- **imprint**
- **cast**
- **plaster**
- **resin**
- **magnifying lens**
- **centimeter ruler**
- **positive**
- **negative**
- **tooth**
- **prey**
- **carnivore**
- **dinosaur**
- ***Tyrannosaurus rex***
- ***Triceratops horridus***
- ***Hypacrosaurus***
- ***Gorgosaurus***
- ***Maiasaura***

DIG IN ...

How a dinosaur fossil forms

- Set up all materials on a supply table.
- Show and describe a fossil and pass it around the room.
- Ask the following questions: What is this? Have you seen anything like it before? What? Describe the fossil. How long is it? How heavy is it? Where did the animal live? How did it live? How did it die?
- Use the Internet or books to learn more about how a fossil is formed. Describe each step and write key words or draw a picture on chart paper. Emphasize that several conditions must occur for a fossil to form. Fossils are rare. Most plants and animals in the world end up inside other animals as food. Make the connections among fossils and sediments and sedimentary rocks — fossils form when sediments cover the original organism.
- Give construction paper to each child. Have them fold the paper into six parts — one fold down the middle and two across — and number each section of the paper.
- Using the flow chart **How a Fossil Forms** as a guide, create captions for each square. Write declarative sentences on the board for students to copy in their charts.
- Have students draw a picture for each of the six boxes, and then share their completed projects with each other.

Dig tools

Paper, pencils, art supplies, construction paper; a cast of a dinosaur tooth; seashells, leaves, pennies; pictures of fossils; fossil and dinosaur reference books.

How a Dinosaur Fossil Forms

Step 1:
Life The dinosaur is alive and growing.

Step 2:
Death The dinosaur dies.

Step 3:
Sediment Sediments quickly cover the dinosaur.

Step 4:
Time Over a long time more sediments settle on the dinosaur.

Step 5:
Fossilization Water, sand and minerals fossilize the dinosaur.

Step 6:
Exposure The fossil remains are revealed and found after wind and water remove layers of sediment.

Make it fossilize

Students describe one or more conditions for a fossil to form, and complete the chart on how a dinosaur fossil forms. They can write words and sentences or create drawings for each step in the formation of a fossil and can put the steps in order. They understand that other fossils form in the same way. They know that not all animals become fossils and that a fossil does not have all of the parts of the living animal or plant. They can list examples of when an animal does not become a fossil. They understand that fossils are rare and can give an example of one that can be used to learn about the past. They can make drawings to show how objects become buried in sediments, and can explain why the object on the bottom is the oldest.

Dino Web sites

The Children's Museum — Dino Institute Teacher Dig 2003

<http://www.childrensmuseum.org/dinodig/overview.htm>

Museum of Paleontology, University of California, Berkeley

<http://www.ucmp.berkeley.edu/index.html>

Enchanted Learning — Comprehensive e-book about dinosaurs

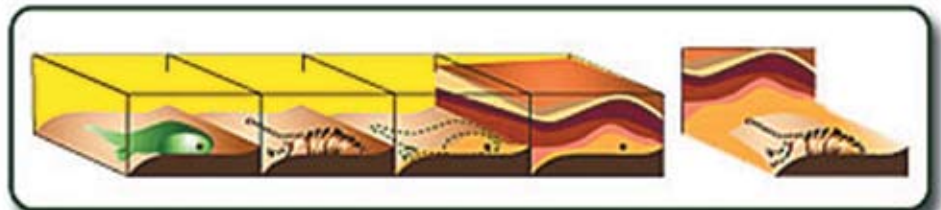
<http://www.zoomdinosaurs.com>

Dino Diary

Students draw pictures and write words and sentences to describe how a dinosaur becomes a fossil. Other questions they may answer in their diaries include: Where would fossils form today? Are there fossils in Indiana? What part of an animal or plant rarely becomes a fossil? What parts turn into fossils? Can anyone find a fossil? End the class period with writings and drawings under “**Today I discovered ...**” in their diaries.

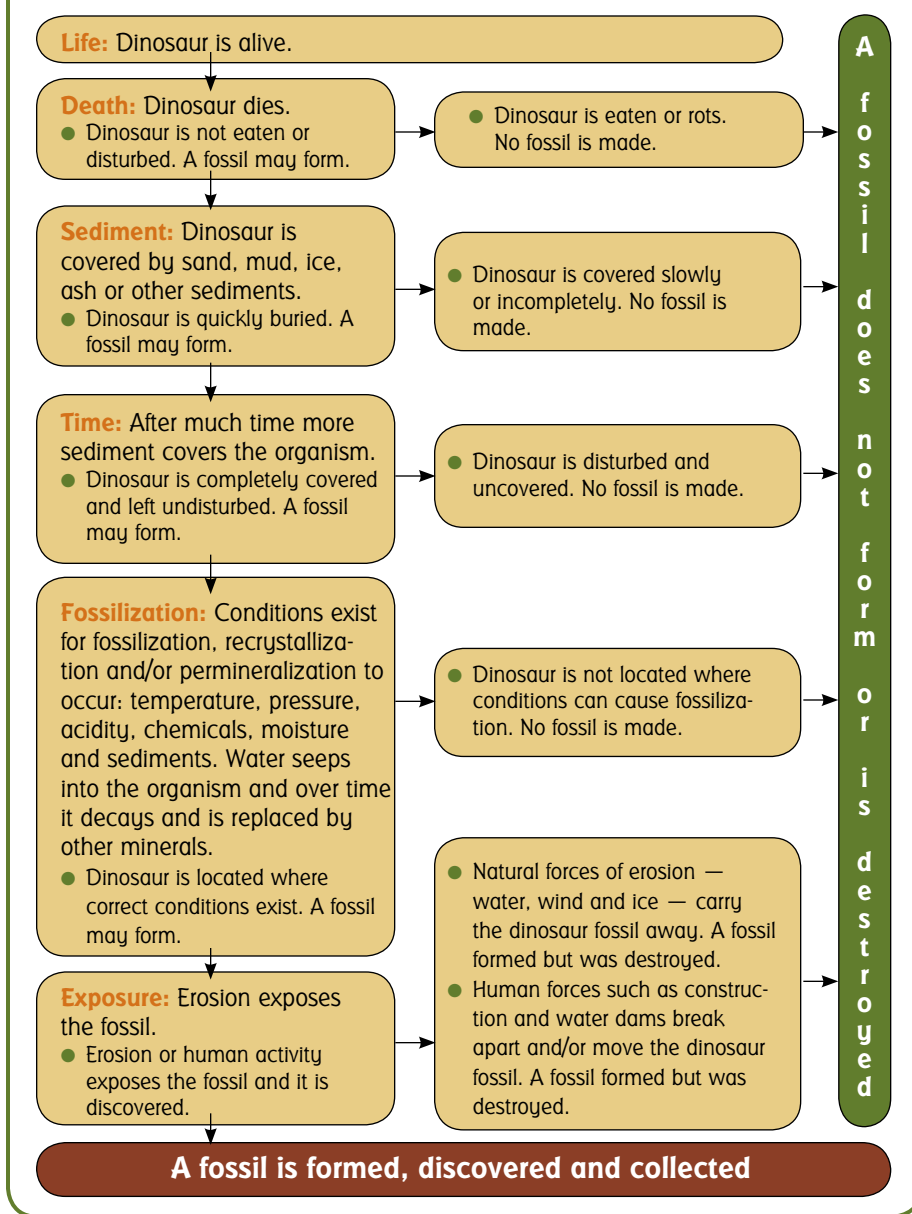
Dino books

- Norman, David and Angela Milner. *Eyewitness: Dinosaur*. New York: DK Publishing, 2000. An exploration in text and photos of the world of dinosaurs, with emphasis on teeth, claws, eggs and fossils.
- Taylor, Paul D. *Eyewitness: Fossil*. New York: Alfred A. Knopf, 1990. A beautifully illustrated photo essay about different types of fossils and how they formed.
- Willis, Paul. *Dinosaurs*. New York: Reader's Digest Children's Books, 1999. An introduction to how dinosaurs looked, behaved and ate, and what is known about them through the study of fossils.



When a dinosaur dies the remains change several times before the fossils are formed.

How a dinosaur fossil forms — step by step



Paleo-points for the teacher

Use the following steps to aid in understanding how a fossil forms. Use a fleshed-out (one that shows skin and muscles) dinosaur model and a model of a dinosaur skeleton. Go through each step to demonstrate how the dinosaur could become fossilized if all of the required conditions are met. The conditions necessary to form fossils can change at any time, which is why fossils are rare.

Bonus: Digging deeper!

Some children may enjoy cutting out each box in the chart and making a book out of the six sections. Have them scramble the pieces and practice putting them back in correct order to illustrate how a fossil is formed. Other students will enjoy making flipbooks to demonstrate the steps in a fossil formation. Show the class how to draw each step on a small piece of paper and gather the pieces together into a flipbook.

What happens when The Children’s Museum finds a fossil?

It’s fun but not easy to get a fossil out of the ground and into the lab for preparation. The first thing scientists do when they find dinosaur fossils is to make a map of the site in order to keep track of where every fossilized bone was found. Then they start digging. Fossilized bones are wrapped in plaster field jackets to keep them snug for shipment to the lab. Scientists also like to study the matrix of rock around the fossilized bones for clues.

When all of the fossilized bones have been cleaned and reassembled, scientists must determine a way to display the skeleton. Often they make a special frame that holds all the fossilized bones in place. If there are missing bones, scientists make plastic and rubber casts of fossilized bones from other dinosaur skeletons. Then they decide how the skeleton will be posed — running or standing still, eating or fighting? The result is an amazing display!



© Black Hills Institute of Geological Research, photograph by Larry Shaffer

For 65 million years this bone was preserved underground. Now foil and plaster protect it until it can be prepared.

EXPERIENCE 2

Fossils: Observing, Making and Learning

Indiana Academic Standards

Science — 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.2.2, 3.2.3, 3.2.4, 3.2.6, 3.2.7, 3.4.1, 3.4.2, 3.4.5, 3.5.5, 3.6.3, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5, 4.2.4, 4.2.5, 4.6.3, 5.1.1, 5.1.3, 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7, 5.2.8, 5.4.7, 5.4.8, 5.5.1, 5.5.7, 5.5.8

Language Arts — 3.5.2 3.6, 4.4.1, 4.5.4, 4.6, 4.7.12, 5.4.5, 5.6, 5.7.10

Math — 3.5.2, 4.5.2

Get ready to dig

Tyrannosaurus rex ruled the Cretaceous world 65 million years ago! Just look at the size of Stan, the **Dinosphere** *T. rex*. A close examination of Stan's fossilized bones and fierce claws and teeth explains why *T. rex* is called the "Terrible Lizard King." Such adaptations made it easy for Stan to capture and eat prey.

In this experience students will examine resin casts of fossilized dinosaur bones. They will make observations, draw diagrams and share their findings. They will make a clay mold to create a plaster copy of the fossil. Throughout the process they will model how a real bone becomes a fossilized bone. They will compare the resin model dinosaur bone with the plaster cast they create.

Focus Questions

- How does a fossil form?
- Can fossils be made today?
- Are all fossils the same?
- What can be learned by comparing fossils?
- What can be learned about a dinosaur fossil?

Objectives

Students will:

- Listen to and observe information from a dinosaur book.
- Observe and examine fossils.
- Make a list comparing and contrasting fossils.



© Black Hills Institute of Geological Research

Stan is **Dinosphere's** full-size skeleton replica of an adult *T. rex*.

Dinosaur skeletons

Visit the **Dinosphere** Web site to see amazing skeletons of fossilized dinosaur bones. **The Children's Museum** dinosaur skeletons are unique because real fossilized bones are on display. Fossilized bone is much heavier than the cast replicas used in some exhibits. The real fossils are displayed so that visiting scientists can remove individual specimens for study. The museum replaces a borrowed fossil with a cast replica, allowing visitors to enjoy and learn from the exhibit while scientists examine the real fossil. Fourteen dinosaur skeletons are on display in **Dinosphere**. All but Stan the *T. rex*, one baby *Hypacrosaurus*, one *Leptoceratops* and the two *Bambiraptor* specimens contain real fossilized bones. Bucky, made from real fossilized bones, is a unique skeleton of a teenage *T. rex*.

In this experience students explore how casts of fossilized bones are created and used to learn about dinosaurs. Students make observations, draw diagrams and share their findings. They make a clay mold to create a plaster copy of a real fossil.

DIG IN ...

Fossils: Observing, Making and Learning

Part 1

Divide the class into three groups. Pass out a *T. rex* fossil cast to each group. Help the class locate each fossil on the *T. rex* skeleton. Ask each group to describe the resin cast and make observations in their **Dino Diaries** about the piece. Have them measure the length and width of the cast in centimeters and record their findings. Ask them to feel the texture, estimate the mass, name the color and describe the shape of the fossil. Then have them draw pictures of the cast and write three or more observations about it. Allow time for the students to share their drawings and talk about their observations. Ask each group to select a student to share the group's findings with the class.

Part 2

Provide each student with modeling clay, plastic cups, plaster, water, stir stick and paper towels. Prepare a slab of clay in the shape of the fossil. The clay should be about 3 centimeters thick. Have students squeeze and mold the clay in the shape of the fossil and press the slabs onto their desks.

Show students how to prepare another piece of clay for a wall long enough to go around the entire first slab. It should be about 4 centimeters wide and about 2 centimeters thick.

Ask students to press the resin cast of the fossil into the clay slab, making sure that enough pressure is applied to leave details imprinted in the clay. Students should carefully remove the resin cast from the clay and examine the imprint for details. If details are not clear have students repeat this step.

Help students press the wall clay around the sides of the first slab, making sure the corners are pressed together to form

a tight seal. This creates a shallow bowl to hold wet plaster. Students should try to make the entire piece level around the top. Now they have a mold that can be used to make a cast.

Show the students how to lightly coat the interior of the mold with vegetable spray. Read aloud the directions for mixing the plaster while the students mix theirs. Ask them to pour the wet plaster into the mold in one continuous pour, filling to the top of the mold. Then show them how to shake the mold gently to make any bubbles rise to the surface. For best results allow the plaster cast fossil to harden overnight.

Part 3

Students remove the plaster cast fossil from the mold. Save the clay for future use. Students examine the fossil cast and record their findings in their **Dino Diaries**.

Ask students to compare and contrast their cast fossil with the resin fossil. Have them identify three or more modern animals that have claws and teeth like the *T. rex*. The list might include lions, tigers, eagles, owls and other carnivores. Use textbooks, trade books and the Internet to find examples of other animals with teeth and claws similar to the fossils created. Ask students to record observations in their **Dino Diaries**.

Make a chart that includes body parts of the animals students identify, including what they were used for. For example, *Lion* — sharp claws — used to grab and hold animals to eat. From this chart students should be able to make inferences as to how the fossils from Stan were used for protection, hunting and eating.

Vocabulosaurus

- **adaptation** — a body part or behavior that produces an advantage for the animal. This could be feathers, fur, scales, teeth, beaks, or migration and hibernation.
- **model** — a representation that is both alike and different from the real thing.

- **fossil**
- **mold**
- **imprint**
- **cast**
- **plaster**
- **resin**
- **magnifying lens**
- **centimeter ruler**
- **positive**
- **negative**
- **prey**
- **carnivore**
- **dinosaur**



© Black Hills Institute of Geological Research, photograph by Neal L. Larson

The shape of and serrations on this *T. rex* tooth indicate the dinosaur was a meat-eater.

- Tooth resin cast — *T. rex*
- Claw resin cast — *T. rex*
- Skeleton diagram of Stan — *T. rex*

For each student:

- Plaster (1 cup)
- Cup for water
- Bowl (for mixing)
- Stir stick
- Modeling clay
- Spray vegetable oil
- Paper towels
- Magnifying lens
- Centimeter ruler
- Dino Diary**

Dig tools



Once the mold is made, copies can be produced and studied. The real fossilized bones are on display in *Dinosphere*.

© Black Hills Institute of Geological Research



Dino Web sites

Dinosaurs at Kid Sites

<http://www.kidsites.com/sites-edu/dinosaurs.htm>

Dinosphere Paleo Prep Lab link on **The Children's Museum** Web site shows how a fossil is prepared.

<http://www.childrensmuseum.org>

Zoom Dinosaurs skeletons link

<http://www.enchantedlearning.com/subjects/dinosaurs/anatomy/Skeleton.shtml>

Paleo-points for the teacher

Making a plaster cast of a fossil takes a little practice. Some students may need help making the imprint in the clay. The clay can be reworked for a new imprint. Coat the item to be imprinted with a light layer of vegetable oil. This will make sure the plaster casts will be removable. You may also want to demonstrate making a plaster cast of the fossil before letting students try it. Although the students will enjoy making their own fossils, the real value is in how they use the casts to understand the experience.

Dino books

- Norman, David and Angela Milner. *Eyewitness: Dinosaur*. New York: DK Publishing, 2000. An exploration in text and photos of the world of dinosaurs, with emphasis on teeth, claws, eggs and fossils.
- Relf, Patricia with the Sue Science Team of The Field Museum. *A Dinosaur Named Sue: The Story of the Colossal Fossil*. New York: Scholastic, 2000. A detailed description of Sue, the most complete *T. rex*.
- Taylor, Paul D. *Eyewitness: Fossil*. New York: DK Publishing, 2000. A beautifully illustrated photo essay about different types of fossils and how they formed.
- Willis, Paul. *Dinosaurs*. New York: Reader's Digest Children's Books, 1999. An introduction to how dinosaurs looked, behaved and ate, and what is known about them through the study of fossils.

Dino Diary

At the end of each class period students write under “**Today I discovered ...**” in their diaries. Entries include drawings and descriptions of the resin and plaster casts of the fossilized dinosaur claws and teeth. Entries also include lists of different animals and body parts that are similar to their fossils. Studying other dinosaurs in **Dinosphere** and identifying their adaptations can add additional drawings and descriptions for the diaries. For example, students may write about the horns of Kelsey the *Triceratops*, the teeth of the hypacrosaur or the toe claws of the gorgosaur.

Make it fossilize

Students complete a chart that compares and contrasts resin casts and plaster casts of fossilized dinosaur teeth and claws. Students match skeletal bones to a drawing of the dinosaur. They compare and sort animals by their adaptations and by comparison with modern animals. Students list one or more examples of how a specific adaptation might help a modern animal and a dinosaur survive.

Bonus: Digging deeper!

Students can paint their plaster fossils to resemble fossils on display in **Dinosphere**. The teeth can be painted to show both fossilized bone and enamel. The hand claw has a “blood vein” running down the side. Students can paint this in with watercolors or markers. Students can use many other objects to make casts from plaster once they have learned how to make the dinosaur fossil. Other items could include real fossilized bones, leaves, coins, handprints, seashells and other objects.

EXPERIENCE 3

Fossilized Dinosaur Teeth Adaptations

Indiana Academic Standards

Science — 3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.4.1, 3.4.2, 3.5.3, 3.5.5, 3.6.3, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.1.5, 4.2.4, 4.2.5, 4.6.3, 5.1.1, 5.1.2, 5.1.3, 5.2.3, 5.2.4, 5.2.6, 5.2.7, 5.4.4, 5.4.7, 5.4.8, 5.5.6, 5.5.7, 5.5.8, 5.6.2

Language Arts — 3.4.4, 3.5.2, 3.6, 4.4.1, 4.4.7, 4.5.4, 4.6, 4.7.12, 5.4.5, 5.6, 5.7.10

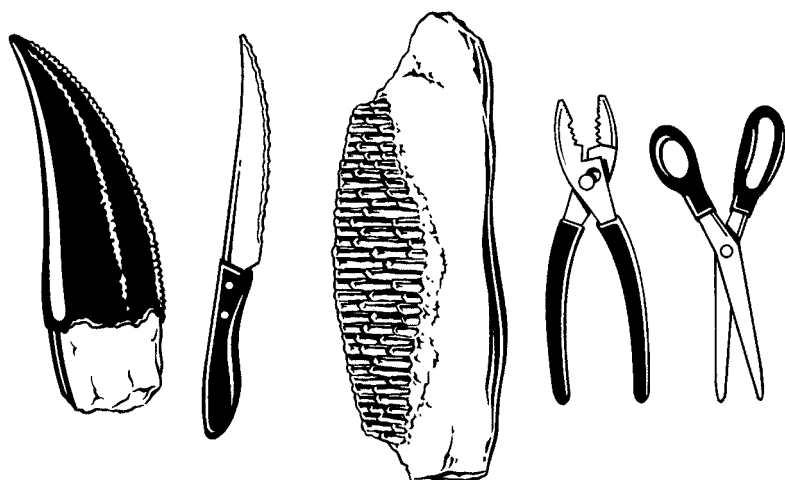
Math — 3.6.9, 4.6.1, 4.6.2, 5.6.1

Social Studies — 3.3.5, 4.3.6, 4.3.7, 5.3.5



© Black Hills Institute of Geological Research, photograph by Peter L. Larson

A big plant eater means a big jaw. This is a portion of just one side of Kelsey's jaw.



Focus Questions

- What types of teeth did dinosaurs have?
- How did their teeth help dinosaurs?
- What adaptation helped a meat eater survive?
- What adaptation helped a plant eater survive?

Objectives

Students will:

- Select and use a model of a dinosaur tooth to collect data.
- Complete an investigation to model an adaptation.
- Describe how an adaptation helps an animal survive.
- List adaptations of plant- and meat-eating dinosaurs.

Get ready to dig

Students research *Tyrannosaurus rex* and *Triceratops horridus* dinosaurs to study their fossilized teeth. Students determine that *Triceratops* teeth work the way pliers and scissors operate, and *T. rex* teeth are like sharp knives. Students match and sort dinosaurs by the type and use of their teeth. The purpose of the activity is to understand how dinosaur teeth were used. Students use models of fossilized dinosaur teeth to understand how they were used. Students learn that dinosaurs probably ate a variety of foods.

Vocabulosaurus

- *T. rex*
- *Triceratops*
- *Hypacrosaurus*
- *Gorgosaurus*
- *Maiasaura*
- fossilized teeth
- model
- tools

DIG IN ...

Fossilized Dinosaur Teeth Adaptations

- Students view books, pictures, Web sites and videos about dinosaurs. Ask students to observe the fossilized dinosaur teeth. Pictures of the following dinosaurs should be included: *T. rex*, *Triceratops*, *Hypacrosaurus*, *Gorgosaurus* and *Maiasaura*.
- Divide the students into groups of four and ask them to draw pictures of each type of fossilized tooth. Then have them sort the pictures by the shape and use of the fossilized teeth: long, round and pointed (*T. rex* and *Gorgosaurus*), and short, flat and thick (*Triceratops*, *Hypacrosaurus* and *Maiasaura*). Students should describe why each picture is placed in its particular group and how the specific tooth is used.
- Referring to the dinosaur pictures, ask each group to name types of food each dinosaur eats. Make a list of their answers on the board. The list should include plants, flowers, fish, reptiles, insects and other dinosaurs. Then ask the students to match the foods on the list with the two groups of dinosaurs that are sorted by teeth types. Will some of the foods be easier to eat with one type of teeth than another? Ask students to explain why a particular type of tooth will be useful for eating a specific type of food.
- Give each group of students a model set of fossilized dinosaur teeth, a pencil and a clothespin. Ask students to match the dinosaur teeth pictures with the dinosaur teeth models. Then have them compare the pencil and the clothespin to the model teeth and decide which type of tooth each most closely resembles. Allow students time to share their choices. They should observe that clothespins work like horse or cow teeth and that pencils are like lion or tiger teeth.
- Ask students to look at the list of foods on the board and study their dinosaur teeth models to determine what type of



Bucky's tooth is still as sharp as it was 65 million years ago.

foods their dinosaurs might have eaten. Give a cup of cut yarn pieces to each group. Pour out a small quantity for each student and place the empty cup in the center of the desk or table. Each student should try using the clothespin and the pencil to pick up one or more pieces of yarn and put them in the cup. Have each group discuss which was useful in picking up the yarn pieces (clothespin) and which was not (pencil). One student from each group can share the group's observations and experiences to explain their reasons.

- Give a **Fossilized Dinosaur Teeth Adaptation** worksheet (see next page) to each student. Students should complete the worksheet using information, observations and experiences from the activity.
- Make a data table on the chalkboard for the amounts of yarn picked up by each group with the clothespin and the pencil. Show the results in a simple bar graph. Ask the students questions about the data. Challenge the class to make up a question from the data on the chalkboard.

Each student needs:

Goggles
Pencils
Clothespins (wooden or plastic)
Yarn pieces
Foam packaging pieces
Dino Diary

Each group of four students needs:

Dig tools
Fossilized Dinosaur Teeth
Adaptation Worksheet
Dinosaur pictures
Cup of yarn pieces
Clothespin
Pencil



Photographing each fossil as it is found helps scientists learn more about the way the dinosaur lived and died.

Fossilized Dinosaur Teeth Adaptation

Name: _____ Date: _____

Select one dinosaur from your group. My dinosaur is a _____

My Fossilized Dinosaur Tooth

My Model Tooth

Write sentences that describe your dinosaur and dinosaur tooth.

Write sentences that describe your dinosaur tooth model.

Did you select a clothespin or a pencil? _____



© Black Hills Institute of Geological Research



© Black Hills Institute of Geological Research

Plant-eating maiasaurs and meat-eating gorgosaurs have unique teeth adaptations designed for the foods they consume.

Make it fossilize

Students complete the **Fossilized Dinosaur Teeth Adaptation** worksheet. Students will make inferences about plant- and meat-eating dinosaurs. They should be able to list reasons why different models of teeth, clothespins and pencils, are better suited for different types of food.

Dino Diary

At the end of each class period students write under “**Today I discovered ...**” in their diaries. Students may copy the **Fossilized Dinosaur Teeth Adaptation** chart into their **Dino Diaries**. Students will enjoy making a data table and a simple bar graph in their diaries. Encourage them to take the **Dino Diaries** home and ask family members questions about the data charts and graphs.

Paleo-points for the teacher

When students learn how a living animal uses an adaptation, they can begin to make inferences on how a dinosaur may have used a similar body part. Some students may be able to better understand the importance of an adaptation by comparing it to a bird’s beak and the type of foods a bird eats.

Dino Web sites

The Father of Taxonomy — Carolus Linnaeus (Carl von Linné)

<http://www.ucmp.berkeley.edu/history/linnaeus.html>

Enchanted Learning — Comprehensive e-book about dinosaurs

<http://www.zoomdinosaurs.com>

Dino books

- Barrett, Paul. *National Geographic Dinosaurs*. Washington, D.C.: National Geographic Society, 2001. A thorough look at dinosaurs in an easy-to-use manner organized by age and type.
- Fiffer, Steve. *Tyrannosaurus Sue*. New York: W. H. Freeman, 2000. The story of the most complete *T. rex* ever found, told with historical background information about dinosaur hunting.
- Taylor, Paul D. *Eyewitness: Fossil*. New York: Alfred A. Knopf, 1990. A beautifully illustrated photo essay about different types of fossils and how they formed.



*Some scientists believe that several small carnivore teeth found with Stan could indicate that *T. rex* infants ate alongside their parents.*



It is easy to see why this dinosaur is called a duckbill.

What did dinosaurs eat?

Were they meat-eating carnivores or plant-eating herbivores? It is not easy to determine what dinosaurs ate. In some cases scientists have actually found the fossilized bones of the last animal a dinosaur consumed before its death. Some meat-eating dinosaurs were found with the fossilized bones of other dinosaurs located where their stomachs would have been. Other dinosaurs have been found with fossilized bones of their own species where their stomachs would have been. This means some dinosaurs may have eaten their own kind. On the other hand, a duckbill dinosaur called an *Edmontosaurus* was found with bark, pine needles and conifer cones inside its ribcage.



© Black Hills Institute of Geological Research, photograph by Neal L. Larson

A fossil is a window into the past that offers students unparalleled learning opportunities.

Dinosaur dung

This is a perfect opportunity to use science vocabulary to set the mood for class discussion on unpleasant topics. Using the word “dung” or “feces” lets students know that it is acceptable to talk about bodily functions in a mature and scientific way. Coprolites are the fossilized feces or digestive wastes of dinosaurs. Only on rare occasions have the coprolites been found “inside” a dinosaur skeleton. Coprolites have been found around the world and come in different sizes and shapes. Fossilized dinosaur bones, lizard bones and plant materials have been found in the coprolites.

Much of the information about the diet of dinosaurs comes by indirect methods. Scientists can study the shape of fossilized dinosaur teeth and rib cages to compare them with those of modern animals. For example, the beak of a *Triceratops* like Kelsey suggests that it was a plant eater. The beak would be perfect for snipping off

vegetation. The flat teeth of the duckbill dinosaurs were made to grind plants. A plant eater would also need a large rib cage to support a stomach large enough to digest the plant materials.

Living reptile carnivores, meat eaters, have flat, knife-shaped teeth with serrations. This helps them hold on to and cut and saw into the flesh of other animals. A large lizard has teeth that make it easy to cut through animals with thick or tough skins. Some modern reptiles, such as the crocodile, have spearlike teeth without serrations. These are used to grasp slippery fish or larger land animals. These two types of teeth are similar to those of *Tyrannosaurus* and other meat-eating dinosaurs. Modern birds of prey have sharp claws or talons much like *Tyrannosaurus* but on a much smaller scale.

Modern iguanas have leaflike teeth with rounded serrations for cutting plants. Cows, sheep and goats have flat teeth and spend much time chewing and grinding plants. Many dinosaurs had the same types of teeth, evidence that they were most likely plant eaters. Also, some had large rib cages, indicating large stomachs for digesting large amounts of plant material. Some dinosaurs have been found with a pile of well-rounded smooth stones where the rib cage was located. These stones are called gastroliths, or stomach stones, which modern herbivores use to help grind food in their stomachs.



© Black Hills Institute of Geological Research, photograph by Larry Shaffer

Each feature of a leg bone is studied to learn how the dinosaur stood and moved.

Dinosphere museum link: When you visit

Students will be able to see real fossil bones in **Dinosphere**. Students can follow the journey a fossilized bone takes from the dig site to the museum. The various steps are outlined in **Dinosphere** and on **The Children’s Museum** Web site. In the museum’s **Paleo Prep Lab** students will be able to touch real fossilized dinosaur bones and meet people who work on fossils. **Dinosphere** has many areas where students can explore dinosaur fossils and help to uncover fossilized bones in a simulated dig site. Students can identify, sort and make drawings of the different teeth found in the 14 animals on display in **Dinosphere**.

Bonus: Digging deeper!

You can add other types of tools to be used in the **Fossilized Dinosaur Teeth Adaptation** activity, such as scissors or spoons. Students can show how these items can model how a dinosaur’s teeth helped it to eat the foods available. Also, other items can be used to model the claws and toes of dinosaurs in **Dinosphere**. Try the exercise with other items to show diversity in the food chain. For example, use beans, grains of rice, toothpicks, buttons and items placed in water. Try to determine which tool works best with each item. Students can collect data and graph the results.

Lesson 2

Dinosaurs — Many Types From Different Times and Places

Introduction

Students learn that a dinosaur is named by three criteria and that each part of a name has a meaning. Students create new dinosaur names and decode real names using Greek and Latin words. They also learn the diversity of size and shape that makes

studying dinosaurs so exciting. Students take measurements, make drawings and construct models to learn about dinosaurs. This lesson focuses on the way we name dinosaurs after unique body parts or behaviors.



© Black Hills Institute of Geological Research

Triceratops is one of the most popular dinosaurs but only a few have been found.



The Children's Museum of Indianapolis

*Dinosaur toy models help us understand size and interaction. This trio is represented in *Dinosphere* at the T. rex Attack scene.*

Science names

The Englishman Richard Owen first used the word *dinosauria* in 1842. It is made from *dino*, which means terrible, and *sauria*, which means lizard. Put together, the words mean “terrible lizard.” A dinosaur that appears to be fast (*veloci*) and able to steal (*raptor*) eggs or other food is named *Velociraptor*. These dinosaurs are named after body parts or behaviors. By learning a few Latin or Greek words students are able to understand how dinosaurs are named.

Students will learn that there are also nicknames for plants, animals and dinosaurs. For example, in **Dinosphere** the *Triceratops horridus* is nicknamed Kelsey, while Bucky is the nickname of one *T. rex*. A plant or animal may have a nickname and a common name as well as a scientific name.

EXPERIENCE 1

What's in a Dinosaur Name?

Vocabulosaurus

● **Greek and Latin** words — Scientists use many of these words and word parts to describe plants, animals and the world. Many word parts are included in this lesson. The focus is on the following:

- *uni*
- *bi*
- *tri*
- *rex*
- *odon*
- *mega*
- *micro*
- *saurus*
- *ped*
- *ops*
- *cephale*
- *cerat*
- *rhino*
- *tyrant*
- *vore*

Indiana Academic Standards

Science — 3.1.2, 3.1.3, 3.1.5, 3.2.3, 3.2.5, 3.2.7, 3.4.1, 3.4.2, 3.4.5, 3.5.5, 4.1.1, 4.1.3, 4.1.4, 4.2.5, 4.2.7, 5.2.3, 5.2.4, 5.2.7, 5.4.8, 5.6.2
Language Arts — 3.1.8, 3.4.4, 3.5.2 3.6, 4.1.4, 4.4.1, 4.4.7, 4.6, 4.7.12, 5.1.4, 5.4.5, 5.6, 5.7.10

Get ready to dig

Dinosaurs are a special group of animals with interesting names that often are long and hard to pronounce. Students are empowered when they can pronounce these multi-syllabic names and know what they mean. Dinosaurs are named for unique body parts or behaviors, for the location where they were found, or after a person. This makes for some fun and confusion!

The *Edmontosaurus* was originally found in and named after a layer of rocks near Edmonton, Canada. So an *Edmontosaurus* is the dinosaur from Edmonton. Ask students if they can guess where you might travel to dig up an *Argentinosaurus*. They should be able to tell you Argentina.

Other dinosaurs are named after famous people or for the lucky person who found them. Who do you think the dinosaur *Jenghizkhanosaurus* was named after? The answer is Genghis Khan.

Focus Questions

- How is a dinosaur named?
- What does the name mean?
- Can new dinosaur names be created?
- Can words be broken into parts that have meaning?

Objectives

Students will:

- Name three different ways dinosaurs are named.
- List dinosaurs and the body parts they are named after.
- List one or more new dinosaur names by a body part.
- Use an apparatus (see pp. 22 – 23) to decode real and created dinosaur names.

Dig tools

Paper, pencils, scissors; drawings of dinosaurs; **Dino Diaries**; dino word strips; **What's in a Dinosaur Name?** chart. Additional Greek and Latin words are located in the reference section, page 102.



Discovery of an imprint of *Edmontosaurus* skin was a significant and rare find on The Children's Museum's Dino Institute Teacher Dig 2003 in South Dakota.

The Children's Museum of Indianapolis

DIG IN ...

What's in a Dinosaur Name

Part 1 — Science names

- Ask students to name any dinosaurs they can think of. Make a list of their responses. Use the reference section of this unit of study to list the **Dinosphere** dinosaurs. Ask students to use their **Dino Diaries** to draw a picture and write the name of their favorite **Dinosphere** dinosaur. If they cannot name a dinosaur use Kelsey the *Triceratops* for the lesson. Ask them if they know what the dinosaur name means. Several students will know that *Triceratops* means “three-horned” dinosaur. Write the name and the word parts on the board and ask students to copy it in their diaries. (Greek *kerat* or *cerat* = horned)
- Tell students that scientists and other students name dinosaurs in three different ways. Write the following on the board:
Dinosaur Name
(1) body part or behavior
(2) where found
(3) person — finder or famous.
In **Dinosphere** there are examples of all three types of dinosaur names.

Kelsey the *Triceratops horridus* is named after **body parts**. The *Gorgosaurus linsteri* will be named after the Linster family, **who** found it. The *Edmontosaurus annectens* is named for Edmonton, Canada, **where** it was found.

- List on the board the following words and their meanings:
uni – one, *bi* – two, *tri* – three, *quad* – four, *cera* – horn, *rhino* – nose
Ask students how many horns a “Quadceratops” will have. Since *quad* means four, the answer is four horns. Ask students to make as many different types of combinations of the words on the board as they can. Have them draw a picture of the head of their new dinosaur that shows the correct number of body parts for the name. Ask them to write sentences to describe their dinosaur. For example, “My Quadceratops has four horns.”

Part 2 – Create a Dinosaur Name

Students will create a genus name using the **What's in a Dinosaur Name?** worksheet.

- Make copies of the **What's in a Dinosaur Name?** worksheet. Students can cut the three word strips apart. Each strip contains a list of Latin and Greek words they will use to create a genus name for a dinosaur they create. Then cut along the dotted lines of the skull drawing. Slip each of the three strips into the slots in the skull.
- Have students move each strip up and down to make new names, then write the names they create in their **Dino Diaries**. They can start by using two strips and add the third strip as their skills improve. Make sure they leave a blank space for the species name of their dinosaur.
- Ask them to follow the same rules that scientists use when they name a dinosaur species. The species is named after a place or a famous person. For example, the four-horned dinosaur that might be found in Indianapolis becomes *Quadceratops indianapoliensis*.
- Students create new names and list them in their **Dino Diaries**. Use the **What's in a Dinosaur Name?** chart to help decode real dinosaur names.
- A larger list of Greek and Latin word parts used in science can be found in the reference section of this unit of study on page 102. Use these words to make more dinosaurs names. Have students share their new names with the class. Make three blank strips where students add the new words.



