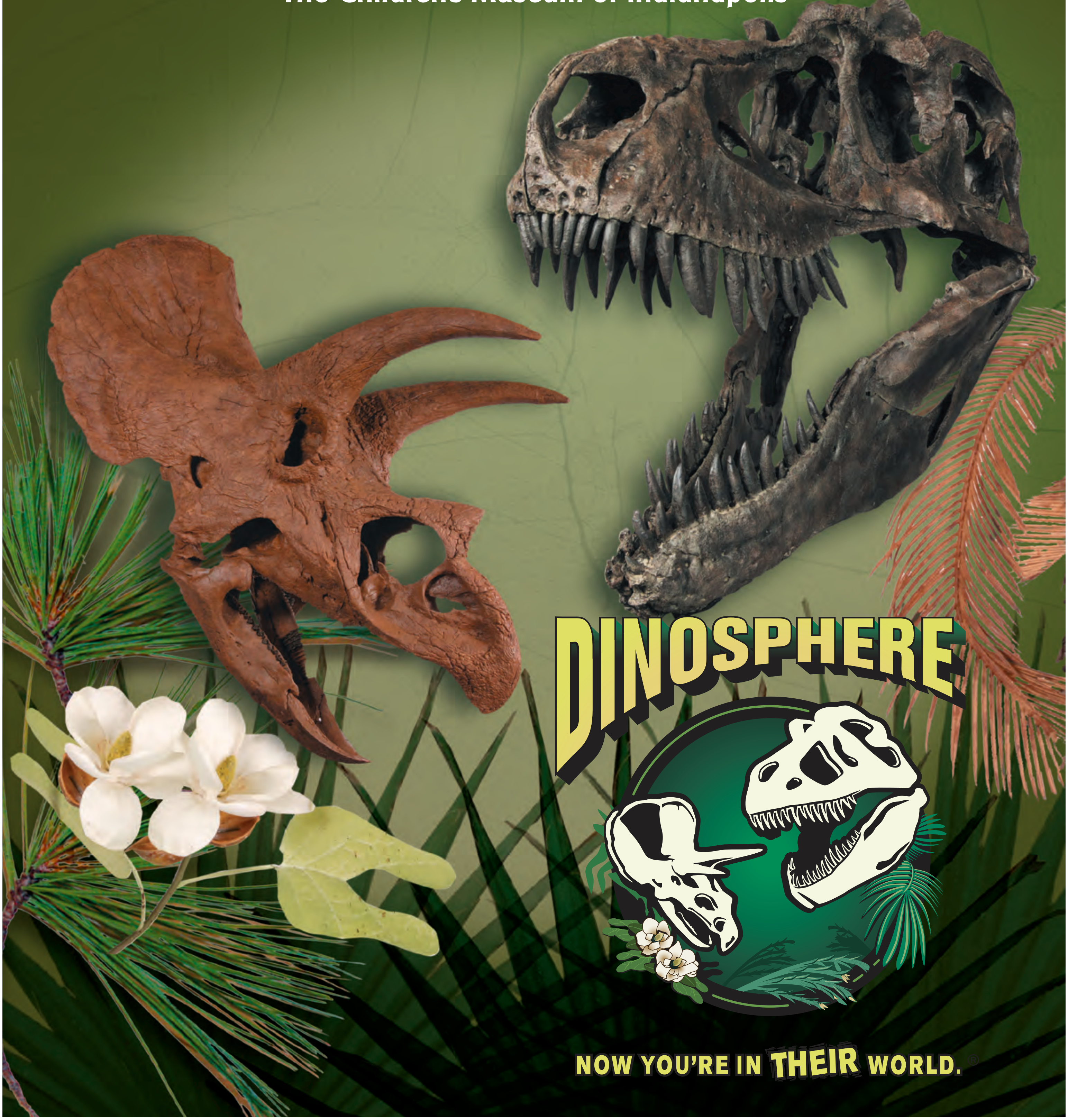
DINOSPHERE

A K – 2 UNIT OF STUDY

The Children's Museum of Indianapolis



DINOSPHERE

NOW YOU'RE IN THEIR WORLD.®

Acknowledgments

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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

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

T. rex Attack

Thump, shake, crash,

Through the tall trees by the waterhole,

Something big scares the *Triceratops.*

She stops, sniffs and checks.

Watch out — it's *Tyrannosaurus rex!*

— Caroline Crosslin, age 6

Dinosphere

A K – 2 Unit of Study

Enduring Idea:

Fossils are clues that help us learn about dinosaurs.

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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.

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

A Unit of Study for Grades K – 2

This unit of study is designed for teachers of Kindergarten and Grades 1 and 2. A companion unit of study with different lessons and activities is available for Grades 3, 4 and 5. Each experience is intended for a specific grade level. However, the 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 Were Different Types and Sizes

Students learn how dinosaurs are classified and compare dino shapes and sizes.

Lesson Two

Some Dinosaurs Lived Together

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

Lesson Three

Fossil Clues Help Us Learn About Dinosaurs

Students learn what a fossil is, and observe and examine fossils to make their own drawings, casts and models.

Lesson Four

What Happened to the Dinosaurs?

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 **Dinosphere** 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, Hypa-crosaurus, 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.

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.thedinosaurnest.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 discovered …"** Each experience ends with a writing component in the science journal. Two styles of templates are provided in the resource section of this unit.

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

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

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* specimens featured in **Dinosphere**. The Zerbst family found and excavated Kelsey, the *Triceratops* and 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 lifelike 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
Dinosaurs Were Different Types and Sizes

Get ready to dig

Students learn that dinosaurs are diverse in size, type and shape. Students take measurements, make drawings and construct models to learn about dinosaurs. Dinosaurs are a special group of animals with interesting names, many of which are long and hard to pronounce. Students are empowered when they can pronounce these multisyllabic names and know what they mean. Dinosaurs are named based on the location they were found or after a person. Students learn how a dinosaur is named using Greek and Latin words and how each part of a name has a meaning. Students create new dinosaur names and decode real names using Greek and Latin words. This lesson focuses on the way dinosaur names reflect their unique body parts or behaviors. Each experience is intended for a specific grade level. However, the lessons are designed to build upon each other. Teachers may want to include more than one of the following experiences.

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Hypacrosaurus stebingeri, *a small duckbill dinosaur. The shaded bones are real fossils.*

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." The name of the three-horned dinosaur *Triceratops* comes from *tri,* meaning "three," and *cerat,* meaning "horn." 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. Students will learn that there are also nicknames for plants, animals and dinosaurs. For example, in **Dinosphere** the *Triceratops* is nicknamed Kelsey, while Bucky is the nickname of one *T. rex.* A plant or animal might have a nickname, a common name and a scientific name.

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Unlike its larger cousin Triceratops, Leptoceratops *is rare in the fossil record.*

EXPERIENCE 1 — DINOSAUR NAMES

Join the Dinosaur Age

Indiana Academic Standards — Kindergarten

Science — 1.1, 2.2, 4.3, 6.1
Language Arts — 1.3, 1.12, 2.1, 2.2, 2.3, 2.5, 5.1, 5.2, 7.2, 7.3
Math — 3.1, 5.1
Social Studies — 4.2

Focus Questions

- **What are dinosaurs?**
- **How do people know about dinosaurs?**
- **What are bones and skeletons?**

Objectives

Students will:

- Role-play activities associated with dinosaurs and paleontologists.
- Interact at different classroom stations to learn about dinosaurs.

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

Vocabulosaurus

- **dinosaur**
- **paleontologist**
- **scientist**
- **bone**
- **dig**
- **skeleton**

Dig tools

Dinosaur models, puzzles, selected books and songs (including *Dinosaur Bones* by Bob Barner); sand table or plastic wading pool filled with sand; clay and play dough; handheld magnifying lens; centimeter ruler, paper, pencil and scissors; drawings of dinosaurs; **Dino Diaries**.

DIG IN ...

1. Set up several learning and play stations within the classroom.
2. Read *Dinosaur Bones* by Bob Barner to the class in a reading circle.
3. Sand table — use sand and dinosaur bone replicas to create a dig site. Students bury and uncover dinosaurs. Use handheld magnifying lens, centimeter ruler, goggles, brushes and **Dino Diaries** to make and record observations. Students draw and color their discoveries.
4. Reading circle — provide several dinosaur books and puzzles for students to explore.
5. Computer stations — bookmark dinosaur Web sites for the class to explore. Provide students with vests, pith helmets and goggles to role-play dinosaur hunters as they use the computer.
6. Dinosaur romp — create an area with a plastic tablecloth or large butcher paper and markers for dinosaur play. Students can design and color landscapes. Place models of dinosaurs and trees for students to use to role-play and re-create stories read aloud in the reading circle.
7. Dinosaur songs — play CDs of dinosaur songs available from Web sites.
8. Clay dinosaurs — use clay or play dough to make dinosaurs or dinosaur tracks. Provide rollers and tools.
9. Bring the group back together and read the book aloud again in the reading circle.
10. Repeat these steps using a different book each day until the class has completed all stations.

EXPERIENCE 1 — DINOSAUR NAMES

Common and Science Names

Indiana Academic Standards — Grade 1

Science — 1.1, 1.2, 1.4, 2.6, 2.7, 5.2, 5.3
Language Arts — 1.2, 1.14, 1.17, 5.4, 7.1, 7.5, 7.10
Math — 2.5, 6.2

Focus Questions

- **How are dinosaurs named?**
- **What does a dinosaur's name mean?**
- **How do you write dinosaur names?**
- **Can words be broken into parts that have meaning?**

Objectives

Students will:

- List dinosaurs and the body parts they are named after.
- Name the word parts and meanings of *Triceratops.*
- List new dinosaur names by a body part.
- Create drawings of dinosaurs and their body parts.

Vocabulosaurus

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

- ***uni*** – one
- ***bi*** – two
- ***tri*** – three
- ***rex*** – king
- ***odon*** – tooth
- ***mega*** – big
- ***micro*** – small
- ***saurus*** – lizard
- ***ped*** – foot
- ***ops*** – face
- ***cephale*** – head
- ***cerat*** – horn
- ***rhino*** – nose
- ***tyrant*** – terrible
- ***vore*** – eats

Dig tools

Drawings of dinosaurs; **Dino Diaries**; *The Littlest Dinosaurs* by Bernard Most.

© Black Hills Institute of Geological Research

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

DIG IN ...

1. Read *The Littlest Dinosaurs* by Bernard Most to the class in a reading circle.
2. Ask students to name any dinosaurs they can think of. Make a list on the board of several they mention. Ask them to use their **Dino Diaries** to draw a picture and write the name of their favorite dinosaur. If they cannot think of a dinosaur use one of the children's books listed in this unit to show them examples. Several students may know that *Triceratops* is a three-horned dinosaur. Write the name and the word parts on the board and ask students to copy it in their diary (Greek *kerat* or *cerat* = horned). Tell students that one way scientists name a dinosaur is based on how it looks or behaves.
3. List on the board the following words and their meanings: uni = one, *di* = two, *tri* = three, *quad* = four, *cerat* = 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 different combinations of the words on the board. Have them draw a picture of the head of their new dinosaur that shows the correct number of horns for its name. Students can write or dictate sentences to describe their dinosaur. Example: "My Quadceratops has four horns."
4. Use books and models to show different dinosaurs. Ask the students to try to name the different dinosaurs they see. Sort the dinosaurs by their names. For example, sort all that end in "saurus" or have horns.
5. Bring the group back together and read the book aloud again in the reading circle.

EXPERIENCE 1 — DINOSAUR NAMES
Create a Dinosaur Name

Indiana Academic Standards — Grade 2

Science — 1.3, 1.6, 2.4, 2.5, 4.1, 4.4, 5.4, 5.6
Language Arts — 1.3, 1.8, 2.4, 2.7, 5.5, 7.1, 7.11
Math — 6.2

Focus Questions

- **What does a dinosaur name mean?**
- **How do you write dinosaur names?**
- **Can words be broken into parts that have meaning?**

Objectives

Students will:

- List dinosaurs and the body parts they are named after.
- List new dinosaur names by a body part.
- Create drawings of dinosaurs and their body parts.
- Use a chart (see pp. 12 – 13, **What's in a Dinosaur Name?**) to decode real and created dinosaur names.

Vocabulosaurus

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

- ***uni*** – one
- ***bi*** – two
- ***tri*** – three
- ***rex*** – king
- ***odon*** – tooth
- ***mega*** – big
- ***micro*** – small
- ***saurus*** – lizard
- ***ped*** – foot
- ***ops*** – face
- ***cephale*** – head
- ***cerat*** – horn
- ***rhino*** – nose
- ***tyrant*** – terrible
- ***vore*** – eats

Dig tools

Paper, pencils and scissors; drawings of dinosaurs; **Dino Diaries**; dinosaur word strips and **What's in a Dinosaur Name?** chart; and *Where to Look for a Dinosaur* by Bernard Most.

© Black Hills Institute of Geological Research

Bucky Derflinger discovered Bucky, the teenage T. rex.

DIG IN ...

1. Read *Where to Look for a Dinosaur* by Bernard Most to the class in a reading circle.
2. Have students create a dinosaur name using the **What's in a Dinosaur Name?** worksheet.
3. Make copies of the **What's in a Dinosaur Name?** worksheet and *T. rex* skull drawing. 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 apart the three sections of the skull drawing. Slip the three strips into the three openings in the skull.
4. 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. Use the **What's in a Dinosaur Name?** worksheet to help decode real dinosaur names.
5. Bring the group back together and read the book aloud again.

What's in a Dinosaur Name?