A Gorgosaurus ready for display.

© Black Hills Institute of Geological Research

What's in a Dinosaur Name?

Name: _____

Cut apart the dinosaur name strips on this page. Slide the name strips into the *Tyrannosaurus rex* **What's in a Dinosaur Name?** skull worksheet. Move the strips up and down to create dinosaur names. You can make names of dinosaurs that are in **The Children's Museum Dinosphere**. For example, try *Triceratops*, which means three-horned face. Find the three name strips for tri, cerat and ops.

Word Parts

uni
one

tri
three

tyrant
terrible

bi
two

mega
big

Word Parts

cerat
horn

rhino
nose

cephale
head

ped
foot

micro
small

Word Parts

vore
eat

odon
tooth

ops
face

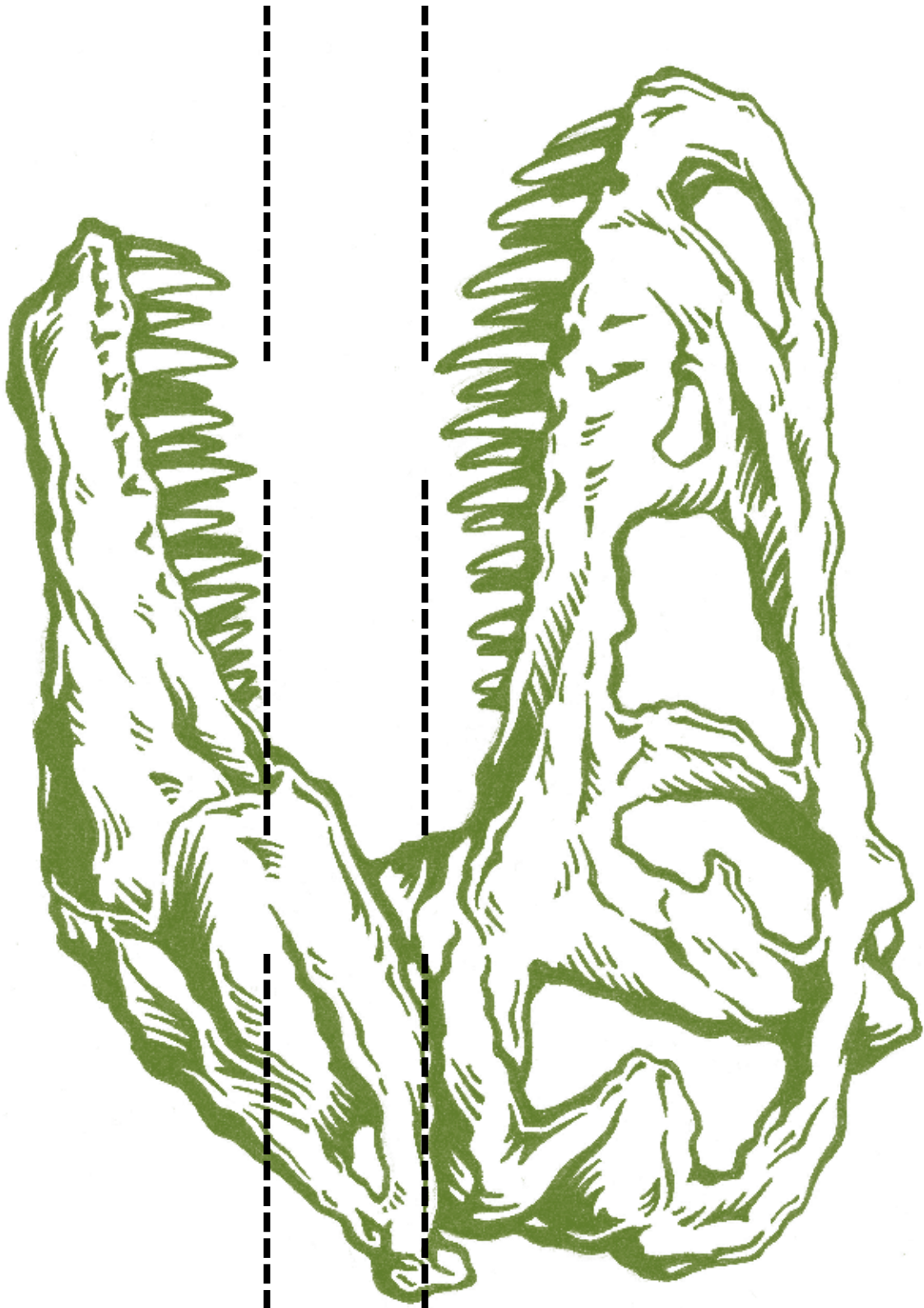
saurus
lizard

rex
king

What's in a Dinosaur Name?

Name: _____

Cut along each dotted line.



Make it fossilize

Students can list the three ways dinosaur names are created and can use 10 or more Latin and Greek words to describe a dinosaur. With practice students will be able to use the **What's in a Dinosaur Name?** chart to decode actual dinosaur names found in **Dinosphere**. They should be able to recreate *Triceratops horridus* and *T. rex* using word parts from the worksheet.

Paleo-points for the teacher

Classifying Plants and Animals

Scientists classify all plants and animals including dinosaurs using the binomial system created by Swedish naturalist and physician Carolus Linnaeus (Carl von Linné) in the 1750s. The binomial, or two-word, system uses one Latin or Greek word to represent the genus and another word for the species. The system uses the following major divisions to classify plants and animals:

Kingdom – Phylum – Class – Order – Family – Genus – Species

An easy way to remember the divisions is with this phrase:

Kids **P**lease **C**ome **O**ver **F**or **G**reat **S**cience!

Dinosphere dinosaurs are classified with this system. The complete listing can be found in the reference section of this unit of study.

Dino Web sites

Dinosphere link on **The Children's Museum** Web site

<http://www.childrensmuseum.org>

Museum of Paleontology

<http://www.ucmp.berkeley.edu/index.html>

Enchanted Learning — Comprehensive e-book about dinosaurs

<http://www.zoomdinosaurs.com>

Dino books

- Taylor, Paul D. *Eyewitness: Fossil*. New York: DK Publishing, 2000. A beautifully illustrated photo essay about different types of fossils and how they formed.
- Willis, Paul. *Dinosaurs*. Pleasantville, N.Y.: Reader's Digest Children's Books, 1999. An introduction to dinosaurs — how they looked, behaved and ate, and what is known about them through the study of fossils.

Dino Diary

At the end of each class period students write or draw pictures under the heading **"Today I discovered ..."** in their diaries. The diaries will include notes and lists of dinosaur names from the lessons and pictures and drawings of real and created dinosaurs. Students should have written several new words and sentences that use the dinosaur names. Ask for volunteers to read aloud any part of their diaries to the class.

Bucky and Stan – *Tyrannosaurus rex*

Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria ("ruling reptiles") Subclass Dinosauria (extinct reptiles, "terrible lizards")
Order	Saurischia (lizard-hipped) Suborder Theropoda (beast-footed)
Family	Tyrannosauridae (tyrant lizard)
Genus	<i>Tyrannosaurus</i> (tyrant)
Species	<i>rex</i> (king)

Kelsey – *Triceratops horridus*

Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria ("ruling reptiles") Subclass Dinosauria (extinct reptiles, "terrible lizards")
Order	Ornithischia (beaked, bird-hipped plant-eaters) Suborder Marginocephalia (fringed heads)
Family	Ceratopsidae (frilled dinosaurs, including horned dinosaurs)
Genus	<i>Triceratops</i> (three-horned face)
Species	<i>horridus</i> (horrible refers to the horn)

Classifying Kelsey — A Dinosphere Dinosaur

All Organisms

Plant Kingdom
Fungi Kingdom
Animal Kingdom
Protists Kingdom
Bacteria Kingdom

Animal Kingdom

Invertebrates (95% of all animals do not have backbones),
Porifera, Nematoda, Arthropoda, Arachnida, Mollusca,
Cnidaria,
Chordata (5% of all animals have backbones), and other
phyla.



Chordata Phylum Subphylum Vertebrata

Mammalia (mammals), **Archosauria** (“ruling reptiles”), Chondrichthyes (cartilaginous fish), Osteichthyes (bony fish), Amphibia (frogs, toads, salamanders, etc.), Aves (birds), Reptilia and other classes.

Archosauria Class

Living reptiles — Testudines/Chelonia (turtle/tortoise), Squamata (lizards/snakes), Crocodylia (crocodiles, alligators/caymans).
Nonliving extinct reptiles — Pterosauria (winged reptiles), Plesiosauria and Ichthyosauria (marine reptiles), and other orders.
Dinosauria subclass (“terrible” lizards from the Mesozoic Era)

Dinosauria Subclass

Saurischia (lizard-hipped), **Ornithischia** (bird-hipped), and others

Ornithischia

Ornithopoda Suborder (bird-foot), Thyroophora Suborder (roofed/plated, armored),
Marginocephalia Suborder (fringed head) and others

Marginocephalia Suborder

Pachycephalosauria Family (thick-headed reptiles), **Ceratopsidae Family** (horn-faced) and others

Ceratopsidae Family

Psittacosaurus, Protoceratops, Pachyrhinosaurus, Styracosarus, Chasmosaurus, **Triceratops** and others

Genus *Triceratops*

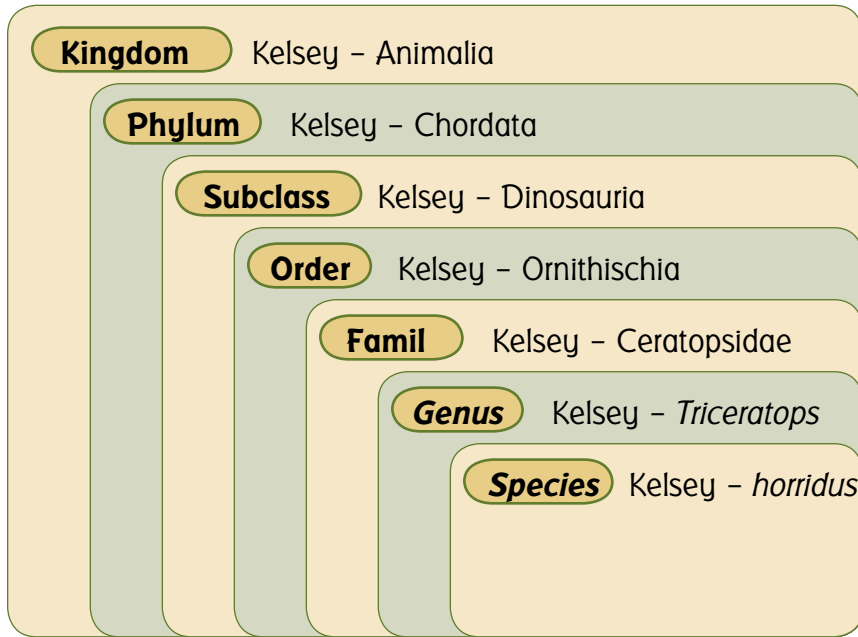
albertensis, *alticornis*, *eurycephalus*, *galeus*, ***horridus***, *maximus*, *prorsus*, *sulcatus* species and others

Species *horridus*

Triceratops horridus

This makes Kelsey an organism in the **Animal** kingdom, in the **Chordata** phylum, subphylum **Vertebrata**, in the class **Archosauria**, subclass **Dinosauria**, in the order **Ornithischia**, suborder **Marginocephalia**, in the family **Ceratopsidae**, of the genus ***Triceratops*** and the species ***horridus***. This classification system can be used with each dinosaur in **Dinosphere**. An easy way to remember the different groups, Kingdom — Phylum — Class — Order — Family — Genus — Species, is with the phrase, Kids Please Come Over For Great Science! The chart on the next page shows how each classification fits within a larger group.

How Plants and Animals Are Classified



More information on how dinosaurs are classified can be found at the following taxonomy Web site. It is not intended for elementary students, but may be helpful for teacher research. *The Dinosauricon*, by Mike Keesey: <http://dinosauricon.com/main/index.html>



This fossilized cricket lived millions of years ago.



Crabs are invertebrates (animals without backbones) that lived in the Dinosaur Age and still exist today.

The Children's Museum of Indianapolis

The Children's Museum of Indianapolis

Bonus: Digging deeper!

In this lesson students explored ways that scientists name dinosaurs according to body parts or behaviors. Scientists name all plants and animals by following certain systematic rules. Dinosaurs are named three ways:

- by body part or behavior,
- according to where the dinosaur was found, and/or
- after a person who found the dinosaur or who was important to the discovery.

In **Dinosphere** there are examples of all three types of dinosaur names:

- Kelsey, a *Triceratops horridus*, is named after **body parts**.
- The *Gorgosaurus linsteri* will be named after the Linster family, **who** found it.
- The *Edmontosaurus annectens* is named for Edmonton, Canada, **where** it was found.

Use reference materials from the Internet and from books to find interesting names of dinosaurs. Help your class decode these names. Each morning a new name can be added to the chalkboard or word list. Students will enjoy seeing how the binomial system also works for plants and other animals. Research the names of some common plants and animals that are found at home and in the classroom. Make a list in your room or label the ones you find. The information in paleontologist Robert Bakker's article provides a clear understanding of how dinosaurs are named.

Dinosphere museum link: When you visit

When students visit **Dinosphere** they see life-size fossilized dinosaurs in a variety of sizes. They can use the Greek and Latin word parts they have learned in class to understand the names of dinosaurs in the exhibits. In **Dinosphere** many other mammals and plants are on display to immerse visitors in the sights, sounds and smells of the Cretaceous Period. With a little extra effort students and teachers can name the plants and animals as accurately as any scientist. A complete listing of the scientific names of the plants and animals on display in **Dinosphere** is found in the reference section of this unit of study.

Triceratops

*Three horns on my face,
I lived in the Cretaceous with
many strange beasts,
If you invite me to dinner,
Make it a plant-eaters feast!*

— Caroline Crosslin

When to Capitalize and Italicize Dino Names

T. REX — No! *T. rex* — Yes

by Robert Bakker

What's a species?

Tyrannosaurus rex has two names, and so does every species of beetle, bott fly, pronghorn antelope and bacteria. And so do you. Every single species of plant and animal has two names! As in many Asian human cultures, the family name comes first: ***Tyrannosaurus*** is not the name of one single species but of a cluster of closely related species. In Mongolia we find ***Tyrannosaurus baatar***, a little earlier than our American ***T. rex***. You can tell ***T. baatar*** from ***T. rex*** because ***T. baatar*** has more teeth and the tooth crowns are sharper.

Here's an example from dog species: ***Canis lupus*** is the wolf. ***Canis latrans*** is the coyote. Two species in the species cluster we call ***Canis*** (the technical name for a cluster is a genus). The definition of "species" is simple: it's a group of closely related individuals who keep their genes to themselves in the wild. Wolves and coyotes are two separate species because they coexist in Canada and Montana and they don't interbreed, even though they are very similar genetically (in zoos, if you force them, wolves and coyotes might interbreed).

How do you tell species apart from fossil bones?

When we say ***T. rex*** was a different species from ***T. baatar***, we mean the differences in teeth and bones are so great that we think these two populations would not interbreed if they ever met. Can we tell all species apart from their fossil bones? No, not all of them can be identified. There are some species groups alive today who do not mix their genes but whose bones are so similar that if they were fossils we wouldn't know the species are separate. A classic example: Some species of the High Plains Pocket Gophers are virtually identical in their skeletons but do have such strong differences in genes that they cannot interbreed.

Fortunately, most of these "hidden species" are small critters such as rodents. Nearly all living species of really big animals today can be told apart from their bones — you can tell an African elephant from an Indian elephant, and you can tell apart all five rhino species from bones, and

all the 27 species of gator and croc. If we have complete specimens, we probably could tell apart nearly all the dinosaur species. But when all we have is some bone fragments from dinos, it's usually really hard to be sure that a box of bones comes from one species or two or three.

How do we write species names?

The species-group (genus) is always capitalized and always in italics. Always write: *Tyrannosaurus*. Never: *tyrannosaurus*. Never: Tyrannosaurus. The rules apply to us humans too. We are *Homo sapiens* and it's wrong to write Homo sapiens. We are the only species of *Homo* alive now. But over the last million years there were others, such as the famous Neanderthal man, *Homo neanderthalensis*.

The species name is never capitalized, but always italicized. Always write: *Tyrannosaurus rex*. Never: Tyrannosaurus Rex. Never: T. rex.

Most of the time, when we're talking about dinosaurs, we don't use both names, just the species-group name. Most dino books talk about *Stegosaurus* without being specific, without naming the separate species called *Stegosaurus unguatus*, *S. stenops* or *S. laticeps*. That's OK, because all the "steggies" look pretty much alike to the untrained eye. If you went to a zoo and saw coyotes and wolves in pens next to each other, and you wanted to talk about all the doggie-species together, it would be fine to say, "Look at the *Canis*!"

Why do we say *T. rex* all the time? It is because this one species is so big and famous, and because the two names sound so cool when said together.

Practice speaking species-talk

Do this to practice. Make yourself a nametag that says, "Hi — I'm a *Homo sapiens*! My favorite dino is *Tyrannosaurus rex*." Make each of your friends wear a nametag, with their own favorite dinosaur species — they'll have to look up the species name. For instance, the common Mongolian raptor is ***Velociraptor mongoliensis***. The common T'tops is ***Triceratops prorsus***. It's OK to abbreviate the species-group name if there's no risk of confusion. That's why folks say *T. rex*.

What's a dinosaur "family"?

Species groups who are closely related are brought together into what are called families. The dog family, home to wolves, coyotes, foxes and jackals, is Family Canidae. Always capitalize Latin family names. *T. rex* and its cousins *Albertosaurus* and *Gorgosaurus* are in the Family Tyrannosauridae. We can use an informal lower-case way to talk about families. We use the "id" (that doesn't mean we're psychoanalyzing dinos). If I say "the canid family," that's informal-speak for Family Canidae. If I say "the tyrannosaurids," that means the same thing as "tyrannosaur family" or Family Tyrannosauridae. You don't have to capitalize tyrannosaurids. But you do have to capitalize words with the Latin ending *-idae*. That means you are speaking formally, so you must capitalize: Tyrannosauridae.

Don't get overwrought on this one — you'll confuse the second-graders and bore the adults. Stick to "id" and lower case unless you're talking to grad students. "Everybody loves the tyrannosaurids at The Children's Museum!"

Extra credit for dino-geeks: Here's a paragraph that has all the Family usages:

"The Family Tyrannosauridae includes all the big dino meat-eaters with two-finger hands, such as *Tyrannosaurus* and *Gorgosaurus*, and the tyrannosaur family is the most famous family of all dinosaurs, since the world-favorite species, *T. rex*, is a tyrannosaurid."

Dinosphere has the following dinosaurs.

Family Tyrannosauridae:

Gorgosaurus linsteri; *T. rex*.

Family Ceratopsidae: *Triceratops horridus*

Family Protoceratopsidae: *Leptoceratops* new species (it hasn't been formally named yet).

Family Hadrosauridae: *Maiasaura* new species (we're not sure yet on the proper name).

Some of us tyrannosaurid-aficionados think the differences in teeth are so great that the Mongolian species *baatar* belongs to its own genus. That would mean we couldn't call it *Tyrannosaurus baatar*. Instead, we'd say *Tarbosaurus baatar*. This is a tough call. Heads and bodies are alike in the two species but the teeth are very different.

EXPERIENCE 2

Size, Scale and Models

Indiana Academic Standards

- Science** — 3.1.1, 3.1.2, 3.1.4, 3.1.5, 3.2.1, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.5.1, 3.5.2, 3.5.3, 3.5.5, 3.6.3, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.1, 4.2.2, 4.2.4, 4.2.5, 4.2.7, 4.5.3, 4.6.3, 5.1.1, 5.1.3, 5.2.3, 5.2.4, 5.2.5, 5.2.6, 5.2.7, 5.2.8, 5.4.8, 5.5.1, 5.5.2, 5.5.6, 5.5.8, 5.6.3
- Language Arts** — 3.4.4, 3.5.2, 3.6, 4.4.1, 4.4.7, 4.5.4, 4.6, 4.7.12, 5.4.5, 5.6, 5.7.10
- Math** — 3.5.2, 3.5.5, 4.1.4, 4.5.2, 4.5.8, 4.6.1, 4.6.2, 5.1.3, 5.5.4, 5.6.1
- Social Studies** — 4.3.2

Get ready to dig

One of the strangest things about dinosaurs is their size. Some were real giants, while others were the size of small birds. Students will take measurements and create charts to learn about the size of dinosaurs. Students can learn how scientists estimate the volume of dinosaurs by

using a simple displacement procedure. For every hour spent in the field digging up a fossilized dinosaur, paleontologists and technicians need 20 hours to clean, repair, mount and erect the skeleton. Students will learn how fossilized bones fit together when they make their own dinosaur skeleton.

Focus Questions

- How big were dinosaurs?
- Are dinosaurs big and small?
- What can the fossilized bones reveal?

Objectives Students will:

- Estimate the size of dinosaurs using metric, U.S. and other units of measurement.
- Measure and compare dinosaurs to known objects.
- Compare the volume of dinosaur models using displacement.
- Create a scale model of a dinosaur.

Dig tools

Meter stick and centimeter rulers; scale drawings of the skeletons of Kelsey and Stan; goggles; pipe cleaners, scissors, bell wire, graduated cylinder, 2-liter bottle, permanent marker, water; scale models of Kelsey and Stan or other dinosaurs.



© 2002 Dan Counter, Black Hills Institute of Geological Research

Plaster is used to create a strong jacket around the fossils.

Vocabulosaurus

- **scale drawing** — a representation of something reduced according to a ratio; for example a 1:10 scale drawing means 1 unit of measure represents 10 units of the real object.
 - **model** — a representation of an object that can show many but not all of the features of the actual item. It is used when the actual object cannot be used.
 - **displacement** — a method to determine the volume of an object by measuring the amount of water it displaces when submerged in a graduated cylinder.
- | | |
|--------------------|--------------------|
| ● units | ● backbone |
| ● meter | ● skeleton |
| ● bar graph | ● wire |
| ● head | ● sculpture |
| ● tail | ● model |

DIG IN ...

Size, Scale and Models
Part 1 — Supersize That Dinosaur

- Pass out pictures of the skeletons of Kelsey and Stan to the class. Ask the students to estimate how long or tall each dinosaur is. Ask them to compare those sizes to known objects. For example, ask if they are larger or smaller than a dog, cow, car, school bus, house and school. They should be able to make statements that determine that the dinosaurs mentioned are larger than a _____ but smaller than a _____.
- Use a meter stick to determine how tall several students are. Round off to the nearest meter or half meter. Record the height of the students and find an average.
- Make drawings to show the relationship between students and dinosaurs. For example Kelsey is 9 meters long and Stan is 13 meters long from head to tail. Ask the class to predict how many students would have to line up head to foot to match the size of the two dinosaurs. Use the hallway if needed to let students line up to demonstrate the length of the dinosaurs.



© Black Hills Institute of Geological Research

What might have caused the death of this very large maiasaur?

- Have students use reference materials to find the length of other dinosaurs. Make sure they select some of the smaller ones such as Baby Louie, the *Oviraptor*. Try to find the length of each of the **Dinosphere** dinosaurs.
- Work with the class to make a bar graph of the sizes of dinosaurs. Make two different graphs for the same dinosaurs — one in meters and the other in “student” units.

Part 2 — How Do People Compare in Size to a Dinosaur?

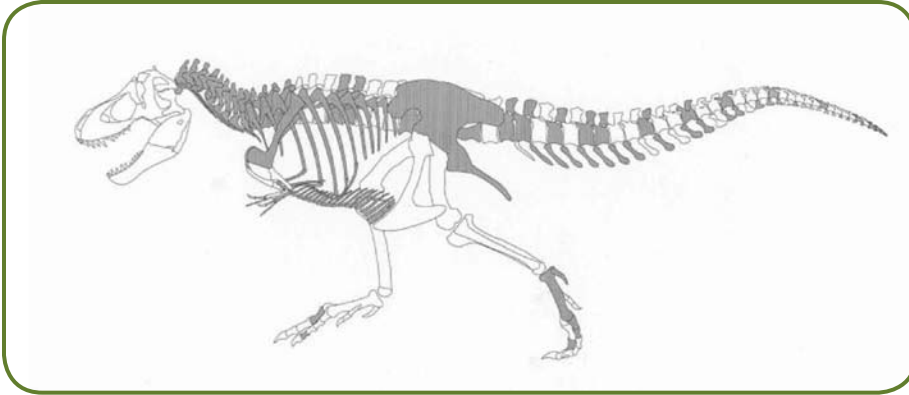
- Make a chart to record measurements. Include five columns for head-to-toe, back foot, hand, skull and largest tooth. In each of these columns put the measurements for Stan or Bucky. Use the scale on the skeleton drawings to

estimate the lengths. The scale shows the relationship of the drawing to a real skeleton. If the scale is 1=10 this means that every unit on the drawing represents 10 units on the fossilized bone.

- Work with the class to convert the five measurements to centimeters and meters.
- Make another row on the chart and have the class make the same measurements for Kelsey. Record the results on the chart.
- Divide the class into teams of two. Have students use centimeter rulers to make the same measurements on each other and record the measurements on their own chart.
- Ask students to share and compare their findings with the class.

Dinosaur Measurement Comparison

Animal	Length (Head-Toe)	Back Foot	Hand	Skull	Largest Tooth
Stan	13 meters (43 feet)	1 meter (3 feet)	28 centimeters (11 inches)	1.5 meters (5 feet)	25 centimeters (10 inches)
Kelsey	9 meters (22 feet)	40 centimeters (1 ft. 4 in.)	45 centimeters (1 ft. 6 in.)	2 meters (6 ft. 6 in.)	2 centimeters (1/2 - 1 inch)
Me					
Partner					



The shaded bones are real fossils. It is rare to find all the bones of a dinosaur.



The Children's Museum of Indianapolis

You can create wire sculptures of **Dinosphere** dinosaurs by referring to skeletal drawings. Wire models help students understand how dinosaurs moved and lived.

Part 3 — The Volume of a Dinosaur: Which Is Bigger, Kelsey or Stan?

- Cut the top from a 2-liter plastic bottle. Remove the label. Use two plastic models of Stan and Kelsey, making sure they are to scale.
- Test the size of the 2-liter bottle and dinosaur models. Place each model one at a time in the 2-liter bottle without water. Make note of how far the model fits into the bottle. The bottle must be large enough for it to be completely inside.
- Fill the bottle with enough water (about two-thirds of the way up) so that the model will be completely covered when submerged.
- Write "L1" for level one with a permanent marker on the outside of the bottle at the waterline.
- Place the Kelsey dinosaur inside the bottle. Make sure that it will go completely under water. (If not take

it out and return to step 3. Put more water in the bottle and re-mark the waterline.)

- Write "L2" for the new waterline where the water has risen because the Kelsey model is inside the bottle in the water. This is the amount or volume that has been displaced by the model. It is also the volume of the Kelsey plastic model.
- Remove the dinosaur. Observe that the water level should have gone back down to the original level. Some water may have stuck to the model or spilled. If so, just carefully refill the water to the original waterline.
- The amount of water that is needed to fill between "L1" and "L2" is the amount displaced. It is also the volume of the object. Add water up to the "L2" line. Make sure the model is not inside the bottle.
- Slowly pour the water from the bottle into a graduated cylinder. Pour only until you reach the "L1" mark on the bottle. (If you pour too much, pour it

back from the cylinder until the water is at the "L1" mark.) Read the amount of water that is in the graduated cylinder. This is the volume in milliliters (ml) of the Kelsey dinosaur model.

- Repeat the procedure with the Stan model. Record the volume of each model.

Part 4 — Make a Dinosphere Dinosaur Model

- Use **Dinosphere** skeleton drawings as a reference to make a model skeleton. Students can work together in teams to help each other but they should each make their own model. You may want to invite older students to help with this project.
- Each student will need at least 10 regular-size pipe cleaners. Students may use scissors to cut pieces to fit. Have students wear goggles. It is a safe and fun way to make sure your students protect their eyes.
- Remind the class that they are making scale versions of the dinosaurs, not life-size models. Review that a model is a scaled representation of the real thing.
- Place each wire over the skeleton drawings for reference. Cut and bend each piece. Start by making a loop for the head with a long wire as the backbone and tail. Add two separate wires at the front and back for the legs and arms. Leave enough extra wire on the legs to make the feet. Make careful observations to determine how many toes and claws the model should have. Finish the model by adding wire loops for the rib cage. Students may observe that the rib loops should be cut into separate ribs. Older students can use bell wire in place of pipe cleaners for their models. Wire cutters or strong scissors can be used to cut the wire. Make sure students wear safety goggles when working with wire.
- Tighten or glue the "knots" where the wire pieces come together. Pose the model in a realistic way. Visit **Dinosphere** online or use other resources to help place your skeleton in the correct position.

Make it fossilize

Check the charts and measurements to ensure that the students write the units they use for each measurement. The units may be meters (m), centimeters (cm), and students. They can explain why a model is a good tool to use in science. Students should know that a model could show some things well and some not at all. They should be able to give examples of other models.

Dino books

- Barrett, Paul. *National Geographic Dinosaurs*. Washington, D.C.: National Geographic Society, 2001. A thorough look at dinosaurs in an easy-to-use manner organized by age and type.
- Cooley, Brian. *Make-a-Saurus: My Life With Raptors and Other Dinosaurs*. Toronto: Annick Press, 2000. A fun, resource-filled, step-by-step guide for making a model of a dinosaur.
- Fiffer, Steve. *Tyrannosaurus Sue*. New York: W. H. Freeman, 2000. The story of the most complete *T. rex* ever found, told with historical background information about dinosaur hunting.
- Willis, Paul. *Dinosaurs*. New York: Reader's Digest Children's Books, 1999. An introduction to how dinosaurs looked, behaved and ate, and what is known about them through the study of fossils.

Dino Web sites

Dinosphere link on **The Children's Museum** Web site

<http://www.childrensmuseum.org>

Jurassic Park Institute

<http://www.jpoinstitute.com>

Weighing a Dinosaur — Robert Lawrence, D.C. Everest Junior High School, Schofield, Wisc.

http://www.geology.wisc.edu/museum/hughes/dinosaurweight_students.html

Enchanted Learning — Comprehensive e-book on dinosaurs

<http://www.zoomdinosaurs.com>

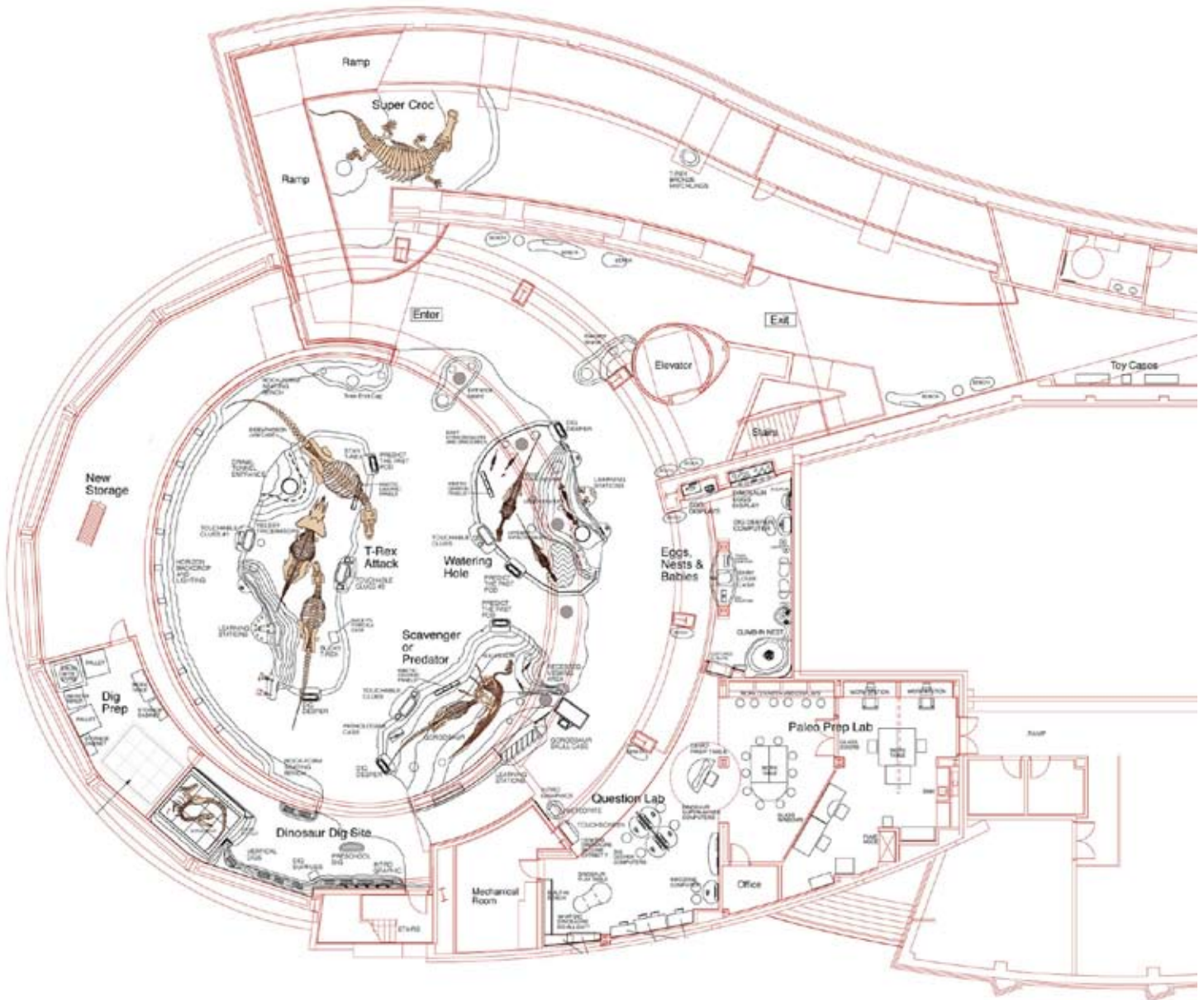
Dino Diary

Students use their diaries to create the **Dinosaur Size** chart. Make simple charts for younger children to complete and then glue into their **Dino Diaries**. Students write statements that their dinosaur is smaller than _____ or larger than _____. When students measure the volume of Kelsey and Stan, draw the steps on the board and have them make drawings for each step of the displacement procedure. Ask the class to list how a model is like and different from the real thing it represents. Have them write about other models they have made, used or seen. End each class period with time to write under the heading **"Today I discovered ..."** in their diaries. Ask for volunteers to read aloud parts of their **Dino Diaries**.

Paleo-points for the teacher

If your students have trouble making the measurements pair your students with older students. They can help with the project and both groups will enjoy working together. You may want to expand the "greater than, less than" statements by introducing the math symbols that stand for these statements. For example, House > Kelsey > car, which means Kelsey is smaller than a house but larger than a car. This may help students understand these symbols in a way they have experienced.

Learning how to find the volume of an object with displacement is a useful skill. Most students have not been exposed to this procedure and will have a great deal of fun "doing" science. Note that it is important for the entire object to be submerged when taking measurements. A student may hold an object below water with one finger but this will make the measurement incorrect because of the volume of the finger. Instruct students to use a pencil or other low-volume stick to hold the object under. This may be needed when determining the volume of a plastic object that floats. Also, it may be advisable to tie a string around a heavy object that sinks quickly to allow it to be retrieved without pouring the water out.



Bonus: Digging deeper!

Use the measurements your class made of Kelsey and Stan. Mark off the lengths and heights on the playground or parking lot. Students can use chalk, stones or markers to make a life-size drawing of the dinosaurs. Once the drawings are complete estimate how many students will fit inside. Make a prediction, and then have everyone join in to check your prediction. If needed, invite other classes to fill in your dinosaur.

Dinosphere museum link: When you visit

When students visit **Dinosphere** they see life-size fossilized dinosaurs. The skeleton drawings and diagrams in this unit of study are the actual plans used to construct **Dinosphere**. You will be able to estimate the actual size of dinosaurs when you visit. Students can ask questions and interact with dinosaur experts and paleontologists in the **Paleo Prep Lab** and **Question Lab**.

Lesson 3

Some Dinosaurs Lived Together



© 2004 Michael Skrepnick, "Watering Hole," acrylic, The Children's Museum of Indianapolis

Paleo-artist Michael Skrepnick based this "Watering Hole" scene on the most current research about dinosaur habits and interactions.

Introduction

Students study **Dinosphere's** dinosaurs to try to determine how they lived together. All animals have basic needs that include food, water, air, habitat and others of their own kind in order to reproduce. Students look for clues to see how dinosaurs met their basic needs by living in groups.

They compare how modern animals live in order to find indirect clues about dinosaur behavior. Students will look for clues to how dinosaurs lived together and hunted in the main scenes at **Dinosphere**. Each scene explores a different aspect of animal interaction.

EXPERIENCE 1

Why Do Animals Live in Groups?

Get ready to dig

Evidence of dinosaurs living together is rare for most species. Most fossils are incomplete and disarticulated (bones no longer joined together) when found. On rare occasions dinosaurs have been found with fossilized eggs and babies, with evidence of teeth and claw marks from other dinosaurs and with different sized animals of the same species. These fossils help to explain how dinosaurs lived together. In the Mongolian desert a *Protoceratops* and a *Velociraptor* were found preserved in a death embrace, with the teeth and beak of the *Protoceratops* clenched around the leg of the *Velociraptor*. One claw of the *Velociraptor* was stuck into the ribs of the *Protoceratops*. This is direct evidence of how these two dinosaurs interacted. Another way to learn about dinosaurs is to study living animals. Their behavior can provide clues about how dinosaurs behaved and interacted.

Indiana Academic Standards

Science — 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.2.6, 3.2.7, 3.4.4, 3.4.5, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.5, 4.2.6, 4.2.7, 4.4.2, 4.4.3, 4.4.4, 4.4.6, 5.1.1, 5.1.2, 5.1.3, 5.4.4, 5.4.7, 5.4.8, 5.6.1



© 2004 Michael Steppnick, "T. rex Attack," acrylic, The Children's Museum of Indianapolis

Vocabulosaurus

- **predator** — an animal that lives by hunting and eating other animals, or prey. A lion is a predator. It hunts antelope, its prey.
- **prey** — an animal hunted by predators as food. Some prey are also predators. For example, a hawk is a predator that eats snakes. Snakes are also predators that eat frogs. Snakes are both predators and prey.
- **herd** ● **group**
- **family**

Focus Questions

- What was a dinosaur group?
- What types of activities do animals do together?
- How did dinosaurs interact with each other?
- How did they feed each other?

Objectives **Students will:**

- Give examples of how families cooperate and work together.
- List basic needs of animals.
- List benefits and problems for animals living in groups.
- Identify, compare and contrast dinosaur interactions.

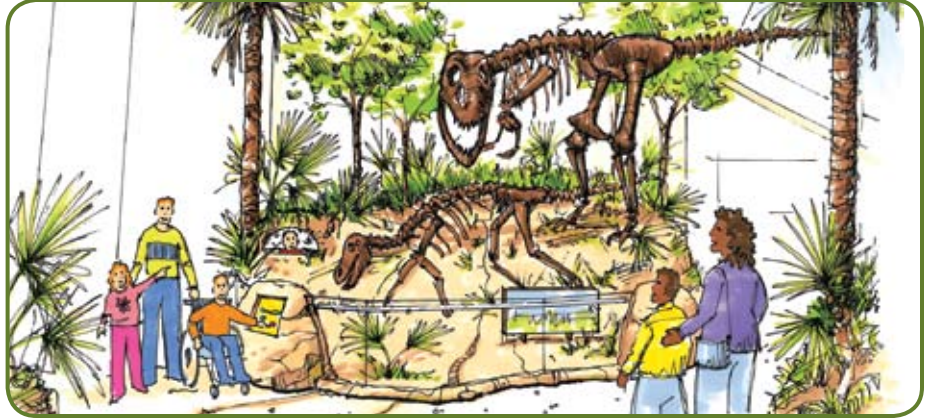
Dig tools

Artist paintings and skeletal diagrams of the four main scenes of **Dinosphere**: *T. rex Attack*, *Watering Hole*, *Predator or Scavenger*, and *Eggs and Nest*; pictures of animals in groups, families and alone; *Maia: A Dinosaur Grows Up* by John R. Horner.

DIG IN ...

Why Do Animals Live in Groups?

- Ask the class to name animals that live in groups and animals that live alone. The group list could include herds, such as cows, sheep, antelope, and horses, and schools of fish — like in the book *Swimmy* by Leo Lionni; and animal families, such as bears, dogs, wild cats, monkeys and others. Animals that are often alone include some sharks, lions, crocodiles, alligators and other large predators. Use books and Internet resources to find examples of animals in groups.
- Discuss with the class reasons why animals may need to be in a group. They should list the following: friendship, protection, families, reproduction, food, water, learning, homes and fun.
- Write the different reasons on the board or chart paper. Ask students to give one example for each grouping reason. Ask the class why some animals do not form groups and list the examples. This could include that large males such as lions, moose, elephants, antelopes and owls do not form groups.
- Ask the class to list what is good about living in a family group. Answers should include protection, food, home, learning, fun and love. All of these are good reasons to live in a family. Direct the discussion to the benefits animals have by living in family groups.
- Read *Maia: A Dinosaur Grows Up* by John R. Horner to your class. This book follows in detail the life cycle of a baby duckbill dinosaur from the Cretaceous Period. It is filled with facts and illustrations about the dinosaur as it grows from an egg to an adult.
- Discuss with the class ways that the dinosaurs in the book met their basic needs and have students list those ways in their **Dino Diaries**. Describe how living in a group helped the animals in the book find food, shelter and water.



The Children's Museum of Indianapolis

Dino Diary

Students should select one of the scenes from the book *Maia* to study and draw. Encourage them to label parts of the dinosaur and make notes about how it might help the animal live in groups. They should also make several lists on how and why modern animals live together. End each class period with time to write under “**Today I Discovered ...**” in their diaries.

Dino Web sites

Dinosphere link on **The Children's Museum** Web site

<http://www.childrensmuseum.org>

Dinosaur illustrations

<http://www.search4dinosaurs.com/pictures.html#about>

Jurassic Park Institute

<http://www.jp institute.com>

Bonus: Digging deeper!

Students can use what they have learned about animals and dinosaurs and construct simple food chains. Start by putting the following chart (see p. 36) on the board. Have students complete the chart in their **Dino Diaries**. Add more food chains to the chart.

Make it fossilize

Students should be able to give reasons for their ideas about why dinosaurs lived in groups. The main focus is to be able to make a comparison with a modern animal to understand how a dinosaur may have behaved. Students should list reasons for their choices. Students can list the basic needs of the dinosaurs in a story about a family of maiaosaurs. The assessment of this lesson is measured by the way students communicate what they believe orally and in writing.

Dinosphere museum link: When you visit

The **Dinosphere** story line, complete with drawings and maps of the scenes, is included in the resources section of this unit. Students can observe photographs of living animals to learn how and when they come together in groups. From this information students will better understand the reason why **Dinosphere** fossils are arranged the way they are. At each of the main scenes and through exhibit activities and labels, visitors explore the science of how dinosaurs lived together and interacted.

Paleo-points for the teacher

Students may not understand that animal groups form and re-form for different reasons. Many antelope form large herds and migrate during certain parts of the season. Other times they are in smaller family groups that may not include a dominant male. Some animals such as African lions form prides in which the females and young live together without the older males. There are many other types of animal groups students can learn about.

Students can find out more about how animals lived by looking at how artists and scientists have depicted their behavior. Science and art have worked together to make the world of dinosaurs come alive. New information sometimes makes older artwork incorrect. When new science discoveries occur, new paintings, drawings and ideas emerge. For example, the *Iguanodon* was once thought to have a horn on its nose. It was depicted that way in art until complete skeletons were uncovered in Belgium with the horn on the front hands. As we learn more our drawings of dinosaurs will continue to change and reflect new thinking. Ask students to view old movies, television shows and artwork to look at how dinosaurs have been depicted. Have them see if they can find ways science has changed what we think of how dinosaurs should be shown.

Dino books

- Brandenburg, Alike. *Dinosaur Bones*. New York: Thomas Y. Crowell, 1988. An easy-to-read discussion of the way scientists study fossil remains to learn about dinosaurs.
- Currie, Philip J. and Eva B. Koppelhus. *101 Questions About Dinosaurs*. Mineola, N.Y.: Dover Publications, 1996. Answers to children's frequently asked questions about dinosaurs.
- Horner, John R. and James Gorman. *Maia: A Dinosaur Grows Up*. Philadelphia: Running Press, 1989. A detailed story of the life cycle of a baby duckbill dinosaur from the Cretaceous Period filled with facts and illustrations.
- Lionni, Leo. *Swimmy*. New York: Knopf, 1991. The story of how a small fish works with others in a group to survive the predators in the ocean.
- Murphy, Jim. *Dinosaur for a Day*. New York: Scholastic, 1992. A wonderfully illustrated diary of a typical day in the life of a family of small, swift *Hypsilophodon* dinosaurs. (Some liberty may have been taken with background plants and animals not from the Cretaceous.)
- Norman, David and Angela Milner. *Eyewitness: Dinosaur*. New York: DK Publishing, 2000. An exploration in text and photos of the world of dinosaurs, with emphasis on teeth, claws, eggs and fossils.

- Paul, Gregory S., ed. *The Scientific American Book of Dinosaurs*. New York: St. Martin's Press, 2000. A survey of current topics, knowledge and answers about the prehistoric era from the best minds in paleontology.
- Willis, Paul. *Dinosaurs*. Pleasantville, N.Y.: Reader's Digest Children's Books, 1999. A beautifully illustrated photo essay about different types of fossils and how they formed.
- Zoehfeld, Kathleen Weidner. *Dinosaur Babies*. New York: HarperCollins, 1999. Good examples of how a mother maia-saur takes care of her babies.

Dino video

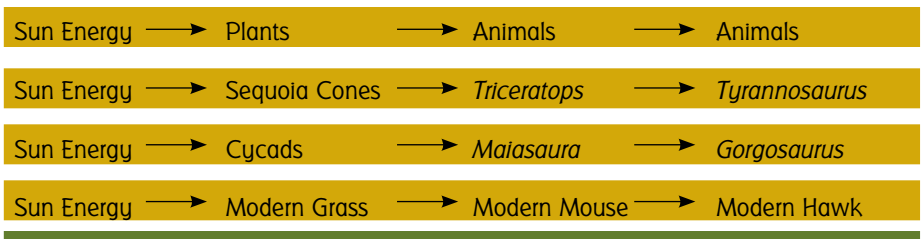
Walking With Dinosaurs, BBC and Discovery Channel, 1999.



© Black Hills Institute of Geological Research

Gorgosaurus are theropods — dinosaurs with three toes on their feet.

Cretaceous Food Chain ⇒ Energy Flow



EXPERIENCE 2

Dinosaur Interaction

Indiana Academic Standards

Science — 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.2.6, 3.2.7, 3.4.4, 3.4.5, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.2.5, 4.2.6, 4.2.7, 4.4.2, 4.4.3, 4.4.4, 4.4.6, 5.1.1, 5.1.2, 5.1.3, 5.4.4, 5.4.7, 5.4.8, 5.6.1

Language Arts — 3.4.4, 3.5.2 3.6, 4.4.1, 4.4.7, 4.5.4, 4.6, 4.7.12, 5.4.5, 5.6, 5.7.10

Social Studies — 3.3.5, 4.3.7, 5.3.5



A pencil sketch by artist Michael Skrepnick depicts the question posed in **Dinosphere**: Did the gorgosaur kill the duckbill, or is it just a scavenger with an opportune find?

© 2003 Michael Skrepnick, "Predator or Scavenger," pencil sketch, The Children's Museum of Indianapolis.

Get ready to dig

Evidence of dinosaurs living together is rare for most species. Most fossils are incomplete and disarticulated (bones no longer joined together) when found. On rare occasions dinosaurs have been found with fossilized eggs and babies, with evidence of teeth and claw marks from other dinosaurs, and with different sized animals of the same species. These fossils help to explain how dinosaurs lived together. In the Mongolian desert a *Protoceratops* and a *Velociraptor* were found preserved in a death embrace, with the teeth and beak of the *Protoceratops* clenched around the leg of the *Velociraptor*. One claw of the *Velociraptor* was stuck into the ribs of the *Protoceratops*. This is direct evidence of how these two dinosaurs interacted. Another way to learn about dinosaurs is to study living animals. Their behavior can provide clues about how dinosaurs behaved and interacted.

Vocabulosaurus

- **predator** — an animal that lives by hunting and eating other animals, or prey. A lion is a predator. It hunts antelope, its prey.
- **prey** — an animal hunted by predators as food. Some prey are also predators. For example, a hawk is a predator that eats snakes. Snakes are also predators that eat frogs. Snakes are both predators and prey.
- **scavenger** — an animal that eats another animal it did not help to kill. A crow is a scavenger when it eats the remains of a dead animal.
- **herd** ● **group**
- **family**

Focus Questions

- What types of activities did dinosaurs do together?
- How did they interact with each other?
- How did they feed each other?
- How did their body parts help them?

Objectives Students will:

- List basic needs of a dinosaur.
- Identify and compare interactions in photographs of modern animals living in groups.
- List benefits and problems for animals living in groups.
- Identify three main areas in **Dinosphere** where dinosaurs may have interacted.
- Give example of dinosaurs living in groups.

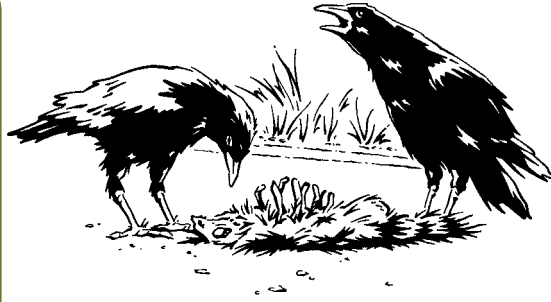
Dig tools

Artist paintings and skeletal diagram of the four main scenes of **Dinosphere**: *T. rex* Attack, Watering Hole, Predator or Scavenger, and Eggs and Nest; pictures of animals in groups, families and alone.

DIG IN ...

Dinosaur Interaction

- Pass out the four **Dinosphere** scenes. Some students can look at the scenes on the computer at the **Dinosphere** Web site.
- Read the story line for each **Dinosphere** scene, located in the reference section of this unit of study.
- Ask the class to match each drawing with the story line. They should be able to tell from the descriptions read aloud.
- Pass out the skeletal diagrams of the four scenes that visitors see in **Dinosphere**. Read the story line again. Students should be able to match each story with both the drawings and the skeletal diagrams.
- Ask the class to sort the scenes by how the animals are living in groups. Are they together for food? Protection? To learn? What modern animals can be seen in similar groups? Give examples of modern animals for each of the scenes shown. Ask the students to provide evidence for their choices and observations.
- Look at each **Dinosphere** scene and try to answer the main question. Ask students to use what they have learned by studying living animals to decide if the **Dinosphere** scenes are correct. Have them give reasons for their answers. Have each student select one scene to draw a picture of and write a story to tell what they think it is about. Make sure they give examples of living animals. For example, a student might say that Stan and Bucky are working together to attack Kelsey just like African lions work together to hunt. Divide the class into groups. Meet with each group and share the following questions for their report.



A scavenger such as this crow will not pass up a free meal on the side of the road. Scientists speculate that the gorgosaur in the **Dinosphere** attack scene may not have killed the *maiasaur* but is just scavenging the carcass.

Tyrannosaurus rex Attack Scene: What will be the outcome?

Stan is an adult *Tyrannosaurus rex* and Bucky is a teenager. They are about to attack Kelsey, a large, full-grown *Triceratops horridus*. Stan looks like it is dodging Kelsey while Bucky makes its move to attack. All three animals have body parts that will protect them and help them fight. Stan has a huge mouth filled with teeth. Kelsey has long, sharp, strong horns that can stab deep into any animal. If *T. rex* always wins, would there be any food left for him to eat? What will happen? Who will win? How will the animals interact? Use reference materials to learn about the body parts on these terrific creatures. What animals living today might interact the same way? The noise and movement have terrorized two opossum-sized mammals, *Didelphodon*, hiding inside a nearby burrow. *Didelphodon* are nocturnal animals and this afternoon skirmish has interrupted their nap. They could be trampled, so they stay hidden, hoping the predators will be chased away.

The Watering Hole Scene: Hypacrosaurus, Leptoceratops — is this a family?

Is this a safe place to be? A family of hypacrosauruses is visiting the watering hole to drink. They must drink, but is it safe? Research other modern watering holes that animals use. In Africa many different animals come to drink at the local watering hole. At different times of the day, different animals use the same watering hole. How does the antelope get water without being attacked by lions? What would be the best time for these hypacrosauruses to visit this dinosaur watering hole?

Predator or Scavenger Scene: Was it an attack or a scavenger opportunity?

Did the *Gorgosaurus* kill the duckbill? Or did it just find it dead and ready to eat? Is this a picture of a predator that has killed its prey? *Gorgosaurus* has all the tools needed to hunt and kill *Maiasaura*, but this gorgosaur has several broken bones. Could a human with a broken leg or arm find food easily? Sometimes on the side of the road a crow or other bird is seen eating a dead raccoon or a deer. A crow cannot kill a deer or a raccoon, but it would eat the free meal it finds. Ask students if they think the gorgosaur would eat a dead and rotting dinosaur?

Dinosaur Eggs, Nests and Babies Area — Oviraptor

Many living snakes and other reptiles just lay eggs and leave the babies to take care of themselves. Did the dinosaurs take care of their eggs and babies? If they did, what benefit or good things did the babies receive from the care? Ask students how their lives would be different if their parents had not taken care of them when they were babies. What reasons can they give for why dinosaurs would take care of their eggs and young?

Each group can make a drawing or a list and give examples of what they think is the real story in each **Dinosphere** scene. Have the groups report their findings to the entire class. There is not a correct answer but each group should be able to defend their findings.

Make it fossilize

Students should be able to give reasons for their ideas about why dinosaurs lived in groups. The main focus is to be able to make a comparison with a modern animal to understand how a dinosaur may have behaved. Students should list reasons for their choices. They may agree or disagree with each other and with the way the scene is shown in **Dinosphere**. The assessment of this lesson is in the way they communicate what they believe orally and in writing.

Dino Diary

Students should select one of the scenes in **Dinosphere** to draw and study. Encourage them to label parts of the dinosaur and make notes about how each part might help the animal live in groups. They should also make several lists on how and why modern animals live together. End each class period with time to write under the heading “**Today I Discovered ...**” in their diaries.

Dino Web sites

Dinosphere link on **The Children’s Museum** Web site

<http://www.childrensmuseum.org>

Dinosaur illustrations

<http://www.search4dinosaurs.com/pictures.html#about>

Jurassic Park Institute

<http://www.jpoinstitute.com>

Dino books

- Brandenburg, Alike. *Dinosaur Bones*. New York: Thomas Y. Crowell, 1988. An easy-to-read discussion of the way scientists study fossil remains to learn about dinosaurs.
- Currie, Philip J. and Eva B. Koppelhus. *101 Questions About Dinosaurs*. Mineola, N.Y.: Dover Publications, 1996. Answers to children’s frequently asked questions about dinosaurs.
- Horner, John R. and James Gorman. *Maia: A Dinosaur Grows Up*. Philadelphia: Running Press, 1989. A detailed story of the life cycle of a baby duckbill dinosaur from the Cretaceous Period filled with facts and illustrations.
- Lionni, Leo. *Swimmy*. New York: Knopf, 1991. The story of how a small fish works with others in a group to survive the predators in the ocean.
- Murphy, Jim. *Dinosaur for a Day*. New York: Scholastic, 1992. A wonderfully illustrated diary of a typical day in the life of a family of small, swift *Hypsilophodon* dinosaurs. (Some liberty may have been taken with background plants and animals not from the Cretaceous.)
- Norman, David and Angela Milner. *Eyewitness: Dinosaur*. New York: DK Publishing, 2000. An exploration in text and photos of the world of dinosaurs, with emphasis on teeth, claws, eggs and fossils.
- Paul, Gregory S., ed. *The Scientific American Book of Dinosaurs*. New York: St. Martin’s Press, 2000. A survey of current topics, knowledge and answers about the prehistoric era from the best minds in paleontology.

- Willis, Paul. *Dinosaurs*. Pleasantville, N.Y.: Reader’s Digest Children’s Books, 1999. A beautifully illustrated photo essay about different types of fossils and how they formed.
- Zoehfeld, Kathleen Weidner. *Dinosaur Babies*. New York: HarperCollins, 1999. Good examples of how a mother maiasaur takes care of her babies.

Dino video

Walking With Dinosaurs, BBC and Discovery Channel, 1999.

Paleo-points for the teacher

Scientists have indirect evidence that dinosaurs lived in groups. Eggs, nests and nursery areas have been found. In these areas fossilized dinosaur bones of different ages have been found, which provides evidence that individuals of various ages lived together. Also, fossilized dinosaur trackways have been found that show animals of various ages traveling together. This provides strong evidence that some dinosaurs lived in groups.

Dinosphere museum link: When you visit

The **Dinosphere** story line, complete with drawings and maps of the scenes, is included in the resources section of this unit. Students can observe photographs of living animals to learn how and when they come together in groups. From this information students will better understand the reason why **Dinosphere** fossils are arranged the way they are. At each of the main scenes and through exhibit activities and labels, visitors explore the science of how dinosaurs lived together and interacted.

Bonus: Digging deeper!

View a dinosaur video with your class. There are several excellent educational videos available. View the movie with a focus on dinosaur interactions and basic needs. Afterward, have students make a list of all the ways dinosaurs in the movie met their basic needs, interacted and lived in groups.

Lesson 4

Dinosaurs Are Not Alive Today — Or Are They?



Paleontologist Peter Larson examines dinosaur bones at the Bucky dig site. Fossil bones on the surface hint at the treasure below.

Get ready to dig

Often all that is learned from a scientific investigation is that there are many more questions than answers. In the study of dinosaurs there are many great questions still to investigate. One of the biggest mysteries is what happened to the big dinosaurs. Did they die gradually or at the same time in a huge catastrophic event? Did they all disappear at the same time all over the earth? Some scientists think that some smaller dinosaurs survived and evolved into birds. In this exercise students will explore theories about why dinosaurs

are not here today. They may not come up with new answers but they may think of new questions. **Asking questions is what science is really all about.**

Extinction

What happened to the dinosaurs? Students learn reasons why dinosaurs are not alive today. They learn that paleontologists, scientists who study dinosaur life, use fossil clues and observations to understand dinosaurs. They will also learn why some scientists believe that dinosaurs may be related to today's birds. Students role-play to learn about the life discoveries of famous paleontologists.



The Children's Museum of Indianapolis

Eva Koppelhus and Philip Currie are paleontologists whose work helps others study and prepare fossils.

Paleontologists

Sir Richard Owen, Robert Bakker and Barnum Brown are dinosaur hunters whose discoveries rocked the world of paleontology. In this experience students learn about the people who have discovered and named dinosaurs. Students learn that paleontology draws upon a diverse group of scientists. Through research and reports students learn about the skills and educational background needed to be an official fossil hunter, a paleontologist.

EXPERIENCE 1

What Happened to the Dinosaurs?

Indiana Academic Standards

Science — 3.1.4, 3.1.5, 3.2.3, 3.2.6, 3.2.7, 3.4.5, 4.1.1, 4.1.2, 4.1.3, 4.1.4, 4.4.6, 5.1.1, 5.1.2, 5.1.3, 5.1.4, 5.4.4, 5.4.5, 5.4.8

Language Arts — 3.4.4, 3.5.2, 3.6, 4.4.1, 4.4.7, 4.5.4, 4.6, 4.7.12, 5.4.5, 5.6, 5.7.10

Math — 4.6.1, 4.6.2, 5.6.1

Social Studies — 3.3.5, 4.3.7, 5.3.5



Vocabulosaurus

● **paleontologist** — a scientist who studies ancient life from fossils, including plants, invertebrates (animals without backbones) and vertebrates (animals with backbones).

- **volcano**
- **extinct**
- **unique**
- **common**
- **idea**
- **climate**
- **meteorite**



Volcanic eruptions change the land and the atmosphere.

Focus Questions

- What happened to the dinosaurs that made them go away?
- Do dinosaurs have descendants living today?
- Who discovers information about dinosaurs?
- What do scientists use as evidence for a dinosaur idea or theory?

Objectives

Students will:

- List three or more reasons why dinosaurs are not alive today.
- Understand that anyone can study dinosaurs.
- Demonstrate how a fossil clue can support an idea or theory.
- Give examples of how anyone can study dinosaurs.
- How can someone learn more about dinosaurs?

Dig tools

Dinosaur reference books;
computer access; chalkboard;
Dino Diaries

DIG IN ...

What happened to the dinosaurs?

- Introduce this lesson by reading *The Magic School Bus in the Time of the Dinosaurs* by Joanna Cole, and join Mrs. Frizzle and her class on a fun dinosaur adventure tour of the Mesozoic Era.
- Provide reference books about dinosaurs to the class. Each group should have one or more books to use. Bookmark dino Web sites for students to use on computers.
- Divide the students into groups of four or five. Ask students to write the numbers 1 through 10 down the side of one page in their **Dino Diaries**. Then ask the class a simple question: Where have all of the dinosaurs gone?
- Set a time limit of five minutes. Ask each student to write reasons or words to answer the question next to the numbers in their **Dino Diaries**. Remind the class to write as fast as possible. Spelling does not count in this exercise. At the end of the set time students tally up their responses. You may want to add extra time. The focus is on encouraging students to brainstorm and record ideas. Each student receives one point or tally mark for each reason.
- Set an additional time limit of 10 minutes. Ask each group to share their ideas within the group. Tell them not to let the other groups hear their conversation. They can add any new ideas in their **Dino Diaries**. At the end of the 10-minute time, ask each group to tally all of their answers and points for the group, and select a representative to report this in the class discussion.
- Ask each group to select one reason dinosaurs are not alive today that most people agree on. This is the common or popular answer that other students in the class have on their lists. Ask one person in each group to put a check mark next to that common reason on their list.
- Have one member of each group stand and give another common reason. Each time another group has the same reason on its list, the group reporting gets 10 points. For example, if the first group names volcanoes as a common reason and three other groups also have that somewhere on their lists, the first group receives 30 points. Tally all the group points at the end of this round.
- Hand out dinosaur reference materials and allow computer access. Tell the class they have only 10 minutes to search for more information. They may continue to write reasons why dinosaurs are not alive today. Each new reason earns an additional point. Students will be motivated to read new materials in search of dinosaur information.
- Ask each group to select one reason dinosaurs are not alive today that is unique. This reason should be one they think no other group has selected. Ask one person in each group to draw a star next to their unique answer. Allow time for each group to select one idea.
- Have students repeat the reporting process as above. Remind students to name a unique reason they think no other student has listed. Award extra points for any new ideas.
- Ask each group to add up their points. All of the students are winners because they have searched, discussed, evaluated and learned reasons why dinosaurs are not alive today. Have students summarize what they have learned in their **Dino Diaries**. Ask them to include one or more questions that they still would like answered about dinosaurs.

Make it fossilize

Review the reasons that students listed. Explain to the class that ideas in science have evidence or data to support them. Scientists do not say, "Because I said so." Instead, scientists show evidence and data to support their ideas. The class can start to examine the ideas about what happened to dinosaurs, focusing on the evidence. Scientists use facts to challenge speculations and build theories.

Dino Diary

Students use their diaries to play the **What Happened to the Dinosaurs?** game and to complete the **What Happened to the Dinosaurs?** chart. Students should be able to generate two or more dinosaur questions that they would like to investigate. End each class period with time to write under the heading "**Today I discovered ...**" in their diaries.

Dino Web sites

Dinosphere link on **The Children’s Museum** Web site

<http://www.childrensmuseum.org>

Jurassic Park Institute

<http://www.jpoinstitute.com>

Museum of Paleontology

<http://www.ucmp.berkeley.edu/index.html>

Enchanted Learning — Comprehensive e-book about dinosaurs

<http://www.zoomdinosaurs.com>

Dino books

- Barrett, Paul. *National Geographic Dinosaurs*. Washington, D.C.: National Geographic Book, 2001. A comprehensive look at dinosaurs in an easy-to-use manner organized by age and type.
- Branley, Franklyn M. *What Happened to the Dinosaurs?* New York: Thomas Y. Crowell, 1989. Easy to understand reasons for dinosaur extinction theories.
- Cole, Joanna. *The Magic School Bus: In the Time of the Dinosaurs*. New York: Scholastic, 1994. Mrs. Frizzle and her class go on a dino adventure tour of the Mesozoic Era.
- Currie, Philip J. and Eva B. Koppelhus. *101 Questions About Dinosaurs*. Mineola, N.Y.: Dover Publications, 1996. Answers to children’s frequently asked questions about dinosaurs.
- Paul, Gregory S., ed. *The Scientific American Book of Dinosaurs*. New York: St. Martin’s Press, 2000. A survey of current topics, knowledge and answers about the prehistoric era from the best minds in paleontology.

Paleo-points for the teacher

Younger students may not be able to understand extinction. Science explains that extinction is a normal process and every year some species become extinct. At the end of the Mesozoic Era a large extinction event occurred. However, it was not the first. Evidence suggests that much larger extinctions occurred prior to the Dinosaur Age. Students may agree with, disagree with or not understand evolution and its importance to adaptation. You can approach both extinction and evolution in a manner that allows students to ask questions. Science supports asking questions. Studying dinosaurs excites children and encourages them to learn.

Put the following chart on the board. The three reasons listed are some of the strongest. Information about these three ideas is presented in **Dinosphere**. Students will be able to find many more. Encourage them to look at the evidence or data for each theory and to ask more questions.

Bonus: Digging deeper!

Students may enjoy researching and listing their **Top Dinosaur Extinction Theories** to share with the class. After reasons are selected the class can put them in order of least likely to most likely. They will enjoy making up their own reasons, however fanciful, to add to the list. Encourage students to use their imaginations.

Dinosphere museum link: When you visit

Dinosphere contains the latest information from today’s leading paleontologists about what may have happened to the dinosaurs. Visitors can learn more information at the many computer learning stations. There are labels and activities that explore extinction theories and the most recent trends in learning about dinosaurs. Visit **Dinosphere** or **The Children’s Museum** Web site to learn more.

What Happened to the Dinosaurs?	
Theory or idea	Evidence that supports theory
Dinosaurs were killed when:	
A meteorite hit Earth	Layer of chemicals in soil, large impact crater
Great volcanoes erupted	Large lava fields around world
Geological changes occurred	Climate changes, seasonal changes, new plants and animals
Dinosaurs are not extinct:	
Some dinosaurs evolved into modern birds	More than 60 similarities between birds and dinosaurs

EXPERIENCE 2

Paleontologists

Indiana Academic Standards

- Science** — 3.1.5, 3.2.3, 4.1.3, 4.1.4, 5.1.3
Language Arts — 3.1.8, 3.4.4, 3.6, 4.1.4, 4.4.1, 4.4.7, 4.5.4, 4.6, 4.7.12, 5.1.4, 5.4.5, 5.6, 5.7.10
Social Studies — 3.3.5, 4.3.7, 5.3.5



© Black Hills Institute of Geological Research, photograph by Larry Shaffer

Careful examination of this jaw reveals signs of injury and disease — more clues about the life and death of the dinosaur.



© Black Hills Institute of Geological Research, photograph by Neal L. Larson

Bucky Derflinger, right, works with another young scientist to uncover fossilized dinosaur bones.

Vocabulosaurus

- **paleontologist** — a scientist who studies fossils.
- **volcano**
- **extinct**
- **unique**
- **common**
- **idea**
- **climate**
- **meteorite**

Focus Questions

- Can a young person participate in science?
- Who discovers information about dinosaurs?
- How can someone learn more about dinosaurs?

Objectives

Students will:

- Describe an activity of a paleontologist.
- Name an important paleontologist.
- List one or more significant discoveries of a paleontologist.
- Place in chronological order two or more dinosaur discoveries.

Dig tools

Dinosaur Hunters and Important Dates in Dinosaur Discovery resource material from this unit of study; reference books; **Dino Diaries**; computer access; construction paper and markers.

DIG IN ...

- Introduce the word paleontologist to the class. Decode the word into its parts: *paleo*, old or ancient; *olog*, study of; and *ist*, a person. A paleontologist is a scientist who studies ancient life from fossils, including plants, invertebrates (animals without backbones) and vertebrates (animals with backbones). Ask the class if they can name a person who is a paleontologist and describe what his or her job is like.
- Make a copy of **Dinosaur Hunters** and assign each team of two or three students one of the listed paleontologists. Provide reference books and allow computer access for students to read about their scientist's life, contributions and important discoveries. Students can take notes in their **Dino Diaries**.
- Provide students with materials to create a poster about their paleontologist. It should include information from the handout as well as information they have discovered in their research. Remind students to include important dates on the poster.
- Ask each group to give a short report about their paleontologist. Reports can include role-playing skits or interviews and demonstrating online resources.
- When all groups have finished their presentations, ask one member of each group to hold up the group's poster. Review the important discoveries and dates on each one with the class. Then ask the groups to line up in chronological order according to when their paleontologists made discoveries. When they have lined up in correct order, place their posters on display in the classroom.



© Black Hills Institute of Geological Research, photograph by Peter L. Larson

A few bones on the surface hint at the Triceratops below.

Make it fossilize

Ask the class to select one or more paleontologists to use in a report or story. They should write sentences or paragraphs describing the paleontologists. A simple prompt could be: "A paleontologist is a person who studies the life of dinosaurs. My favorite is" In their **Dino Diaries** they can write words or draw pictures of the activities of a paleontologist and describe the tools they use. Remind students that a variety of people including children can participate in science activities. Ask students to share what they have learned with their families. Use the Internet to search for dinosaur sites or dig opportunities for families. Plan a visit to **The Children's Museum** or a dinosaur dig site. Encourage students and their families to write a letter to a paleontologist and share their interest in dinosaurs and fossils.

Dino Diary

Make sketches of a paleontologist at work. Label the tools they are using, the site or location and the subjects they are working with. Students should put a caption under each drawing listing the names of the paleontologists.

Dino Web sites

Great Fossil Hunters of All Time

<http://www.enchantedlearning.com/subjects/dinosaurs/>

Fossil Halls, American Museum of Natural History

http://www.amnh.org/exhibitions/Fossil_Halls/fossil-halls2.html

Sternberg Museum of Natural History (unofficial virtual tour)

<http://www.oceansofkansas.com/Sternbrg.html>



© Black Hills Institute of Geological Research, photograph by Larry Shafer

For every hour digging in the field another 10 hours are needed to prepare the fossils.

Dino books

- Achenbach, Joel. "Dinosaurs: Cracking the Mystery of How They Lived." *National Geographic Magazine*, March 2003, 2–33. A report on how scientists from a variety of disciplines are working together to better understand dinosaurs.
- Funston, Sylvia. *The Dinosaur Question and Answer Book*. From Owl Magazine and the Dinosaur Project. New York: Little, Brown, 1998. A good classroom resource filled with information about dinosaurs and easy for children to use.
- Paul, Gregory S., ed. *The Scientific American Book of Dinosaurs*. New York: St. Martin's Press, 2000. A survey of current topics, knowledge and answers about the prehistoric era from the best minds in paleontology.
- Relf, Patricia with the Sue Science Team of The Field Museum. *A Dinosaur Named Sue: The Story of the Colossal Fossil*. New York: Scholastic, 2000. A detailed description of Sue, the most complete *T. rex*.
- Willis, Paul. *Dinosaurs*. New York: Reader's Digest Children's Books, 1999. An introduction to how dinosaurs looked, behaved and ate, and what is known about them through the study of fossils.

Dino video

Dinosaur! With Walter Cronkite, "The First Clue — Tale of a Tooth"; "The Fossil Rush — Tale of a Bone"; "Birth of a Legend — Tale of an Egg"; "Giant Birds of the Air — Tale of a Feather." A&E Home Video, 4-volume set, 1991. 200 minutes.

Paleo-points for the teacher

Students may think that the only job of a paleontologist is to dig up fossilized bones. However, the field is diverse. Paleo-botanists study plants and sedimentologists study the soil found with fossils. Another paleontologist may spend years learning how leg and hip bones work together. There are many different areas for men and women to pursue in the field of paleontology. In the *National Geographic* magazine article "Dinosaurs: Cracking the Mystery of How They Lived" (March 2003), many different and specialized paleontologists and their work are featured.

Bonus: Digging deeper!

Make a timeline from the **Important Dates in Dinosaur Discovery**. A reference timeline is included in the resources material in this unit of study. Students can illustrate each discovery on poster board. Many new and important dinosaur discoveries have been made since 1970. Use additional reference materials to complete the timeline.

Dinosphere museum link: When you visit

Dinosphere contains the newest information about dinosaurs from today's leading paleontologists. Visitors can learn more information at the many computer learning stations. There are labels and activities that explore extinction theories and the latest trends in learning about dinosaurs. Visit **Dinosphere** or **The Children's Museum** Web site to learn more. At **Dinosphere** students can visit the **Question Lab** or the **Paleo Prep Lab** to meet and ask questions of paleontologists and dinosaur experts.

Culminating Experience: Dinosphere — Now You're in *Their* World!

ENDURING IDEA — FOSSILS ARE CLUES THAT HELP US LEARN ABOUT DINOSAURS.

Experience 1 — Classroom Dinosaur Dig

Experience 2 — Cretaceous Treat



Each layer of dirt at the Bucky site may contain clues about life in the Cretaceous Period.