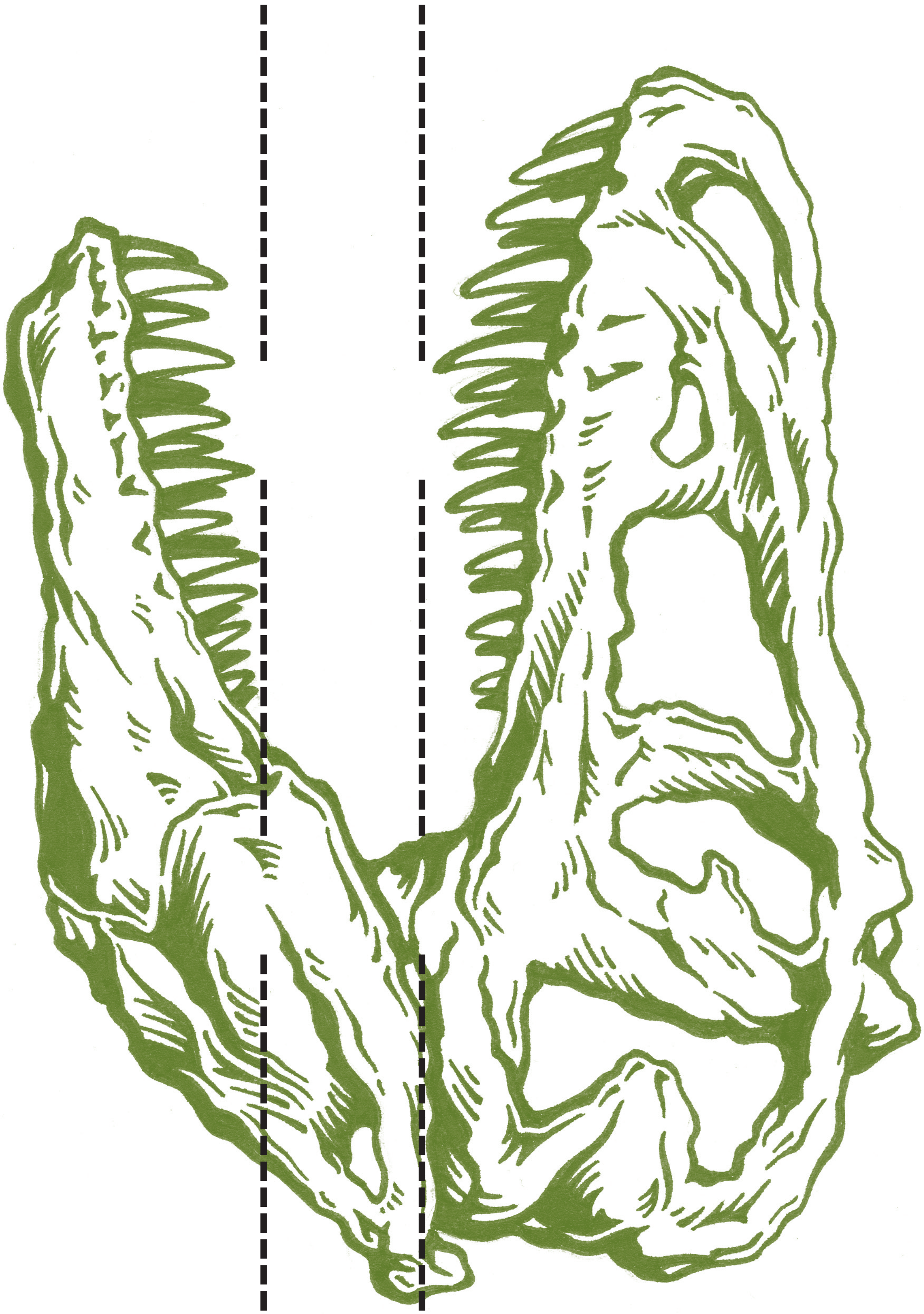
Name: ____________________

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	Word Parts	Word Parts
uni one	**cerat** horn	**vore** eat
tri three	**rhino** nose	**odon** tooth
tyrant terrible	**cephale** head	**ops** face
bi two	**ped** foot	**saurus** lizard
mega big	**micro** small	**rex** king

What's in a Dinosaur Name?

Name: ______________________________ *Cut along each dotted line.*



Make it fossilize

Kindergarten — Students should be able to identify dinosaurs and know they have bones and skeletons.

Grades 1 and 2 — Students should be able to list examples of dinosaur names and to use 10 or more Latin and Greek words or word parts to describe a dinosaur.

Grade 2 — With practice students should 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 re-create *Triceratops* and *Tyrannosaurus rex* using word parts from the worksheet.

Paleo-points for the teacher

Like all animals, dinosaurs are named and classified using the binomial system created by Swedish naturalist and physician Carl von Linné (best known by his Latin name, Carolus Linnaeus.) All living organisms fit into this system that includes kingdom, phylum, class, order, family, genus and species. Each division can be further divided into smaller subgroups. One way to better understand this system is to apply it to Kelsey, the **Dinosphere** *Triceratops*. Follow the classification of Kelsey, starting with the animal kingdom and ending at the genus and species.

Dino Web sites

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

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

Museum of Paleontology
http://www.ucmp.berkeley.edu/index.html

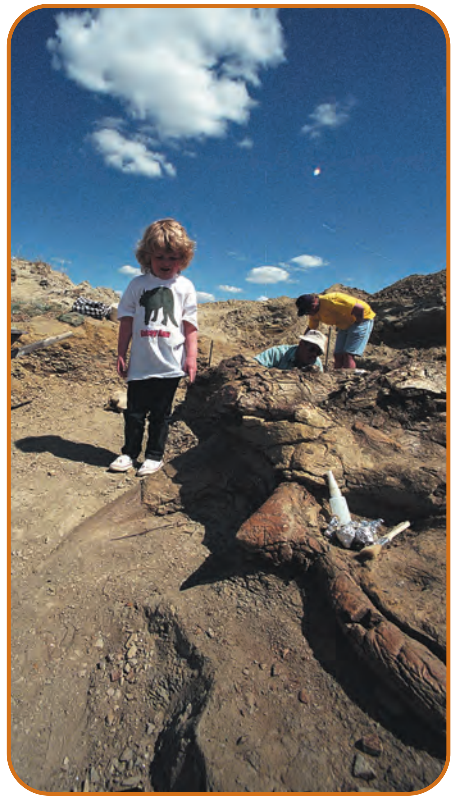
Songs for Teaching — Dinosaur Songs
http://www.songsforteaching.com/DinosaurSongs.html

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

The Dinosauricon, by Mike Keesey — Complete taxonomy of dinosaurs
http://dinosauricon.com/main/index.html

Dino Diary

At the end of each class period students write or draw pictures under the heading **Today I discovered ...** in their diaries. The diary may include drawings, notes and lists of dinosaur names from the lessons, and drawings of real and created dinosaurs. Ask for volunteers to share or read aloud any part of their journal to the class.



Young Kelsey visits the excavation site of the Triceratops *that shares her name.*

Dino books

- Barner, Bob. *Dinosaur Bones.* San Francisco: Chronicle Books, 2001. A colorful look at dinosaur bones and skeletons with rhyming text and fun information.
- Most, Bernard. *The Littlest Dinosaurs.* San Diego: Harcourt Brace Jovanovich, 1989. Simple descriptions of dinosaurs that are less than 14 feet long.
- Most, Bernard. *Where to Look for a Dinosaur.* San Diego: Harcourt Brace Jovanovich, 1993. How scientists look for and find dinosaur fossils.
- 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.

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 back-bones), and other phyla.
Chordata Phylum Subphylum Vertebrata	Mammalia (mammals), **Archosauria** ("ruling reptiles"), Chondricthyes (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
Ornithschia	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

Kingdom Kelsey – Animalia

Phylum Kelsey – Chordata

Subclass Kelsey – Dinosauria

Order Kelsey – Ornithischia

Family Kelsey – Ceratopsidae

Genus Kelsey – *Triceratops*

Species Kelsey – *horridus*

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

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Unique circumstances are needed for an insect like this dragonfly to fossilize.

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

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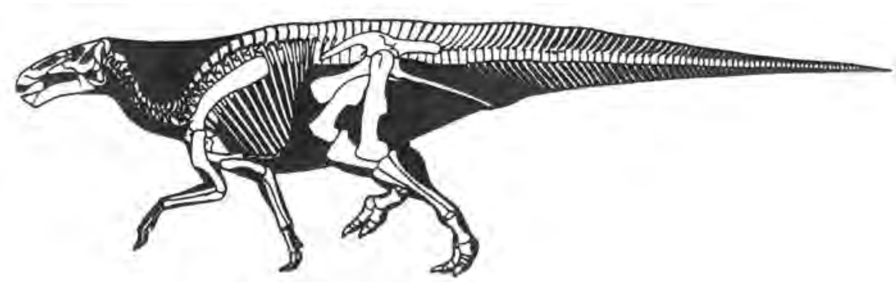
Fish and other fossilized animals help scientists understand the diversity of life during the Cretaceous Period.



The Children's Museum of Indianapolis

***Dinosphere** visitors can help prepare fossilized bones from an* Edmontosaurus *that were collected during the 2003 teacher dig.*

The Children's Museum of Indianapolis

This fossilized shrimp is similar to crayfish and shrimp living today.

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:

1. by body part or behavior,
2. according to where the dinosaur was found, and/or
3. 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 *Edmontosaurus annectens* is named for Edmonton, Canada, **where** it was found.
- The *Bambiraptor fenbergi* is named after a **person**.

EXPERIENCE 2 — DINOSAUR SIZE

The Children's Museum of Indianapolis

Leptoceratops is a small, dog-sized, primitive member of the Ceratopsidae family.

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. 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.

© Black Hills Institute of Geological Research

What might have caused the death of this maiasaur?

EXPERIENCE 2 — DINOSAUR SIZE

Supersize That Dinosaur

Indiana Academic Standards — Kindergarten

Science — 1.1, 1.2, 2.1, 2.2, 6.1
Language Arts — 1.3, 7.1, 7.2, 7.3
Math — 1.9, 3.1, 4.2, 5.1, 6.2,
Social Studies — 1.1

Taking careful measurements with rulers helps in understanding size and scale.

Focus Questions

- **How big were dinosaurs?**
- **Are dinosaurs big and small?**
- **How can dinosaurs be measured?**

Objectives

Students will:

- Estimate the size of dinosaurs.
- Measure using metric, U.S. and other units of measurement
- Measure and compare dinosaurs to known objects.

Vocabulosaurus

- **units**
- **meter**
- **bar graph**
- **head**
- **tail**
- **backbone**
- **skeleton**

Dig tools

Meter stick and centimeter rulers; chalk, construction paper and glue; skeletal drawings of Kelsey and Stan; *The Littlest Dinosaurs* by Bernard Most; **Dino Diaries**.

Kelsey must have had a keen sense of smell.

DIG IN ...

1. Read *The Littlest Dinosaurs* by Bernard Most to the class to introduce students to the different sizes of dinosaurs.
2. Duplicate and pass out pictures of the skeletons of Kelsey, a *Triceratops*, and Stan, a *Tyrannosaurus rex*, to the class. Explain the scale of the drawings, and then ask the students to estimate how long or tall each dinosaur is. Ask them to compare the dinosaurs to known objects. For example, ask if they are larger or smaller than a dog, cow, car, school bus, house and your school. They should be able to make statements that determine that the dinosaurs mentioned are larger than a ___ but smaller than a ___.
3. Use a meter stick to determine how tall several students are. Round off to the nearest meter or use half-meter measurements. Remember to round up anything larger than half a meter to the next meter. Record the height of the students and find the average height.
4. Ask the class to predict how many students would have to lie across the floor head to foot to match the size of the two dinosaurs. Use the hallway or go outdoors and create a full-size drawing of a dinosaur. Have students make drawings in their **Dino Diaries** and record the measurements.
5. Have students make comparisons of dinosaurs to animals they know. Find the length of each of the **Dinosphere** dinosaurs or other favorites from dinosaur books.
6. Help students cut out the Kelsey and Stan skeletons and glue them onto large construction paper. Ask students to draw pictures next to the skeletons to show comparative size, using familiar objects such as trees, bushes, dogs, cats and cars.

EXPERIENCE 2 — DINOSAUR SIZE

Make a Dinosaur

Indiana Academic Standards — Grade 1

Science — 1.1, 1.2, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4, 2.6, 2.7, 5.1, 5.2, 6.1
Language Arts — 2.7, 5.4, 7.1, 7.5, 7.10
Math — 1.10, 4.4, 5.5

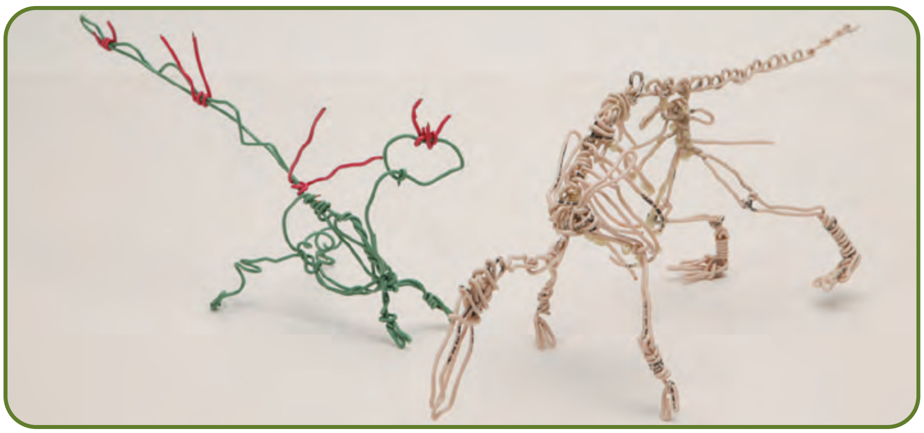
Focus Questions

- **How big were dinosaurs?**
- **Are dinosaurs big and small?**
- **What can the fossilized bones of dinosaurs tell us?**

Objectives

Students will:

- Estimate the size of dinosaurs.
- Measure, observe and compare dinosaur body parts.
- Create skeletal dinosaur models.



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.*

Vocabulosaurus

- **units**
- **meter**
- **bar graph**
- **head**
- **tail**
- **backbone**
- **skeleton**
- **wire**
- **sculpture**
- **scale**
- **model**

A model is a representation of an object that can show many but not all features of the actual object. A model is used when the actual object cannot be.

Dig tools

Meter stick and centimeter rulers; scale drawings of the skeletons of Kelsey and Stan; pipe cleaners, scissors, goggles and bell wire; scale plastic models of a *Triceratops* and a *Tyrannosaurus rex;* **Dino Diaries** and selected books *The Littlest Dinosaurs* by Bernard Most and *Dinosaurs, Dinosaurs* by Byron Barton.

DIG IN ...

1. Read aloud *Dinosaurs, Dinosaurs* by Byron Barton to provide students with background information.
2. 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.
3. Each student will need at least 10 regular-size pipe cleaners. Students may use scissors to cut pieces to fit. Have students wear goggles.
4. Remind the class that they are making models of the dinosaurs, not life-size versions. Review that a model is a scaled representation of the real thing.
5. 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 arms and legs. 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.
6. 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.
7. 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.
8. Ask students to draw a picture and add words or sentences about their dinosaur in their **Dino Diaries**.

EXPERIENCE 2 — DINOSAUR SIZE

Compare Dinosaur Body Parts

Indiana Academic Standards — Grade 2

Science — 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 2.1, 2.2, 2.3, 2.4, 2.5, 5.1, 5.2, 5.4, 5.6, 6.1, 6.2
Language Arts — 2.7, 5.6, 7.9, 7.11
Math — 1.9, 1.11, 1.12, 5.1, 5.2, 5.3, 6.2,

Focus Questions

- **How big were dinosaurs?**
- **Are dinosaurs big and small?**
- **What can the fossilized bones tell us?**

Objectives

Students will:

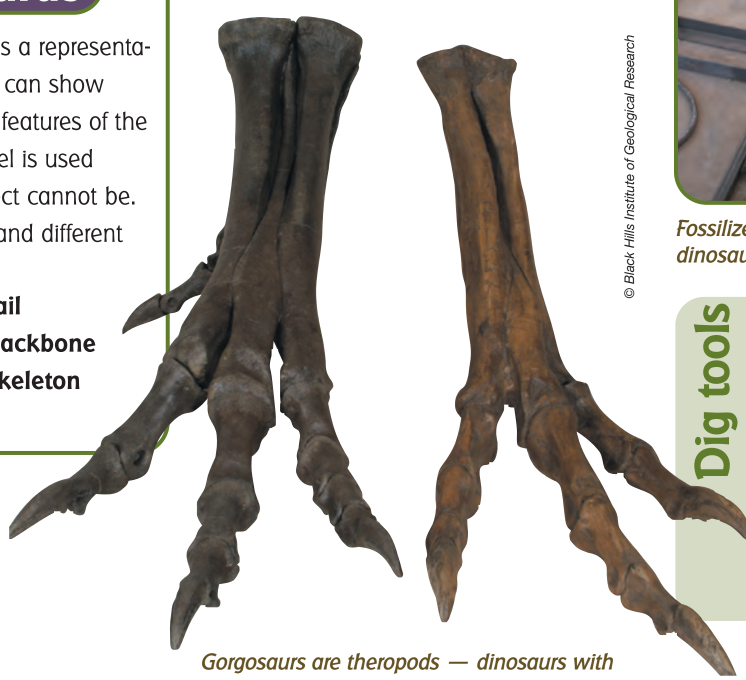
- Estimate the size of dinosaurs.
- Measure, observe and compare dinosaur body parts.
- Create skeletal dinosaur models.