Introduction

Not everyone is lucky enough to be Bucky Derflinger, the youngest person ever to find a *Tyrannosaurus rex*. When Bucky was a fourth-grader he found his first fossilized *T. rex* bone and took it to school. His South Dakota teacher told him

it was not a fossilized dinosaur bone. It's a good thing that he did not give up looking for dinosaurs, because a few years later he found the only teenage *T. rex*. Today the dinosaur named for Bucky is on display in **Dinosphere**.



Modeling clay is used to make an imprint of the fossilized bone. From this impression a rubber mold can be made. Many copies or replicas can be made from the mold.

Why aren't dinosaurs found in Indiana?

Students often ask this question.

Dinosaurs probably lived in Indiana long ago, but several major changes in climate have occurred in this area since the end of the Cretaceous. Large glaciers scoured, scraped and eroded the surface and bedrock of Indiana, where dinosaur bones may have been deposited. When the climate changed the melted glaciers produced tremendous quantities of water that moved sediments, soil, rocks and fossils out of the area. Fragile fossils cannot survive the strong natural forces that have shaped the Hoosier state. The youngest bedrock in Indiana, from the Carboniferous Period, 360 – 286 million years ago (mya), is much older than the Mesozoic Era fossil beds of the dinosaurs, 248 – 65 mya. Thus fossilized dinosaur bones have not been found in Indiana.

EXPERIENCE 1

Classroom Dinosaur Dig

Indiana Academic Standards

Science — 3.1.3, 3.1.5, 3.2.2, 3.2.3, 3.2.4, 3.2.5, 4.2.4, 4.6.3, 5.2.3, 5.2.4, 5.2.6, 5.2.7, 5.4.8

Language Arts — 3.5.2, 3.6, 4.4.1, 4.5.4, 4.6, 4.7.12, 5.4.5, 5.7.10

Social Studies — 3.3.5, 4.3.7, 5.3.5

Focus Questions

- How do dinosaur hunters make new discoveries?
- What are good ways to share discoveries?
- Where can someone find more information about dinosaurs?

Objectives Students will:

- Create a simulated dig to discover fossilized dinosaur bones.
- Take notes, make a map and propose theories about dinosaurs.
- Write and display information about dinosaurs.
- Share what they have learned with others.

Dig tools

Plastic skeleton model from *The Tiny Perfect Dinosaur — Book, Bones, Egg & Poster Series*: #1 *Leptoceratops*, #2 *Tyrannosaurus rex*, #5 *Triceratops*, #7 *Hypacrosaurus* (more than one kit will be needed for large classes); aluminum baking pan 8 inches square and 3 inches deep (one for each group); sandy soil, plastic spoon, toothpicks; clay; pens, pencils, centimeter rulers; and the **Dino Diaries**.



© Black Hills Institute of Geological Research, photograph by Neal L. Larson

Each fossil in a bone bed is mapped in a grid. The position is important to understanding how the animal lived and died.

Vocabulosaurus

- **articulated** — fossilized bones that are still positioned in lifelike poses. The Kelsey site had articulated fossilized bones, indicating little geologic energy in the area.
- **disarticulated** — fossilized bones that are not positioned in the way the animal's skeleton would appear naturally. They may be broken, missing or rearranged. The Bucky site had disarticulated fossilized bones, which indicates much geologic energy there.
- **simulation** – an exercise that models a real practice. A simulation can teach about the real thing but it will not be exactly like the real thing. A car-driving video game is a simulation.

- **dig**
- **excavate**
- **grid**
- **probe**
- **bone bed**

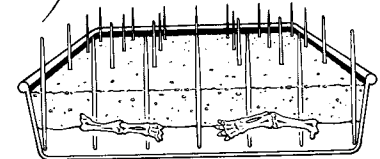
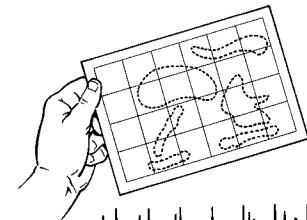
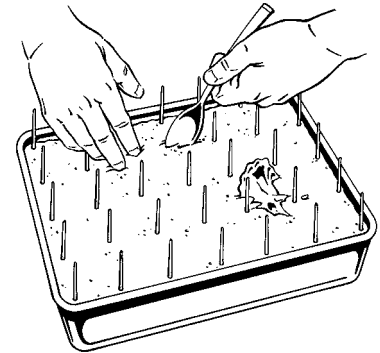
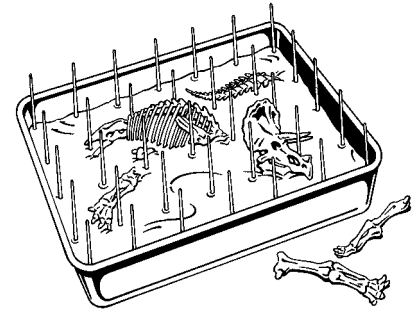
DIG IN ...

Classroom Dinosaur Dig

- Tell the class that today they will be dinosaur hunters on an expedition of discovery. Read to the class the story of Bucky Derflinger found in the information about Bucky the *T. rex* in the resource section of this unit of study. Show students the Bucky information found on **The Children's Museum** Web site. Ask the class to imagine out loud what it would be like to go on a dinosaur dig. Show them the **Dino Institute Teacher Dig 2003** on **The Children's Museum** Web site. Students can see photos of a dig and read about what it is like to find real fossilized dinosaur bones. Read *The Magic School Bus in the Time of the Dinosaurs* by Joanna Cole, and join Mrs. Frizzle and her class on a fun dino adventure tour of the Mesozoic Era.
- Tell the students that they are going to create a simulated dinosaur dig right in their classroom. Explain that a simulation has some parts that are just like the real experience and other parts that are different. Simulations are used when you cannot do the real activity, for example if it is too dangerous or too difficult.
- Divide the students into groups of five or six students. Each group will prepare a dig site for another group to excavate. Students should make careful notes about their sites in their **Dino Diaries**.
- Give an aluminum pan to each group. Have students press a layer of clay less than 2 centimeters thick into the bottom of their pan. Following the diagram, help students insert toothpicks into the clay to make a grid like the one shown. The grid squares should be about 4 centimeters square. When the toothpick grids are complete, ask students to make a drawing of the grid in their **Dino Diaries**.
- Give a skeleton model to each group. Each group should work in a separate part of the classroom to keep their dig secret. Each group should agree on how they will place the skeleton in the aluminum pan. Instruct them to use all of the bones and place them either in an articulated way like the fossilized bones of Kelsey or a disarticulated way

like those of Bucky. Once the group agrees on the placement they should each draw a map of the bones using the grid lines made from the toothpicks as a guide for the drawings.

- Once students have positioned the skeleton in the pan according to the map, ask them to carefully cover it with the sandy soil, pressing the soil down and adding more until the plastic bones are completely covered. Now the groups are ready to trade dig sites to start the simulation.
- Before the class starts to dig, tell them the rules. There are about 25 grid squares in each pan. Each student is allowed to select one square to dig. But first, students must make a grid map in their **Dino Diaries**. Digging is not done until all grid squares have been probed with a toothpick. All discovered bones must be mapped before they are removed from the dig site.
- Have student take turns probing at the site. Show them how to carefully push a toothpick into the soil. Tell students to push straight down to feel for any objects. They should mark any "hits" on their grid map. Continue probing until all the students have had a turn and all the grid squares have been probed. Do not dig at the site yet.
- Have each group stop and share what they have learned. Ask them to make predictions as to what may be in the dig site. Ask each group to decide which grid should be excavated (dug up with a spoon) first. It is important that they proceed slowly and take notes and make drawings of their progress. At different times in the simulation ask groups to stop working and make reports and predictions about the findings. When the simulated dig is complete have students write a report complete with drawings and maps of the site. Assemble the excavated plastic dinosaur models and display them with the simulated dig site and the reports.



Dino Diary

Students use their diaries to write notes and make drawings of their dig site and to copy the grid map. They should include their predictions as they work on their site. End the activity by allowing students time to write under the heading “**Today I discovered. ...**”

Dino Web sites

The Children’s Museum —
Dino Institute Teacher Dig 2003
<http://www.childrensmuseum.org/dinodig/overview.htm>

Fossil Halls, American Museum of Natural History
http://www.amnh.org/exhibitions/Fossil_Halls/fossil-halls2.html

Sternberg Museum of Natural History
(unofficial virtual tour)
<http://www.oceansofkansas.com/Sternbrg.html>

Smithsonian Museum of Natural History
(virtual tour of dinosaur exhibits)
<http://www.hrw.com/science/siscience/biology/animals/burgess/dino/tourfram.html>

Dinosaur Webquests
The Children’s Museum Dinosphere Webquests
<http://www.childrensmuseum.org>

Paramount Elementary School, Robin Davis
http://www.alt.wcboe.k12.md.us/mainfold/schoopag/elementary/paramount/class_webs/1/davistr/DinosaurWebquest.html

Vince Vaccarella for CPE 542 —
Technology in Education
http://www.lfelem.lfc.edu/tech/DuBose/webquest/Vaccarella/WQPS_VV.html

Dino books

- Cole, Joanna. *The Magic School Bus in the Time of the Dinosaurs*. New York: Scholastic Inc., 1994. Join Mrs. Frizzle and her class on a fun dino adventure tour of the Mesozoic Era.
- Norman, David and Angela Milner. *Eyewitness: Dinosaur*. New York: DK Publishing, 2000. An exploration in text and photos of the world of dinosaurs, with emphasis on teeth, claws, eggs and fossils.
- Willis, Paul. *Dinosaurs*. New York: Reader’s Digest Children’s Books, 1999. An introduction to how dinosaurs looked, behaved and ate, and what is known about them through the study of fossils.

Models

The Tiny Perfect Dinosaur — Book, Bones, Egg & Poster Series: #1 Leptoceratops, #2 Tyrannosaurus rex, #5 Triceratops, #7 Hypacrosaurus. Kansas City, Mo.: Andrews McMeel Publishing, 1991–1999.

Paleo-points for the teacher

The simulated dig can be repeated many times. One way to extend the lesson is to use plaster of paris instead of soil to hide the model bones. Students can use plastic forks and knives and paper clips to remove the plaster. Add brown paint and sand to the plaster for a more realistic look to the simulation.

A substitute model can be used in place of the plastic skeleton provided in the kit. Make copies of the Kelsey and Stan skeletons found in the resources section of this unit of study. Glue the skeletons on foam board or polystyrene trays then carefully cut out the skeleton. Make several models so that some can be cut apart into individual bones.

Dinosphere museum link: When you visit

Visit **Dinosphere** in person or via **The Children’s Museum** Web site to learn more about Bucky Derflinger and the teenage *T. rex*. Boys and girls of all ages can contribute to science — and may even make a great find.

One Last Question

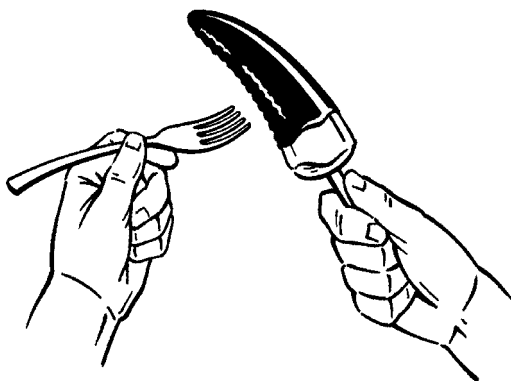
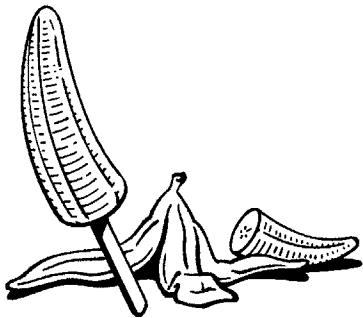
Maybe one of the most intriguing questions we can ask students is:

What is one thing that fossil bones may never tell us about dinosaurs?

EXPERIENCE 2

Cretaceous Treat

Scientists continue to study and debate what *T. rex* ate and how he used his teeth. Some think that the strong serrated teeth were used for tearing flesh, while others say they were for crushing bones. Either way, a 25-centimeter banana-shaped tooth is impressive by any standard. You can have fun making an edible *T. rex* tooth. All you need are a few ingredients and a visit to the **Dinosphere** Web site to see close-up photos of *T. rex* teeth.

Dino fun — *T. rex* Cretaceous Treat

Scientists continue to study and debate what *T. rex* ate and how he used his teeth. Some think that the strong serrated teeth were used for tearing flesh, and others say they were for crushing bones. A 25-cm banana-shaped tooth is impressive by any standard. You can have some fun making an edible *T. rex* tooth. All you need are a few ingredients and a visit to the **Dinosphere** Web site to see close-up photos of *T. rex* teeth for the model of your Cretaceous treat.

Ingredients: bananas (one half per student), craft sticks, white and dark chocolate, two pans, wax paper, heat source and freezer.

1. Peel the bananas.
2. Cut each one in half across the diameter.
3. Insert a craft stick in the cut end of each banana half.
4. Place on wax paper and freeze overnight.
5. Melt white and dark chocolate in separate pans.
6. Carefully dip the pointed end of the banana in the white chocolate first, covering the length of the piece.

7. Students must count the Cretaceous Period by fives to allow the chocolate to cool. For example: 5 Cretaceous, 10 Cretaceous, 15 Cretaceous — all the way to 65 Cretaceous million years ago.
8. When the white chocolate is cool, dip the pointed end of the banana into the dark chocolate almost all the way back to the cut end to make it look like the strong enamel part of a *T. rex* tooth. (Try using a fork to sculpt serrations on the backside of the tooth.)
9. Let the chocolate cool again and then enjoy the Cretaceous treat.

There is nothing to be afraid of when you are biting and chewing on a *T. rex* — as long as it is not the other way around!

Dinosphere Dinosaurs Table of Contents

What Are Dinosaurs?	54
How Long Ago Did Dinosaurs Live?.	54
Why Focus on the Cretaceous Period?	55
What Is a Fossil?	56
Classifying Plants and Animals	56
Dinosphere Dinosaurs — Background Information	
Stan, <i>Tyrannosaurus rex</i> (South Dakota)	57 – 60
Bucky, <i>T. rex</i> (South Dakota)	61 – 63
Kelsey, <i>Triceratops horridus</i> (Wyoming)	64 – 66
Baby Louie, <i>Oviraptor</i> (China)	67 – 70
<i>Maiasaura peeblesorum</i> (Montana)	71 – 72
<i>Gorgosaurus</i> sp. (Montana)	73 – 75
Frannie, <i>Leptoceratops</i> sp. (Montana)	76 – 78
<i>Hypacrosaurus stebingeri</i> family (Montana)	79 – 81
<i>Bambiraptor feinbergi</i> (Montana)	82 – 83
<i>Didelphodon vorax</i> (South Dakota)	84
Dig Site Excavation Maps Kelsey, <i>Triceratops horridus</i>	85
Dinosphere Dinosaur Classification Chart	86
Dinosphere Floor Plan	87
Dinosphere Scenes	
<i>Tyrannosaurus rex</i> Attack Scene — Stan, Bucky and Kelsey	88 – 89
Watering Hole Scene — <i>Hypacrosaurus</i> family, <i>Leptoceratops</i>	90 – 91
Predator or Scavenger Scene — <i>Gorgosaurus</i> , <i>Maiasaura</i> and <i>Bambiraptor</i> . . .	92 – 93
Dinosaurs Eggs, Nests and Babies	94
Dinosphere Fossil List	95
Important Dates in Dinosaur Discovery	96
Dinosphere Paleontologists and Advisers	97
Dinosaur Hunters	97 – 98
Dinosphere Unit of Study Books	99
Dinosaur Videos and Models	100
Dinosaur Web Sites and Webquests	100
Glossary	101 – 102
What's in a Dinosaur Name? — Latin and Greek words	103 – 104
Indiana Science Standards	
Kindergarten, Grades 1, 2, 3, 4 and 5	105 – 109
National Science Standards	
Grades K – 4 and K – 8	110
Dino Diary — Black Line Masters	111 – 114

Resource Materials

What are dinosaurs?

Dinosaurs are a special group of animals that were alive more than 65 million years ago. Dinosaurs are an extinct subclass of Archosauria, the “ruling reptiles.” Other extinct reptiles include the flying pterosaurs and the marine plesiosaurs and ichthyosaurs. Living reptiles include three orders: turtles/tortoises, crocodiles/alligators and lizards/snakes. A reptile is a member of the animal kingdom and has a backbone. Reptiles have scales and

claws, and develop from yolk-filled eggs that are laid or mature inside the mother’s body. Many scientists are working to understand the relationship between dinosaurs and living animals such as birds. Today it is generally accepted that dinosaurs and birds share a common ancestry. Some scientists believe that the dinosaurs are not extinct but have slowly evolved into birds. Children can use a simple five-step rubric to identify a dinosaur.



© Black Hills Institute of Geological Research, photograph by Neal L. Larson

It takes a large workspace to prepare a Triceratops skull that is more than 2 meters long.

All dinosaurs:

1. are diapsids, which have two additional sets of openings in their skulls not counting the nostrils or the eye sockets. All reptiles except turtles are diapsids.
2. were alive during the Mesozoic Era that lasted from 245 to 65 million years ago. Geologists divide the Mesozoic Era into three distinct periods — Triassic, Jurassic and Cretaceous.
3. had one of two types of hip joints, called bird-hipped or lizard-hipped.
4. held all four legs under the body, not out to the sides like modern lizards and crocodiles.
5. moved and lived on land — did not live in the water or fly in the air.

If the animal meets all of these criteria, it is a dinosaur.



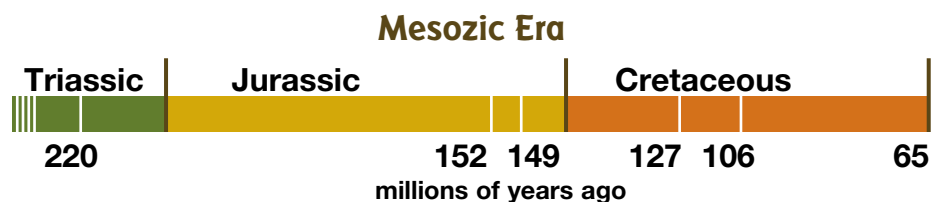
© Black Hills Institute of Geological Research, photograph by Neal L. Larson

The multiple openings in this skull help identify it as a diapsid.

How long ago did dinosaurs live?

It may be impossible for students to understand how long ago dinosaurs lived. It is easier for adults to understand long periods of time. A first-grader begins to understand how long a school week is, but may not be able to grasp a decade. A high-school student understands the significance of being 18 years old, but may not fully comprehend the time span of a century. Many adults find it hard to imagine what the world was like 10,000 years ago. Such a large amount of time is difficult to put into perspective. Dinosaurs were alive during the Mesozoic

Era that started more than 245 million years ago and lasted for 160 million years. This means that the extinction of dinosaurs was complete 61 million years before the earliest human fossils, from 4 million years ago. John McPhee coined the term “deep time” in 1981 to help people understand the immensity that is covered in geologic time. It is likely that young students will have difficulty understanding the Dinosaur Age. What can be understood is that dinosaur fossils are astonishing tools that excite children to learn about the past.



Why focus on the Cretaceous Period?

The Cretaceous world (144 – 65 million years ago) must have been a pretty amazing place. There were lots of different kinds of dinosaurs, including the ones best known today, such as *Tyrannosaurus rex* and *Triceratops*. Dinosaurs lived all over the world, even in the polar regions. There were small birdlike dinosaurs and huge, long-necked sauropods. It was during the Cretaceous Period that the first flowering plants appeared, along with trees such as maples, oaks and walnuts. What happened at the end of the Cretaceous — a meteorite striking the earth, erupting volcanoes or changing climates — continues to fascinate people today. This was the last period of the Dinosaur Age. Almost half of all the dinosaurs known were alive during the Cretaceous Period. They included *Iguanodon*, *Deinonychus*, *Hypsilophodon*, *Torosaurus* and *Saltasaurus*. Many of the present-day continents were starting to form. The Western Interior Seaway covered the middle of present-day North America from Alaska to Mexico, filling the land from the Rocky Mountains to western Iowa.



© Black Hills Institute of Geological Research, photograph by Neal L. Larson

An impression is left behind when a fossil is removed from the ground.



Ammonites are extinct mollusks from the Mesozoic Era. Their fossilized shells are found in great quantities and help to date other fossils found nearby.

The Children's Museum of Indianapolis

Also alive during the Cretaceous Period were dragonflies and other insects, frogs, turtles, crocodiles, fish and small mammals. Other non-dinosaurs swam the saltwater oceans and flew through the warm, moist skies. Marine reptiles included giant ichthyosaurs, plesiosaurs, pliosauers, and mosasaurs that lived on a diet of fish, squid and shellfish. In the air flew other fantastic creatures that were not dinosaurs. The pterosaurs, or flying reptiles, were as small as crows or owls and others were giants. The *Quetzalcoatlus* flew with a wingspan more than 12 meters long — bigger than some airplanes. Pterosaur wings consisted of a thick layer of skin covering their fingers and hands. Plant life included ferns, cycads

(plants with huge fan-shaped leaves similar to pineapple plants) and evergreen trees. At the end of the Dinosaur Age broad-leaved trees such as oaks and flowering plants such as the magnolia began to appear. Common grasses of today were not present then. The Cretaceous Period holds the fossil clues to solving the mysteries of the dinosaurs.

Resource Materials



© Black Hills Institute of Geological Research

These pieces will need hours of preparation before the Gorgosaurus skull is ready for *Dinosphere*.

What is a fossil?

The word fossil comes from the Latin “dug up.” Scientists define fossil as **preserved evidence of ancient life**. Preserved means that ancient life has survived in a form recognizable today. Many times but not always, fossils are living things that have mineralized or turned to stone. A fossil can also be an imprint of skin, a footprint hardened into rock, the hard parts of an insect trapped in amber, the thin carbon layer of a leaf or the actual bones and tissues of a mammoth. Evidence includes bones, teeth, claws, shells and any hard parts that have become mineralized. Most scientists agree that a fossil must be 10,000 years or older to qualify as ancient life. Many living things can become fossils — plants, animals, single cell organisms and bacteria are all forms of life.

Often the terms *dinosaur bone* and *fossil* are used interchangeably. However, no dinosaur bones have survived intact from the Mesozoic Era — only fossilized dinosaur bones. Each bone has gone through a rare process where actual living tissue has been replaced or altered by minerals. Most plants and animals do not become fossils because they are consumed as food! Animals eat plants and other animals to

live. The process of eating and digesting the food destroys most chances for those food items to become fossils. However, some scientists have become experts at learning what clues can be found in dinosaur coprolite, or dung. The dinosaur fossils found so far represent only a very small sampling of life in the Mesozoic Era. Mud and water play an important role in how living organisms become fossilized. Mud and water are associated with lakes, deltas, floodplains and shores — all areas that optimize the formation of fossils. Many plants and animals may have lived in geographic areas and climates that rarely support fossil formation.

Some organisms that were alive in the Dinosaur Age are still living today. They are called living fossils. Examples include crocodiles, turtles, cockroaches, ferns, coelacanths, horsetail rushes, ginkgos, spiders, dragonflies and horseshoe crabs. The fossil record is rich in opportunities to learn about the past but much more lies buried, waiting to be uncovered. This helps to make digging for fossils an ongoing and exciting endeavor for adults and children.

Dinosphere contains many examples of Cretaceous Period plants and animals other than dinosaurs. A complete list of exhibit fossils is located in the resource section of this unit.

Classifying plants and animals

Scientists classify all plants and animals, including dinosaurs, using the binomial system created by Swedish naturalist and physician Carl von Linné (Carolus Linnaeus) in the 1750s. The binomial, or two-word, system uses one Latin or Greek word to represent the genus and the second for the species. The system uses the following major divisions to classify plants and animals:

Kingdom — Phylum — Class — Order — Family — Genus — Species

An easy way to remember the different groups is with this phrase:

Kids Please Come Over For Great Science!

Dinosphere dinosaurs can be classified with this system. The complete classification listing can be found on page 85.

Kelsey – *Triceratops horridus*

Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria (“ruling reptiles”) Subclass Dinosauria (extinct reptiles, “terrible lizards”)
Order	Ornithischia (beaked, bird-hipped plant-eaters) Suborder Marginocephalia (fringed heads)
Family	Ceratopsidae (frilled dinosaurs, including horned dinosaurs)
Genus	<i>Triceratops</i> (three-horned face)
Species	<i>horridus</i> (horrible — describes the horns)

Dinosphere Dinosaurs: Stars of the Cretaceous — Dinosaur Background Information

Stan — *Tyrannosaurus rex* One full-size cast replica skeleton in Dinosphere

Background

T. rex lived about 67 million years ago, and only in the areas currently called the Great Plains, or the western portions of North America (the United States, Mexico and Canada). The “tyrant lizard king” species existed for a span of 3 million years of Earth’s history (30 times as long as modern humans have existed so far). Life was tough at the top of the food chain. Despite its reputation as a biting, slashing killer, *T. rex* lived on the edge. A tasty herd of migrating duckbills might not show up on time. Without a ready supply of food, starvation loomed. There were fights with potential mates or rivals and wounds became infected and rapidly fatal. Disease was also a threat, including osteoarthritis and bone deformities that could make movement painful and difficult. Families of tyrannosaurs may have helped each other, however. They may have cared for their young and brought food to them in the nest. As the youngsters grew, they learned how to hunt from adults. Perhaps sleek teenagers served as a diversion to drive prey to waiting adults. Even grown theropods may have banded together to find food. Large duckbills or a triceratops may have been too big for one carnivore to take on, but two or more could work together to attack and kill prey. *T. rex* had other adaptations that helped it to hunt effectively. Forward-facing eyes could quickly spot and focus on prey. An acute sense of smell located food, while strong legs moved swiftly to the attack.

Why Stan is significant:

Completeness

The *T. rex* known as Stan probably has the best preserved and most complete dinosaur skull yet discovered anywhere in the world. Nearly every fossilized bone of Stan’s skull was recovered during excavation. In addition, the skull was almost entirely disarticulated, meaning that each fossilized bone was separated from the others. Disarticulation allowed the fossilized bones to be preserved with little or no distortion or crushing during millions of years of burial. The disarticulation of the fossilized skull bones also provided scientists a unique ability to examine each individual specimen as well as to study each one’s connection and movement in relation to the others. Thus, an entire new body of knowledge has been acquired about the functions and kinetics (motions) of *T. rex* skulls and also of other large theropod skulls. Forty-seven separate fossilized bones plus 35 loose fossilized teeth were reassembled in the reconstruction of Stan’s skull. Only two small skull bones from the inside of Stan’s lower jaw were missing. The study and reconstruction of these skull elements provided clear evidence that *T. rex* had the largest brain, the keenest eyesight and sense of smell, the strongest teeth and the most powerful jaws of any other dinosaur identified to date.

Skull and brain

The brain was long and narrow, with well-developed olfactory bulb(s), optic nerves and auditory nerves. Hence, scientists believe that the *T. rex* had extremely good senses of smell, sight and hearing. The skull was deep and massive and featured a rather short snout. Forward-facing eyes provided depth perception, which allowed the *T. rex* to judge distance while moving.

Teeth and jaws

A tyrannosaur’s mouth, teeth and jaws were specialized for biting and swallowing chunks of prey. More than 50 saw-edged teeth, some as long as 12 inches, could tear into flesh like knives. Bulging muscles on the skull enabled *T. rex* to twist its head and gulp down whole chunks of meat. And as teeth were shed, new teeth grew to fill the gaps. The jaws were narrow toward the front but widened out to be broad at the cheeks. The lower jaw was hinged at the midpoint between the jawbone and the chin to increase the size of the bite. The joint between the left and right mandibles (lower jaw) was moveable. Sharp teeth were up to 7 inches (18 cm) long, and the largest teeth were shaped like saw-edged steak knives. The worn crowns on Stan’s teeth indicate that *T. rex* ate tough, likely fresh, meat rather than rotting carcasses (and thus was not just a scavenger but a hunter). The aging, long roots of older teeth dissolved so that they could fall out and be replaced by stronger new teeth. The upper teeth were curved and very sharp, like huge scalpels. When eating, the *T. rex* probably moved the lower jaw backward so that the sharp lower teeth could tear through flesh while the upper teeth held dinner in place.

Arms

The first complete *Tyrannosaurus* forearms were found in 1988; before that discovery, the arms were thought to have been weaker than they are considered now. Although *T. rex* arms were no longer than human arms, one single arm was probably strong enough to lift 400 pounds. The muscular but short arms may have propped up the dinosaur’s body as it rose from lying or crouching to standing. The arms may also have been used as grappling hooks to fight and hold other dinosaurs.

Resource Materials

Stan's pathologies

Stan has some interesting pathologies — or healed injuries — that create a picture of what life was like for such predators. The *T. rex* has several broken and healed ribs, as well as a scar that may match the size and shape of a *T. rex* tooth. At some point, Stan also suffered a broken neck. As it healed, two vertebrae fused together and a third was immobilized by extra bone growth. Even more spectacular is a hole in the back of the skull. A piece of fossilized bone 2 by 5 inches broke off inside the braincase. Pete Larson, of the Black Hills Geological Institute, speculates that the size of the hole matches a *T. rex* tooth. Whatever the immediate effect of these injuries, Stan lived through them to fight another day. Perhaps disease or old age finally killed the *T. rex*. As Stan's carcass rotted in the sun, scavengers pulled apart much of the skeleton and skull. Spring floods eventually covered the bones, which remained buried for 65 million years.

Discovery

In the spring of 1987, amateur paleontologist Stan Sacrison was exploring outcrops of the Hell Creek Formation near the town of Buffalo, S.D., when he came across a large dinosaur pelvis weathering out of a sandy cliff face 100 feet above the prairie.

Site

Most *Tyrannosaurus* specimens, including Stan, are from Hell Creek Formation, Harding County, S.D.

Size

Stan is one of the last, largest and most powerful of all predatory dinosaurs. The *T. rex* is likely to have been the largest carnivorous land animal (theropod) of any age. An adult *T. rex* is about as heavy as an elephant, tall enough to look through a second-story window and long enough to stretch out across the width of a tennis court (10 to 14 meters from head to tail). Like other tyrannosaurs, Stan was lightweight (4.5 to 7 tons) because of hollow bones and large skull openings.

Name

T. rex was described in 1902 by American paleontologist Henry Fairfield Osborn, who called it the "dinosaur king." From then until the 1960s, only three *T. rex* skeletons were known to exist. *T. rex* anatomy wasn't well known until new discoveries aided the completion of the whole skeleton form. The discovery of two more skeletons, one in Montana in 1988 and another (Sue) in 1990, allowed for better understanding of the *Tyrannosaurus* skeleton and anatomy. Since then, through books, movies and comic strips, *T. rex* has become the most popular, best-recognized dinosaur of all.

Lifestyle and behavior

T. rex may have hunted alone or in packs. It may have followed migrating herds of herbivorous dinosaurs and targeted the sick, young and weak dinosaurs, and may also have ambushed its prey, charging with wide-open jaws at perhaps 20 mph when an unsuspecting dinosaur came near. The *T. rex* diet included *Triceratops* and *Edmontosaurus*. Fossils of these species have been found with *T. rex* bite marks. Although it may have laid eggs, no fossilized *Tyrannosaurus* eggs have yet been found. *T. rex* grew continuously throughout its long life. Because fossilized dinosaur bones have been found in regions that were cold when the dinosaurs were alive, and since birds are the closest relatives of dinosaurs (not crocodiles, lizards or snakes), *Tyrannosaurus* and other dinosaurs may have been warm-blooded.

Dinosphere link

Stan is a cast model of the original in the collection of the Black Hills Institute.

Dinosphere Dinosaur Classification

Kingdom — Phylum — Class — Order — Family — Genus — Species
Kids Please Come Over For Great Science!

Stan — *Tyrannosaurus rex*

Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria ("ruling reptiles") Subclass Dinosauria (extinct reptiles, "terrible lizards")
Order	Saurischia (lizard-hipped) Suborder Theropoda (beast-footed)
Family	Tyrannosauridae (tyrant lizard) Carnosauria (meat-eating lizard)
Genus	<i>Tyrannosaurus</i> (tyrant lizard)
Species	<i>rex</i> (king)

Tyrannosaurus rex — Stan

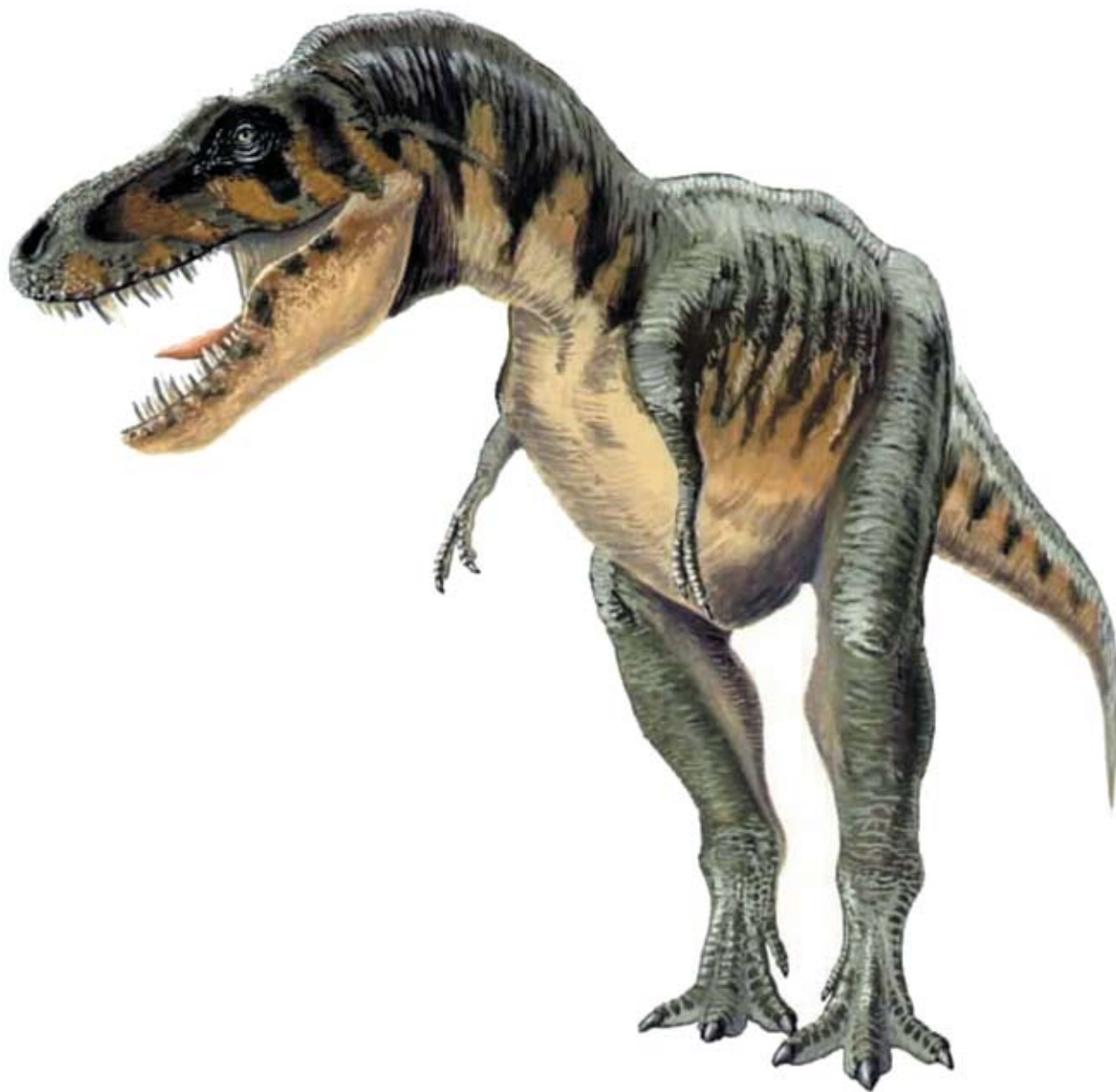


The Children's Museum of Indianapolis

Resource Materials

Drawing

Tyrannosaurus rex — Stan



A fleshed-out T. rex.

The Children's Museum of Indianapolis

Bucky — *Tyrannosaurus rex*

One full-size fossilized bone skeleton in **Dinosphere**

Background

Bucky the *T. rex* is a rare find. This remarkable dinosaur is the first juvenile *T. rex* ever placed on permanent exhibit in a museum. Twenty-year-old Bucky Derflinger found the fossil in 1998 near the small town of Faith, S.D. A rancher and rodeo cowboy, Derflinger is the youngest person ever to discover a *T. rex*.

Why Bucky is significant: Completeness

Bucky is thought to be the sixth most complete *T. rex* (out of more than 40) ever discovered. Bucky is an important find. It is the first known *T. rex* discovered with a furcula (wishbone). The furcula may be an important link between dinosaurs and birds.

Discovery

This dinosaur is also from the Hell Creek Formation, but it is a true teenager, approximately two-thirds the size of an adult. *T. rex* and other predators are relatively rare finds. On average, one predator is found for every 30 or 40 herbivores discovered. Juvenile finds are even more rare.

Site

The fossil remains of Bucky were scattered and difficult to find. So far the excavation site for this creature is nearly half the size of a football field, making the Bucky dig site the largest known *T. rex* excavation to date. Bucky is extremely well-preserved and was easily prepared because the surrounding rock matrix was rather soft and easy to remove. The fully-prepared fossils have a dark, chocolate-brown patina.