Vocabulosaurus

- **model** — A model is a representation of an object that can show many but not all the features of the actual object. A model is used when the actual object cannot be. A model is both like and different from the real thing.
- **units**
- **meter**
- **bar graph**
- **head**
- **tail**
- **backbone**
- **skeleton**

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

Fossilized foot bones can reveal how fast this dinosaur moved.



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

Dig tools

Meter stick and centimeter rulers; scale drawings of the skeletons of Kelsey and Stan; pipe cleaners, scissors, goggles and bell wire; scale plastic models of a *Triceratops* and a *Tyrannosaurus rex*; and selected books — *The Littlest Dinosaurs* by Bernard Most and Dinosaurs, *Dinosaurs* by Byron Barton.

DIG IN ...

1. Read *The Littlest Dinosaurs* by Bernard Most to the class to introduce students to the different sizes of dinosaurs.
2. Make a chart to record measurements. In each of these columns record the measurements your students take.
3. Work with the class to convert the measurements to centimeters and meters.
4. Divide the class into teams of two. Have students use centimeter rulers to take measurements of each other. Record the measurements on their chart. Encourage students to problem-solve to find ways to make accurate measurements. For example, they will need to decide which way to measure the skull. You may ask some students to demonstrate for the others how to wrap or roll the centimeter ruler around their skull for a measurement. *See below.*
5. Ask students to share and compare their findings with the class.

Make it fossilize

Kindergarten — Students use cutout dinosaurs and scale drawings of themselves and familiar objects. They also take measurements in "student" units by lying head to foot along the length of a dinosaur.

Grade 1 — Check the accuracy of the models with skeletal drawings and images from **Dinosphere**. Students should understand that a model might show some things well and some not at all. They should be able to explain why a model is a good tool to use in science.

Grade 2 — Check the charts and measurements. One important part of the lesson is that the students write the units they use for each measurement. The units may be meters (m), centimeters (cm), or feet (ft.) and inches (in.).

Dino Diary

Younger students describe in words, numbers and drawings the length of dinosaurs compared to their own size. Students use the information to create the **Dinosaur Size** chart. Make simple charts for younger children to complete and then glue into the **Dino Diaries**. Students write statements that their dinosaur is smaller than ______ or larger than ______. Ask the class to list how a model is similar to and different from the real thing it represents. Have students draw and write about other models they have made, used or seen. Some examples include toy cars, stuffed animals and dolls. End each class period with time for students to write or draw under the heading **Today I discovered ...** in their diaries. Ask for volunteers to read aloud parts of their **Dino Diaries**.

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					

Dino Web sites

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

Jurassic Park Institute (JPI)
http://www.jpinstitute.com

Enchanted Learning — Comprehensive e-book on dinosaurs
http://www.zoomdinosaurs.com

Paleo-points for the teacher

If your students have trouble taking measurements pair your class with an older class. Older students can help with the project and the two groups will enjoy working together.

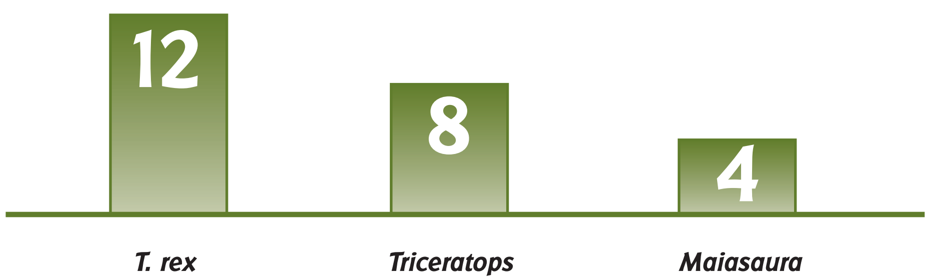
You may want to expand on the "greater than, less than" statements by introducing the math symbols that stand for these statements. For example, House > Kelsey > car, which means Kelsey is smaller than a house, but larger than a car. This may help students understand these symbols in a way they have experienced. For younger children, create pictures to scale of dinosaurs and common objects. They can practice putting the pictures in order of largest to smallest.

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.
- Barton, Byron. *Dinosaurs, Dinosaurs.* New York: Crowell, 1989. A colorful picture book of dinosaurs.
- 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.
- Most, Bernard. *The Littlest Dinosaurs.* San Diego: Harcourt Brace Jovanovich, 1989. A simple book describing dinosaurs that are less than 14 feet long.
- 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.

Bonus: Digging deeper!

Create a survey to find out which is the favorite dinosaur among your students. Ask the class for nominations and make a list on the board. Then have students vote by a show of hands. Students can copy the five most popular dinosaurs in their **Dino Diaries**. Make a tally sheet, data sheet and a simple bar graph.

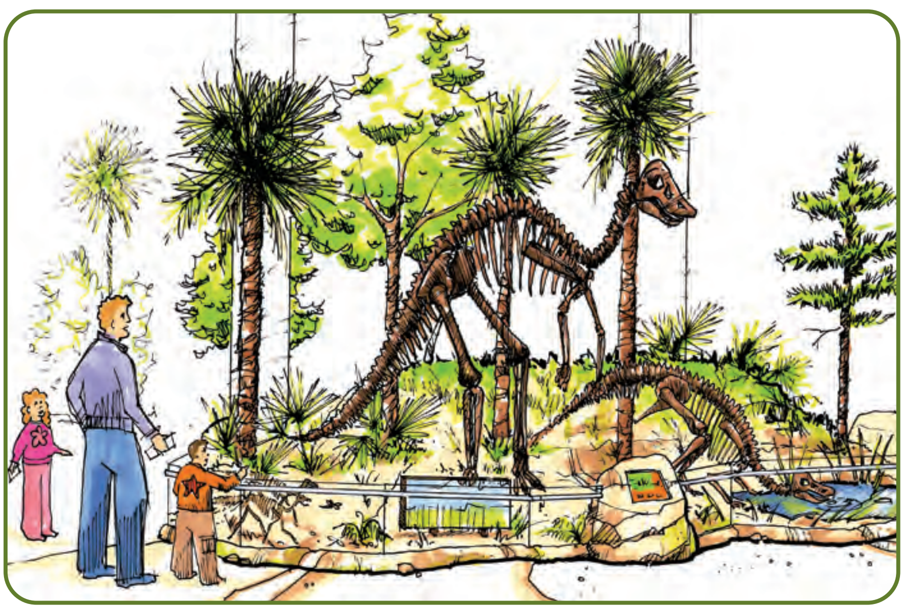


Dinosphere museum link: When you visit

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.

Lesson 2
Some Dinosaurs Lived Together

Michael Skrepnick's attack scene is based upon the most current research and findings about how dinosaurs interacted.



A family of hypacrosaurs pauses for a drink of water, but predators lurk nearby.

Get ready to dig

Students try to determine how dinosaurs lived together. Students look for clues to how dinosaurs met their basic needs of food, water, air, habitat and reproduction by living in groups. They will 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.

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.

EXPERIENCE 1 — WHY DO ANIMALS LIVE IN GROUPS?

What Is an Animal Group?

Indiana Academic Standards — Kindergarten

Science — 1.1, 1.2, 2.2, 3.2, 4.1, 4.2
Language Arts — 1.3, 2.2, 4.3, 5.1, 7.2
Math — 3.1, 3.2, 4.1, 4.2, 6.2, 6.3
Social Studies — 5.2

Focus Questions

- **How is my family a group?**
- **What was a dinosaur group?**
- **What types of activities do animals do together?**

Objectives

Students will:

- Give examples of how families cooperate and work together.
- List basic needs of all animals.
- List animals that live in groups and a reason why.

Vocabulosaurus

- **herd**
- **family**
- **group**
- **cooperate**

Dig tools

Artist paintings and skeletal diagrams of the main scenes in **Dinosphere** — *T. rex Attack*, Watering Hole, Predator and Prey; pictures of animals in groups, families and alone; pre-cut geometric shapes; glue; scissors; **Dino Diaries**.

The first animal group young children come to know and understand is their own family.

DIG IN ...

1. Show a wallet photo of a family member and then show a family group photo. Explain that people live in groups. Ask the class to give ideas about why this is a good thing to do. Ask them to think about and give example of times when they are not in groups and how they feel when they are not. List ways families cooperate and work together as a group.
2. Provide students with pictures of various animals, some in groups and some alone. Ask the class to determine if the animals are living in a group or alone. The pictures should include families, herds and individuals, and animals eating together and alone. Have the class sort the pictures to show groups and individuals.
3. Show pictures of the main dinosaur scenes from **Dinosphere**. The sketches are included in the resources section of this unit. Discuss each picture and decide whether the dinosaurs are living and interacting in groups. Show students the dinosaur books available in the classroom. Skim through the books to look for examples of dinosaurs living together or interacting.
4. Provide the students with pre-cut geometric shapes — squares, rectangles, circles, triangles and others. Instruct each child to make a large dinosaur and a small dinosaur out of the shapes. Glue the shapes of the two dinosaurs in their **Dino Diaries**. Ask the students to describe how the two dinosaurs are interacting. Ask them if they are a family, friends, part of a herd, getting ready to fight each other or have some other reason for being together.
5. Ask each student to share with the group. Some may enjoy using models of dinosaurs within the room to role-play some of the interactions.

EXPERIENCE 1 — WHY DO ANIMALS LIVE IN GROUPS?

Animals Groups

Indiana Academic Standards — Grade 1

Science — 1.1, 1.2, 1.3, 2.7, 4.2, 4.3, 4.4
Language Arts — 2.2, 5.4, 6.1, 7.1, 7.5, 7.10
Social Studies — 5.2

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:

- Identify ways dinosaurs interacted.
- Give examples of how families cooperate and work together.
- List benefits and problems for dinosaurs living in groups.
- Classify animals that live in groups and those that do not.

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**

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.*

Dig tools

Artist paintings and skeletal diagrams of the main scenes of Dinosphere: *T. rex Attack,* Watering Hole, Predator or Scavenger; pictures of animals in groups, families, and alone; **Dino Diaries**; *Swimmy* by Leo Lionni and *Dinosaur Days* by Joyce Milton.

DIG IN ...

1. 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. List ways families cooperate and work together as a group. Direct the discussion to the benefits animals have by living in family groups.
2. Ask the class to name animals that live in groups. The list could include herds, such as cows, sheep, antelope, horses; schools of fish like in the book *Swimmy* by Leo Lionni; and animal families, such as bears, dogs, wild cats, monkeys and others.
3. 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.
4. Write the different reasons on the board or chart paper.
5. Read *Dinosaur Days,* by Joyce Milton, which gives many examples of dinosaurs interacting and living in groups.
6. Show pictures of the main dinosaur scenes from **Dinosphere**. The sketches are included in the resources section of this unit. Discuss each picture and decide if the dinosaurs are living or interacting in groups. Show students the dinosaur books available in the classroom. Skim through the books to look for examples of dinosaurs living together or interacting.
7. Ask the students to list reasons in their **Dino Diaries** why dinosaurs may have lived in groups. Help students make comparisons between living animals and dinosaurs. Let students know this is the same indirect method scientists use to learn about dinosaurs.

EXPERIENCE 1 — WHY DO ANIMALS LIVE IN GROUPS?

Dinosaur Interaction

Indiana Academic Standards — Grade 2

Science — 1.1, 1.2, 1.3, 1.4, 1.5, 2.5, 4.1, 4.2, 4.3, 4.4, 5.4, 5.6
Language Arts — 2.4, 2.5, 2.6, 2.7, 5.2, 7.1, 7.5, 7.9, 7.11
Math — 6.2
Social Studies — 5.2

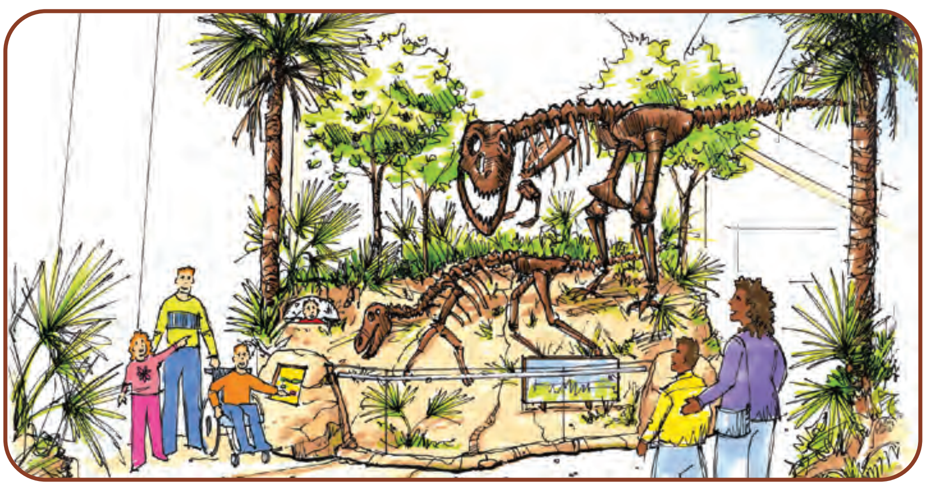
Focus Questions

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

Objectives

Students will:

- List basic needs of animals.
- List benefits and problems for animals living in groups.
- Identify, compare and contrast dinosaur interactions.
- Draw a scene of dinosaur group interaction.



Dig tools

Artist paintings and skeletal diagrams from 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; pre-cut geometric shapes, glue and scissors; *Swimmy* by Leo Lionni and *Dinosaur Days* by Joyce Milton, **Dino Diary**.

DIG IN ...

1. Pass out **Dinosphere** scenes. The story line and drawings of each scene are in the resources section of this unit, and they can be seen on the **Dinosphere** Web site.
2. Read aloud to the class the story line for each scene. Ask the class to match the drawing with the story line. Students should be able to match each story with both the drawings and the skeletal diagrams.
3. Ask the class to sort the scenes by reasons the animals are living in groups. Are they together for food? Protection? To learn?
4. Have students pick one scene of dinosaurs living and interacting together. Ask them to describe what is happening in the scene and to write words or one sentence in their **Dino Diaries** to describe how the dinosaurs are acting with each other: hunting, finding food, protecting, etc.
5. Use the geometric shapes to create dinosaurs interacting in groups. Glue together similar shapes to create families of dinosaurs.

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** • **family** • **group**

Make it fossilize

Kindergarten — Students can give examples of how families cooperate and work together. They begin to be able to list basic needs of all animals. They name animals that live in groups and give reasons why.

Grade 1 — Students identify ways dinosaurs interacted and met basic needs shared by all animals. They can list dinosaurs that lived in groups and can describe benefits and problems for dinosaurs living in groups.

Grade 2 — Students should be able to give reasons for their ideas about why dinosaurs lived in groups. Students compare their observations by talking, writing and sharing reports.

Dino Web sites

Dinosaur Illustrations
http://www.search4dinosaurs.com/pictures.html#about

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

Jurassic Park Institute (JPI)
http://www.jpinstitute.com

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.