Size

Bucky is almost the size of an adult *T. rex*. It is approximately 34 feet long and more than 10 feet tall.

Name

T. rex was described in 1902 by American paleontologist Henry Fairfield Osborn, who named it the “dinosaur king.” From then until the 1960s, only three *T. rex* skeletons were known to exist. *T. rex* anatomy wasn’t well known until new discoveries aided the completion of the whole skeleton form. The discovery of two more skeletons, one in Montana in 1988 and another (Sue) in 1990, allowed for better understanding of the *Tyrannosaurus* skeleton and anatomy. Since then, through books, movies and comic strips, *T. rex* has become the most popular, best-recognized dinosaur of all.

Fossils

To date, more than 33 percent of Bucky has been uncovered and verified. Bucky has a nearly complete set of gastralia (belly ribs) and a rare ulna (lower arm bone). Fossilized bones include the first furcula (wishbone) and the first bicolor toe ever found. Ancillary fossil material unearthed from the Bucky site will help scientists tell a more complete story. Materials excavated include *Triceratops*, *Edmontosaurus*, *Nanotyrannus*, crocodile, turtle, fish, shark and some plant material. It is interesting to speculate how all these remains came to be deposited in the same location. Perhaps Bucky died by a river and the remains, along with skeletons from other animals, washed downstream before sand and silt covered and preserved them.

Dinosphere link

Two *T. rex* specimens — one adult and one juvenile — are displayed in a hunting scenario in **Dinosphere**. The two have encountered a *Triceratops* and are rushing in for the kill. Perhaps the younger *T. rex*, Bucky, acts as a diversion to keep the *Triceratops* off-balance. Stan, the adult, is coming in at the *Triceratops* from behind. The outcome of the battle is uncertain. Perhaps the two will be successful and enjoy a meal. Perhaps the powerful triceratops will gore one or both predators.

Dinosphere Dinosaur Classification

Kingdom — Phylum — Class — Order — Family — Genus — Species

Kids Please Come Over For Great Science!

Bucky — *Tyrannosaurus rex*

Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria (“ruling reptiles”) Subclass Dinosauria (extinct reptiles, “terrible lizards”)
Order	Saurischia (lizard-hipped) Suborder Theropoda (beast-footed)
Family	Tyrannosauridae (tyrant lizard) Carnosauria (meat-eating lizard)
Genus	<i>Tyrannosaurus</i> (tyrant lizard)
Species	<i>rex</i> (king)

Resource Materials

Skeleton Diagram *Tyrannosaurus rex* — Bucky



The shaded bones are real fossils.

Scale: 1 cm = .5 m

Tyrannosaurus rex — Bucky



The Children's Museum of Indianapolis

Resource Materials

Kelsey — *Triceratops horridus*

One full-size fossilized bone skeleton in **Dinosphere**

Background

Kelsey the *Triceratops* is a ceratopsian, or “horned dinosaur,” that lived during the Late Cretaceous Period more than 65 million years ago. Appearances can be deceiving. *Triceratops*, often depicted as a passive, plant-eating behemoth, was actually one of the most dangerous animals in the Cretaceous world to a predator such as *T. rex*. There is debate about whether *Triceratops* lived in herds. The skeletons of other ceratopsians have been found together in large bone-beds, but *Triceratops* is often found alone. Paleontologist Bob Bakker has speculated that they roamed the Cretaceous forests on their own and did not migrate. Only when *T. rex* couldn’t find a herd of duckbills would it try to attack a large and dangerous prey like *Triceratops*. It took a lot of food to feed a *Triceratops*. Since it was herbivorous, it ate many pounds of cycads, ferns and other low-lying plants daily. It may also have used its horns to knock down small trees and then snipped the leaves with its parrot-like beak. Scientists know some of the plants that *Triceratops* devoured by studying *phytoliths* — tiny parts of plants that left scratch marks on the animals’ teeth or remained between teeth even after the animal fossilized. Kelsey has a short, pointed tail, a bulky body, columnar legs with hoof-like claws, and a bony neck frill rimmed with bony bumps. Like other *Triceratops*, Kelsey has a parrot-like beak, many cheek teeth and powerful jaws.

Why Kelsey is significant: Completeness

More than 50 percent of Kelsey’s skeleton has been uncovered, making this specimen one of the top three *Triceratops* skeletons known to science and perhaps the most complete. Although *Triceratops* is one of the most popular dinosaurs with children, remarkably few have been found, and most that have been found are fragmentary.

Discovery

Kelsey was found by the Zerbst family in Niobrara County, Wyo., in 1997 and named after a young granddaughter. Kelsey was discovered eroding from a hillside on the ranch of Leonard and Arlene Zerbst. To date, the Zerbsts and paleontologists from the Black Hills Institute have excavated and prepared Kelsey’s skeleton. Alongside Kelsey were found more than 20 fossilized teeth shed by a predatory dinosaur, *Nanotyrannus*, a smaller cousin of *T. rex*. Perhaps Kelsey died of natural causes and was scavenged, or was attacked and killed by predators.

Site

Triceratops roamed what is now western North America at the very end of the Dinosaur Age. Kelsey was found on the famous Lance Creek fossil bed, where many Late Cretaceous dinosaur fossils have been excavated.

Size

The sheer bulk and size of *Triceratops* — up to 22 feet long and 9 feet tall and weighing as much as 6 tons — commanded attention. A thrust from one of its three sharp horns (the two above the eye sockets each measured up to 3 feet long) could be lethal to an attacker. Kelsey has a large skull more than 6 feet (2 m) long, one of the largest skulls of any land animal ever discovered. The head is nearly one-third as long as the body.

Name

This specimen was named after the Zerbsts’ granddaughter Kelsey Ann. John Bell Hatcher described the first *Triceratops* fossils in 1889. Othniel C. Marsh named the specimen “three-horned face.” The name refers to the two large brow horns and the smaller nose horn of these

animals. This easily recognized dinosaur has become widely popular, particularly among children who have seen movies featuring the behemoth as a peaceful, plant-eating creature.

Fossils

Triceratops skulls are huge — measuring up to 7 feet long — and heavy. Kelsey’s is solid fossilized bone, up to two inches thick, from the top of the frill to the tip of the beaklike mouth. The skull is also bumpy — or in scientific terms, displays *rugosity*. Some scientists speculate that this may be an indication of older age. The frill at the top of the skull was originally thought to be crucial for protecting the neck area. Scientists now think the frill may have been more important in mating rituals. A flush of blood over the frill might have attracted females or deterred rival males in shoving matches. Still another explanation for the frill is heat regulation. As the body warmed up, heat escaped from the frill and body temperature was stabilized. Kelsey’s fossilized bones of interest are the huge cranium, massive femur, mandible teeth and great horn.

Dinosphere link

In **Dinosphere**, Kelsey charges the adult *T. rex*, Stan. Bucky, the younger *T. rex*, circles around Kelsey, ready to strike. Though two against one may seem like a mismatch, the outcome in such a fight would be uncertain. The *Triceratops* could wound one or both of the tyrannosaurs.

Dinosphere Dinosaur Classification

Kingdom — Phylum — Class — Order — Family — Genus — Species

Kids Please Come Over For Great Science!

Kelsey – *Triceratops horridus*

Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria (“ruling reptiles”) Subclass Dinosauria (extinct reptiles, “terrible lizards”)
Order	Ornithischia (beaked, bird-hipped plant-eaters) Suborder Marginocephalia (fringed heads)
Family	Ceratopsidae (frilled dinosaurs, including horned dinosaurs)
Genus	<i>Triceratops</i> (three-horned face)
Species	<i>horridus</i> (horrible — describing the horns)

Skeleton Diagram *Triceratops horridus* — Kelsey



The shaded bones are real fossils.

Scale: 1 cm = 28 cm

Resource Materials

Drawing

Triceratops horridus — Kelsey



Scale: 1 cm = 28 cm

Baby Louie — *Oviraptor*

One full-size fossilized bone skeleton in Dinosphere

Background

About 65 million years ago in what is now Hunan Province, China, a dinosaur egg was just about to hatch. Sometime before, the mother had probably scooped out a wide, shallow nest, then laid eggs two at a time in a circular pattern in as many as three layers. Finally, the mother settled down on top of the nest, spreading out to keep it warm and safe from predators. But something went wrong. Perhaps something scared the mother and the nest was trampled. Maybe a predator tried to steal the eggs. Scientists who have studied the specimen say it looks as if Baby Louie was stepped on and crushed. However it happened, slowly rising water probably covered the eggs. But as silt and sand settled over the nest, Baby Louie's fossilized bones remained surprisingly intact. Today, Baby Louie is a "star" dinosaur specimen that scientists continue to study. Paleontologist Charlie Magovern wants to look closely at the nest and focus on two other eggs, affectionately dubbed Huey and Duey. Perhaps improved scanning technology will help to determine if there are little fossilized bones inside those eggs as well. Baby Louie is the only known articulated dinosaur embryo ever discovered.

Why Baby Louie is significant: Completeness

It is not always obvious which species of dinosaur laid a particular egg, even when fossilized bones are found inside. This is because embryonic skeletons are small and fragile, and the skeleton is initially made of cartilage that does not preserve well before calcification occurs. This specimen however, is remarkably well-preserved and remains in an articulated position. Baby Louie was delicately prepared by utilizing a powerful microscope and small needles to carefully free it from the rock matrix. Several years have been devoted to preparing this dinosaur specimen for exhibit.

A unique find

Baby Louie is an unusual dinosaur specimen representing an unknown giant species of *Oviraptor* with some very birdlike characteristics. This Late Cretaceous specimen consists of the fossilized remains of a small dinosaur in an egg. While most embryonic remains are jumbled piles of fossilized bones, Baby Louie is extremely rare in that the fossilized bones are intact and well articulated. Did dinosaurs incubate their eggs? Did they raise their young? How were they related to modern birds? These are questions to which Baby Louie may be able to provide answers. Recently paleontologists identified a fossilized bone from the skull as part of a lower jaw. The shape of this fossilized bone — beaklike without teeth — is similar to the lower jaw of the group of dinosaurs that includes *Oviraptor*. Some scientists believe this is an extremely large new species.

Discovery

The amazing discovery of this dinosaur embryo within its nest is beginning to unlock the mystery of what kind of theropod laid such eggs. In 1994 Charlie Magovern discovered this embryo while working on a large egg block from China in his preparation laboratory. He named the embryo Baby Louie after photographer Louie Psihoyos, who photographed it for the May 1996 issue of *National Geographic*. Charlie spent years using a stereoscopic microscope and small needles to free the tiny fossilized bones from the rock.

Site

Baby Louie was excavated from the ancient rocks of the Shiguo Formation in the Hunan Province of China.

Name

In 1923, the first of these dinosaurs ever found was dubbed *Oviraptor* or "egg robber" because the remains were in a nest of eggs mistakenly identified as those of another species. It was proven in 1994 that the eggs were actually laid by the dinosaur itself, leading to the assumption that *Oviraptor* cared for its young much as today's birds do. What scientists know about Baby Louie has changed over time. At first, Baby Louie was thought to be a therizinosaur embryo. Artist Brian Cooley sculpted a fleshed-out version for the cover of the May 1996 *National Geographic*. Later, scientists examining Baby Louie found telltale signs of an ornithomimid. Other scientists have reviewed the findings and now believe the embryo is an *Oviraptor* or perhaps a new genus. The debate continues.

Fossils

Baby Louie's fossilized bones include many that are crucial to identification, including cranium, mandible, femur, dorsal vertebra, tibia, cervical vertebra, metatarsal and manus claw.

Dinosphere link

Baby Louie is displayed in a special case in **Dinosphere**. The exhibit will play an important role in the discussion of eggs, nests and dinosaur babies.

Dinosphere Dinosaur Classification Kingdom — Phylum — Class — Order — Family — Genus — Species

Kids Please Come Over For Great Science!

Baby Louie – *Oviraptor*

Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria ("ruling reptiles") Subclass Dinosauria (extinct reptiles, "terrible lizards")
Order	Saurischia (lizard-hipped) Suborder Theropoda (beast-footed)
Family	Coelurosauridae (birdlike Theropods)
Genus	<i>Oviraptor</i> (egg-robber)
Species	unknown at this time

Resource Materials

Fossil

Oviraptor embryo — Baby Louie



The Children's Museum of Indianapolis

Baby Louie's skull and other bones are clearly visible. The fossil bones are full size.

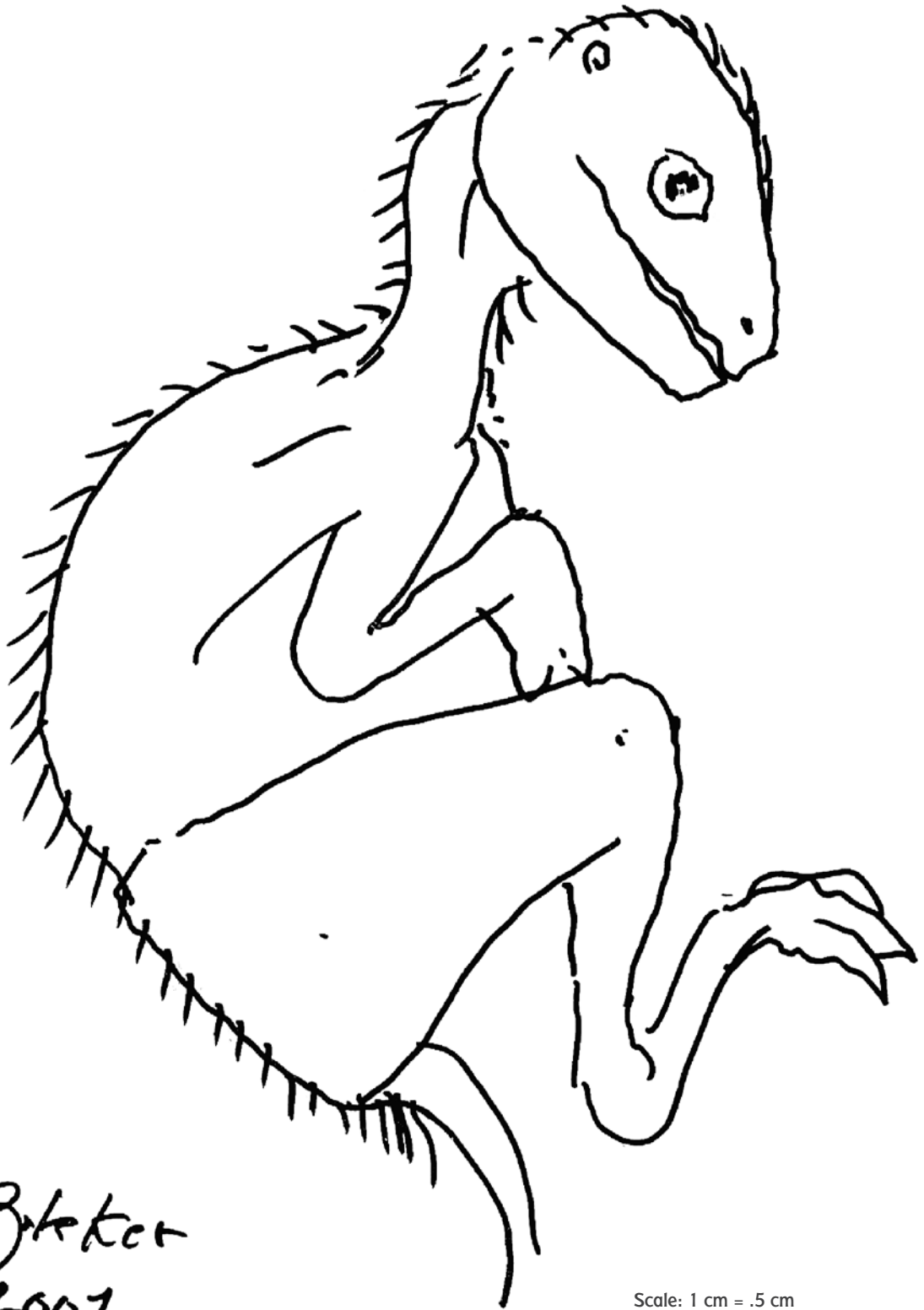


1995 Brian Cooley, "Baby Louie," polyester resin. The Children's Museum of Indianapolis.

This model of Baby Louie was created by paleo-artist, Brian Cooley.

Drawing

Oviraptor embryo — Baby Louie



R.V. Baker
© 2001

Scale: 1 cm = .5 cm

Resource Materials

Sculpture

Oviraptor embryo — Baby Louie



© 2003 Gary Staab, "Baby Louie," resin/glass/feathers, The Children's Museum of Indianapolis

Working from the fossilized bones, artist Gary Staab created this model of what Baby Louie might have looked like as a hatchling.

Maiasaura peeblesorum

One full-size fossilized bone skeleton in Dinosphere

Background

When paleontologist John Horner walked into a small rock shop in Bynum, Mont. in 1978, he had no idea what he was about to find. The owners, the Brandvolds, showed Horner a coffee can full of little fossilized bones. Horner saw at once that they were fossilized baby dinosaur bones and asked where they were found. The Brandvolds showed him the site, which was later dubbed “Egg Mountain” for the hundreds of eggs and nests excavated over many seasons. The Brandvolds, it turns out, had discovered a new species of dinosaur, which Horner named *Maiasaura*, meaning “good-mother lizard.” Horner speculated that these dinosaurs cared for their young. He studied baby *Maiasaura* skeletons and surmised from their soft fossilized bones that they couldn’t walk just after hatching. He guessed that they probably stayed for about a month in the nest and depended on the adults to bring them food. Bits of fossilized eggshell were also found, indicating hatchlings stayed long enough to trample their shells. Though more recent research has challenged Horner’s hypothesis, the “good-mother lizard” moniker has stuck. Like the hypacrosaur, *Maiasaura* were duck-billed hadrosaurs. They probably had to eat many pounds of leaves, berries, seeds and woody plants each day to survive. *Maiasaura* had a toothless beak for snipping plants and hundreds of specialized teeth for chewing and grinding. Teeth were frequently worn down by all the chewing, but for each functioning tooth up to four or five were growing and ready to replace it. Maiasaurs had to eat almost constantly to get enough food to maintain their weight. And because they traveled in large herds for protection (perhaps up to 10,000 in number), they migrated in search of new food supplies.

Discovery

The **Dinosphere** *Maiasaura* is a composite skeleton, meaning it is made up of the fossilized bones of several individual dinosaurs. The fossils come from the Two Medicine Formation in Teton County, Mont. Cliff and Sandy Linster and their seven children —

Brenda, Cliph, Bob, Wes, Matt, Luke and Megan — discovered a rich fossil site that holds the fossilized bones of many maiasaurs. For many years they have spent their summer vacations excavating dinosaurs at the site.

Site

The first *Maiasaura* fossils consisted of a 75 million-year-old nesting colony found in the badlands of Montana by John Horner and Robert Makela in 1978. The colony contained eggs, babies and adults. The number of specimens found gave rise to the belief in parental care and also to the theory that maiasaurs were social, with females nesting and living in large herds. Also found at the Linsters’ dig site were the remains of a large meat-eating gorgosaur and several small bambiraptors. These creatures likely fed upon the maiasaurs.

Name

Paleontologist John Horner named *Maiasaura* “good-mother lizard” because he believed that these dinosaurs took care of their offspring well after they hatched.

Size

Maiasaurs were large — up to 30 feet long, 12 to 15 feet tall and weighing roughly 3 to 4 tons. They walked on all fours, although they could also stand on two legs for feeding. Their hands had four fingers and their feet were shaped like hooves. They also had long, stiff tails that helped with balance.

Dinosphere link

Meat-eating dinosaurs such as *Gorgosaurus* probably preyed on the maiasaur herds. In **Dinosphere** a maiasaur lies on the ground with a gorgosaur standing above it. Visitors are challenged to look for clues and solve this whodunit. Did the maiasaur die from natural causes or did the gorgosaur kill it? Fossilized Edmontosaurus skin and a jaw bone fossil are displayed in the **Paleo Prep Lab**.

Dinosphere Dinosaur Classification

Kingdom — Phylum — Class — Order — Family — Genus — Species

Kids Please Come Over For Great Science!

Duckbill — *Maiasaura peeblesorum*

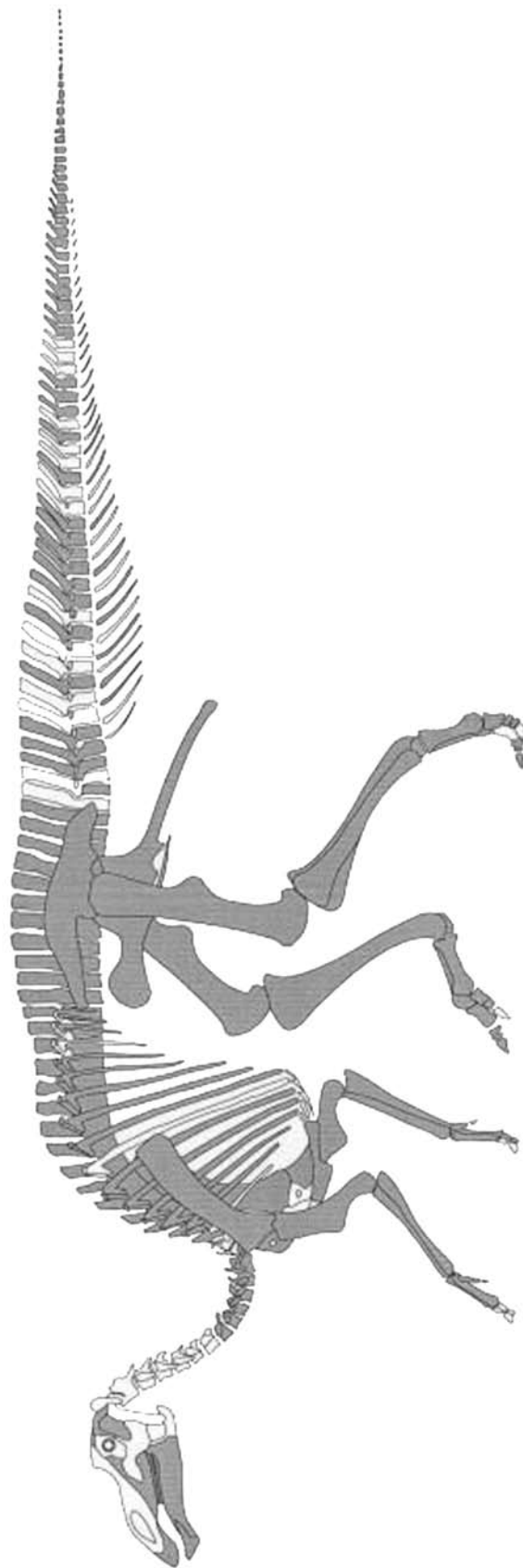
Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria (“ruling reptiles”) Subclass Dinosauria (extinct reptiles, “terrible lizards”)
Order	Ornithischia (bird-hipped) Suborder Ornithopoda (bird-footed)
Family	Hadrosauridae (bulky lizard)
Genus	<i>Maiasaura</i> (good-mother lizard)
Species	<i>peeblesorum</i> (named after the Peebles family, who once owned the badlands)

Duckbill — *Edmontosaurus annectens*

Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria (“ruling reptiles”) Subclass Dinosauria (extinct reptiles, “terrible lizards”)
Order	Ornithischia (bird-hipped) Suborder Ornithopoda (bird-footed)
Family	Hadrosauridae (bulky lizard)
Genus	<i>Edmontosaurus</i> (Edmonton lizard)
Species	<i>annectens</i> (from or connected to)

Resource Materials

Skeleton Diagram *Maiasaura peeblesorum*



The shaded bones are real fossils.

Scale: 1 cm = .5 m

Gorgosaurus sp.

One full-size fossilized bone skeleton in Dinosphere

Background

When people see an illustration of *Gorgosaurus* they almost always think of its popular cousin, *Tyrannosaurus rex*. There are many similarities. Both were fierce carnivores with dozens of sharp teeth designed for biting and swallowing prey. They were bipeds with small muscular arms and a long tail that balanced the body. Eyes on the front of the skull and a highly developed sense of smell were important adaptations for hunting prey. There are a few differences between the two, however. First, they were not contemporaries. *Gorgosaurus* lived about 74 to 80 million years ago, several million years before the oldest known *T. rex*. Second, *Gorgosaurus* had a bony plate (rugose lacrimal) over its eyes. Then there's the difference in size. *Gorgosaurus* was about 25 feet long, slightly smaller than *T. rex*.

Why the *Gorgosaurus* is significant Completeness

There have been only 20 *Gorgosaurus* specimens ever found, and this one is the most complete. One of the most valuable aspects of its discovery is a thin, V-shaped fossilized furcula, a bone commonly found in birds and often referred to as a wishbone. Long considered a characteristic only of birds, this evidence helps to bolster the claim that birds and dinosaurs are related. Further, almost all of the fossilized teeth are intact and still attached to the jawbone. The body is 75 percent complete.

Discovery

Cliff and Sandy Linster found this gorgosaur in 1997 in Teton County, Mont. It is an interesting and significant find. The furcula (wishbone) may help bolster the claim that birds and dinosaurs are related. There are interesting pathologies in the skeleton. Preparators have found major injuries in the left femur, a mostly healed compound fracture of the right fibula, and some fused vertebrae at the base of the tail. Scientists surmise that this gorgosaur walked with pain and probably had help from others in its pack to survive.

Site

Gorgosaurus finds are rare, more so than *T. rex*. *Gorgosaurus* specimens have been discovered only in North America, excavated at sites in Montana, New Mexico and Alberta, Canada.

Size

An adult *Gorgosaurus* measures approximately 25 feet in length and 10 feet high at the hip. *Gorgosaurus* is smaller than *T. rex* and a more slender, fierce, fleet-footed hunter, capable of pursuing prey at speeds in excess of 20 mph. It has a strong, muscular neck and more than sixty 4- to 5-inch-long serrated teeth. The teeth are not well suited to chewing, so *Gorgosaurus* may have swallowed large chunks of flesh whole. It has powerful legs, three-toed feet with sharp claws and longer arms than *T. rex*.

Name

Lawrence Lambe, who named it "fearsome lizard," first described *Gorgosaurus* in 1914. It was dubbed *Gorgosaurus* in reference to its enormous mouth and teeth. Later, scientists suggested it was a smaller form of *Albertosaurus* and took away its distinction as a separate species. In 1992, Phil Currie argued that *Gorgosaurus* was distinct from *Albertosaurus* and the terminology was restored.

New species

The well-preserved fossilized breastbone, extraordinary curved hand claws and rugose lacrimal (eyebrow bone) suggest it is a species previously unknown to science. Paleontologists, including Robert Bakker and Phil Currie, are currently studying the find.

Fossils

The fossilized bones are rare and complete. Fossilized bones of interest include a fibula with a stress fracture, and healed caudal and scapula fractures. Preparators working on the skull also found interesting features that were identified as vestibular bulae, very delicate structures in the nasal passages that are unusually well preserved. The find may shed new light on dinosaur physiology.

Dinosphere link

Found with the gorgosaur were the remains of a maiasaur and two *Bambiraptor* specimens. Perhaps the gorgosaur was feasting on the maiasaur while the raptors waited for their turn. Visitors to **Dinosphere** are challenged to decide whether the maiasaur was killed or scavenged.

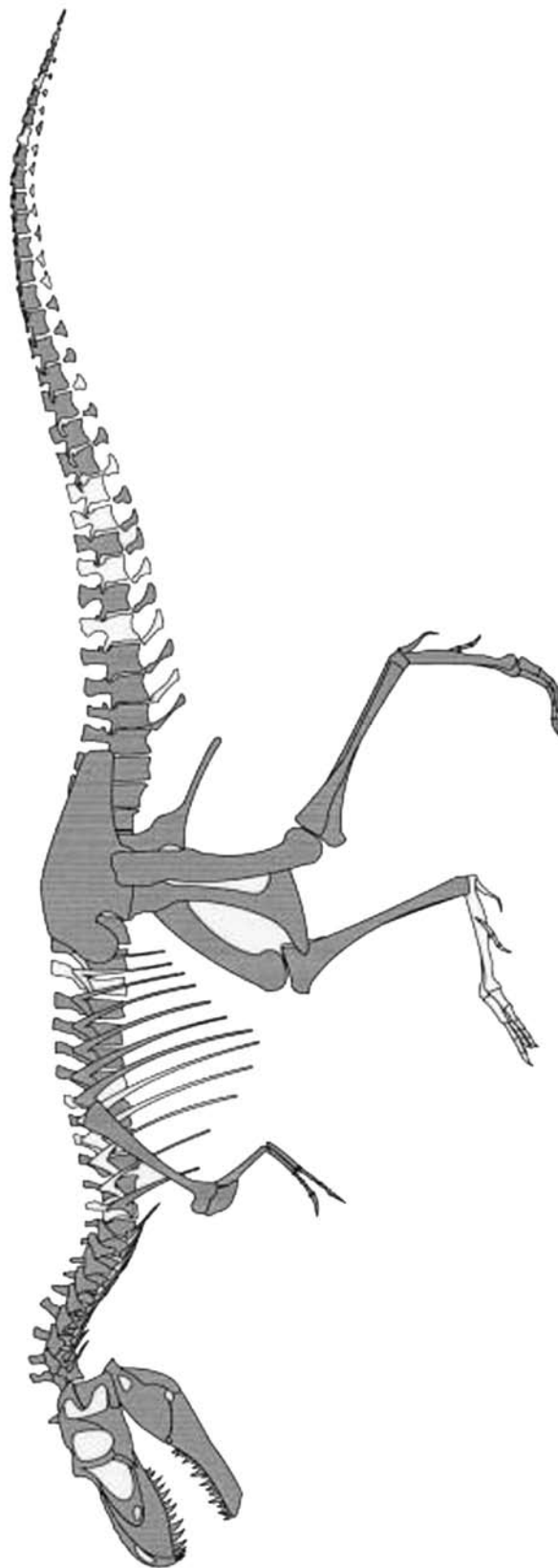
Dinosphere Dinosaur Classification
Kingdom — Phylum — Class — Order
— Family — Genus — Species
Kids Please Come Over For Great Science!

Gorgosaurus sp.

Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria ("ruling reptiles") Subclass Dinosauria (extinct reptiles, "terrible lizards")
Order	Saurischia (lizard-hipped) Suborder Theropoda (beast-footed)
Family	Tyrannosauridae (tyrant dinosaurs) Carnosauria (meat-eating lizards)
Genus	<i>Gorgosaurus</i> (fearsome lizard)
Species	Not currently named.

Resource Materials

Skeleton Diagram *Gorgosaurus* sp.



The shaded bones are real fossils.

Scale: 1 cm = .5 m

Drawing
Gorgosaurus sp.



Scale: 1 cm = .5 m

Frannie — *Leptoceratops* sp.

One full-size fossilized bone skeleton and one cast model skeleton in Dinosphere

Background

There's something mysterious about *Leptoceratops*. It doesn't seem to belong to the usual cast of Cretaceous creatures. Phil Currie explains that at the end of the Mesozoic Era, most dinosaurs were specialists. That is, they had adapted and evolved in special ways to meet the challenges of a changing environment. *Leptoceratops*, however, was a generalist. It was around for a very long time in geological history and did not seem to develop unique adaptations. Perhaps it survived on the fringes of the forest or in the uplands where there was less competition for food from fewer predators. *Leptoceratops* is a small, primitive member of the ceratopsian family. Unlike its larger cousin *Triceratops*, the diminutive *Leptoceratops* is a rare occurrence in the fossil record.

Why Frannie is significant: Completeness

This specimen is a fully adult *Leptoceratops* that contains about 60 percent original fossilized bone. Paleontologists believe that this dinosaur may represent an entirely new genus, *Prenoceratops*, and scientists at Johns Hopkins University are currently reviewing the data. *Leptoceratops* is a primitive cousin of another **Dinosphere** specimen — Kelsey the *Triceratops*. *Leptoceratops*, however, had only a small frill and no horns. It measured approximately 6 feet long and weighed about 120 to 150 pounds. About 3 feet tall, *Leptoceratops* probably walked on four feet but may have had the ability to stand on two for feeding. Its slender build indicates that it could move quickly. Like a *Triceratops*, *Leptoceratops* had the characteristic parrot beak that helped snip and grind plants. Scientists point out, however, that *Leptoceratops* teeth were different from those of other ceratopsians, being broader rather than long. *Leptoceratops* had only two teeth in each position, compared to the batteries of teeth found in other herbivores. And each tooth had only a single root, compared to ceratopsians' double root. Paleontologists are not sure if *Leptoceratops*

was a solitary or herding animal. They have found only a few of these creatures in the fossil record, so it is possible that it roamed by itself or in very small herds. In 1999, fossils of six sub-adults were found in a bone bed in the Two Medicine Formation, perhaps lending credence to the idea that *Leptoceratops* lived in small groups.

Discovery

Dorothy and Leo Flammand found this *Leptoceratops* specimen in Pondera County, Mont., in the summer of 1995. About 60 percent of the skeleton is actual fossilized bone. Using the matrix as a dating tool, it is estimated that the age of the fossil is between 65 and 74 million years old.

Site

The Flammands found this dinosaur among the rocks of the St. Mary's Formation, which dates back to the Maastrichtian Stage of the Late Cretaceous, 72 to 65 million years ago.

Size

This animal is a Protoceratopsian dinosaur, a primitive member of the ceratopsian family, that weighed less than 150 pounds, stood at less than 3 feet tall on all fours, and was less than 6 feet long.

Name

Barnum Brown described the first *Leptoceratops* in 1914. He named the specimen using the Latin words for "slender horned face." Since then, a few specimens have been located in Wyoming, Montana and Alberta, Canada.

Fossils

Fossilized bones of interest include the cranium, which is the hallmark of the species, unique teeth, phalanges for digging and an unusual scapula.

Dinosphere link

In **Dinosphere**, the *Leptoceratops* watches for predators and feeds on low-lying plants near a group of hypacrosaur at a small watering hole. This scene shows something about dinosaur diversity: Not all dinosaurs were large or carnivorous. Some, like *Leptoceratops*, were small creatures that spent most of their time hiding or feeding.

Dinosphere Dinosaur Classification

Kingdom — Phylum — Class — Order — Family — Genus — Species

Kids Please Come Over For Great Science!

Frannie — *Leptoceratops* sp.

Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria ("ruling reptiles") Subclass Dinosauria (extinct reptiles, "terrible lizards")
Order	Ornithischia (bird-hipped) Suborder Marginocephalia (fringed heads)
Family	Ceratopsidae (frilled dinosaurs)
Genus	<i>Leptoceratops</i> (slender horned face)
Species	not named at this time

Skeleton Photos *Leptoceratops* sp. — Frannie

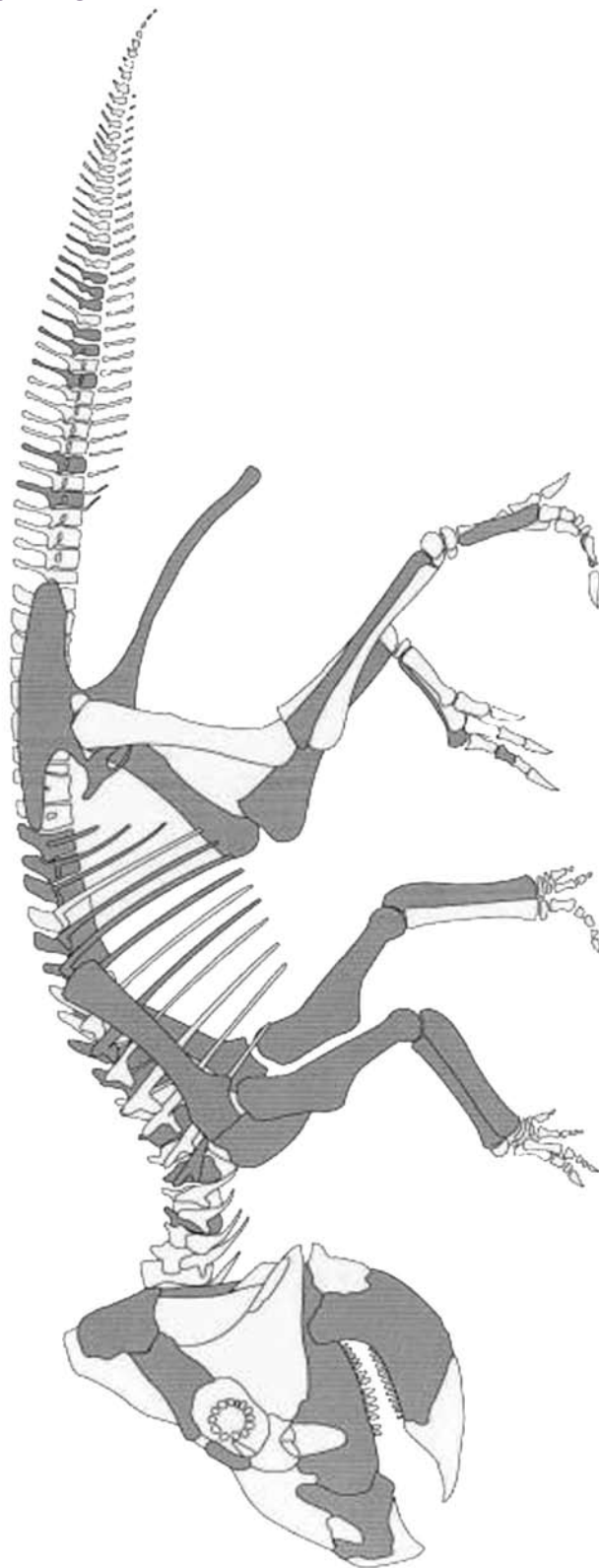


The Children's Museum of Indianapolis

Leptoceratops is a small, primitive member of the *Ceratopsidae* family.

Resource Materials

Drawing *Leptoceratops* sp. — Frannie



The shaded bones are real fossils.

Scale: 1 cm = 8 cm

Hypacrosaurus stebingeri

One full-size adult fossilized bone skeleton, one full-size juvenile fossilized bone skeleton, one full-size baby fossilized bone skeleton and one full-size baby cast model skeleton in Dinosphere.

Background

Hypacrosaurus is a large, plant-eating dinosaur that roamed the earth towards the end of the Cretaceous Period. This creature is commonly known as one of the hadrosaurs, or “duckbill dinosaurs.” While some dinosaurs are rare in the fossil record, *Hypacrosaurus* is abundant. Some scientists liken duckbills to large herds of bison that once roamed the plains of North America. Barnum Brown described the first specimen in 1913 and noted its prominent nasal crest. The ancient remains of these three specimens provide a unique opportunity to show dinosaur family dynamics.

Why the hypacrosaur are significant:

Completeness

The largest is a composite skeleton of an adult hypacrosaur containing 75 percent fossilized bones. The juvenile skeleton is a composite containing 70 percent fossilized bones. The infant specimen contains 35 percent original fossilized bones.

Discovery

Hypacrosaurus is well represented in the fossil record and thus is one of the best known dinosaurs in the world, with specimens in several museums. Because they required so much food to survive, it is likely that herds migrated to find a constant food supply. There was also safety in numbers, as carnivores were less likely to attack a herd of large, healthy adults. But traveling in numbers had its dangers. If a herd tried to cross a flooded river, hundreds could drown. That’s one explanation for what might have happened to the **Dinosphere** specimens, which were found in fossilized bone beds containing parts of individual hypacrosaur.

Site

The fossilized bones of these hypacrosaur were discovered in 1990 in the rocks of the Two Medicine Formation in northernmost Montana, and were excavated over a period of five years.

Size

Hypacrosaurus was a big animal, averaging 30 feet long and 15 feet tall. To maintain its size, it had to eat as much as 60 pounds of plant material per day. Rows and rows of teeth on either side of its jaws sliced tough fibers. Like other duckbill dinosaurs, *Hypacrosaurus* had a long snout and a beak that helped it shred plants. It likely stayed in the forests, snipping plants and leaves up to 6 feet off the ground. It had strong back legs that supported its weight. Some scientists speculate that it could also balance on its hind legs to reach leaves in tall trees. Its front legs were shorter, but three of its four fingers were wrapped in a “mitten,” making it easier to walk. A long, thick tail helped the animal keep its balance. Scientists estimate it could travel up to 12 miles per hour in a hurry but that it usually walked on all fours at a much more leisurely pace.

Name

Hypacrosaurus means “almost the highest lizard,” which refers to the height of the crest on its head.

Unique features

Like many duckbill dinosaurs the *Hypacrosaurus* has an expanded nasal crest on its head that may have been used as a resonating chamber for communicating. Oddly enough only the adults had crests, leading paleontologists to theorize that the juveniles would have made much different sounds. Some scientists believe the crest may have been used as a display or signal to other hypacrosaur, possibly in mating rituals. These animals are thought to have formed large herds, established migratory patterns and created nesting sites. It’s possible that adult female hypacrosaur traveled to nesting colonies in a sandy site, where they could scoop shallow impressions to hold up to 20 eggs. The eggs might have

been covered by sand and plant material to keep them warm during incubation because the mothers were far too large to sit on the nest. After hatching from the cantaloupe-size eggs, babies measured about 24 inches long. Scientists debate whether the adults cared for the babies or left them to fend for themselves. Since they grew so quickly, young hypacrosaur would have needed a supply of protein. Perhaps they ate insects in addition to plants. It’s unclear how soon they may have joined the herd. Tiny young dinosaurs were apt to be trampled, so they may have banded together until they were big enough to travel.

Fossils

Fossilized bones of interest include the cranium and expanded nasal crest that may have aided in production of sound, a unique dental battery, dorsal and caudal vertebrae, chevron, femur, humerus, pes claw and manus claw.

Dinosphere link

In the **Dinosphere** story line, the four hypacrosaur have separated from the herd to come to a watering hole. The adult is nervous and can smell a predator. While the juveniles drink, the baby is chasing a dragonfly, perhaps looking for a quick snack. Danger lurks nearby, both in the water and on the land; the mother is alert and ready to protect her young. Displaying the four together affords the opportunity to talk about dinosaur families, herding and migration.

Dinosphere Dinosaur Classification

Kingdom — Phylum — Class — Order — Family — Genus — Species

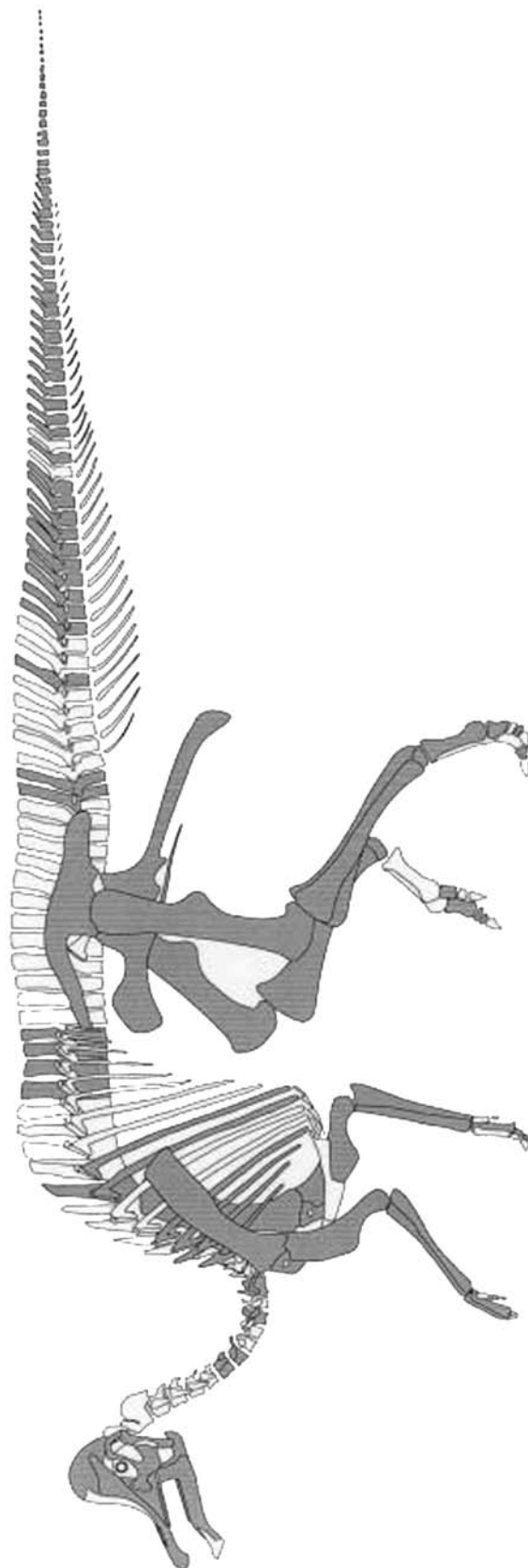
Kids Please Come Over For Great Science!

Duckbill — *Hypacrosaurus stebingeri*

Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria (“ruling reptiles”) Subclass Dinosauria (extinct reptiles, “terrible lizards”)
Order	Ornithischia (bird-hipped) Suborder Ornithopoda (bird-footed)
Family	Hadrosauridae (bulky lizard)
Genus	<i>Hypacrosaurus</i> (almost the highest lizard)
Species	<i>stebingeri</i> (after Eugene Stebinger, who found the first specimens)

Resource Materials

Skeleton Diagram *Hypacrosaurus stebingeri*



The shaded bones are real fossils.

Scale: 1 cm = .5 m

Drawing
Hypacrosaurus stebingeri



The hypacrosaur is a large plant-eating duckbill that roamed the earth toward the end of the Dinosaur Age.

The Children's Museum of Indianapolis

Resource Materials

Bambiraptor feinbergi

Two full-size juvenile cast model skeletons in **Dinosphere**

Background

Bambiraptor lived about 74 to 80 million years ago, several million years before the oldest known *T. rex*. A carnivore, it lived and died with *Gorgosaurus* and *Maiasaura*.

Why *Bambiraptor* is significant:

Bambiraptor is significant because it is the most birdlike of all the raptor dinosaurs found. It is not known if they actually flew, but the well-preserved fossilized bones show strong relationship to birds. This small raptor is important in establishing the link between dinosaurs and birds. Only one skeleton has been found.

Completeness

The specimen is in excellent condition. **Dinosphere** features two cast models of the original.

Discovery

Wes Linster, son of Cliff and Sandy Linster, found the first teeth-filled jawbone of *Bambiraptor*.

Site

The specimen was found in 1993 at the Linster family site in Teton County, Mont.

Size

Bambiraptor was about 3 feet long and weighed about seven pounds. Its 5-inch skull is about the size of a light bulb.

Name

Bambiraptor was named for its size. *Bambiraptor feinbergi* was named in honor of Michael and Ann Feinberg, who helped to ensure these fossils would be in the public domain for all to enjoy.

Fossils

The original is an almost perfect specimen similar to *Archaeopteryx*, especially the furcula (wishbone) and semi-lunate (wrist) bone. Some scientists believe *Bambiraptor* has the largest relative brain size of any known dinosaur.

Dinosphere link

Found with the *Bambiraptor* specimens were the remains of a maiasaur and a gorgosaur. Perhaps the raptors were trying to scavenge some of the maiasaur that the gorgosaur was eating. They would need to be quick to get food away from a gorgosaur. Visitors to **Dinosphere** are challenged to decide whether the maiasaur was killed or scavenged.

Dinosphere Dinosaur Classification

Kingdom — Phylum — Class — Order — Family — Genus — Species

Kids Please Come Over For Great Science!

Bambiraptor feinbergi

Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria ("ruling reptiles") Subclass Dinosauria (extinct reptiles, "terrible lizards")
Order	Saurischia (lizard-hipped) Suborder Theropoda (beast-footed)
Family	Coelurosauridae (very advanced meat-eaters)
Genus	<i>Bambiraptor</i> (baby raptor)
Species	<i>feinbergi</i> (in honor of Michael and Ann Feinberg)

Photograph
Bambiraptor feinbergi



The Children's Museum of Indianapolis

Bambiraptor feinbergi is a small birdlike dinosaur with a very large brain case.

Scale: 1 cm = 5 cm

Resource Materials

Didelphodon vorax Two full-size sculpted models in Dinosphere

If you have seen an opossum, you know what *Didelphodon* might have looked like. Though no one has found anything more than a few pieces of a *Didelphodon* — fossilized teeth, jaw and skull fragments — scientists have speculated that it resembled today's opossum in shape and size. In fact, the genus name, *Didelphodon*, means "opossum tooth."

Barry Brown was searching for fossils in 2001 in Harding County, S.D., when he spotted

a small area of eroding rock that was filled with "micro material" — tiny fossilized bones, teeth and claws from mammals, fish, amphibians, reptiles and dinosaurs. Finding a canine tooth still imbedded in the jaw was significant because previously fossil hunters had seen only loose fossilized teeth. The *Didelphodon* jaw helps scientists determine the size, position and number of the animal's other teeth, and serves as a useful comparison tool when studying other early mammals.

Despite its small size, *Didelphodon* was among the largest mammals in the world 65 million years ago. Dinosaurs ruled the land and mammals were an easy target for the

giant carnivores. *Didelphodon* likely burrowed into the ground and slept during the day for protection. At night, it relied on its keen sense of smell and good vision to find insects, small reptiles, amphibians, other mammals and dinosaur eggs. Its teeth were especially well-suited for crushing, so it could probably feast on clams, snails and baby turtles as well.

Like today's kangaroos and koalas, the *Didelphodon* was a marsupial that probably carried its young in a pouch. Though marsupials are found today primarily in Australia and South America, *Didelphodon* fossils have been found only in North America. In **Dinosphere**, the *Didelphodon* jaw will be exhibited near the two tyrannosaurs and the triceratops. Visitors can easily imagine what it would have been like to hide in a burrow while big dinosaurs battled nearby.

Dinosphere Classification

Kingdom — Phylum — Class — Order —

Family — Genus — Species

Kids Please Come Over For Great Science!



The Children's Museum of Indianapolis

These two *Didelphodon* models are based upon small fossilized teeth and jaw bone.

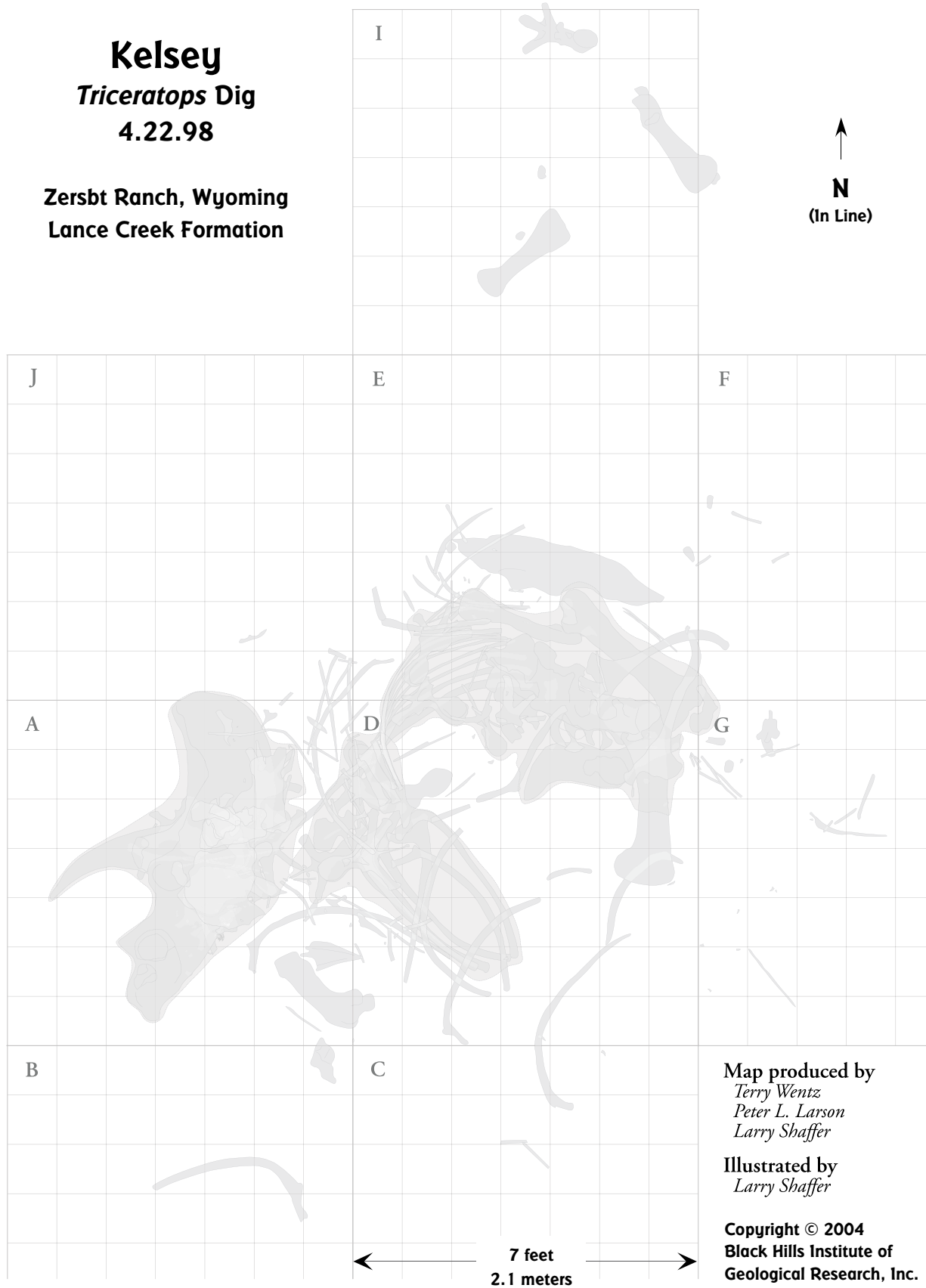
Didelphodon Vorax

Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Mammalia (mammals) Subclass Theria (advanced mammals) Infraclass Metatheria (pouched animals)
Order	Marsupialia Suborder Didelphimorphia (opossums)
Family	Didelphidae
Genus	<i>Didelphodon</i> (opossum tooth)
Species	<i>vorax</i>

Dig Site (Excavation) Map — Kelsey, *Triceratops horridus*

Kelsey
Triceratops Dig
4.22.98

Zersbt Ranch, Wyoming
Lance Creek Formation



Map produced by
Terry Wentz
Peter L. Larson
Larry Shaffer

Illustrated by
Larry Shaffer

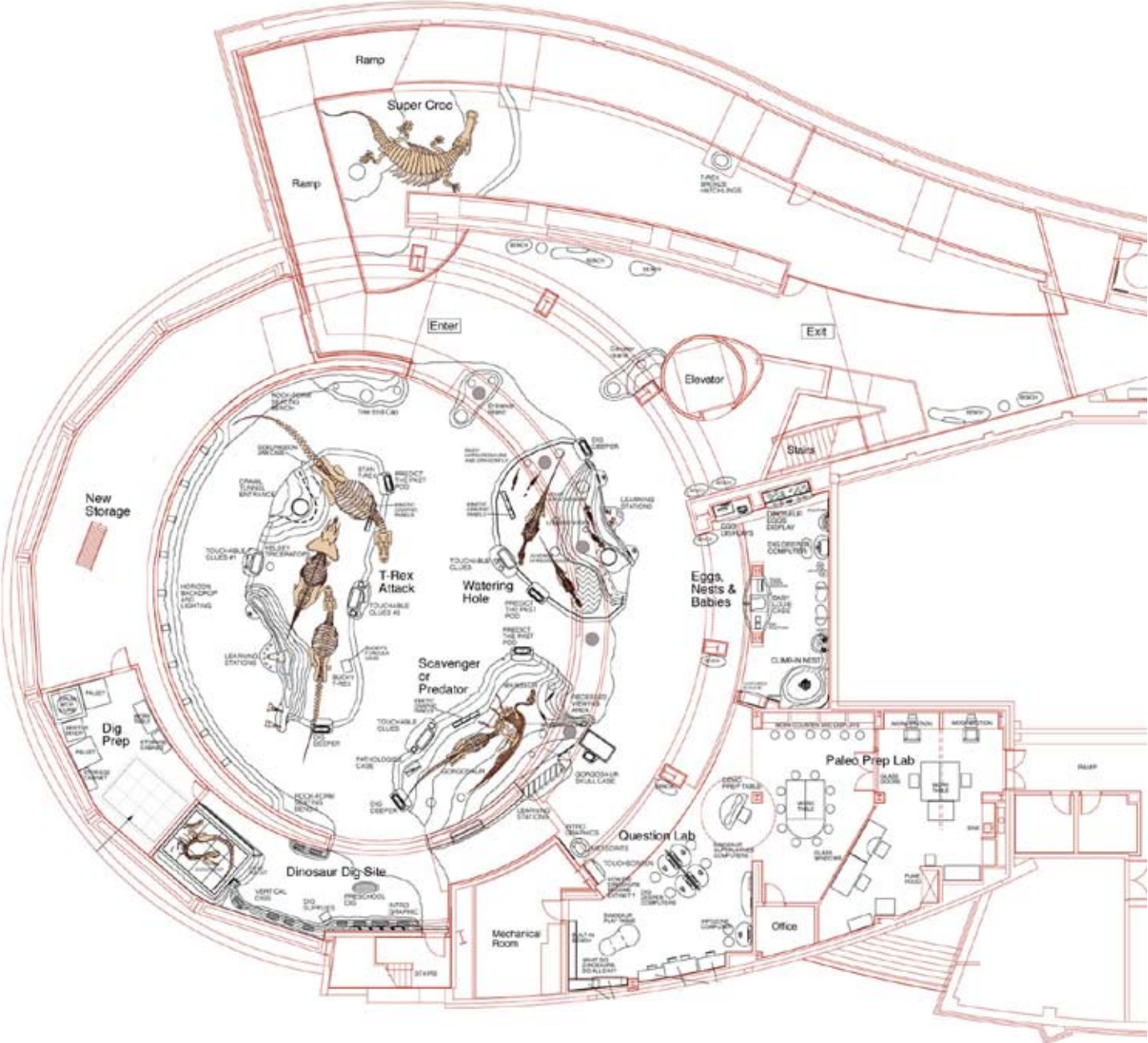
Copyright © 2004
Black Hills Institute of
Geological Research, Inc.

Dinosphere Dinosaur Classification Chart

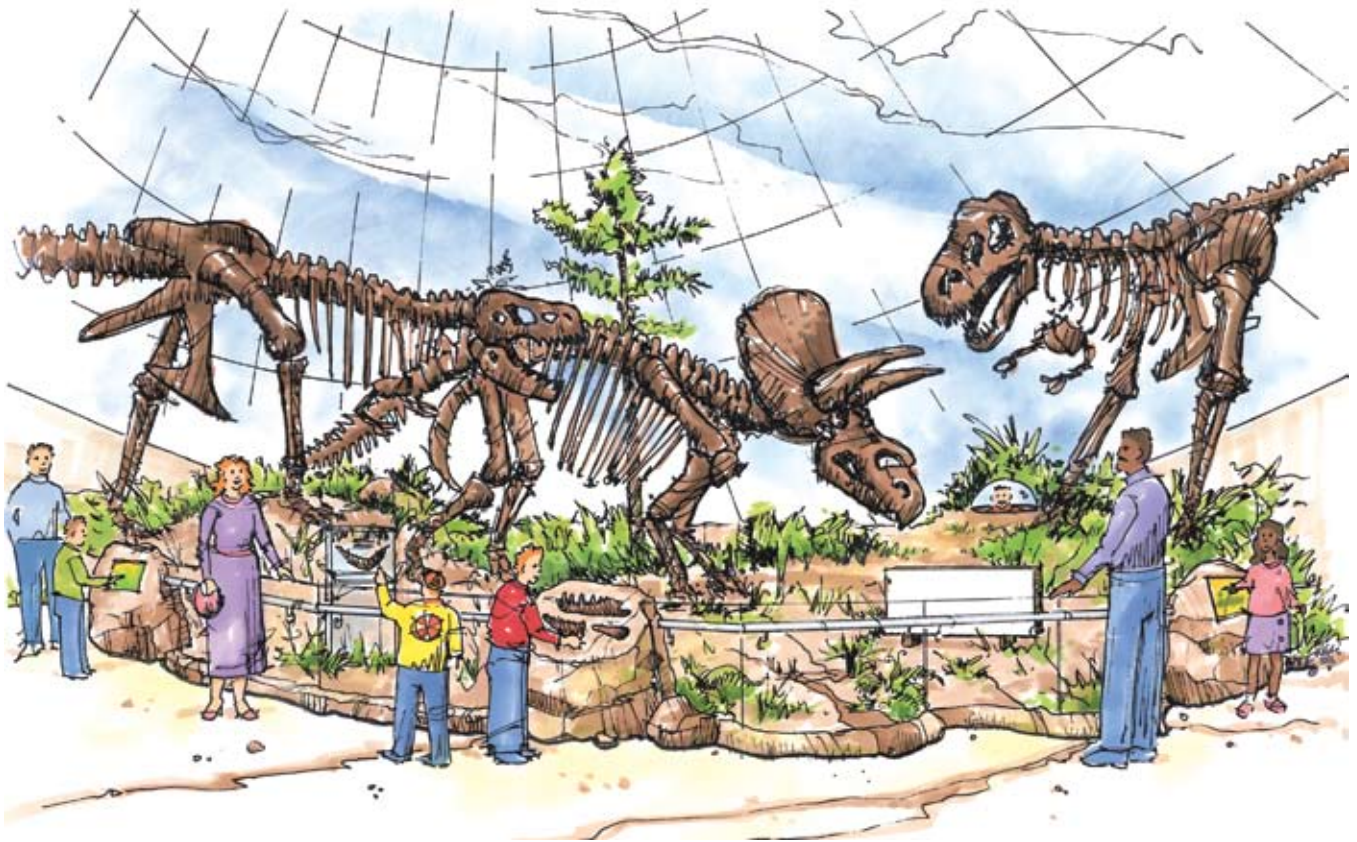
Saurischia — lizard-hipped		Ornithischia — bird-hipped		
Saurapod	<p>Saurpoda — lizard-footed</p> <p>* Barosaurus <i>Camarasaurus</i> * Diplodocus <i>Aragosaurus</i> * Saltasaurus <i>Patagosaurus</i></p>	Ornithopoda	<p>Ornithopoda — bird-footed</p> <p><i>Camptosaurus</i> <i>Corythosaurus</i> * Edmontosaurus annectens <i>Heterodontosaurus</i> * Maiasaura peeblesorum <i>Prosaurolophus</i> * Hypacrosaurus stebingeri</p>	
	Theropod		<p>Theropoda — beast-footed</p> <p><i>Allosaurus</i> * Oviraptor (Baby Louie) <i>Ceratosaurus</i> * Gorgosaurus sp. <i>Troodon</i> * Tyrannosaurus rex (Stan, Bucky) * Bambiraptor feinbergi</p>	Thyreophora
			Marginocephalia	<p>Ankylosauria — armored reptiles</p> <p><i>Ankylosaurus</i> <i>Hylaeosaurus</i></p>
			<p>Ceratopsia — horn-faced</p> <p><i>Protoceratops</i> * Leptoceratops sp. (Frannie) <i>Brachyceratops</i> * Triceratops horridus (Kelsey)</p>	
			<p>Pachycephalosauria — thick-headed reptiles</p> <p><i>Pachycephalosaurus</i></p>	

*Dinosaur fossil bones in **Dinosphere**

Dinosphere Floor Plan



Dinosphere Scenes



The Children's Museum of Indianapolis

The horns, claws, teeth and armor on these dinosaurs make the outcome undecided. Studying the fossils can reveal clues about how the fight might end.

Tyrannosaurus rex Attack Scene — What will be the outcome?

Enduring idea

Fossils are clues that help us learn about dinosaurs.

Secondary messages

Fossils show that life could be dangerous and short at the top of the food chain. Fossils show that some dinosaurs lived in family groups.

Tertiary messages

Dinosaurs fought for food, mates and territory. Disease and wounds were constant threats. Some dinosaurs helped each other.

Story line

What was it like to be a top predator? Fossils show that life could be dangerous and short at the top of the food chain. Fossilized *T. rex* bones display numerous injuries. By comparing tyrannosaurs to modern-day predators, scientists surmise that they were not always successful in catching prey. And when they were not hunting, dinosaurs were fighting each other for food, mates and territory.

In this scene two hungry tyrannosaurs, an adult and a juvenile, are stalking a *Triceratops*. Two against one seems like unfavorable odds, but the *Triceratops* is no pushover. It boasts three sharp horns that can inflict fatal wounds on either predator. Suddenly, the *Triceratops* charges the adult

T. rex, aiming for the torso. The younger *T. rex* quickly lunges for the *Triceratops*. Maybe it's a foolish move. It risks being crushed underfoot or impaled. Who will win? Who will lose? Or will this encounter end in a stalemate?

The noise and movement have terrorized two opossum-size didelphodons hiding inside a nearby burrow. They are nocturnal animals and this afternoon skirmish has interrupted their nap. Because they could be trampled, they stay hidden, hoping the predators will be chased away.

Prey are not always easy to catch, so the two tyrannosaurs may go days or weeks without eating anything. In the meantime, they often fight with other tyrannosaurs over mates or territory. Broken bones, bites and claw marks are common injuries for these animals, while starvation always looms. It's not an easy life for a top predator like *T. rex*.

Dinosphere *Tyrannosaurus rex* Attack Scene Michael Skrepnick Mural Sketch What will be the outcome?



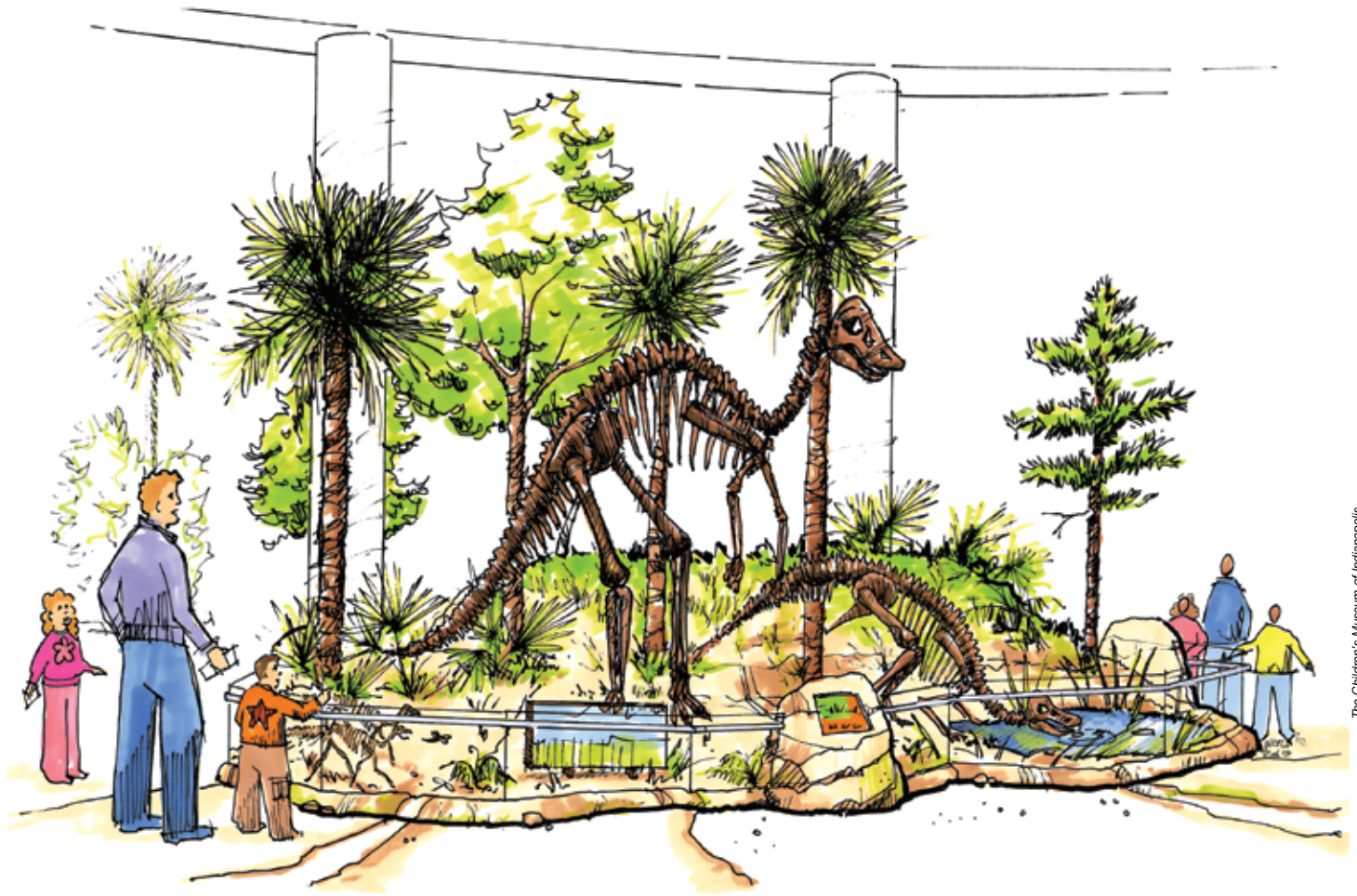
© 2004 Michael Skrepnick, "T. rex Attack," acrylic, The Children's Museum of Indianapolis

Paleo-artist Michael Skrepnick's "T. rex Attack" scene is based upon the most current research and findings about how dinosaurs interacted.



© 2003 Michael Skrepnick, "T. rex Attack," pencil sketch, The Children's Museum of Indianapolis

Dinosphere Watering Hole Scene



The Children's Museum of Indianapolis

A family of hypacrosaurus pause for a drink of water, but predators lurk nearby.

The Watering Hole Scene: *Hypacrosaurus*, *Leptoceratops* — Is this a family?

Enduring idea

Fossils are clues that help us learn about dinosaurs.

Secondary message

Fossils show that some dinosaurs lived in family groups.

Tertiary messages

Some dinosaurs lived in herds and migrated to find food. Some dinosaurs helped each other. Some dinosaurs took care of their hatchlings.

Story line

How did dinosaurs interact with one another? The fossils featured in **Dinosphere** indicate that some dinosaurs lived in family groups. Fossilized bones of big and little dinosaurs are found together in fossil beds. Trackways show that some dinosaurs traveled together in herds for protection or to find food.

In this scene it's early morning in the Cretaceous world and creatures are gathered at a watering hole — a dangerous place for most animals. Adult and juvenile duckbill dinosaurs are thirsty. They've separated from the herd to find water. Nearby, two baby dinosaurs playfully chase a dragonfly. Do you think these dinosaurs are strangers? Or could

they be a family, traveling together to stay safe and find food?

There's a crunching noise in some low-lying bushes by the water. One *Leptoceratops* snips and swallows leaves and twigs, while another slowly backs into a shallow hole to watch for predators.

In the murky water, garfish and frogs dart, wriggle and squirm. On a nearby rock, a turtle stretches out in the hot sun, while insects buzz overhead.

Dinosphere Watering Hole Scene



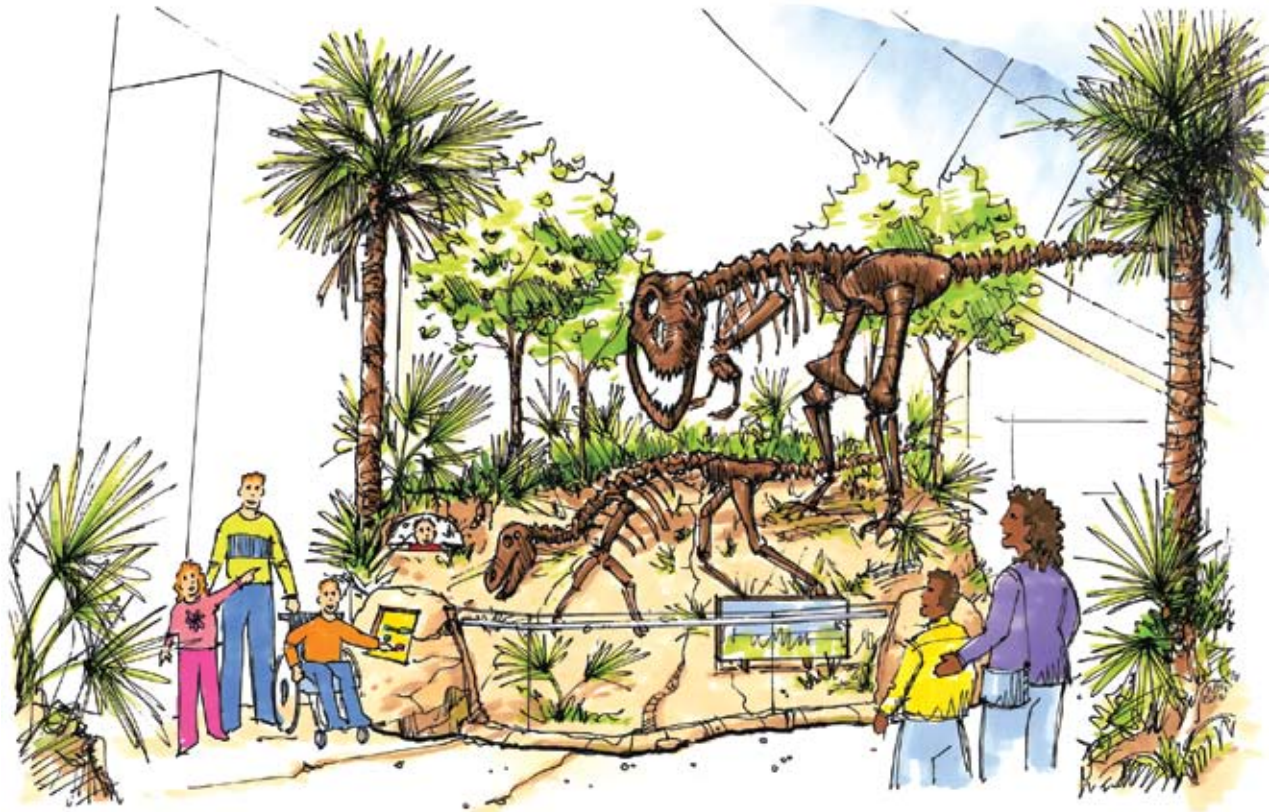
© 2004 Michael Skrepnick, "Watering Hole," acrylic, The Children's Museum of Indianapolis

Paleo-artist Michael Skrepnick's "Watering Hole" scene is based on the most current research about dinosaur habits and interactions.