Dino Diary

Have students select one of the scenes in **Dinosphere** to draw and study. Encourage them to draw and write about how the dinosaurs interacted in groups. End each class period with time to write and draw under the heading **Today I discovered …** in their diaries.

The Children's Museum of Indianapolis

This pen-and-ink drawing by paleontologist Robert Bakker shows what Baby Louie may have looked like as he hatched.

Paleo-points for the teacher

Scientists have direct 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 provide 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.

Dino books

- Currie, Philip J. and Eva B. Koppelhus. *101 Questions About Dinosaurs.* Mineola, New York: Dover Publications, 1996. Answers to children's frequently asked questions about dinosaurs.
- 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.
- Milton, Joyce. *Dinosaur Days.* New York: Random House, 2003. A brief summary and simple description of various dinosaurs of the Cretaceous.
- 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.

Bonus: Digging deeper!

Dinosaur For A Day by Jim Murphy and *Dinosaur Babies* by Kathleen Weidner Zoehfeld are two excellent books to read aloud. They both provide an in-depth look at the way dinosaurs may have interacted. Both also contain items that some teachers may think are misleading. For example, the pictures contain plants (grapes) and animals (mammal bats) that may not have been present in the Dinosaur Age. More dinosaur illustrations can be found at The Children's Museum **Dinosphere** Web site or at **http://www.search4dinosaurs.com/pictures.html#about**

Lesson 3

Fossil Clues Help Us Learn About Dinosaurs

Get ready to dig

In this lesson students learn what fossils are and how they form. They explore how fossil bones are assembled to form skeletons. They make a clay mold to create a plaster model of a fossilized tooth. They also learn that by studying fossils they can discover 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. By understanding how fossils form, students learn more about the dinosaurs' world. In this experience students learn how a living dinosaur became a fossil. Visit **The Children's Museum** Web site to find out how fossils became part of the exhibit. At the Web site click on the **Dino Institute** teacher dig to see Indiana teachers discover and dig 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 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.

The Children's Museum of Indianapolis

Discovery of an imprint of Edmontosaurus *skin was a significant and rare find on The Children's Museum's 2003 teacher dinosaur dig in South Dakota.*

Where do you 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. Sometimes kids get to dig for fossils by volunteering on dig sites. One great fossil site for duckbill dinosaurs 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!

The Children's Museum of Indianapolis

When a plant or animal dies the remains change several times before the fossils are formed.

EXPERIENCE 1 — HOW A DINOSAUR FOSSIL FORMS

What Is a Fossil?

Indiana Academic Standards — Kindergarten

Science — 1.1,1.2, 2.2
Language Arts — 1.3, 4.3, 5.1, 5.2, 7.2, 7.3
Math — 1.1, 3.1, 3.2, 6.2, 6.3

Focus Questions

- **How does a fossil form?**
- **Can fossils be made today?**
- **What can be learned by comparing fossils?**
- **What can be learned about a dinosaur fossil?**

Objectives

Students will:

- List one condition needed for fossils to form.
- List, observe and examine different types of fossils.
- Make a cast model of a fossil.
- Compare and contrast, make drawings of and write about fossils.

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.
- **model —** a representation that is both like and different from the real thing.
- **erosion**
- **expose**
- **sediment**
- **mold**
- **imprint**
- **cast**
- **plaster**
- **resin**
- **magnifying lens**
- **dinosaur**
- ***Tyrannosaurus rex***
- **tooth**

© Black Hills Institute of Geological Research

The molds made from these bones will be used to make replicas of the originals.

DIG IN ...

1. Read the book *Bones, Bones, Dinosaur Bones* by Byron Barton to the class. Students learn that dinosaur fossils are the preserved ancient remains of dinosaurs.
2. Pass out a small piece of clay and a seashell to each student.
3. Instruct them to roll out the clay and make a flat surface. Show them how they can push the shell into the clay to make an impression. Try other items such as pennies, leaves and classroom items. Use the cast dinosaur teeth provided with this unit to make impressions.
4. Demonstrate to the class on a large piece of rolled-out clay what happens when a toy dinosaur "walks" across the soft clay. They should see footprint impressions in the clay. Demonstrate and discuss how this is one way that fossils are formed. Emphasize that to become a fossil the clay would have to become hard and be buried for a very long time. Then part of it must be exposed above the ground in order to be found.
5. Allow students to make dinosaur tracks in their clay with toy models and to draw pictures of tracks.
6. Cut the sponges into the shape of dinosaur feet, using the samples found in the resources section of this unit. These can be made into sponge stamps to make more tracks. Students can stamp the tracks into their **Dino Diaries** as an example of a fossil. Have them write one or more words to describe the fossils.

Dig tools

- Tooth resin cast *T. rex*
- Claw resin cast *T. rex*
- Drawings of dinosaur tracks and footprints from the resource materials in this unit, **Dino Diaries**.
- Sponges and paints; plastic dinosaur models; cast of a dinosaur fossil; seashells, leaves, pennies; *Bones, Bones, Dinosaur Bones* by Byron Barton.

EXPERIENCE 1 — HOW A DINOSAUR FOSSIL FORMS

Layered Fossil Parfait: Deeper Is Older

Indiana Academic Standards — Grade 1

Science — 1.1, 1.2, 1.4, 2.6, 2.7, 5.2, 5.3
Language Arts — 1.2, 1.14, 1.17, 5.4, 7.1, 7.5, 7.10
Math — 2.5, 6.2

Focus Questions

- **How does a fossil form?**
- **Can fossils be made today?**
- **Are fossils buried deeper older or younger?**
- **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.
- Observe and examine cast fossils.
- Make a cast model of a dinosaur fossil.
- Create a model of a buried fossil.

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.
- **model** — a representation that is both like and different from the real thing.
- **erosion**
- **expose**
- **sediment**
- **life**
- **death**
- **extinct**
- **mold**
- **magnifying lens**
- **centimeter ruler**
- **dinosaur**
- ***Tyrannosaurus rex***
- ***Triceratops***
- ***Hypacrosaurus***
- ***Gorgosaurus***
- ***Maiasaura***

Parfait Fossil Cup

Dig tools

Fossil parfait materials: clear cups, spoons, whipped cream, gummy dinosaurs or other animals, grape jelly, vanilla wafer cookies, fruit slices, M&Ms and/or raisins; shredded coconut, cookie decorating sprinkles and food coloring. Selected books: *Bones, Bones, Dinosaur Bones* by Byron Barton; *Dinosaur Bones* by Aliki; *Digging Up Dinosaurs* video or book by Aliki; **Dino Diaries**.

DIG IN ...

1. Complete the experience for Kindergarten.
2. Read aloud *Dinosaur Bones* by Aliki. Emphasize the section that shows the layers of the earth and how fossils are formed.
3. Explain to the class that the deeper something is buried the older it may be. Use the class garbage can to demonstrate this science concept. (You may want to wear plastic or latex gloves.) Tell the class that the materials at the bottom of the trashcan are older because they have been in the can longer than the items on top.
4. Draw a diagram of the trashcan and label each item. Refer back to the book to show how older fossils are found in the lower levels of the earth.
5. Make a dinosaur fossil model. Give each student a small clear plastic cup. Give the following items to each student: a gummy candy dinosaur or other animal (the buried fossil), a vanilla wafer cookie (a layer of hardened sediment), fruit slices (sediment layers), raisins and/or M&Ms (rocks) shredded coconut (grass) and cookie decorating sprinkles (surface dirt). Supply each group with two bowls of whipped cream (soil), a jar of grape jelly (underground water) and spoons. Use food coloring to tint one bowl of whipped cream yellow (sandy soil) and one red (clay). Tint the coconut green.
6. Demonstrate how to use the ingredients to create the layered fossil parfait. Draw on the board what the cup will look like. You may want to use scissors to cut apart the gummy candy or break up the cookies to show that most fossils do not survive intact.
7. Students make a layered fossil parfait and make a picture in their **Dino Diaries** of each layer that is put into their cup. When drawings are complete ask each student to determine which layer is the oldest in his or her cup. Share the findings with the class but each hungry junior paleontologist eats his or her own layered fossil parfait.

EXPERIENCE 1 — HOW A DINOSAUR FOSSIL FORMS

Make a Cast of a *Tyrannosaurus rex* Fossil

© 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.*

Indiana Academic Standards — Grade 2

Science — 1.3, 2.5, 3.1, 3.5, 4.4, 5.6, 6.3
Language Arts — 2.7, 2.8, 5.2, 5.5, 7.1, 7.4, 7.9
Math — 5.1, 6.2

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:

- List different types of fossils.
- Make a cast model of a dinosaur fossil.
- List some conditions that are needed for fossils to form.
- Create a model of a buried fossil.

© Black Hills Institute of Geological Research, photograph by Robert Farrar

Each part of a fossil must be cleaned. Often a small tool is used to chip away any remaining rock covering.

Dig tools

Claw resin cast — *T. rex*
Tooth resin cast — *T. rex*
Drawings of dinosaur tracks and footprints from the resource materials in this unit.
Paper, pencil, art supplies, construction paper; plaster of paris; modeling clay; plastic dinosaur models; a cast of a dinosaur fossil; seashells, leaves, pennies; *Dinosaur Bones* by Aliki and *Digging Up Dinosaurs* video or book by Aliki

Vocabulosaurus

- **fossil** — Latin for "dug up," it is 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**
- **sediment**
- **life**
- **death**
- **extinct**
- **mold**
- **imprint**
- **cast**
- **plaster**
- **resin**
- **magnifying lens**
- **centimeter ruler**
- **positive**
- **negative**
- **adaptation**
- **prey**
- **carnivore**
- **dinosaur**
- ***T. rex***
- ***Triceratops***
- ***Hypacrosaurus***
- ***Gorgosaurus***
- ***Maiasaura***

DIG IN ...

Day 1

1. Students will enjoy and find better understanding of what a fossil is by completing prior fossil experiences in this lesson.
2. Show the Reading Rainbow video *Digging Up Dinosaurs* or read aloud the book by Aliki.
3. Discuss with the class how a dinosaur fossil forms.
4. Introduce and show fossil examples. Pass around the resin models of the *T. rex* teeth.
5. 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 it used to live?
6. Use the Internet or books to learn more about how a fossil is formed. Describe each step and write 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 another animal as food. Make the connections between fossils and sediments and sedimentary rocks — fossils form when sediments cover the original organism.

Day 2

1. Review how a fossil forms with the class.
2. Pass out clay to the group. Roll out the clay. Each student should make impressions with the *T. rex* tooth.
3. Tell the students that their impression is like a fossil mold. All that is needed is for mud or other materials to fill in the impression or mold and a cast will be made.
4. Tell the class that you will simulate or model what might have happened long ago when a fossil mold or cast was formed. Mix up enough plaster of paris for the class. This is best done is several small portions instead of one large amount. Pour wet plaster into each clay impression or mold. Allow the plaster to dry overnight before removing it from the clay. Students will have created a cast of the clay mold.
5. Ask them to draw pictures of their fossil casts in their **Dino Diaries** and share with the group.

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.

How to make a fossil cast

Make an impression.

Fill the impression with plaster of paris.

Remove the cast from the mold.

EXPERIENCE 1 — HOW A DINOSAUR FOSSIL FORMS

BONUS — Kelsey: Clues of the Dig Site Map

Indiana Academic Standards — Grade 2

Science — 1.2, 1.3, 1.5, 1.6, 2.4, 2.5, 6.1
Language Arts — 5.5, 5.6, 7.1, 7.9, 7.11
Math — 5.1, 5.4, 6.1, 6.2,
Social Studies — 3.2, 3.5, 3.6

Focus Questions

- **How are fossils mapped?**
- **What clues are found on a dig site map?**
- **Can a dig site map help make a skeleton?**
- **What clues does the map show?**
- **Are some bones missing in a dig site?**

Objectives

Students will:

- Examine and match bones from a dig site to a skeleton.
- Read a dig site map of dinosaur bones.
- Make and use a color-coded key for a map.

© Black Hills Institute of Geological Research

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

Dig tools

Dino Diaries, pencil, colored pencils or markers; chart paper or chalkboard; copies of the skeletal drawing of Kelsey the *Triceratops* and the dig site map of where she was excavated, both found in the resource section of this unit.

DIG IN ...

1. Review the materials covered in the previous lesson with your students. Your class may benefit from completing lessons from other grades.
2. Divide the class into teams of three or four students.
3. Pass out a skeletal drawing and a dig site map of Kelsey to each group. Have each group study the drawings.
4. Each group should write three or more things they observe or know about the drawings. Students write these observations in their **Dino Diaries.**
5. Each group makes a list of questions about the dig site map and the skeleton. Students write the questions in their **Dino Diaries**.
6. The dig site map shows several layers. Help students understand this view by making a drawing on chart paper or the board of a side view of the dig showing one or more big bones.
7. Ask each group to try to match up the bones in the dig site map with the skeletal drawing of Kelsey assembled. They will need to know that the dig site map shows broken bones and that some of Kelsey's bones are missing.
8. Have students use colored pencils or markers to color-code bones from the dig site map and the skeleton. For example, the skull on the skeleton and the skull on the dig site map should be colored the same. Ask them not to color any unmatched bones.
9. Ask students to give reasons why they matched the bones the way they did, using their maps and drawings to support their decisions.

Vocabulosaurus

- **fossil** — Latin for "dug up," it is evidence of past life, the remains or traces of plants and animals that have turned to stone or rock.
- ***Triceratops***
- **dig site**
- **excavation**
- **skeleton**
- **skull**

Make it fossilize

Kindergarten — Students describe one or more conditions for a fossil to form after listening to a book about fossil formation. They make tracks in clay as a model of a real fossil.

Grade 1 — Students describe one or more conditions for a fossil to form after listening to a book about fossil formation. They make a drawing and a model of how an object can be buried in sediments and understand that the oldest object is on the bottom.

Grade 2 — Students create a fossil cast of a dinosaur tooth and can provide answers to complete the chart on how a dinosaur fossil can form. Students examine and match fossil drawings from a real dig site (excavation) map to a completed skeleton.

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 journals 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 I find a fossil? End the class period with writings and drawings under **Today I discovered …** in their **Dino Diaries**.

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 books

- Barton, Byron. *Bones, Bones, Dinosaur Bones.* New York: HarperCollins, 1990. A story of looking for, finding and assembling some dinosaur bones.
- Brandenberg, Aliki. *Dinosaur Bones.* New York: Thomas Y. Crowell, 1988. A discussion in easy terms of the way scientists study fossil remains to learn about dinosaurs.
- Brandenberg, Aliki. *Digging Up Dinosaurs.* New York: Harper & Row, 1988. An easy-to-read story about finding bones and assembling them at a museum.
- 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.

Dino video

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

Each layer of a dinosaur excavation site has secrets to share like these fossilized rib bones.

Paleo-points for the teacher

Students write words or sentences for each step in the formation of a fossil. Students should put the steps in order of how a dinosaur fossil forms. They should list examples of when an animal does not become a fossil. Give an example of an animal or plant part that does not become a fossil. Tell one example of a rare fossil and how it can be used to learn about the past.

How a Dinosaur Fossil Forms

Step 1	**Life**	The dinosaur is alive and growing.
Step 2	**Death**	The dinosaur dies.
Step 3	**Sediments**	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.

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

This prehistoric 3-D dinosaur puzzle can be reassembled only if paleontologists made good written notes in their field journals.

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

Brooms, glue and small dental picks are used to uncover a vertebrate fossil.

What happens when The Children Museum finds a fossil?