© 2003 Michael Skrepnick, "Watering Hole," acrylic, The Children's Museum of Indianapolis

Dinosphere Predator or Scavenger Scene



The Children's Museum of Indianapolis

Predator or Scavenger? A close examination of these fossils may help determine if the gorgosaur killed or scavenged the maiasaur.

Predator or Scavenger Scene: Was it an attack or a scavenger opportunity?

Enduring idea

Fossils are clues that help us learn about dinosaurs.

Secondary messages

Fossils show that life could be dangerous and short at the top of the food chain. Paleontologists find and prepare fossils and study them for clues about ancient life.

Tertiary messages

Dinosaurs fought for food, mates and territory. Disease and wounds were constant threats. Some dinosaurs lived in herds and migrated to find food. Today's birds may be descendants of the dinosaurs.

Story line

Paleontologists find and prepare fossils and study them for clues about ancient life. The Linsters, a family of amateur paleontologists, found and dug up a gorgosaur, a maiasaur and two *Bambiraptor* specimens at one site in Mont. Other paleontologists prepared and studied these fossils in the laboratory using special technology. They've noted some unique characteristics of the gorgosaur and recognized similarities between *Bambiraptor* and today's birds.

In this scene, scavengers gather silently at a kill site as the sun sets and a full moon rises. They watch and wait as a gorgosaur eats its fill of a maiasaur carcass. Is the gorgosaur a killer or a scavenger? It is a fast and agile runner. Perhaps it chased and outran the

duckbill, then attacked when it separated from the herd. Or the maiasaur may have died from sickness or old age and the gorgosaur took advantage of a ready meal.

Feathered, birdlike *Bambiraptor* sit nearby, watching and waiting for the gorgosaur to leave. One slinks in to snatch a piece of the carcass. This is risky business, since the gorgosaur is within striking distance. The gorgosaur snarls and snaps at the intruders. A meal this big doesn't come along everyday. The gorgosaur will make the scavengers wait a while longer.

Dinosphere Predator or Scavenger Scene Exhibit Perspective Was it an attack or a scavenger opportunity?



© 2004 Michael Skrepnick, "Predator or Scavenger," acrylic, The Children's Museum of Indianapolis.

Paleo-artist Michael Skrepnick's "Predator or Scavenger" scene depicts the question posed in **Dinosphere**: Did the gorgosaur kill the duckbill, or is it just a scavenger with an opportune find?



© 2003 Michael Skrepnick, "Predator or Scavenger," pencil sketch, The Children's Museum of Indianapolis.

Resource Materials

Dinosphere Area

Dinosaur Eggs, Nests and Babies Area — *Oviraptor*

Enduring Idea

Fossils are clues that help us learn about dinosaurs.

Dinosaur Eggs

How did dinosaurs interact with one another? Fossils show that some dinosaurs lived in family groups. Dinosaurs mated and laid eggs of different shapes and sizes. Some laid their eggs and left them. Others took care of their hatchlings. Paleontologists have found many dinosaur nests and eggs, and some fossil bones of female dinosaurs have been found on top of nests. Telltale clues in the fossilized bones of hatchlings suggest that some baby dinosaurs were cared for over a period of time.

Despite careful study of an extraordinary fossil from China, scientists aren't sure what happened to the little dinosaur dubbed Baby Louie. Some speculate that the dinosaur died while hatching, while others believe it died still in the egg.



On loan from the John and Jack Henkle Collection, The Children's Museum of Indianapolis

Fossilized eggs contain clues that help us learn more about dinosaurs.

Dinosphere Fossil List

In addition to the reconstructed dinosaurs described in this unit, **Dinosphere** contains numerous individual fossils that indicate the diverse plant and animal life of the Cretaceous Period.

Fossil	Exhibit	Fossil	Exhibit
Skeleton	<i>Tyrannosaurus rex</i>	Gastrolith	Gastrolith
Skeleton	<i>Triceratops horridus</i>	Bronze egg	<i>Troodon</i>
Skeleton	<i>Gorgosaurus</i> sp.	Bronze egg	<i>Therizinosaurus</i>
Skeleton	<i>Maiasaura peeblesorum</i>	Bronze egg	<i>Tyrannosaurus rex</i>
Skeleton	<i>Leptoceratops</i> sp.	Bronze egg	<i>Hadrosaurus</i>
Skeleton	<i>Hypacrosaurus stebingeri</i>	Bronze egg	<i>Titanosaurus</i>
Skeleton	<i>Oviraptor</i> sp.	Bronze egg	Sauropods
Skeleton Cast	<i>Bambiraptor feinbergi</i>	Egg fragments	<i>Titanosaurus</i>
Furcula	<i>Tyrannosaurus rex</i>	Egg fragments	<i>Oviraptor</i>
Mandible	<i>Tyrannosaurus rex</i>	Raptor embryo and nest	Unidentified
Tooth	<i>Tyrannosaurus rex</i>	Gorgosaur skull & mandible	<i>Gorgosaurus</i>
Horn Core	<i>Triceratops</i>	Water bug	<i>Hemiptera</i>
Teeth	<i>Triceratops</i>	Camarasaur egg	<i>Camarasaurus</i>
Femur	<i>Triceratops horridus</i>	Hadrosaur egg	<i>Hadrosaurus</i>
Mandible	<i>Triceratops</i>	Copal with inclusions	<i>Agathis australis and others</i>
Arm	<i>Gorgosaurus</i>	Ammonite	<i>Rhondiceras</i> sp.
Skull and mandible	<i>Monoclonius</i>	Ammonite in nodule	<i>Promicroceras planicosta</i>
Skeleton	<i>Protoceratops andrewsi</i>	Jurassic ammonite	<i>Dactylioceras</i> sp.
Scute	<i>Ankylosaurus</i>	Archaeopteryx	<i>Archaeopteryx</i>
Skull and mandible	<i>Ankylosaurus</i>	Allosaurus hand	<i>Allosaurus fragilis</i>
Skull and mandible	<i>Camarasaurus</i>	Amber	<i>Agathis australis and others</i>
Skull and mandible	Duckbill	Pinecone fossil	<i>Araucaria mirabilis</i>
Skin cast	<i>Edmontosaurus annectens</i>	Dinosaur track	<i>Anchisauripus</i> sp.
Teeth	<i>Edmontosaurus annectens</i>	Seed fern	<i>Alethopteris grandini</i>
Eggshell	<i>Saltasaurus</i>	Liaoning leaf	<i>Cladus</i> sp.
Egg	<i>Oviraptor</i>	Foot	<i>Apatosaurus louisae</i>
Egg	<i>Hypselosaurus priscus</i>	Fossil wood	<i>Cycadales</i>
Jaw	<i>Didelphodon</i>	Ginkgo leaf	<i>Ginkgoites sibirica</i>
Dragonfly	<i>Cordulagomphus tuberculatus</i>	Grallator trackway	<i>Ichnogenus Grallator</i>
Dragonfly	<i>Aeschnidum cancellosa</i>	Triassic petrified wood	<i>Araucaria</i> sp.
Dragonfly	<i>Aeschnidum cancellosa</i>	Triassic petrified wood	<i>Araucaria</i> sp.
Dragonfly Larva	Dragonfly	Jurassic horseshoe crab	<i>Mesolimulus walchi</i>
Dragonfly Larva	Dragonfly	Keichousaurus	<i>Keichousaurus yuananensis</i>
Pinecones	<i>Sequoia dakotensis</i>	Anomoza leaf	<i>Anomoazmites inconstans</i>
Ammonite	<i>Desmoceras</i> sp.	Rhamphorhynchus	<i>Rhamphorhynchus gemmingi</i>
Ammonite	<i>Scaphites</i>	Pinecone fossil	<i>Araucaria mirabilis</i>
Ammonite	<i>Lemuroceras sitampikyense</i>	Petrified wood	<i>Araucaria mirabilis</i>
Crab	<i>Grapsoides</i>	Jurassic shrimp	<i>Aeger tipularis</i>
Baculite	<i>Baculites</i>	Sycamore leaf	<i>Ficus sycomorus</i>
Guitarfish	<i>Rhombopterygia rajoides</i>	Trilobites	<i>Dalmanites limulurus</i>
Coprolite	<i>Coprolites</i>	Apatasaur vertebra	<i>Apatosaurus</i>

Important Dates in Dinosaur Discovery

600 B.C.	Central Asian traders bring stories of griffins, based on the fossil record of <i>Protoceratops</i> , to the ancient Greeks.
300 A.D.	Chinese scholars record the presence of “dragon bones.”
1677	Robert Plot illustrates a thighbone, possibly of <i>Megalosaurus</i> .
1824	William Buckland names <i>Megalosaurus</i> , the first dinosaur to be scientifically described.
1825	Gideon Mantell and his wife find a dinosaur tooth and name the genus <i>Iguanodon</i> .
1842	Richard Owen coins the term dinosauria .
1850–1851	Models of <i>Iguanodon</i> , <i>Megalosaurus</i> and <i>Hylaeosaurus</i> , made by Waterhouse Hawkins, are displayed in the Great Exhibit at the Crystal Palace in London.
1856	The first dinosaur remains from the United States are described.
1867	Thomas Henry Huxley is the first scientist to suggest that birds are the direct descendants of dinosaurs.
1877–1895	“The Bone Wars,” a fierce scientific rivalry between Othniel C. Marsh and Edward D. Cope, sparks the discovery of hundreds of new dinosaur specimens in the American West.
1878	Miners discover dozens of <i>Iguanodon</i> skeletons at Bernissart, Belgium.
1920s	A series of expeditions, led by Roy Chapman Andrews of the American Museum of Natural History, to Mongolia’s Gobi desert results in the first discovery of dinosaur eggs and of many new types of dinosaurs.
1930s	The Chinese scientist C.C. Young begins a series of expeditions to excavate dinosaurs in China.
1969	John Ostrom, of Yale University, publishes a description of <i>Deinonychus</i> , beginning a revolution in the way scientists and the public perceive dinosaurs.
1970–present	Increasing evidence suggests that dinosaurs are indeed the ancestors of birds. Continued study of specimens shows that dinosaurs were active, complex animals.

Sources:

National Geographic Dinosaurs, by Paul Barrett (National Geographic Books, 2001).
Tyrannosaurus Sue, by Steve Fiffer (W.H. Freeman and Company, 2000).

Dinosphere Paleontologists and Advisers

Robert Bakker

Robert Bakker is one of the most noteworthy dinosaur paleontologists in the United States, an author and curator of the University of Colorado Museum in Boulder. The paleontologist depicted in the movie *Jurassic Park 2* was modeled after Dr. Bakker.

Philip Currie and Eva Koppelhus

Phil Currie is curator of dinosaurs at the Royal Tyrrell Museum of Palaeontology, Alberta, Canada, which has one of the world's largest collections of paleontological materials. He and his wife, Eva Koppelhus, who is a paleobotanist, travel the world in search of fossils and have coauthored several books about dinosaurs.

John Lanzendorf

John Lanzendorf, of Chicago, is the owner of the world's largest and most complete collection of dinosaur art. The John J. Lanzendorf PaleoArt Prize was created in 1999 to recognize the outstanding achievements of scientific illustrations and naturalistic art in paleontology. In **Dinosphere** visitors will see the Gallery of Dinosaur Imagery featuring The John Lanzendorf Collection.

Pete and Neal Larson

The Larson brothers excavated Sue, the most complete *T. rex* found to date, and founded the Black Hills Institute of Geologic Research in Hill City, S.D. The brothers continue to make significant finds and create displays for museums around the world, including **The Children's Museum**.

Michael Skrepnick

Michael Skrepnick is a world-famous Canadian artist whose paintings and drawings of dinosaurs have illustrated articles, books and presentations by top paleontologists. His work is on display in **Dinosphere**.

Paul Sereno

Paul Sereno is a professor in the Department of Organismal Biology and Anatomy at the University of Chicago and considered one of the brightest minds in the research of South American and African dinosaur material. He also led the team to excavate and bring back the Super Croc fossils that serve as the basis for the replica in **Dinosphere**.

Dong Zhiming

Dong Zhiming is a professor of research at the Chinese Academy of Sciences Institute for Paleontology and Paleoanthropology. He is **The Children Museum's** contact for dinosaurs from China and the Gobi.

Dinosaur Hunters

Adapted from "Great Fossil Hunters of All Time"

<http://www.enchantedlearning.com/subjects/dinosaurs/>

Roy Chapman Andrews (1884–

1960) was a biologist, U.S. fossil hunter and director of the American Museum of Natural History from 1935 to 1942. Andrews led five expeditions into Mongolia's Gobi desert from 1922 to 1930, where he discovered the first dinosaur eggs known to science; identified many new species of dinosaurs; made important finds about now-extinct mammals, including the largest known land mammal, *Baluchitherium*; and found evidence of early Stone Age humans in Central Asia.

Robert Bakker is a prominent paleontologist and dinosaur artist who revolutionized people's concept of dinosaurs in the late 1960s. He brought to light new evidence that supported the belief that dinosaurs were warm-blooded, and suggested that dinosaurs were active, fast-moving animals that stood upright and did not drag their tails.

Barnum Brown (1873–1963) was a famous U.S. dinosaur hunter and curator of the American Museum of Natural History. He explored the Red Deer River Canyons of Alberta, Canada. Brown is well-known for excavating more dinosaurs than anyone else in his 66-year career at the museum. The museum did not have a single dinosaur prior to Brown's arrival but had the largest collection in the world at the time of his death. Brown discovered many dinosaurs, including the first *T. rex* specimens.

William Buckland (1784–1856) was a British geologist at Oxford University. He named *Megalosaurus*, the first dinosaur to be scientifically described in a paper in 1824.

Kenneth Carpenter is a paleontologist at the Denver Museum of Natural History. In 1992 Carpenter, along with Bryan Small and Tim Seeber, found the most complete *Stegosaurus* to date near Canon City, Colo. Carpenter named many other dinosaurs and has written books on dinosaurs.

Edwin Colbert (1905–2001) was an American paleontologist who discovered a *Lystrosaurus* in Antarctica. This discovery helped prove the continental drift theory. In 1947 he found large fossilized dinosaur bone beds at the Ghost Ranch in New Mexico. Colbert named many dinosaurs, published papers and was the curator of the American Museum of Natural History and the Museum of Northern Arizona. The dinosaur *Nedcolbertia* was named after him in 1998.

Edwin Drinker Cope (1840–1897) is considered one of the founders of vertebrate paleontology in North America. He collected thousands of specimens and named more than 1,000 species of fossil animals. He also named dinosaur families, including Iguanodontidae in 1869.

Resource Materials

Dinosaur Hunters continued

Philip Currie is one of the world's leading dinosaur paleontologists and curator at the Royal Tyrrell Museum of Palaeontology in Alberta, Canada. He has worked extensively in Canada and Asia and recently excavated feathered dinosaurs in China. He is a leading proponent of the connection between dinosaurs and birds. He discovered a number of new dinosaur species, including *Albertosaurus*.

Georges Cuvier (1769–1832) was a French vertebrate zoologist who developed a natural system of classifying animals based on comparative anatomy. He named many taxonomic groups of mammals, birds, reptiles and fish. His description of an extinct marine reptile, *Mosasaurus*, helped to make the theory of extinction popular.

Benjamin Waterhouse Hawkins (1807–1889) was a British artist and educator who worked with Richard Owen to build life-size dinosaur sculptures. He created sculptures and artwork in England and the United States.

Susan Henderson is an amateur fossil hunter who on August 12, 1990, discovered three large fossilized bones sticking out of a cliff in South Dakota. These fossils belonged to Sue — the largest, most complete and best preserved *T. rex* ever found.

John R. Horner is an American paleontologist from Montana who named *Maiasaura* in 1979 and *Orodromeus* in 1988. He discovered the first egg clutches in the United States and the first evidence of parental care from dinosaurs. He is also the author of many books and was the technical advisor for the movies "Jurassic Park" and "The Lost World."

Thomas Henry Huxley (1825–1895) was the first scientist to suggest that birds are the direct descendants of dinosaurs, in 1867.

Eva B. Koppelhus is a paleobotanist and adjunct research scientist at the Royal Tyrrell Museum of Palaeontology in Alberta, Canada. She studies the microfossils left behind by pollen grains and spores from ancient plants, and writes dinosaur books with her husband, the paleontologist Philip Currie.

Neal Larson and Peter Larson excavated Sue, the most complete *T. rex* found to date, and founded the Black Hills Institute of Geologic Research in Hill City, S.D. The brothers continue to make significant finds and create displays for museums around the world, including **The Children's Museum**.

Gideon Mantell (1790–1852) was a British fossil collector and an early pioneer of dinosaur research. He showed the big fossilized teeth he found in 1822 to the French anatomist Georges Cuvier, who believed they belonged to a new kind of animal, a plant-eating reptile. Mantell named it *Iguanodon*.

Othniel Charles Marsh (1831–1899) was an American paleontologist at Yale University's Peabody Museum, where he established the field of vertebrate paleontology in North America. He named many of the dinosaur suborders, including Sauropoda in 1878 and Theropoda in 1881. He also named many dinosaurs and more than 500 new species of fossil animals found by his team. His feud with E.D. Cope, known as the "Great Bone Wars," brought dinosaurs to the attention of the public.

Ruth Mason (1906 – 1990) found a large dinosaur fossil bed on her family's ranch in Harding County, S.D., when she was 7 years old. Tens of thousands of dinosaur fossils have been found at the Ruth Mason Quarry near the town of Faith since then. The dinosaurs include large numbers of *Edmontosaurus annectens* — duck-billed, plant-eating dinosaurs. The quarry is also the site of **The Children's Museum** Dino Institute Teacher Dig 2003.

John H. Ostrom is best known for his description of *Deinonychus*, published by Yale University in 1969, which began a revolution in the way that scientists and the public perceived dinosaurs.

Sir Richard Owen (1804–1892) was a British anatomist who introduced the term *dinosauria*, from the Greek *deinos*, meaning terrible, and *sauros*, meaning lizard. He created the term in 1842 to describe several types of large extinct reptiles, fossils of which had been discovered in Europe. Owen's classification went unchallenged until 1877 when the groups were divided into two orders, Saurischia and Ornithischia. Owen also named and described many dinosaurs.

Robert Plot (1640–1696), a British naturalist, published a drawing in 1677 of a fossilized bone fragment found in Oxfordshire. His was the first known drawing of a fossilized dinosaur bone — a thighbone, possibly of *Megalosaurus*.

C.C. Young (1897–1979) was a Chinese paleontologist responsible for supervising the collection and research of dinosaurs in China from 1933 into the 1970s. He was responsible for some of the most important fossil finds in history. The Chinese Academy of Sciences Institute of Paleontology and Paleoanthropology in Beijing houses one of the most important collections in the world due to Young's scientific work.

Dinosphere Unit of Study Books

- Achenbach, Joel. "Dinosaurs: Cracking the Mystery of How They Lived." *National Geographic Magazine*, March 2003, 2–33.
- Barner, Bob. *Dinosaur Bones*. San Francisco: Chronicle Books, 2001.
- Barrett, Paul. *National Geographic Dinosaurs*. Washington, D.C.: National Geographic Society, 2001.
- Barton, Byron. *Bones, Bones, Dinosaur Bones*. New York: HarperCollins, 1990.
- ———. *Dinosaur, Dinosaur*. New York: Thomas Y. Crowell, 1989.
- Brandenburg, Ailiki. *Dinosaur Bones*. New York: Thomas Y. Crowell, 1988.
- ———. *Digging Up Dinosaurs*. New York: Thomas Y. Crowell, 1988.
- Branley, M. Franklyn. *What Happened to the Dinosaurs?* New York: Thomas Y. Crowell, 1989.
- Cohen, Daniel. *Tyrannosaurus Rex*. Mankato, Minn.: Bridgestone Books, 2001.
- Cole, Joanna. *The Magic School Bus in the Time of the Dinosaurs*. New York: Scholastic Inc., 1994.
- Cooley, Brian. *Make-a-Saurus: My Life With Raptors and Other Dinosaurs*. New York: Annick Press Ltd., 2000.
- Currie, Philip J. and Eva B. Koppelhus. *101 Questions About Dinosaurs*. Mineola, N.Y.: Dover Publications, 1996.
- Edgar, Blake. *Dinosaur Digs Discovery Travel Adventures*, Insight Guides. Maspeth, N.Y.: Langenscheidt Publishers Inc., 1999.
- Fiffer, Steve. *Tyrannosaurus Sue*. New York: W. H. Freeman and Company, 2000.
- Funston, Sylvia. *The Dinosaur Question and Answer Book*. Owl Magazine and the Dinosaur Project. New York: Little, Brown and Company, 1997.
- Kerley, Barbara. *The Dinosaurs of Waterhouse Hawkins*, New York: Scholastic, 2001.
- Lionni, Leo. *Swimmy*. New York: Alfred A. Knopf, 1991.
- Milton, Joyce. *Dinosaur Days*. New York: Random House, 1985.
- Most, Bernard. *The Littlest Dinosaurs*. San Diego: Harcourt Brace Jovanovich, 1989.
- ———. *Where to Look for a Dinosaur*. San Diego: Harcourt Brace Jovanovich, 1993.
- Murphy, Jim. *Dinosaur for a Day*. New York: Scholastic Inc., 1992.
- Norman, David and Angela Milner. *Eyewitness: Dinosaur*. New York: DK Publishing, 2000.
- Paul, Gregory S., ed. *The Scientific American Book of Dinosaurs*. New York: St. Martin's Press, 2000.
- Relf, Patricia with the Sue Science Team of The Field Museum. *A Dinosaur Named Sue: The Story of the Colossal Fossil*. New York: Scholastic Inc., 2000.
- Taylor, Paul D. *Eyewitness: Fossil*. New York: DK Publishing, 2000.
- Wallace, Joseph. *Familiar Dinosaur: The Audubon Society Pocket Guides*. New York: Alfred A. Knopf, 1993.
- Willis, Paul. *Dinosaurs*. Pleasantville, N.Y.: Reader's Digest Children's Books, 1999.
- Zoehfeld, Kathleen Weidner. *Dinosaur Babies*. New York: HarperCollins, 1999.
- ———. *Tyrannosaurus Rex*. New York: Children's Press, 1999.

Dinosaur Books for the Classroom

- Bennett Hopkins, Lee. *Dinosaurs: Poems*. San Diego: Harcourt Brace Jovanovich, 1987.
- Berg, Cherney. *Three-Horn the Dinosaur*. Mahwah, N.J.: Educational Reading Service, 1970.
- Brandenburg, Ailiki. *Fossils Tell of Long Ago*. New York: Thomas Y. Crowell, 1990.
- ———. *My Visit to the Dinosaurs*. New York: Thomas Y. Crowell, 1985.
- Brown, Laurie Krasny and Marc Brown. *Dinosaurs Travel: A Guide for Families on the Go*. Boston: Joy Street Books, 1988.
- Burton, Jane and Dougal Dixon. *Jurassic Dinosaurs*. Milwaukee, Wis.: Gareth Stevens, 1987.
- Carrick, Carol. *Big Old Bones: A Dinosaur Tale*. New York: Clarion Books, 1989.
- ———. *Patrick's Dinosaurs*. New York: Clarion Books, 1983.
- ———. *What Happened to Patrick's Dinosaurs*. New York: Clarion Books, 1986.
- Cauley, Lorinda Bryan. *Trouble With Tyrannosaurus Rex*. San Diego: Harcourt Brace Jovanovich, 1988.
- Hoff, Sydney. *Danny and the Dinosaur*. New York: HarperFestival, 1999.
- Marzollo, Jean. *I'm Tyrannosaurus! A Book of Dinosaur Rhymes*. New York: Scholastic, 1993.
- Pfister, Marcus. *Dazzle the Dinosaur*. New York: North-South Books, 1994.
- Prelutsky, Jack. *Tyrannosaurus Was a Beast: Dinosaur Poems*. New York: Greenwillow Books, 1988.
- Rey, Margaret and Alan J. Shalleck, eds. *Curious George and the Dinosaur*. Boston: Houghton Mifflin, 1989.
- Selsam, Millicent and Joyce Hunt. *A First Look at Dinosaurs*. New York: Walker, 1982.
- Wilhelm, Hans. *Tyrone the Horrible*. New York: Scholastic, 1988.

Cretaceous Period Books — Specific books about the plants and animals in Dinosphere

- Currie, Philip J., Eva Koppelhus and Jan Sovak. *A Moment in Time With Albertosaurus*. Alberta, Canada: Troodon Productions, 1998.
- ———. *A Moment in Time With Centrosaurus*. Alberta, Canada: Troodon Productions, 1998.
- ———. *A Moment in Time With Troodon*. Alberta, Canada: Troodon Productions, 1997.
- Green, Tamara. *Cretaceous Dinosaur World*. Milwaukee, Wis.: Gareth Stevens Publishing, 1998.
- Horner, John R. and James Gorman. *Maia: A Dinosaur Grows Up*. Philadelphia: Running Press, 1989.
- Landau, Elaine. *Triceratops*. New York: Children's Press, 1999.

Resource Materials

Dinosaur Videos

Digging Up Dinosaurs, Reading Rainbow Series, from the book *Digging Up Dinosaurs* by Ailiki Brandenberg. Narrated by LeVar Burton, 30 minutes. New York: Lancit Media Productions, 1983.

Dinosaur! With Walter Cronkite, "The First Clue — Tale of a Tooth"; "The Fossil Rush — Tale of a Bone"; "Birth of a Legend — Tale of an Egg"; "Giant Birds of the Air — Tale of a Feather." A&E Home Video, 4-volume set, 1991. 200 minutes.

"Walking With Dinosaurs," BBC and the Discovery Channel, 1999. 180 minutes.

Models

The Tiny Perfect Dinosaur — Book, Bones, Egg & Poster Series, #1 *Leptoceratops*, #2 *Tyrannosaurus rex*, #5 *Triceratops*, #7 *Hypacrosaurus*, Kansas City, Mo.: Andrews McMeel Publishing, 1991–1999.

Dinosaur Web Sites *

Artwork of Waterhouse Hawkins
<http://rainbow.ideo.columbia.edu/courses/v1001/dinodis3.html>

Dinosphere link on **The Children's Museum** Web site
<http://www.childrensmuseum.org>

The Dinosaur Farm — retail toys, books, etc.
<http://www.dinosaurfarm.com/>

Dinosaur illustrations
<http://www.search4dinosaurs.com/pictures.html#about>

Links to dinosaur sites
<http://www.kidsites.com/sites-edu/dinosaurs.htm>

The Dinosaur Nest — retail toys, books, etc.
<http://www.thedinosaurnest.com/>

9 Dinosaur Songs by Bergman Broom
<http://www.dinosongs.com/music.htm>

The Dinosauricon, by Mike Keesey
<http://dinosauricon.com/main/index.html>

The Father of Taxonomy — Carolus Linnaeus

<http://www.ucmp.berkeley.edu/history/linnaeus.html>

Fossil Halls, American Museum of Natural History
http://www.amnh.org/exhibitions/Fossil_Halls/fossil-halls2.html

Great Fossil Hunters of All Time
<http://www.enchantedlearning.com/subjects/dinosaurs/>

Indiana Fossil Clubs and Sites
<http://www.colossal-fossil-site.com/400-states/2/indiana-2.htm>

Jurassic Park Institute (JPI)
<http://www.jpoinstitute.com>

Museum of Paleontology, University of California, Berkeley
<http://www.ucmp.berkeley.edu/index.html>

Dinosphere Paleo Prep Lab link on **The Children's Museum** Web site shows how a fossil is prepared.
<http://www.childrensmuseum.org>

Songs For Teaching — Dinosaur Songs
<http://www.songsforteaching.com/DinosaurSongs.html>

Sternberg Museum of Natural History (unofficial virtual tour)
<http://www.oceansofkansas.com/Sternbrg.html>

Strange Science — Art of Benjamin Waterhouse Hawkins
<http://www.strangescience.net/hawkins.htm>

Virtual Tour of Dinosaurs, Smithsonian Museum of Natural History
<http://www.hrw.com/science/si-science/biology/animals/burgess/dino/tourfram.html>

Weighing a Dinosaur — Robert Lawrence, D.C. Everest Junior High School, Schofield, Wisc.
http://www.geology.wisc.edu/museum/hughes/dinosaur-weight_students.html

Enchanted Learning — Comprehensive e-book about dinosaurs
<http://www.zoomdinosaurs.com>

Zoom Dinosaur — Skeletons
<http://www.enchantedlearning.com/subjects/dinosaurs/anatomy/Skeleton.shtml>

Dinosaur Webquests

Dinosaur Webquests link on **The Children's Museum** Web site
<http://www.childrensmuseum.org>

Paramount Elementary School, Robin Davis
<http://www.alt.wcboe.k12.md.us/mainfold/schoopag/elementary/paramount/class-webs/1/davisr/DinosaurWebquest.html>

Vince Vaccarella for CPE 542 — Technology in Education
http://www.lfelem.lfc.edu/tech/DuBose/Webquest/Vaccarella/WQPS_VV.html

**Note: Web sites are current and active at time of publication.*

Glossary

Adaptation — a body part or behavior that produces an advantage for the animal. For example: feathers, fur, scales, teeth and beaks, or migration and hibernation.

Articulated — fossils and fossilized bones that are still positioned in lifelike poses. This indicates little geologic energy in the area.

Backbone — the vertebrae forming the axis of an animal's skeleton (also called the spine).

Bar graph — a representation of quantitative comparisons using rectangular shapes with lengths proportional to the measure of what is being compared.

Biography — an account of the series of events making up a person's life.

Biped — animal that walks or stands on two feet.

Bone — rigid connective tissue that makes up the skeleton of vertebrates.

Bone bed — a layer of rock filled with fossilized bones.

Carnivore — a flesh-eating animal.

Cast — a model or replica of something made from an impression or mold.

Centimeter ruler — a device for measuring length in metric units.

Claw — the long, sharp or rounded nail on the end of a foot or hand, like fingernails.

Climate — the average weather conditions at a place over a long period of time.

Common — widely known or occurring frequently.

Conifers — mostly evergreen trees and shrubs with needle-shaped or scale-like leaves. Some types bear cones and some bear fruit.

Contribution — something given or accomplished in common with others.

Cooperate — to work together for a common goal.

Coprolite — fossilized excrement.

Cretaceous Period — the third and last period when dinosaurs lived, during the Mesozoic Era, from 144 to 65 million years ago.

Cycads — palmlike primitive plants, four families of which still exist.

Death — the end of life.

Dental battery — a set of hundreds of small, fossilized teeth that are continually wearing out and being replaced. Many plant-eating dinosaurs had dental batteries.

Dig — the excavation activities at a dig site.

Dig site — a place where fossils are found and dug (excavated).

Dinosaur — extinct reptiles found in the fossil record of the Mesozoic Era.

Dinosauria — "terrible lizard" — coined by Sir Richard Owen.

Disarticulated — Fossilized bones that are not positioned in the way the animal's skeleton would appear naturally. They may be broken, missing or rearranged. The Bucky site had disarticulated fossilized bones, which indicates much geologic energy there.

Discover — to unearth or bring to light something forgotten or hidden.

Displacement — a method to determine the volume of an object by measuring the amount of water it displaces when submerged in a graduated cylinder.

Erosion — wearing away of the land by the action of water, wind and/or ice.

Excavate — to dig out and remove.

Expose — to uncover, as when removing sand or mud from fossils at a dig site.

Extinct — No longer existing.

Family — a group of animals including parents and offspring; a group of organisms related by common characteristics.

Fleshed-out — a picture or model of a living animal depicting the color of its skin and shape of its body.

Fossil — preserved evidence of ancient life. Latin for "dug up," it is the remains or traces of plants or animals that have turned to stone or rock.

Frill — the large bony collar around the neck of dinosaurs such as *Triceratops*.

Gastrolith — a stone or pebble ingested by an animal to help with grinding food for digestion.

Geology — the scientific study of the earth's history and life, especially as recorded in rocks.

Gorgosaurus — an earlier dinosaur relative of *Tyrannosaurus rex*.

Greek and Latin words — used by scientists to describe plants and animals.

Group — two or more animals gathered together for a common goal; a taxonomic term for an assemblage of related organisms.

Head — the upper or anterior part of an animal's body, containing the brain, the primary sense organs and the mouth.

Herbivore — an animal that eats plants.

Herd — animals that live in large groups and travel from place to place together.

Hypacrosaurus — a herding duckbill dinosaur of the Cretaceous Period.

Idea — the product of mental activity: a thought, plan, method or explanation.

Ichthyosaurs — a group of marine (ocean) reptiles that are not dinosaurs but lived at the same time, including plesiosaurs, pliosaurs and mosasaurs.

Imprint — to leave a mark by means of pressure.

Resource Materials

Invertebrates — animals without backbones. This includes shellfish, clams, insects, spiders and others.

Life — the state in which an organism is capable of metabolism, growth and reaction to stimuli.

Living fossil — an ancient organism that lived long ago and continues to exist today. Examples include crocodiles, turtles, cockroaches, ferns, coelacanths, horsetail rushes, ginkgo trees, spiders, dragonflies and horseshoe crabs.

Magnifying lens — a small optical instrument that causes objects to appear larger than they are.

Maiasaura — a herding duckbill dinosaur from the Cretaceous Period.

Meter — a scientific unit of measurement equal to 39.37 inches.

Meteorite — a mass of atmospheric particles that has fallen to the surface of the earth without being totally vaporized. Many small meteorites often strike and others burn up as shooting stars. Very large ones have left craters in the earth's surface.

Model — a representation of an object that can show many but not of all the features of the actual item. A model is both like and different from the real thing.

Mold — a hollow form or matrix used to form a substance into a specific shape.

Negative — the absence of something; unfavorable.

Ornithischia — an order of bird-hipped dinosaurs that were mostly plant-eaters.

Paleontologist — a scientist who studies ancient life from fossils, including plants, invertebrates (animals without backbones) and vertebrates (animals with backbones).

Paleontology — the study of life in past geologic periods as known from fossil remains.

Plaster — a paste made of lime, sand and water that hardens into a smooth solid.

Positive — the presence of something; favorable.

Predator — an animal that lives by hunting and eating other animals, or prey.

Prey — an animal hunted by predators as food. Some prey are also predators.

Pterosauria — a subclass of large flying reptiles, including pterosaurs and pterodons, that were alive during the Dinosaur Age.

Resin — a solid or semisolid organic material, typically translucent and yellowish to brown, formed in plant secretions. Synthetic resins are often used to make cast fossils.

Saurischia — a suborder of lizard-hipped dinosaurs, including prosauropods, sauropods and theropods.

Scale drawing — a representation of something reduced according to a ratio; for example a 1:10 scale drawing means 1 unit of measure represents 10 units of the real object.

Scavenger — an animal that eats another animal it did not help to kill. A crow is a scavenger when it eats the remains of a dead animal.

Scientist — an investigator or other person who applies the principles and methods of science to learn about something.

Sculpture — a three-dimensional work of art; impressed or raised markings on part of a plant or animal.

Sediment — solid fragments of living or dead material deposited by wind, water or glaciers.

Simulation — an exercise that models a real practice. A simulation can teach about the real thing, but it will not be exactly like the real thing.

Sir Richard Owen — a British scientist who coined the term *dinosauria* and created the exhibit at the Crystal Palace in London featuring *Iguanodon* and *Megalosaurus*.

Skeleton — the bones that support an animal.

Skull — the skeleton of the head of a vertebrate; the bony or cartilaginous case that holds and protects the brain and the sense organs, and protects the jaws.

Tail — the rear end or a prolongation of the rear end of an animal.

T. rex tooth — large banana-shaped incisor of a top meat-eating predator of the Cretaceous Period.

Theory — an idea or hypothetical set of scientifically accepted facts, principles or circumstances supported by evidence offered to explain phenomena.

Triceratops — a large plant-eating dinosaur easily recognized by its head, frill and horns.

Tyrannosaurus rex — a large meat-eating dinosaur alive in the Cretaceous Period.

Unique — one of a kind.

Vertebrates — animals that have backbones, including fish, reptiles, amphibians, mammals and birds.

Volcano — an opening in the earth's crust through which molten lava, ash and gases are vented.

Waterhouse Hawkins — a British artist and educator who worked with Sir Richard Owen to build life-size dinosaur sculptures. He also created dinosaur sculptures and artwork in the United States.

Wire — a flexible metal strand used to create model forms.

X-ray — a photograph, as of a skeleton, obtained by the use of electromagnetic radiation.

For a comprehensive glossary of dinosaur terms visit: *Enchanted Learning* <http://www.zoomdinosaurs.com>.

What's in a Dinosaur Name?

Create many new and real dinosaur names with these Greek and Latin words.

a — on, in, at; plural; without
acantho — spiny
acro — high
acu — sharp
ae — plural
aero — air
allo — different, other, strange
alpha — first
alti — high
ambul — walk
amphi — around
ampli — large
an — not
anato — duck
ane — denoting
anim — breath
ankylo — fused
ante — before
anti — against
apato — deceptive
aqua — water
archae — ancient
arium — used for
ary — used for
asis — unhealthy
aster — star
ate — like, possessing
audi — hear
auri — ear
aurus — lizard
avi — bird
bar(o) — heavy
bi — two
bola — throw
brachio — arm
brevi — short
bronto — thunder
caco — bad
camara — chambered

cantho — spine
cardio — heart
carn — flesh
carni — meat
caud — tail
cele — swell
celer — swift
centri — one hundred
cephale — head
ceptor — receiver
cerat — horned
chasm — ravine, canyon
chord — string
cide — killer
circum — around
cle — small
clude — close
coel — hollow
con — with, together
contra — opposite
corpus — body
cory — helmet
cosm — universe
crypt — hidden
cycl — circle
cyto — hollow
dactyl — finger, toe
dec — ten
deca — ten
deino — terrible
derma — skin
di — two
dia — across
din(o) — terrible
diplo — double
dors — back
duce — to lead
dupl — two
dyma — putting on, off
dynam — power
dys — bad
dysis — putting on, off
ella — small
ence — state of
ennial — yearly
epi — upon, over
escent — growing
esia — act, state of
eu — well, good
euoplo — well-armed
exo — outside
extra — outside of
faun — animal
fic — make
fid — split
fiss — split
flora — plant
foli — leaf
form — form of
fy — to make
gallo — rooster
gel — stiffen
gen — original
geny — origin
geo — earth
gerous — bearing
gnathus — jaw
gracile — slender-bodied
graph — drawing
gravi — heavy
gryp — curved
gymno — naked
gyr — rotate
heli — sun
hemi — half
hemo — blood
herb — plant
heter — different, other
hippo — horse
holo — whole
homo — same
hyal — clear
hydra — water
hupa — very
hyper — over, above
hypo — under, below
i — plural
ia — pertaining to
ic — having
ichthy — fish
id — having
idium — small
in — in, into
ina — subclass
ine — pertaining to
infra — below

inter — between
intra — within
intro — go into
ite — belonging to
itis — inflammation
ject — to throw
kilo — thousand
lapse — to slip
lat — wide
later — side
lepto — small
lipse — leave
lite — minerals
luc — light
lun — moon
lysis — loosening
lyte — loosening
ma — act of
macro — large
magni — great
maia — good mother
mani — hand
mari — sea
me — act of
meag — huge
med — middle
meg — large
mes — middle
meta — with, after
micro — small
milli — thousand
mim — copy
mimus — mimic
mimus — mimic
mono — single
morph — form
multi — many
mut — change
mycin — fungi
myo — mouselike
myria — many
mytho — legend
nano — small
nect — swim
neo — new
noct — night
nod — knot
nome — name

Resource Materials

non — not
nonus — nine
noto — back
nov — new
nycho — claw
nychus — claw
oct — eight
ode — of nature, of
oden — tooth
odon — tooth
off — from
oid — form of
ole — small
olig — few
oma — tumor
omni — all
onto — being
onyx — claw
ops — face
opter — wing
orith — bird
ornith — bird
ortho — straight
oscill — swing
ose — full of
ous — pertaining to
over — above
ovi — egg
pachy — thick
pan — all
papr — ward off
par — beside
para — near
pater — father
pect — thick
ped — foot, child
pel — drive
pelt — shield
pend — hang
pene — almost
penia — lack of
penta — five
per — for each
peri — around
phac — lens
phago — to eat
phan — visible
phen — appearance of

phil — loving
phob — fearsome
phon — sound
phore — bears
phores — carries
phot — light
phren — the mind
physic — natural
physis — form, growth
phyto — plant
pico — million
plas — form, mold
plate — flat
plex — network
plexy — paralysis
plo — armored
ploid — division of
plur — more
pod — foot
poeia — making
polar — axis
poly — many
ponic — toil
post — after
pre — before
prim — first
pro — first, in front
pros — toward
prot — first
proter — before
pseud — false
psil — bare
psych — mind
pter — wing
pus — foot
pyro — fire
quadri — four
quasi — as if
quint — five
rad — ray
radic — root
raptor — thief
ras — scrape
re — back again
rect — straight
retro — backward
rex — king
rhage — breaking

rhaphy — sewing up
rheo — flow
rhexis — breaking
robust — strong
rod — wear
rot — turn
rupt — break
s — plural
salto — jump
san — health
saur — lizard
sciss — cut
scler — hard
scope — examine
se — apart
sect — cutting
sed — sit
seism — earthquake
semi — half
sens — feel
sept — seven
sex — six
sinu — curve
sis — act, state of
siss — stand
sist — set, stand
sol — sun
solu — spread out
solut — loosen
somn — sleep
sperm — seed
spher — ball
spine — spiny
spir — breath
stasis — standing
stat — state
steg — plated; roofed
stell — star
steno — narrow
stom — opening
stomy — opening
strat — spread out
strate — spread out
stroph — turning
styra — spiked
sub — under
super — over, above
syn — with

sys — with
tach — swift
taurus — bull
tauto — same
tect — cover
tele — distance, far off
tend — stretch
terr — earth
therm — heat
thetic — setting down
tom — cut
top — face; head; place
tort — twist
tract — draw
trans — over, around
trauma — wound
tri — three
troo — wounded
trop — turning
troph — food
trude — push
tum — swell
turb — disorder
tyrann — tyrant
ula — small
ule — small
ultra — beyond
um — plural
un — not
undul — wavy
urg — work
us — masculine singular
vacu — void
vari — various
veloci — fast
vent — wind
ventr — belly
vers — to turn
vibr — to shake
vit — life
volv — turn
voo — animal
vor — eating
vore — eating
xeno — strange
y — act, state of
zoo — animal

Indiana Science Standards

Kindergarten Science Standards The Nature of Science and Technology

K.1.1 Raise questions about the natural world.

K.1.2 Begin to demonstrate that everybody can do science.

Scientific Thinking

K.2.1 Use whole numbers up to 10 in counting, identifying, sorting and describing objects and experiences.

K.2.2 Draw pictures and writes words to describe objects and experiences.

The Physical Setting

K.3.1 Describe objects in terms of the materials they are made of, such as clay, cloth, paper, etc.

K.3.2 Investigate that things move in different ways, such as fast, slow, etc.

The Living Environment

K.4.1 Give examples of plants and animals.

K.4.2 Observe plants and animals, describing how they are alike and how they are different in the way they look and in the things they do.

The Mathematical World

K.5.1 Use shapes, such as circles, squares, rectangles and triangles, to describe different objects.

Common Themes

K.6.1 Describe an object by saying how it is similar to or different from another object.

Grade 1 Science Standards The Nature of Science and Technology

1.1.1 Observe, describe, draw and sort objects carefully to learn about them.

1.1.2 Investigate and make observations to seek answers to questions about the world, such as "In what ways do animals move?"

1.1.3 Recognize that and demonstrate how people can learn much about plants and animals by observing them closely over a period of time. Recognize also that care must be taken to know the needs of living things and how to provide for them.

1.1.4 Use tools, such as rulers and magnifiers, to investigate the world and make observations.

Scientific Thinking

1.2.1 Use whole numbers up to 100 in counting, identifying, measuring and describing objects and experiences.

1.2.2 Use sums and differences of single

digit numbers in investigations and judge the reasonableness of the answers.

1.2.3 Explain to other students how to go about solving numerical problems.

1.2.4 Measure the length of objects having straight edges in inches, centimeters, or non-standard units.

1.2.5 Demonstrate that magnifiers help people see things they could not see without them.

1.2.6 Describe and compare objects in terms of number, shape, texture, size, weight, color and motion.

1.2.7 Write brief informational descriptions of a real object, person, place or event using information from observations.

The Physical Setting

1.3.1 Recognize and explain that water can be a liquid or a solid and can go back and forth from one form to the other. Investigate by observing that if water is turned into ice and then the ice is allowed to melt, the amount of water is the same as it was before freezing.

1.3.2 Investigate by observing and then describe that water left in an open container disappears, but water in a closed container does not disappear.

1.3.3 Investigate by observing and also measuring that the sun warms the land, air and water.

1.3.4 Investigate by observing and then describe how things move in many different ways, such as straight, zigzag, round-and-round and back-and-forth.

1.3.5 Recognize that and demonstrate how things near the earth fall to the ground unless something holds them up.

The Living Environment

1.4.1 Identify when stories give attributes to plants and animals, such as the ability to speak, that they really do not have.

1.4.2 Observe and describe that there can be differences, such as size or markings, among the individuals within one kind of plant or animal group.

1.4.3 Observe and explain that animals eat plants or other animals for food.

1.4.4 Explain that most living things need water, food and air.

Mathematical World

1.5.1 Use numbers up to 10 to place objects in order, such as first, second and third, and to name them, such as bus numbers or phone numbers.

1.5.2 Make and use simple picture graphs to tell about observations.

1.5.3 Observe and describe similar patterns,

such as shapes, designs and events that may show up in nature, such as honeycombs, sunflowers or shells. See similar patterns in the things people make, such as quilts, baskets or pottery.

Common Themes

1.6.1 Observe and describe that models, such as toys, are like the real things in some ways but different in others.

Grade 2 Science Standards The Nature of Science and Technology

2.1.1 Manipulate an object to gain additional information about it.

2.1.2 Use tools, such as thermometers, magnifiers, rulers or balances, to gain more information about objects.

2.1.3 Describe, both in writing and orally, objects as accurately as possible and compare observations with those of other people.

2.1.4 Make new observations when there is disagreement among initial observations.

2.1.5 Demonstrate the ability to work with a team but still reach and communicate one's own conclusions about findings.

2.1.6 Use tools to investigate, observe, measure, design and build things.

2.1.7 Recognize and describe ways that some materials, such as recycled paper, cans and plastic jugs, can be used over again.

Scientific Thinking

2.2.1 Give estimates of numerical answers to problems before doing them formally.

2.2.2 Make quantitative estimates of familiar lengths, weights and time intervals and check them by measurements.

2.2.3 Estimate and measure capacity using cups and pints.

2.2.4 Assemble, describe, take apart and/or reassemble constructions using such things as interlocking blocks and erector sets. Sometimes pictures or words may be used as a reference.

2.2.5 Draw pictures and write brief descriptions that correctly portray key features of an object.

The Physical Setting

2.3.1 Investigate by observing and then describe that some events in nature have a repeating pattern such as seasons, day and night, and migrations.

2.3.2 Investigate, compare and describe weather changes from day to day but recognize, describe and chart that the temperature and amounts of rain or snow tend to be high,

Resource Materials

medium or low in the same months every year.

2.3.3 Investigate by observing and then describing chunks of rocks and their many sizes and shapes, from boulders to grains of sand and even smaller.

2.3.4 Investigate by observing and then describing how animals and plants sometimes cause changes in their surroundings.

2.3.5 Investigate that things can be done to materials, such as freezing, mixing, cutting, heating, wetting, etc., to change some of their properties and observe that not all materials respond in the same way.

2.3.6 Discuss how people use electricity or burn fuels, such as wood, oil, coal or natural gas, to cook their food and warm their houses.

2.3.7 Investigate and observe that the way to change how something is moving is to give it a push or a pull.

2.3.8 Demonstrate and observe that magnets can be used to make some things move without being touched.

The Living Environment

2.4.1 Observe and identify different external features of plants and animals and describe how these features help them live in different environments.

2.4.2 Observe that and describe how animals may use plants, or even other animals, for shelter and nesting.

2.4.3 Observe and explain that plants and animals both need to take in water, animals need to take in food, and plants need light.

2.4.4 Recognize and explain that living things are found almost everywhere in the world and that there are somewhat different kinds in different places.

2.4.5 Recognize and explain that materials in nature, such as grass, twigs, sticks and leaves, can be recycled and used again, sometimes in different forms, such as in birds' nests.

2.4.6 Observe and describe the different external features of people, such as their size, shape and color of hair, skin and eyes.

2.4.7 Recognize and discuss that people are more like one another than they are like other animals.

2.4.8 Give examples of different roles people have in families and communities.

The Mathematical World

2.5.1 Recognize and explain that, in measuring, there is a need to use numbers between whole numbers, such as $2\frac{1}{2}$ centimeters.

2.5.2 Recognize and explain that it is often useful to estimate quantities.

2.5.3 Observe that and describe how changing one thing can cause changes in something else such as exercise and its effect on heart rate.

2.5.4 Begin to recognize and explain that people are more likely to believe ideas if good reasons are given for them.

2.5.5 Explain that some events can be predicted with certainty, such as sunrise and sunset, and some cannot, such as storms. Understand that people aren't always sure what will happen since they do not know everything that might have an effect.

2.5.6 Explain that sometimes a person can find out a lot (but not everything) about a group of things, such as insects, plants or rocks, by studying just a few of them.

Common Themes

2.6.1 Investigate that most objects are made of parts.

2.6.2 Observe and explain that models may not be the same size, may be missing some details or may not be able to do all of the same things as the real things.

2.6.3 Describe that things can change in different ways, such as in size, weight, color, age and movement. Investigate that some small changes can be detected by taking measurements.

Grade 3 Science Standards Science Standards The Nature of Science and Technology

3.1.1 Recognize and explain that when a scientific investigation is repeated, a similar result is expected.

3.1.2 Participate in different types of guided scientific investigations such as observing objects and events and collecting specimens for analysis.

3.1.3 Keep and report records of investigations and observations using tools, such as journals, charts, graphs, and computers. Discuss the results of investigations and consider the explanations of others.

3.1.5 Demonstrate the ability to work cooperatively while respecting the ideas of others and communicating one's own conclusions about findings.

3.1.6 Give examples of how tools, such as automobiles, computers, and electric motors, have affected the way we live.

3.1.7 Recognize that and explain how an

invention can be used in different ways, such as a radio being used to get information and for entertainment.

3.1.8 Describe how discarded products contribute to the problem of waste disposal and that recycling can help solve this problem.

Scientific Thinking

3.2.1 Add and subtract whole numbers mentally, on paper, and with a calculator.

3.2.2 Measure and mix dry and liquid materials in prescribed amounts, following reasonable safety precautions.

3.2.3 Keep a notebook that describes observations and is understandable weeks or months later.

3.2.4 Appropriately use simple tools, such as clamps, rulers, scissors, hand lenses, and other technology, such as calculators and computers, to help solve problems.

3.2.5 Construct something used for performing a task out of paper, cardboard, wood, plastic, metal, or existing objects

3.2.6 Make sketches and write descriptions to aid in explaining procedures or ideas.

3.2.7 Ask "How do you know?" in appropriate situations and attempt reasonable answers when others ask the same question.

The Physical Setting

3.3.1 Observe and describe the apparent motion of the sun and moon over a time span of one day.

3.3.2 Observe and describe that there are more stars in the sky than anyone can easily count, but they are not scattered evenly.

3.3.3 Observe and describe that the sun can be seen only in the daytime.

3.3.4 Observe and describe that the moon looks a little different every day, but looks the same about every four weeks.

3.3.5 Give examples of how change, such as weather patterns, is a continual process occurring on Earth.

3.3.6 Describe ways human beings protect themselves from adverse weather conditions.

3.3.7 Identify and explain some effects human activities have on weather.

3.3.8 Investigate and describe how moving air and water can be used to run machines, like windmills and waterwheels.

3.3.9 Demonstrate that things that make sound do so by vibrating, such as vocal cords and musical instruments.

The Living Environment

3.4.1 Demonstrate that a great variety of living things can be sorted into groups in many ways using various features, such as how they look, where they live, and how they act, to decide which things belong to which group.

3.4.2 Explain that features used for grouping depend on the purpose of the grouping.

3.4.3 Observe that and describe how offspring are very much, but not exactly, like their parents and like one another.

3.4.4 Describe that almost all kinds of animals' food can be traced back to plants.

3.4.5 Give examples of some kinds of organisms that have completely disappeared and explain how these organisms were similar to some organisms living today.

3.4.6 Explain that people need water, food, air, waste removal, and a particular range of temperatures, just as other animals do.

3.4.7 Explain that eating a variety of healthful foods and getting enough exercise and rest help people to stay healthy.

3.4.8 Explain that some things people take into their bodies from the environment can hurt them and give examples of such things.

3.4.9 Explain that some diseases are caused by germs and some are not. Note that diseases caused by germs may be spread to other people. Also understand that hand washing with soap and water reduces the number of germs that can get into the body or that can be passed on to other people.

The Mathematical World

3.5.1 Select and use appropriate measuring units, such as centimeters (cm) and meters (m), grams (g) and kilograms (kg), and degrees Celsius (°C).

3.5.2 Observe that and describe how some measurements are likely to be slightly different, even if what is being measured stays the same.

3.5.3 Construct tables and graphs to show how values of one quantity are related to values of another.

3.5.4 Illustrate that if 0 and 1 are located on a line, any other number can be depicted as a position on the line.

3.5.5 Explain that one way to make sense of something is to think of how it relates to something more familiar.

Common Themes

3.6.1 Investigate how and describe that when parts are put together, they can do things that they could not do by themselves.

3.6.2 Investigate how and describe that something may not work if some of its parts are

missing.

3.6.3 Explain how a model of something is different from the real thing but can be used to learn something about the real thing.

3.6.4 Take, record, and display counts and simple measurements of things over time, such as plant or student growth.

3.6.5 Observe that and describe how some changes are very slow and some are very fast and that some of these changes may be hard to see and/or record.

Grade 4 Science Standards Science Standards The Nature of Science and Technology

4.1.1 Observe and describe that scientific investigations generally work the same way in different places.

4.1.2 Recognize and describe that results of scientific investigations are seldom exactly the same. If differences occur, such as a large variation in the measurement of plant growth, propose reasons for why these differences exist, using recorded information about investigations.

4.1.3 Explain that clear communication is an essential part of doing science since it enables scientists to inform others about their work, to expose their ideas to evaluation by other scientists, and to allow scientists to stay informed about scientific discoveries around the world.

4.1.4 Describe how people all over the world have taken part in scientific investigation for many centuries.

4.1.5 Demonstrate how measuring instruments, such as microscopes, telescopes, and cameras, can be used to gather accurate information for making scientific comparisons of objects and events. Note that measuring instruments, such as rulers, can also be used for designing and constructing things that will work properly.

4.1.6 Explain that even a good design may fail even though steps are taken ahead of time to reduce the likelihood of failure.

4.1.7 Discuss and give examples of how technology, such as computers and medicines, has improved the lives of many people, although the benefits are not equally available to all.

4.1.8 Recognize and explain that any invention may lead to other inventions.

4.1.9 Explain how some products and materials are easier to recycle than others.

Scientific Thinking

4.2.1 Judge whether measurements and computations of quantities, such as length, area, volume, weight, or time, are reasonable.

4.2.2 State the purpose, orally or in writing, of each step in a computation.

4.2.3 Make simple and safe electrical connections with various plugs, sockets, and terminals.

4.2.4 Use numerical data to describe and compare objects and events.

4.2.5 Write descriptions of investigations, using observations and other evidence as support for explanations.

4.2.6 Support statements with facts found in print and electronic media, identify the sources used, and expect others to do the same.

4.2.7 Identify better reasons for believing something than "Everybody knows that . ." or "I just know" and discount such reasons when given by others.

The Physical Setting

4.3.1 Observe and report that the moon can be seen sometimes at night and sometimes during the day.

4.3.2 Begin to investigate and explain that air is a substance that surrounds us, takes up space, and whose movements we feel as wind.

4.3.3 Identify salt as the major difference between fresh and ocean waters.

4.3.4 Describe some of the effects of oceans on climate.

4.3.5 Describe how waves, wind, water, and glacial ice shape and reshape the Earth's land surface by the erosion of rock and soil in some areas and depositing them in other areas.

4.3.6 Recognize and describe that rock is composed of different combinations of minerals.

4.3.7 Explain that smaller rocks come from the breakage and weathering of bedrock and larger rocks and that soil is made partly from weathered rock, partly from plant remains, and also contains many living organisms.

4.3.8 Explain that the rotation of the Earth on its axis every 24 hours produces the night-and-day cycle.

4.3.9 Draw or correctly select drawings of shadows and their direction and length at different times of day.

4.3.10 Demonstrate that the mass of a whole object is always the same as the sum of the masses of its parts.

4.3.11 Investigate, observe, and explain that things that give off light often also give off heat.

4.3.12 Investigate, observe, and explain that heat is produced when one object rubs against another, such as one's hands rubbing together.

4.3.13 Observe and describe that things that give off heat, such as people, animals, and the sun.

4.3.14 Explain that energy in fossil fuels comes

Resource Materials

from plants that grew long ago.

4.3.15 Demonstrate that without touching them, a magnet pulls all things made of iron and either pushes or pulls other magnets.

4.3.16 Investigate and describe that without touching them, material that has been electrically charged pulls all other materials and may either push or pull other charged material.

The Living Environment

4.4.1 Investigate, such as by using microscopes, to see that living things are made mostly of cells.

4.4.2 Investigate, observe, and describe that insects and various other organisms depend on dead plant and animal material for food.

4.4.3 Observe and describe that organisms interact with one another in various ways, such as providing food, pollination, and seed dispersal.

4.4.4 Observe and describe that some source of energy is needed for all organisms to stay alive and grow.

4.4.5 Observe and explain that most plants produce far more seeds than those that actually grow into new plants.

4.4.6 Explain how in all environments, organisms are growing, dying, and decaying, and new organisms are being produced by the old ones.

4.4.7 Describe that human beings have made tools and machines, such as x-rays, microscopes, and computers, to sense and do things that they could not otherwise sense or do at all, or as quickly, or as well.

4.4.8 Know and explain that artifacts and preserved remains provide some evidence of the physical characteristics and possible behavior of human beings who lived a very long time ago.

4.4.9 Explain that food provides energy and materials for growth and repair of body parts. Recognize that vitamins and minerals, present in small amounts in foods, are essential to keep everything working well. Further understand that as people grow up, the amounts and kinds of food and exercise needed by the body may change.

4.4.10 Explain that if germs are able to get inside the body, they may keep it from working properly. Understand that for defense against germs, the human body has tears, saliva, skin, some blood cells, and stomach secretions. Also note that a healthy body can fight most germs that invade it. Recognize,

however, that there are some germs that interfere with the body's defenses.

4.4.11 Explain that there are some diseases that human beings can only catch once. Explain that there are many diseases that can be prevented by vaccinations, so that people do not catch them even once.

The Mathematical World

4.5.1 Explain that the meaning of numerals in many-digit numbers depends on their positions.

4.5.2 Explain that in some situations, "0" means none of something, but in others it may be just the label of some point on a scale.

4.5.3 Illustrate how length can be thought of as unit lengths joined together, area as a collection of unit squares, and volume as a set of unit cubes.

4.5.4 Demonstrate how graphical displays of numbers may make it possible to spot patterns that are not otherwise obvious, such as comparative size and trends.

4.5.5 Explain how reasoning can be distorted by strong feelings.

Common Themes

4.6.1 Demonstrate that in an object consisting of many parts, the parts usually influence or interact with one another.

4.6.2 Show that something may not work as well, or at all, if a part of it is missing, broken, worn out, mismatched, or incorrectly connected.

4.6.3 Recognize that and describe how changes made to a model can help predict how the real thing can be altered.

4.6.4 Observe and describe that some features of things may stay the same even when other features change.

Grade 5 Science Standards Science Standards The Nature of Science and Technology

5.1.1 Recognize and describe that results of similar scientific investigations may turn out differently because of inconsistencies in methods, materials, and observations.

5.1.2 Begin to evaluate the validity of claims based on the amount and quality of the evidence cited.

5.1.3 Explain that doing science involves many different kinds of work and engages men, women, and children of all ages and backgrounds.

5.1.4 Give examples of technology, such as

telescopes, microscopes, and cameras, that enable scientists and others to observe things that are too small or too far away to be seen without them and to study the motion of objects that are moving very rapidly or are hardly moving.

5.1.6 Explain how the solution to one problem, such as the use of pesticides in agriculture or the use of dumps for waste disposal, may create other problems.

5.1.7 Give examples of materials not present in nature, such as cloth, plastic, and concrete, that have become available because of science and technology.

Scientific Thinking

5.2.1 Multiply and divide whole numbers mentally, on paper, and with a calculator.

5.2.2 Use appropriate fractions and decimals when solving problems.

5.2.3 Choose appropriate common materials for making simple mechanical constructions and repairing things.

5.2.4 Keep a notebook to record observations and be able to distinguish inferences from actual observations.

5.2.5 Use technology, such as calculators or spreadsheets, in determining area and volume from linear dimensions. Find area, volume, mass, time, and cost, and find the difference between two quantities of anything.

5.2.6 Write instructions that others can follow in carrying out a procedure.

5.2.7 Read and follow step-by-step instructions when learning new procedures.

5.2.8 Recognize when and describe that comparisons might not be accurate because some of the conditions are not kept the same.

The Physical Setting

5.3.1 Explain that telescopes are used to magnify distant objects in the sky including the moon and the planets.

5.3.2 Observe and describe that stars are like the sun, some being smaller and some being larger, but they are so far away that they look like points of light.

5.3.3 Observe the stars and identify stars that are unusually bright and those that have unusual colors, such as reddish or bluish.

5.3.4 Investigate that when liquid water disappears it turns into a gas (vapor) mixed into the air and can reappear as a liquid when cooled or as a solid if cooled below the freezing point of water.

5.3.5 Observe and explain that clouds and fog are made of tiny droplets of water.

5.3.6 Demonstrate that things on or near the Earth are pulled toward it by the Earth's gravity.

5.3.7 Describe that, like all planets and stars, the Earth is approximately spherical in shape.

5.3.8 Investigate, observe, and describe that heating and cooling cause changes in the properties of materials, such as water turning into steam by boiling and water turning into ice by freezing. Notice that many kinds of changes occur faster at higher temperatures.

5.3.9 Investigate, observe, and describe that when warmer things are put with cooler ones, the warm ones lose heat and the cool ones gain it until they are all at the same temperature. Demonstrate that a warmer object can warm a cooler one by contact or at a distance.

5.3.10 Investigate that some materials conduct heat much better than others, and poor conductors can reduce heat loss.

5.3.11 Investigate and describe that changes in speed or direction of motion of an object are caused by forces. Understand that the greater the force, the greater the change in motion and the more massive an object, the less effect a given force will have.

5.3.12 Explain that objects move at different rates, with some moving very slowly and some moving too quickly for people to see them.

5.3.13 Demonstrate that the Earth's gravity pulls any object toward it without touching it.

The Living Environment

5.4.1 Explain that for offspring to resemble their parents there must be a reliable way to transfer information from one generation to the next.

5.4.2 Observe and describe that some living things consist of a single cell that needs food, water, air, a way to dispose of waste, and an environment in which to live.

5.4.3 Observe and explain that some organisms are made of a collection of similar cells that benefit from cooperating. Explain that some organisms' cells, such as human nerve cells and muscle cells, vary greatly in appearance and perform very different roles in the organism.

5.4.4 Explain that in any particular environment, some kinds of plants and animals survive well, some do not survive as well, and some cannot survive at all.

5.4.5 Explain how changes in an organism's

habitat are sometimes beneficial and sometimes harmful.

5.4.6 Recognize and explain that most microorganisms do not cause disease and many are beneficial.

5.4.7 Explain that living things, such as plants and animals, differ in their characteristics, and that sometimes these differences can give members of these groups (plants and animals) an advantage in surviving and reproducing.

5.4.8 Observe that and describe how fossils can be compared to one another and to living organisms according to their similarities and differences.

5.4.9 Explain that like other animals, human beings have body systems.

The Mathematical World

5.5.1 Make precise and varied measurements and specify the appropriate units.

5.5.2 Show that mathematical statements using symbols may be true only when the symbols are replaced by certain numbers.

5.5.3 Classify objects in terms of simple figures and solids.

5.5.4 Compare shapes in terms of concepts, such as parallel and perpendicular, congruence, and symmetry.

5.5.5 Demonstrate that areas of irregular shapes can be found by dividing them into squares and triangles.

5.5.6 Describe and use drawings to show shapes and compare locations of things very different in size.

5.5.7 Explain that predictions can be based on what is known about the past, assuming that conditions are similar.

5.5.8 Realize and explain that predictions may be more accurate if they are based on large collections of objects or events.

5.5.9 Show how spreading data out on a number line helps to see what the extremes are, where they pile up, and where the gaps are.

5.5.10 Explain the danger in using only a portion of the data collected to describe the whole.

Common Themes

5.6.1 Recognize and describe that systems contain objects as well as processes that interact with each other.

5.6.2 Demonstrate how geometric figures, number sequences, graphs, diagrams, sketches, number lines, maps, and stories can be used to represent objects, events, and processes in the real world, although such

representation can never be exact in every detail.

5.6.3 Recognize and describe that almost anything has limits on how big or small it can be.

5.6.4 Investigate, observe, and describe that things change in steady, repetitive, or irregular ways, such as toy cars continuing in the same direction and air temperature reaching a high or low value. Note that the best way to tell which kinds of change are happening is to make a table or a graph of measurements.

National Standards for Science Education (Grades K – 4)

Content Standard A — Scientific Inquiry (Grades K – 4)

Fundamental concepts and principles that underlie this standard include **scientific inquiry**:

- Ask a question about objects, organisms, and events in the environment.
- Plan and conduct a simple investigation.
- Employ simple equipment and tools to gather data and extend the senses.
- Use data to construct a reasonable explanation.

Content Standard B — Physical Science (Grades K – 4)

Fundamental concepts and principles that underlie this standard include **physical science**:

- Properties of objects and materials – Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers.
- Positions of motion of objects - Objects are made of one or more materials, such as paper, wood, and metal. Objects can be described by the properties of the materials from which they are made, and those properties can be used to separate or sort a group of objects or materials.

Content Standard D — Earth and Space Science (Grades K – 4)

Fundamental concepts and principles that underlie this standard include

Properties of Earth materials:

- Earth materials are solid rocks and soils,

Resource Materials

water, and the gases of the atmosphere. The varied materials have different physical and chemical properties, which make them useful in different ways, for example, as building materials, as sources of fuel, or for growing the plants we use as food. Earth materials provide many of the resources that humans use.

- Soils have properties of color and texture, capacity to retain water, and ability to support the growth of many kinds of plants, including those in our food supply.
- Fossils provide evidence about the plants and animals that lived long ago and the nature of the environment at that time.

Changes in the earth and sky:

- The surface of the earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.
- Weather changes from day to day and over the seasons. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation.

Content Standard F — Personal and Social Perspectives (Grades K – 8)

Fundamental concepts and principles that underlie this standard include **Personal and Social Perspectives**:

Science and technology in local challenges:

- People continue inventing new ways of doing things, solving problems, and getting work done. New ideas and inventions often affect other people; sometimes the effects are good and sometimes they are bad. It is helpful to try to determine in advance how ideas and inventions will affect other people.
- Science and technology have greatly improved food quality and quantity, transportation, health, sanitation, and communication. These benefits of science and technology are not available to all of the people in the world.

Content Standard G — History and Nature of Science (Grades K – 8)

Fundamental concepts and principles that underlie this standard include **History and Nature of Science**:

Science as a human endeavor:

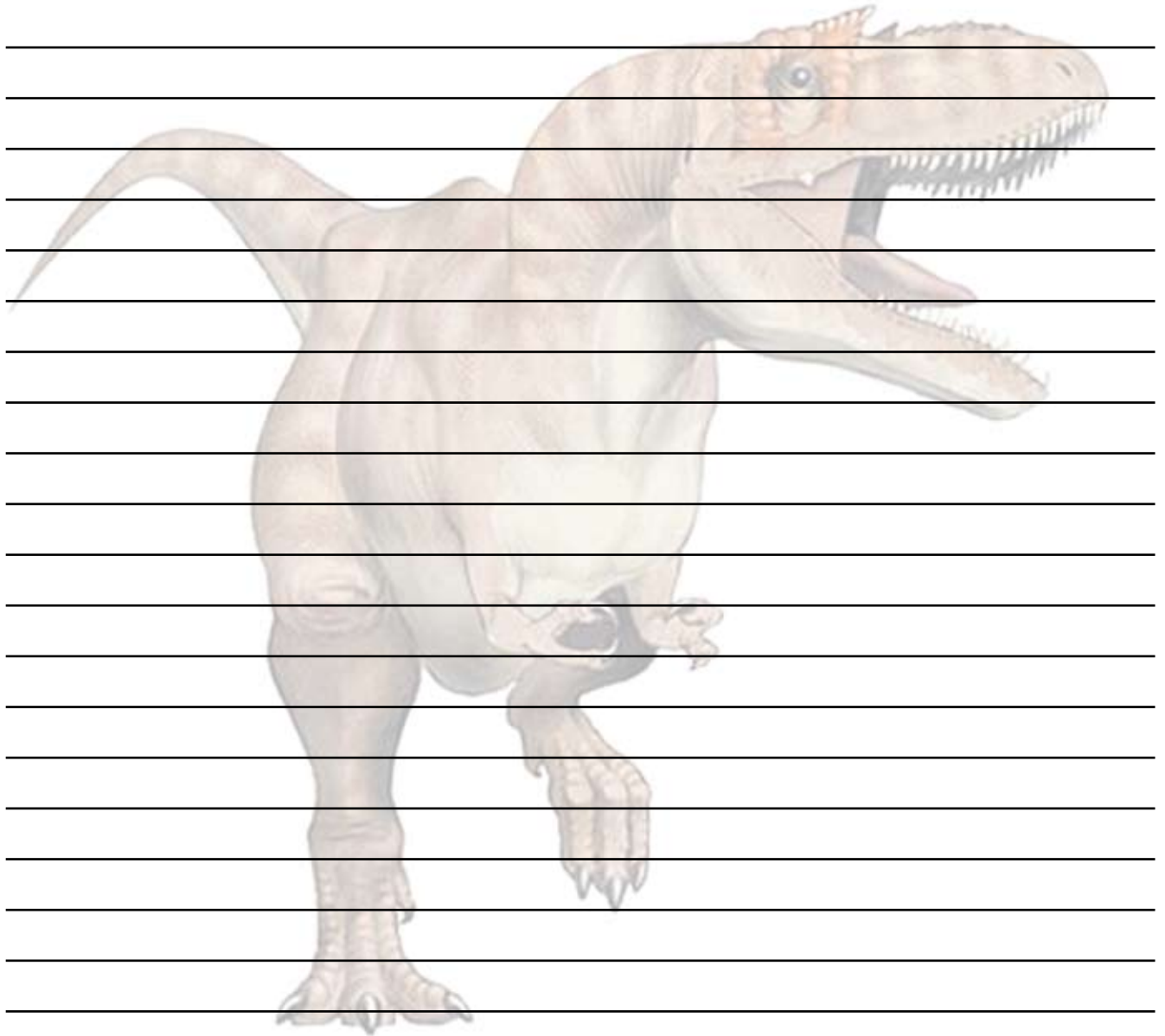
- People have practiced Science and technology for a long time.
- Men and women have made a variety of contributions throughout the history of science and technology.
- Although men and women using scientific inquiry have learned much about the objects, events, and phenomena in nature, much more remains to be understood. Science will never be finished.
- Many people choose science as a career and devote their entire lives to studying it. Many people derive great pleasure from doing science.

Dino Diary

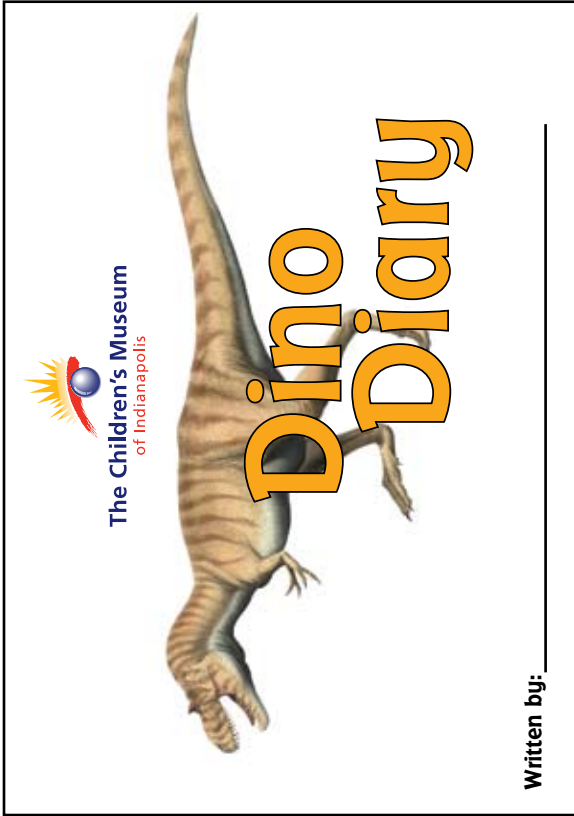
Words, Sentences, Drawings, Notes

(Name)

(Date)



Today I discovered ...



The Children's Museum
of Indianapolis

Dino Diary

Written by: _____

Today I discovered

Today I discovered

Today I discovered

Resource Materials

Written by: _____

Today 1 discovered

Today 1 discovered

Today 1 discovered