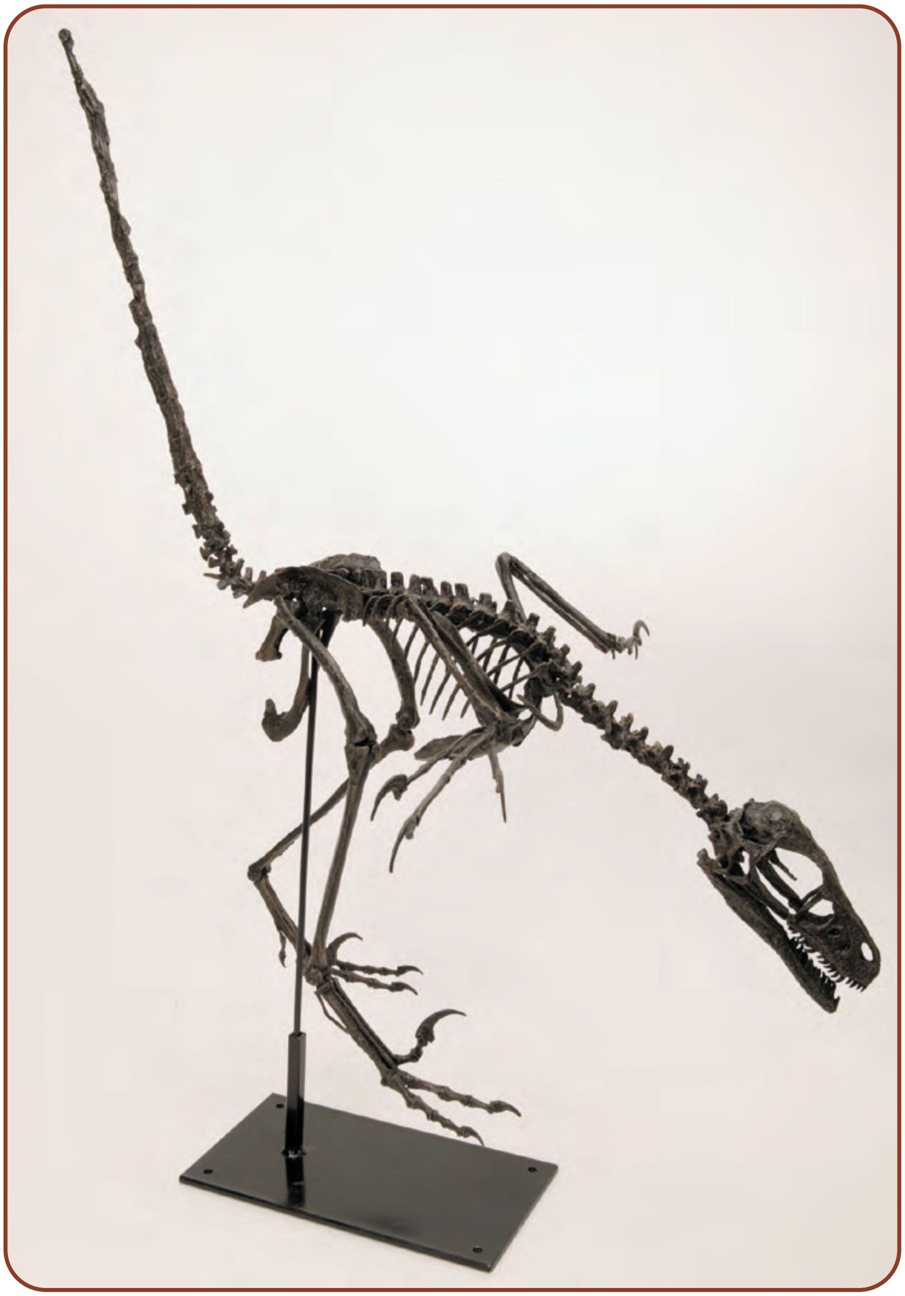
It is fun but not easy to get fossils out of the ground and into the lab for preparation. When dinosaur fossils are found, the first thing scientists do is make a map of the site so they can keep track of where every fossilized bone was found. Then they start digging. Fossilized bones are wrapped in plaster to keep them snug for shipment to the lab. These plaster jackets are called "field jackets." Scientists also like to study the matrix — the rock around the fossilized bones — for clues.

When all the fossilized bones are cleaned and put together, scientists must determine a way to mount the skeleton for display. Usually they make a special frame that holds all the fossilized bones in place. For missing fossilized bones, they make a cast — using plastic and rubber — of fossilized bones from other dinosaur skeletons. They also need to decide how the skeleton will be posed: will it be running or standing still, eating or fighting? The final result is an amazing display!

Bonus: Digging deeper!

Several commercial dinosaur dig kits are available for purchase at **The Children's Museum** Store or to borrow from the **Teacher Resource Link** on the museum's Web site. Students will enjoy working together on a simulated dig. Visit **The Children's Museum** Web site to see teachers and paleontologists digging for dinosaur bones. Plan a trip to **Dinosphere**, where your class can participate in a simulated dig.

EXPERIENCE 2 — FOSSIL SKELETONS: OBSERVING, MAKING AND LEARNING



The Children's Museum of Indianapolis

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

Get ready to dig

T. 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."

© Black Hills Institute of Geological Research

All that is missing from this two-clawed Gorgosaurus *hand is blood, muscle and skin.*

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 fossilized bones are assembled to learn about dinosaurs. They make observations, draw diagrams and share their findings. They compare fleshed-out dinosaurs with skeletons of dinosaurs.

EXPERIENCE 2 — FOSSIL SKELETONS: OBSERVING, MAKING AND LEARNING

Dinosaur Flesh and Bones

Indiana Academic Standards — Kindergarten

Science — 1.1, 2.2, 3.1, 6.1
Language Arts — 7.1, 7.2, 7.3
Math — 3.1, 4.2, 6.2, 6.3

Focus Questions

- **How would you describe a dinosaur skeleton?**
- **What does "fleshed-out" mean?**
- **What is the difference between a skeleton and a fleshed-out drawing?**
- **If the dinosaur skeleton is big, was the dinosaur big?**

Objectives

Students will:

- Listen to and look at information in a dinosaur book.
- Observe and examine fossils.
- Match a skeleton to a dinosaur drawing.
- Construct paper dinosaur skeletons.

DIG IN ...

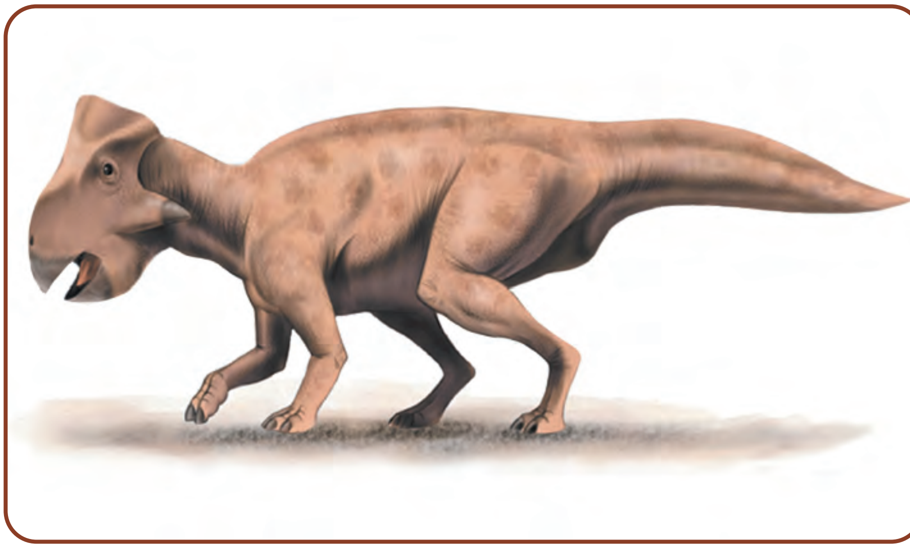
1. Read aloud *Bones, Bones, Dinosaur Bones* by Byron Barton. Emphasize the difference between the pictures of dinosaurs that have skin and muscle (fleshed-out) and those that show skeletons.
2. Make copies of the skeleton diagrams found in the resource section of this unit of study and on the Zoom Dinosaurs Web site. Give copies to students.
3. Have them match the skeletons with pictures of the actual dinosaurs.
4. Visit skeleton information Web sites, such as "Bones — An Exhibit Inside You" on **The Children's Museum** Web site, to see what other animal bones and skeletons look like.
5. Extend the lesson by cutting several of the skeleton drawings into pieces, mixing them up and then having students reassemble them. Ask students to refer to the completed drawings for help.

Vocabulosaurus

- **bone**
- **skeleton**
- **fleshed-out**

Dig tools

Skeleton diagrams and fleshed-out drawings of Stan and Bucky (*Tyrannosaurus rex*) and Kelsey (*Triceratops*); *Bones, Bones, Dinosaur Bones* by Byron Barton.



The Children's Museum of Indianapolis

Frannie, the Dinosphere's Leptoceratops, *has a beak-shaped mouth like her cousin Kelsey, the* Triceratops.

EXPERIENCE 2 — FOSSIL SKELETONS: OBSERVING, MAKING AND LEARNING

X-ray Dinosaurs

Indiana Academic Standards — Grade 1

Science — 1.1, 2.4, 2.5, 2.6, 2.7, 5.2, 6.1
Language Arts — 7.9, 7.11
Math — 4.3, 6.2

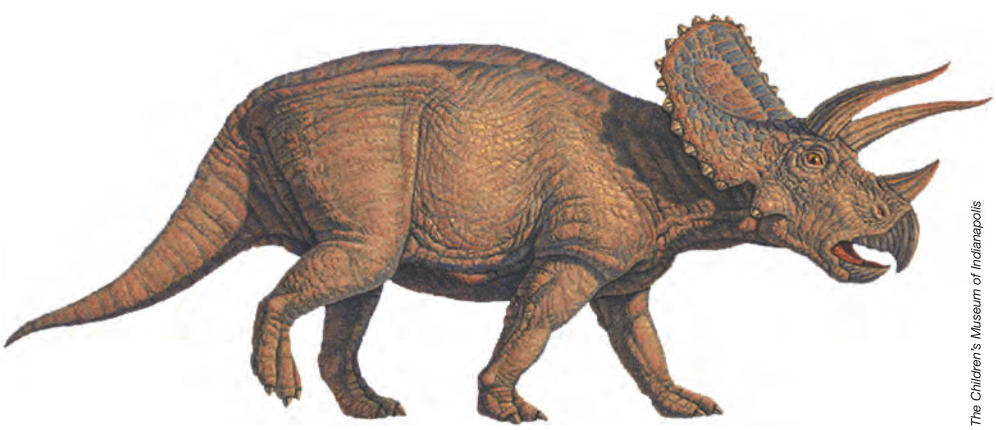
Focus Questions

- **What can be learned by comparing fossils?**
- **What can be learned about a dinosaur fossil?**
- **Do the bones and skeleton of a dinosaur show how it looked?**

Objectives

Students will:

- Observe drawings of fossils.
- Compare and contrast dinosaur skeletons and fleshed-out drawings.
- Make drawings and write about dinosaurs.
- Simulate a dinosaur X-ray with paper and pencil.



The Children's Museum of Indianapolis

This giant plant-eater was named Triceratops *("three-horned face") by Othniel Marsh in 1889.*

DIG IN ...

1. Complete the Kindergarten experience in this lesson prior to this activity. Read *Tyrannosaurus Rex* by Daniel Cohen to the class to provide additional *T. rex* background.
2. Provide students with drawings of dinosaur skeletons to study.
3. Pass out copy paper. Have students trace a dinosaur skeleton on one side of a sheet of paper. Then have them retrace the skeleton with a pencil or marker dark enough to be visible through the other side of the paper.
4. Have students turn their drawings over and draw the true outline of the fleshed-out dinosaur on the other side of the sheet. Let them lightly color the skin and muscles.
5. Students can place their drawings against an outside window or hold them up to a light to see the skeleton showing through from the other side, like an X-ray.
6. Extend the experience by allowing students to repeat the activity using pictures of skeletons from the other **Dinosphere** dinosaurs.

Dig tools

Drawings and skeleton diagram of Stan the *Tyrannosaurus rex* and other dinosaurs; paper; *Tyrannosaurus Rex* by Daniel Cohen

Vocabulosaurus

- **model** — a representation that is both like and different from the real thing.
- **fossil**
- **X-ray**
- **skeleton**
- **fleshed-out**

EXPERIENCE 2 — FOSSIL SKELETONS: OBSERVING, MAKING AND LEARNING

Make a Dinosaur Model

Indiana Academic Standards — Grade 2

Science — 1.1, 1.3, 1.6, 2.5, 3.5, 5.6, 6.2
Language Arts — 5.5, 5.6, 7.9
Math — 4.3, 6.2

Focus Questions

- **Can a model be used to learn about dinosaurs?**
- **What can be learned by comparing fossils?**
- **What can be learned about a dinosaur fossil?**

Objectives

Students will:

- Observe drawings of fossils.
- Compare and contrast dinosaur skeletons and drawings.
- Make drawings of and write about dinosaurs.
- Create and pose a dinosaur model with movable parts.
- List different actions or movements of a dinosaur.

DIG IN ...

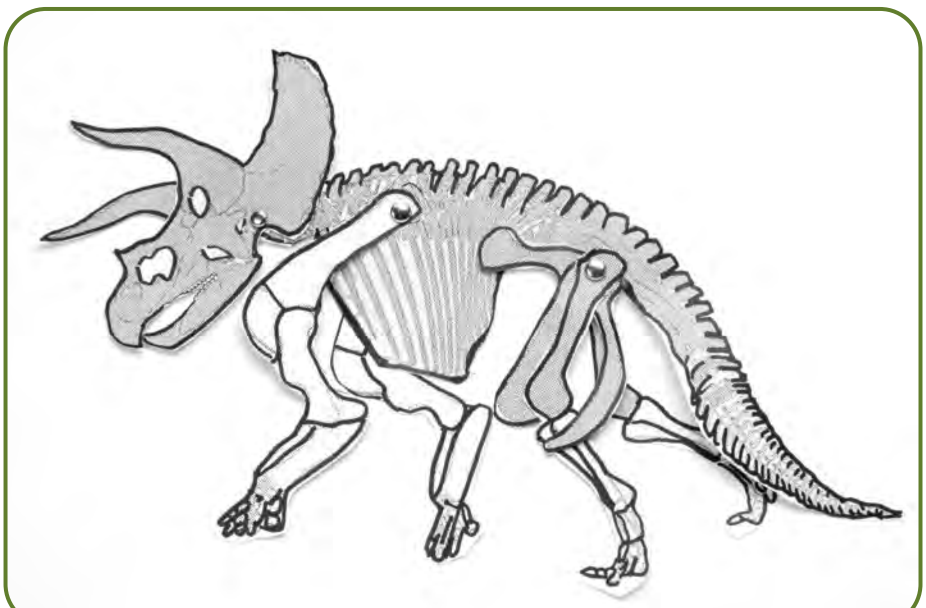
1. Pass out skeleton drawings of **Dinosphere** dinosaurs. Provide students with books and Web sites showing other dinosaur skeletons.
2. Provide students with drawings of fleshed-out dinosaurs or have them make their own.
3. Compare skeleton drawings to fleshed-out drawings.
4. Cut up several of the skeleton drawings, mix up the pieces, and have students work in groups to reassemble the dinosaurs. They can check their finished work by using Web site resources.
5. Give the students brass fasteners to be used as joints for the paper skeletons. This will make the skeleton articulated, which means the bones are joined together and move. This will enable the dinosaur to be posed in different positions.
6. Ask students to list in their **Dino Diaries** what actions the dinosaurs can do. These may include eating, walking, fighting, climbing and sleeping.

Vocabulosaurus

- **model —** a representation that is both like and different from the real thing.
- **fossil**
- **skeleton**
- **dinosaur**
- **articulated**
- **fleshed-out**

Dig tools

Drawings and skeleton diagram of Stan the *Tyrannosaurus rex* and other dinosaurs; **Dino Diaries**; paper; *Tyrannosaurus rex* by Daniel Cohen



A paper model helps students learn where bones are located in the skeleton and how dinosaurs moved and stood.

Make it fossilize

Kindergarten — Students match skeleton bones to a drawing of a dinosaur. They create their own dinosaur puzzles by cutting apart diagrams and putting them back together. Students can match fleshed-out dinosaurs to skeleton drawings.

Grade 1 — Students create a model of a dinosaur showing the skeleton.

Grade 2 — Students create and use a model of an articulated dinosaur, and list different dinosaur actions or movements.

Dino Web sites

Dinosaurs at Kid Sites
http://www.kidsites.com/sites-edu/dinosaurs.htm

Dinosphere Paleo Preb 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

Dino Diary

At the end of each class period students write and draw under the heading **Today I discovered …** in their diaries. Entries include drawings and descriptions of fossilized dinosaur bones, claws and teeth.

Paleo-points for the teacher

Scientists have not always known how the fossilized bones of dinosaurs fit together. The first try at assembling an *Iguanodon* resulted in a hand spike incorrectly placed on its nose as a horn. The famous "Bone Wars" rivalry between Othniel C. Marsh and Edward D. Cope in 1877 was started over the misplaced bone in the long neck of a plesiosaur, a marine reptile. The natural rivalry between these two dinosaur hunters escalated into a feud that lasted a lifetime. Mistakes were often made, but hundreds of new discoveries were also made. Some of the past mistakes can be corrected by using science to study the fossil clues. For more information about the "Bone Wars" and the early days of paleontology, visit the Web sites listed in the resource section of this unit of study.

The Children's Museum of Indianapolis

Bucky, a T. rex. *The shaded bones are real fossils.*

Dino books

- Barton, Byron. *Bones, Bones, Dinosaur Bones.* New York: HarperCollins, 1990. A story about looking for, finding and assembling some dinosaur bones.
- Cohen, Daniel. *Tyrannosaurus Rex.* Mankato, Minn.: Bridgestone Books, 2001. Simple and clear information about the life and habits of *T. rex.*
- 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.*
- 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.

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.

Bonus: Digging deeper!

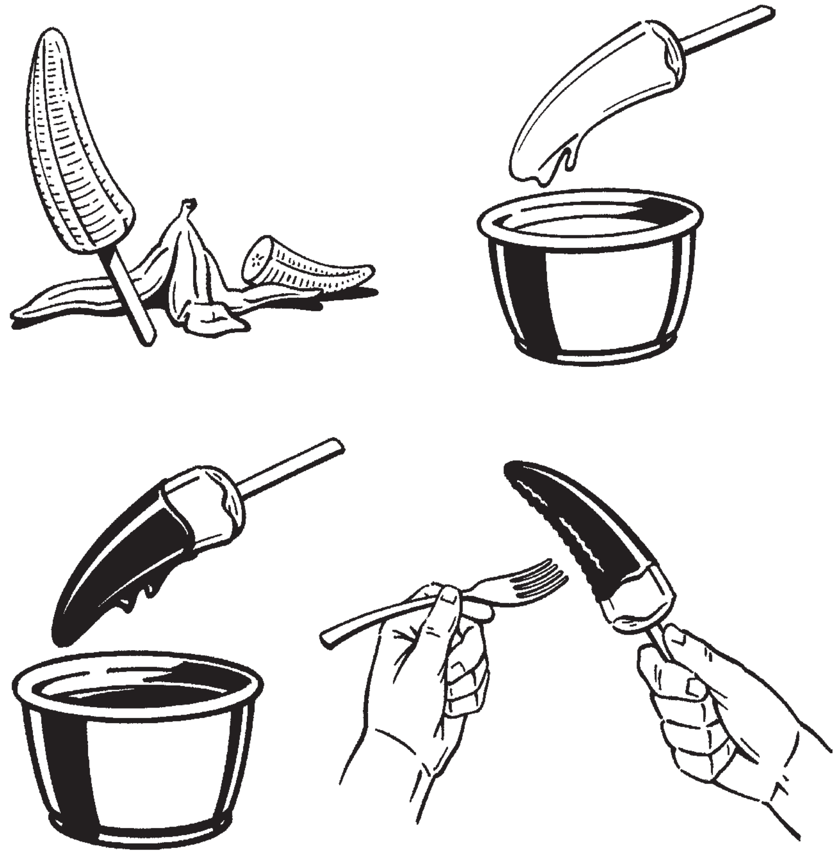
After completing the activities in these lessons, some students can explore more about dinosaur skeletons and fossils bones with the following activities.

Tyrannosaurus rex

1. Divide the class into groups of three or four.
2. Hand out *T. rex* skeleton diagrams to each group along with a box of wooden toothpicks, 10 or more craft sticks, a centimeter ruler, copy paper and glue.
3. Ask each group to study the *T. rex* diagram and make observations in their **Dino Diaries** about the skeleton. Have them measure its length and width in centimeters and record the measurements in their journal. Allow time for the group to share information and talk about their observations.
4. Have them match up toothpicks and craft sticks to the bones on the diagram. Show them how the toothpicks and craft sticks can be broken to match the size of the bones in the diagram. Instruct them to use their centimeter rulers to help get the right sizes.
5. Place the *T. rex* skeleton diagram under a blank piece of paper so that they are able to see through to the skeleton underneath. Have them use the glue, toothpicks and craft sticks to build a model of the skeleton. Encourage them to use the centimeter ruler and diagram to check their progress. Share the finished models with the class.

Students can use wire and clay to make a 3-D model of their dinosaurs. Use pipe cleaners or bell wire to construct a simple frame. Make sure to have students wear goggles when working with wire. Add clay or play dough to the frame to make a fleshed-out dinosaur.

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, 2 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!

Lesson 4

What Happened to the Dinosaurs?

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

Discovering a dinosaur fossil can ignite a lifelong passion for learning in a young scientist.

Get ready to dig

Science is all about questions. 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 use fossil clues and observations to understand dinosaurs. Students will learn major theories about why dinosaurs are not alive today. They will also learn why some scientists believe that dinosaurs may be related to today's birds. Students will learn that paleontologists are scientists who study dinosaurs. Students role-play to learn about the discoveries of famous paleontologists.

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 dino adventure tour of the Mesozoic Era.

EXPERIENCE 1 — QUESTIONS AND CLUES

Dinosaur Questions

Indiana Academic Standards — Kindergarten

Science — 1.1, 1.2
Language Arts — 5.1, 5.2, 7.2

Focus Questions

- **What happened to the dinosaurs that made them go away?**
- **What is one unanswered question about dinosaurs?**
- **Who discovers information about dinosaurs?**
- **How can someone learn more about dinosaurs?**

Objectives

Students will:

- Ask one or more questions about dinosaurs.
- List more questions than answers.
- List more questions from one question.
- Give examples of different jobs used to learn about dinosaurs.

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**

Dig tools

Computer access; chart paper or chalkboard; **Dino Diaries**; books such as *What Happened to the Dinosaurs?* by Franklyn Branley and *The Magic School Bus in the Time of the Dinosaurs* by Joanna Cole.

© Black Hills Institute of Geological Research

The back of the frill, or hood, of the Triceratops *has many grooves for blood vessels. This detail may help solve the mystery of how the frill was used.*

DIG IN ...

1. Talk to your students about what scientists have learned about dinosaurs. Emphasize that although they have learned much about dinosaurs, there are many more things scientists do not know.
2. Tell your students that scientists like questions. They use questions to help them better understand the world. Students can do the same thing. Ask your class to think about dinosaur questions they would like to explore. Review some of the dinosaur topics the class has already covered.
3. Ask the class what would they like to know about dinosaurs. Turn these questions into a "Dinosaur Questions" chart with the class.
4. Select books, such as those listed in this unit of study, to help students find the answers to their questions. Some of the questions may be answered using resource materials from this unit or the **Dinosphere** Web site. Other questions scientists may still be trying to answer.
5. Ask students to share their answers. Tell them that someday answers may come from someone in the class who grew up reading, writing, using numbers and learning science.
6. Allow time for students to draw pictures in their **Dino Diaries** of what a person might look like searching for answers about dinosaurs.

EXPERIENCE 1 — QUESTIONS AND CLUES

What Happened to the Dinosaurs?

Indiana Academic Standards — Grade 1

Science — 1.1.2, 1.4.4
Language Arts — 2.7, 4.1, 5.5, 7.2

Focus Questions

- **What happened to the dinosaurs that made them go away?**
- **Do dinosaurs have descendants living today?**
- **Who discovers information about dinosaurs?**
- **How can someone learn more about dinosaurs?**

Objectives

Students will:

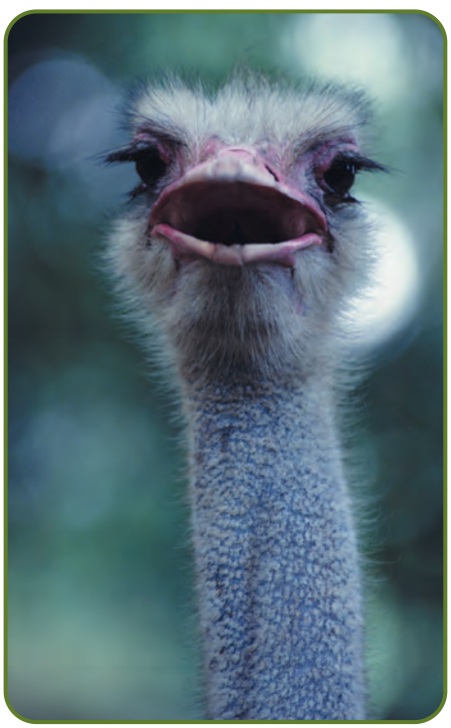
- Give one or more reasons why dinosaurs are not alive today.
- Give examples of how anyone can study dinosaurs.
- Define one or more parts of the word paleontology.
- Define one or more activities of a paleontologist.

Vocabulosaurus

- **paleontologist —** a scientist who studies ancient life from fossils, including plants, invertebrates (animals without backbones) and vertebrates (animals with back-bones).
- **volcano**
- **extinct**
- **unique**
- **common**
- **idea**
- **climate**
- **meteorite**

Dig tools

Computer access; chart paper or chalkboard; **Dino Diaries**. *What Happened to the Dinosaurs?* by Franklyn Branley.



DIG IN ...

1. Talk to your students about what scientists have learned about dinosaurs. Emphasize that although they have learned much about dinosaurs, there are many more things scientists do not know.
2. Tell your class that scientists are also trying to answer the question, "What happened to the dinosaurs?" The harder they try to answer that question, the more new questions are found.
3. Read *What Happened to the Dinosaurs?* by Franklyn Branley to introduce students to some of the popular theories about the end of dinosaurs.
4. As you read make a list of the ideas presented in the book. Make a "What Happened to the Dinosaurs?" chart with the class. Review what you have studied and work with the class to share their ideas. Students should start a list in their **Dino Diaries**.
5. Ask students to propose their answers. Tell them that someday answers may come from someone in the class who grew up reading, writing, using numbers and learning science.

Scientists carefully study modern birds to better understand what happened to dinosaurs at the end of the Cretaceous Period. Evidence suggests a common ancestry between birds and dinosaurs. Some scientists believe dinosaurs are not extinct but have adapted and evolved into birds.

EXPERIENCE 1 — QUESTIONS AND CLUES

Dinosaur Theories

Indiana Academic Standards — Grade 2

Science — 2.1.3, 2.1.4, 2.1.5, 2.3.1, 2.4.4
Language Arts — 2.7, 5.6, 7.1, 7.3, 7.11

Focus Questions

- **What happened to the dinosaurs that made them go away?**
- **What do scientists use as evidence for a dinosaur theory?**
- **How can someone learn more about dinosaurs?**

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 a theory.

Vocabulosaurus

- **paleontologist** — a scientist who studies ancient life from fossils, including plants, invertebrates (animals without backbones) and vertebrates (animals with backbones).
- **theory** — a generally accepted explanation of a set of facts or observations.
- **volcano**
- **extinct**
- **unique**
- **common**
- **idea**
- **climate**
- **meteorite**

Volcanic eruptions change the land and the atmosphere.

DIG IN ...

1. Talk to your students about what scientists have learned about dinosaurs. Emphasize that although they have learned much about dinosaurs, there are many more things scientists do not know.
2. Tell your class that scientists are also trying to answer the question, "What happened to the dinosaurs?" The harder they try to answer that question, the more new questions are found.
3. Read *What Happened to the Dinosaurs?* by Franklyn Branley to introduce students to some of the popular theories about the end of dinosaurs.
4. As you read make a list of the ideas presented in the book. Make a "What Happened to the Dinosaurs?" chart with the class. Review what they have studied and work with the class to share their ideas. Discuss with the class how people create and use a theory to help explain a set of facts. Give examples of theories that students can understand. For example: *Students who wash their hands three times a day have fewer colds than those who wash fewer times.* A prior investigation and data would be needed to support this theory.
5. Visit the **Dinosphere** Web site and research what scientists think happened to the dinosaurs. There are four main theories to explore:
   1) climate change
   2) comet or asteroid
   3) increased volcanic activity
   4) survival as relatives of birds
6. Ask students to propose their answers in their **Dino Diaries**. Tell them that someday answers may come from someone in the class who grew up reading, writing, using numbers and learning science.

Dig tools

Computer access; chart paper or chalkboard; **Dino Diaries**; *What Happened to the Dinosaurs?* by Franklyn Branley and *The Magic School Bus in the Time of the Dinosaurs* by Joanna Cole.

Make it fossilize

Kindergarten — Students state or write one or more questions about dinosaurs. Create and use a "Dinosaur Question" chart that students can refer to throughout the unit and the school year.

Grade 1 — Students create lists of questions about dinosaurs. They define *paleontology* as the study of fossils, and *paleontologist* as a scientist who studies fossils.

Grade 2 — Students give three or more ideas about why dinosaurs are extinct. They begin to recognize fossil clues as evidence in a scientific theory.

Dino Diary

Students use their diaries to write questions they have about dinosaurs. They can also begin to collect information, words and drawings about the paleontologists they study. End each class period with time to make drawings and observations 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 (JPI)
http://www.jpinstitute.com

Museum of Paleontology
http://www.ucmp.berkeley.edu/index.html

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

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 either the **Dinosphere** or **The Children's Museum** Web site to learn more.

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.
- 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.
- 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.

Paleo-points for the teacher

Review the theories that students listed. Tell the class that scientific theories 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 the dinosaurs, focusing on the evidence. Put the following chart on the board. The main ideas listed are some of the strongest. Information about these theories 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.

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.

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
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

© Black Hills Institute of Geological Research, photograph by Henry Rust

Millions of years ago these ribs surrounded a stomach filled with Cretaceous plants.

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.

EXPERIENCE 2 — PALEONTOLOGISTS

The Children's Museum of Indianapolis

At The Children's Museum Paleo Prep Lab you can join in to help make dinosaur discoveries.

© Black Hills Institute of Geological Research

Paleontologists keep precise records in order to be able to reassemble fossils into a complete dinosaur.

© Black Hills Institute of Geological Research, photograph by Henry Rust

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

Sir Richard Owen, Robert Bakker and Barnum Brown were 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 2 — PALEONTOLOGISTS

Paleontologists: Can You Dig It?

Indiana Academic Standards — Kindergarten

Science — 1.1, 1.2
Language Arts — 4.3, 5.1, 5.2, 7.3
Math — 3.1, 6.2, 6.3
Social Studies — 4.2, 4.3

Focus Questions

- **Who discovers information about dinosaurs?**
- **What is a paleontologist?**
- **How can someone learn more about dinosaurs?**

Objectives

Students will:

- Describe an activity of a paleontologist.
- Demonstrate an activity of a paleontologist.
- Role-play a paleontologist.

The Children's Museum of Indianapolis

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

Dig tools

Dinosaur Hunters and **Important Dates in Dinosaur Discovery** resource material from this unit; **Dino Diaries**; computer access; construction paper and markers; handheld magnifying lens; brushes, craft sticks and screens or aquarium nets; goggles, pith helmets, vests; sketch pad and pencil; dinosaur identification books; and replica fossil cast from the dinosaur kit.

DIG IN ...

1. 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), vertebrates (animals with backbones) and bacteria. Ask the class if they can name a person who is a paleontologist and describe what his or her job is like.
2. Create a "Paleontologist Dig" in the classroom. Use a sand table, plastic storage box or wading pool. Fill the container with play sand and plastic models — both skeletons and fleshed-out figures — and rocks.
3. Supply the dig center with the dig tools listed above.
4. Allow small groups to work the site. They can dig, draw, research and then re-bury the finds for the next group.
5. Have older students or volunteers write stories to go with the pictures in the students' **Dino Diaries**. Take photos of students at work in the Paleontologist Dig to show that any person can participate in science activities.
6. Visit the **Dinosphere** Web site to view photos of a real dig. Students can see teachers digging and preparing fossils for the museum.

Vocabulosaurus

- **paleontology** — the study of ancient life from fossils, including plants, invertebrates (animals without backbones), vertebrates (animals with backbones) and bacteria.
- **paleontologist** — a scientist who studies fossils.

EXPERIENCE 2 — PALEONTOLOGISTS

Paleontologists: Scientists Are People Just Like You

Indiana Academic Standards — Grade 1

Science — 1.1.3, 1.2.7
Language Arts — 2.3, 2.7, 5.4, 6.2, 7.1, 7.5
Math — 5.6
Social Studies — 4.2, 5.2

Focus Questions

- **Who discovers information about dinosaurs?**
- **Who discovered a dinosaur?**
- **How can someone learn more about dinosaurs?**

Objectives

Students will:

- Describe an activity of a paleontologist.
- Role-play a paleontologist.
- Name an important paleontologist.
- List one or more significant discoveries of a paleontologist.

Vocabulosaurus

- **paleontology** — the study of ancient life from fossils, including plants, invertebrates (animals without backbones) and vertebrates (animals with backbones) and bacteria.
- **paleontologist** — a scientist who studies fossils.
- **contribution**
- **discovery**
- **biography**

© Black Hills Institute of Geological Research

A giant mold is needed to make a cast of a giant dinosaur.

DIG IN ...

1. Review Kindergarten Experience 2 and adapt it to your classroom.
2. Select three paleontologists from **Dinosaur Hunters**, found in the unit of study resource material. Read their descriptions aloud to the class. Use reference books and Web sites to find photos and more information about each scientist. Ask the class to listen in order to learn about their lives, scientific contributions and important discoveries. Emphasize that at one time these paleontologists were young students using science and fossils to learn about dinosaurs.
3. Discuss how a paleontologist can be a man or woman from any country. Paleontologists share a love for science and discovery. Ask students to take notes or write down important facts in their **Dino Diaries**.
4. Students work together in groups of three or four to create posters about one of the three paleontologists. The poster includes some of the following information: the scientist's name and nationality, and the date and a drawing of one or more of his or her important discoveries. Use dinosaur reference books for more information.
5. Display the finished posters in the class.

Dig tools

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

EXPERIENCE 2 — PALEONTOLOGISTS

Paleontologists: Make Discoveries!

Indiana Academic Standards — Grade 2

Science — 2.1.5
Language Arts — 2.5, 5.2, 5.5, 5.6, 7.11
Math — 5.10
Social Studies — 5.5

Focus Questions

- **Who discovers information about dinosaurs?**
- **Who discovered a dinosaur?**
- **How can someone learn more about dinosaurs?**
- **When did people first learn about dinosaurs?**
- **Which dinosaur was found first?**

Objectives

Students will:

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

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

Many workers with diverse skills are needed to prepare a dinosaur for display.

DIG IN ...

1. Review the previous experiences in this lesson and adapt them to your classroom.
2. Select paleontologists from **Dinosaur Hunters**, found in the resource material in this unit. Read their entries aloud to the class. Ask students to write facts and make drawings about what they learn in their **Dino Diaries**.
3. Use reference books and Web sites to find photos and more information about each scientist. The class listens in order to learn about their lives, scientific contributions and important discoveries. Emphasize that the scientists were once young students using science and fossils to learn about dinosaurs. Discuss how a paleontologist can be a man or woman from any country. Paleontologists share a love for science and discovery.
4. Make teams of three or four students each. Assign a different paleontologist to each team. Have older students or volunteers help the groups read and learn about the scientists.
5. Students work together to create posters about their paleontologist. The posters should include four main items: the paleontologist's name and nationality, and the date and a drawing of one or more of his or her important discoveries. Ask each group to show their poster and give a short report to the class.
6. Ask the students to display the posters in chronological order according to when the paleontologist made his or her discoveries.

Dig tools

Dinosaur Hunters and **Important Dates in Dinosaur Discovery** resource material from this guide; **Dino Diaries**; computer access; construction paper and markers.

Vocabulosaurus

- **paleontologist —** a scientist who studies fossils.
- **contribution**
- **discovery**
- **biography**

Make it fossilize

Kindergarten — Students write words or draw pictures about the activities of a paleontologist and describe tools that are used. They name a variety of people, including themselves, who can participate in science activities.

Grade 1 — Students identify one or more paleontologists and can list one or more facts about them.

Grade 2 — Students identify one or more paleontologists and can list one or more facts about them. Students can place dinosaur discoveries in chronological order.

All Grades — 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.

Bonus: Digging deeper!

Use the information about paleontologists to create a display showing scientists at work. Select one important discovery and recreate it in the classroom. Students will enjoy bringing in dolls, toy jeeps and other items for the dig site. Take a trip outdoors to collect twigs, rocks and grass to use in the display. Use soils, sand and plaster to create the dig site. Present student posters and drawings with the display.

Dino Web sites

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/

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

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.

Dino Diary

Make sketches of paleontologists 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.

Paleo-points for the teacher

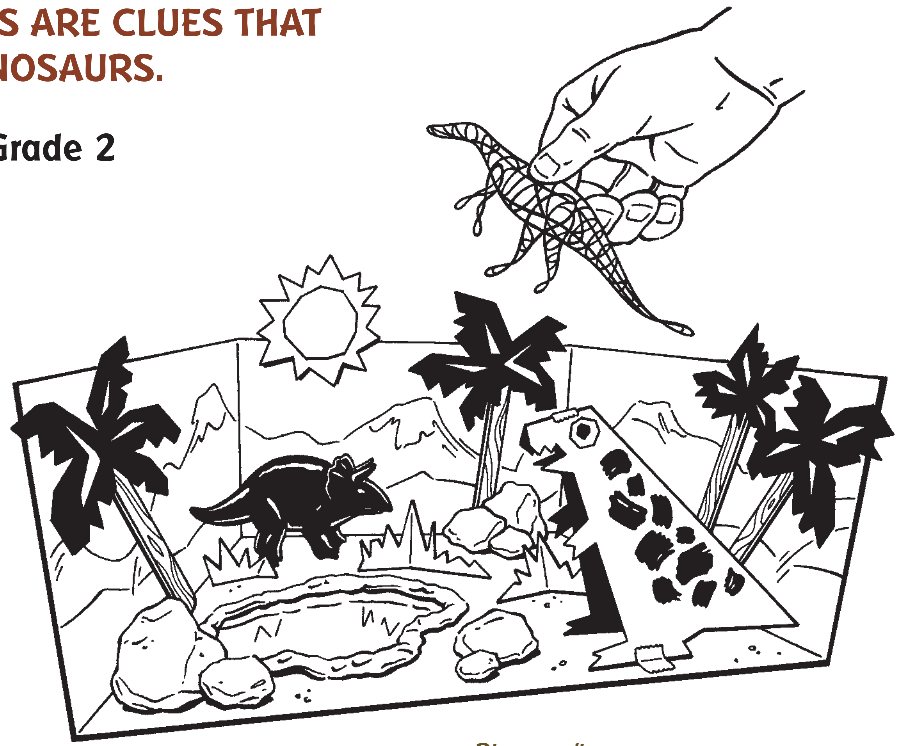
Students may think that the only job of a paleontologist is to dig up fossilized bones. However, the field is diverse. Paleobotanists study plants and sedimentologists study the soil found with fossils. Another paleontologist may spend years learning how leg and hip bones work together. There are many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

Carefully clearing a fossil helps to preserve clues about the animal.

Culminating Experience — Waterhouse Hawkins and the Nano Dinosphere Museum

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

Kindergarten, Grade 1 and Grade 2



Dinosaur diorama

Get ready to dig

In the book *The Dinosaurs of Waterhouse Hawkins* by Barbara Kerley (illustrated by Brian Selznick), students are introduced to an amazing artist and dinosaur educator. In London in 1850 Waterhouse Hawkins created an exhibit that for the first time allowed millions to see into the unknown world of dinosaurs. Students will create a **nano**, or small, classroom version of the Crystal Palace exhibit and **The Children's Museum Dinosphere**. Their diorama will depict the dinosaurs, fossils and paleontologists presented in this unit of study.

Dig tools

The Dinosaurs of Waterhouse Hawkins by Barbara Kerley; art and craft supplies; plaster fossils; timeline; paleontologist reports; skeleton drawings; dinosaur models; **Dino Diaries**.

Vocabulosaurus

- **Waterhouse Hawkins —** A British artist and educator who worked with Richard Owen to build life-size dinosaur sculptures. He also created dinosaur sculptures and artwork in the United States.
- **Sir Richard Owen —** A British scientist who coined the term *dinosauria* and created the exhibit at the Crystal Palace featuring *Iguanodon* and *Megalosaurus*. This was the world's first dinosaur theme park.
- **nano —** tiny, small. It comes from the Greek word for "dwarf." *Nano* is used as a prefix in some words to represent a one-billionth part, such as "nanometer," which means one billionth of a meter. In paleontology nano is used to describe a genus of tiny tyrannosaurs called *Nanotyrannus*.

Focus Questions

- **Who is Waterhouse Hawkins and what did he do?**
- **Who is Richard Owen?**
- **What are some ways to share knowledge with others?**
- **Where can someone learn more about dinosaur art and exhibits?**

Objectives

Students will:

- List the life events and achievements of Waterhouse Hawkins.
- Create a small model of **Dinosphere** in the classroom.
- Write and display information about dinosaurs to share with others.

DIG IN ...

1. Read aloud *The Dinosaurs of Waterhouse Hawkins* by Barbara Kerley to the class. Discuss how Hawkins followed his childhood dream of drawing animals. Ask students to give examples of how scientists might use art to help people understand new ideas. What would people have thought about dinosaurs if Richard Owen had not worked with Waterhouse Hawkins? Can a drawing or sculpture show an idea? Share the beautiful artwork in the book.
2. Make a list of things that are easy to understand with art. The list could include buildings, parks, inventions and others. Make a list of things that words describe better, such as poems, songs or rules.
3. Show students the last page of the book and compare and contrast how both *Iguanodon* and *Megalosaurus* were actually different from the real skeletons when they were found. Both models were created mostly from fossilized teeth and a few fossilized bones.
4. Share with the class the editor's notes about how the book was researched.
5. Visit the **Dinosphere** Web site to study the floor plan of the exhibit. Tell the students to reread the story lines on the main scenes.
6. Ask them to create a story line for their **Nano Dinosphere**.
7. Visit other dinosaur museums via virtual tours. At these sites students will see how other people have displayed fossils and dinosaur exhibits.
8. Take a **Dinosphere Webquest** to learn more about the amazing world of dinosaurs.
9. Ask students to make a sketch of a floor plan for their exhibit. Have each student get his or her plan approved before beginning work on the exhibit. Some students may prefer to work in groups on one display. Encourage students to use their drawings and **Dino Diaries** in the display. Students can use pizza boxes, poster board or cardboard boxes to house their **Nano Dinosphere Museum**.
10. Present your class exhibit for others to see. Invite parents, teachers and other students to visit your students' **Nano Dinosphere** exhibits.

Dino Diary

Students should display their **Dino Diaries** next to their **Nano Dinospheres**. Have students leave a blank section at the end of their journals for guests to sign-in. Classmates can write positive comments about each other's displays in the journals, beginning with **"Today when I visited the Nano Dinosphere Museum I learned. …"**

Dino books

- Kerley, Barbara. *The Dinosaurs of Waterhouse Hawkins,* New York: Scholastic, 2001. The story of Victorian artist Benjamin Waterhouse Hawkins, who built the first life-size models of dinosaurs in the hope of educating the world about them.

Models

The Tiny Perfect Dinosaur — Kit, 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

Students will enjoy seeing other dinosaur exhibits. Many virtual tours of dinosaur museums can be found on the Internet. Once your class has completed the projects invite other classes in for a tour.

Bonus: Dig deeper!

Make a timeline of the events of Waterhouse Hawkins' life. Include both the good and the bad things that happened to him. Ask the class for examples of times when he worked hard and did not give up on his dream. Display the timeline with the class projects.

Dinosphere museum link: When you visit

Students can visit **Dinosphere** to see an excellent dinosaur art collection — the John Lanzendorf Gallery of Dinosaur Imagery. On display are drawings, sketches, paintings and sculptures that depict all aspects of dinosaur life. Students who visit are inspired to make their **Nano Dinosphere** a learning tool for the class and school.

Dino Web sites

Artwork of Waterhouse Hawkins
http://rainbow.ldeo.columbia.edu/courses/v1001/dinodis3.html

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

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

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

Dinosaur Webquests
The Children's Museum Dinosphere Webquests
http://www.childrensmuseum.org

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

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

Dinosphere Dinosaurs

Table of Contents

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.

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

All dinosaurs:

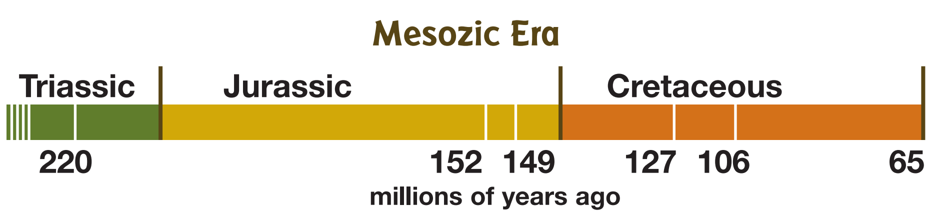
1. **are diapsids, which have two additional sets of openings in their skulls not counting the nostrils or the eye sockets. All reptiles except turtles are diapsids.**
2. **were alive during the Mesozoic Era that lasted from 245 to 65 million years ago. Geologists divide the Mesozoic Era into three distinct 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.

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.

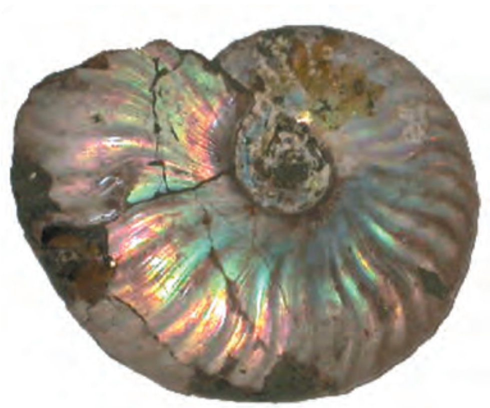


Why focus on the Cretaceous Period?

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.



The Children's Museum of Indianapolis

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

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, pliosaurs, 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.

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

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	*Triceratops* (three-horned face)
Species	*horridus* (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.

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

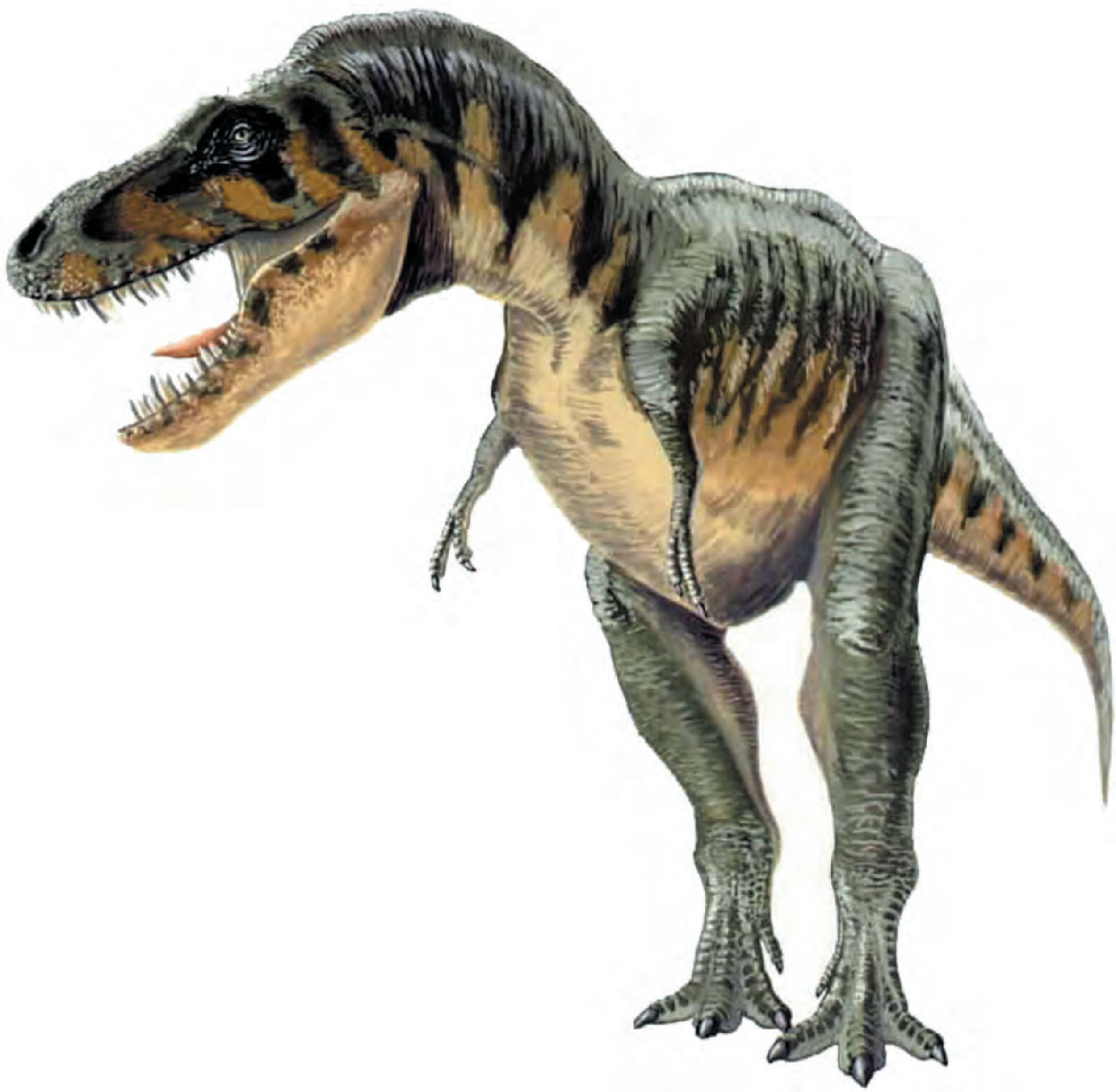
Stan — *Tyrannosaurus rex*

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	*Tyrannosaurus* (tyrant lizard)
Species	*rex* (king)

Tyrannosaurus rex — Stan

The Children's Museum of Indianapolis

Drawing
Tyrannosaurus rex — Stan



The Children's Museum of Indianapolis

A fleshed-out T. rex.

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

Bucky — *Tyrannosaurus rex*

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Genus	*Tyrannosaurus* (tyrant lizard)
Species	*rex* (king)

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

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 hooflike 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

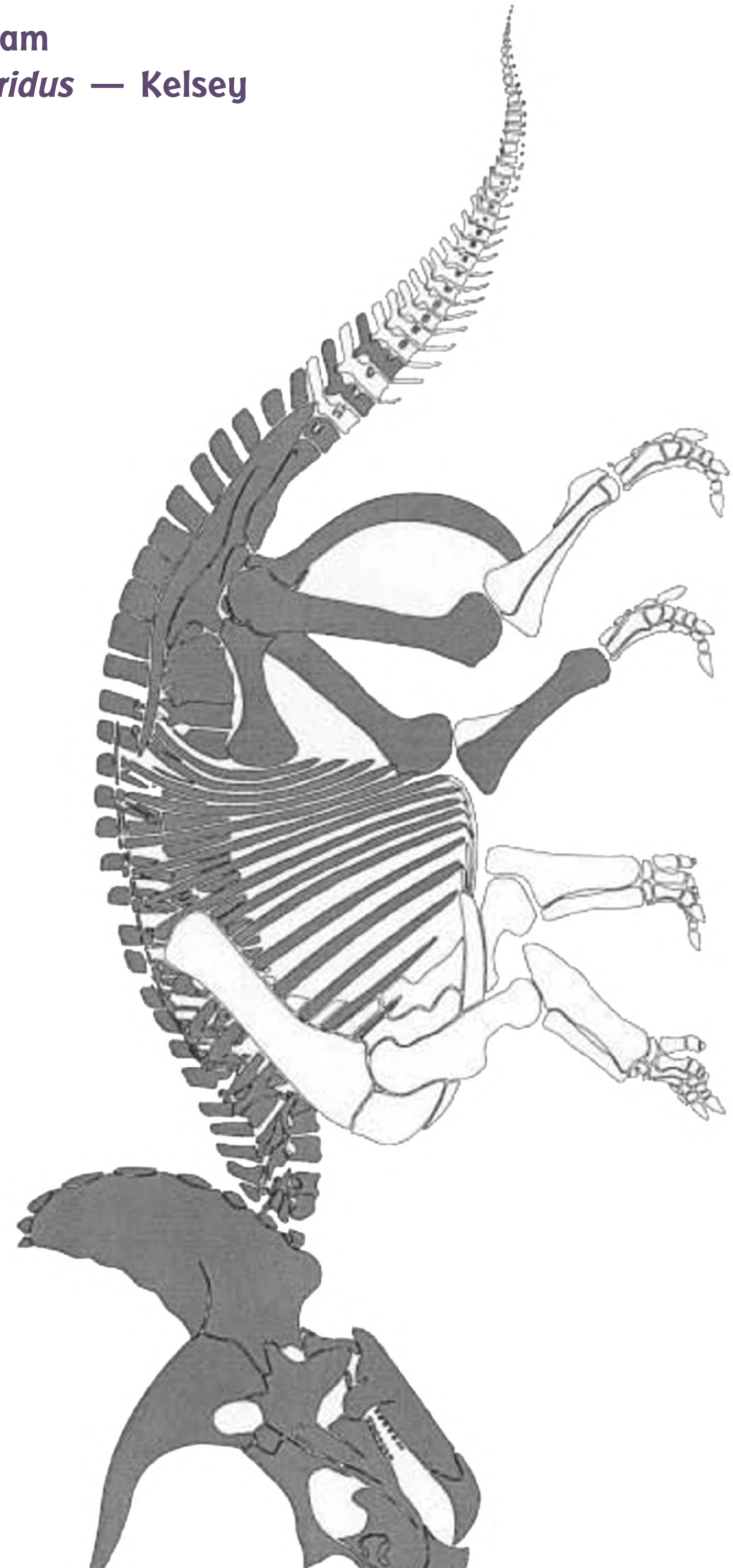
Kingdom — Phylum — Class — Order — Family — Genus — Species

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

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	*Triceratops* (three-horned face)
Species	*horridus* (horrible — describing the horns)

Skeleton Diagram
Triceratops horridus — Kelsey



The shaded bones are real fossils.

Scale: 1 cm = 28 cm

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

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 Therapods)
Genus	*Oviraptor* (egg-robber)
Species	unknown at this time

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

Scale: 1 cm = .5 cm

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

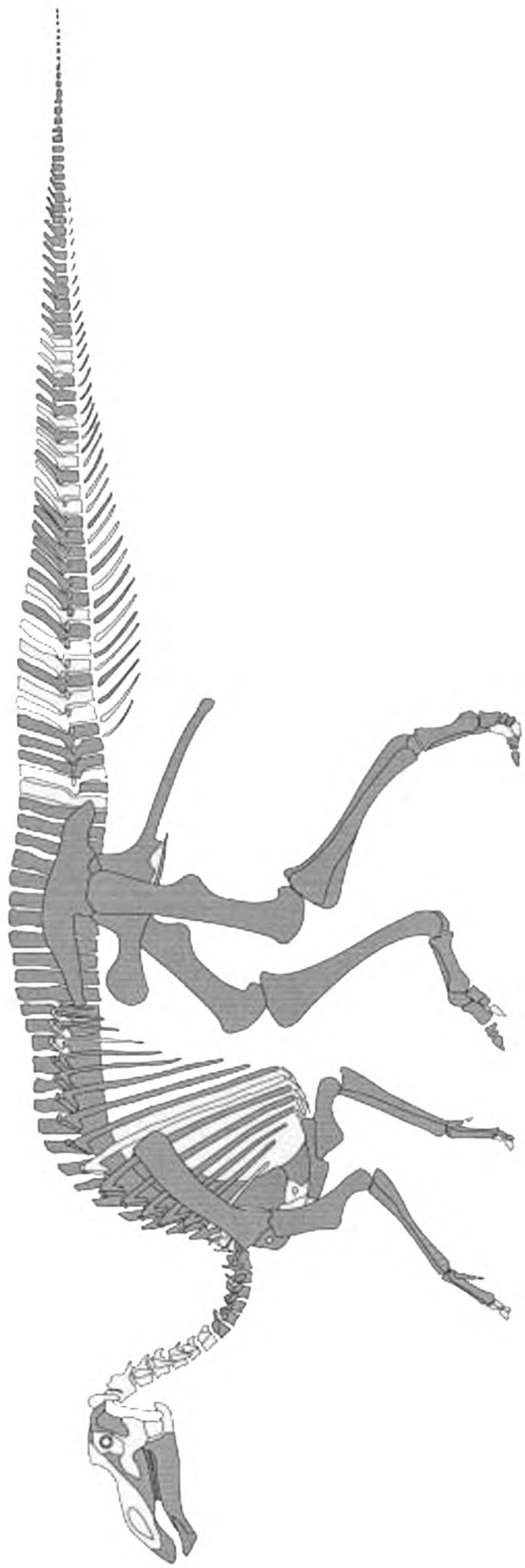
Duckbill — *Maiasaura peeblesorum*

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	*Maiasaura* (good-mother lizard)
Species	*peeblesorum* (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	*Edmontosaurus* (Edmonton lizard)
Species	*annectens* (from or connected to)

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

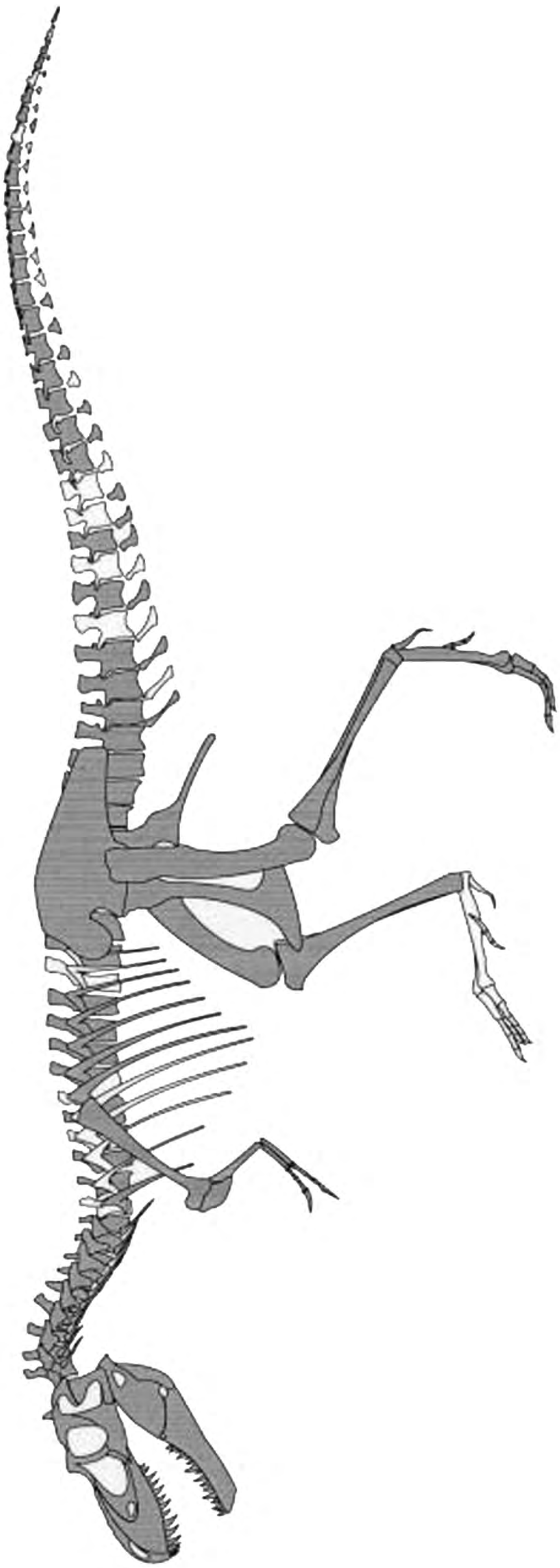
Kingdom — Phylum — Class — Order — Family — Genus — Species

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

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	*Gorgosaurus* (fearsome lizard)
Species	Not currently named.

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

Frannie — *Leptoceratops* sp.

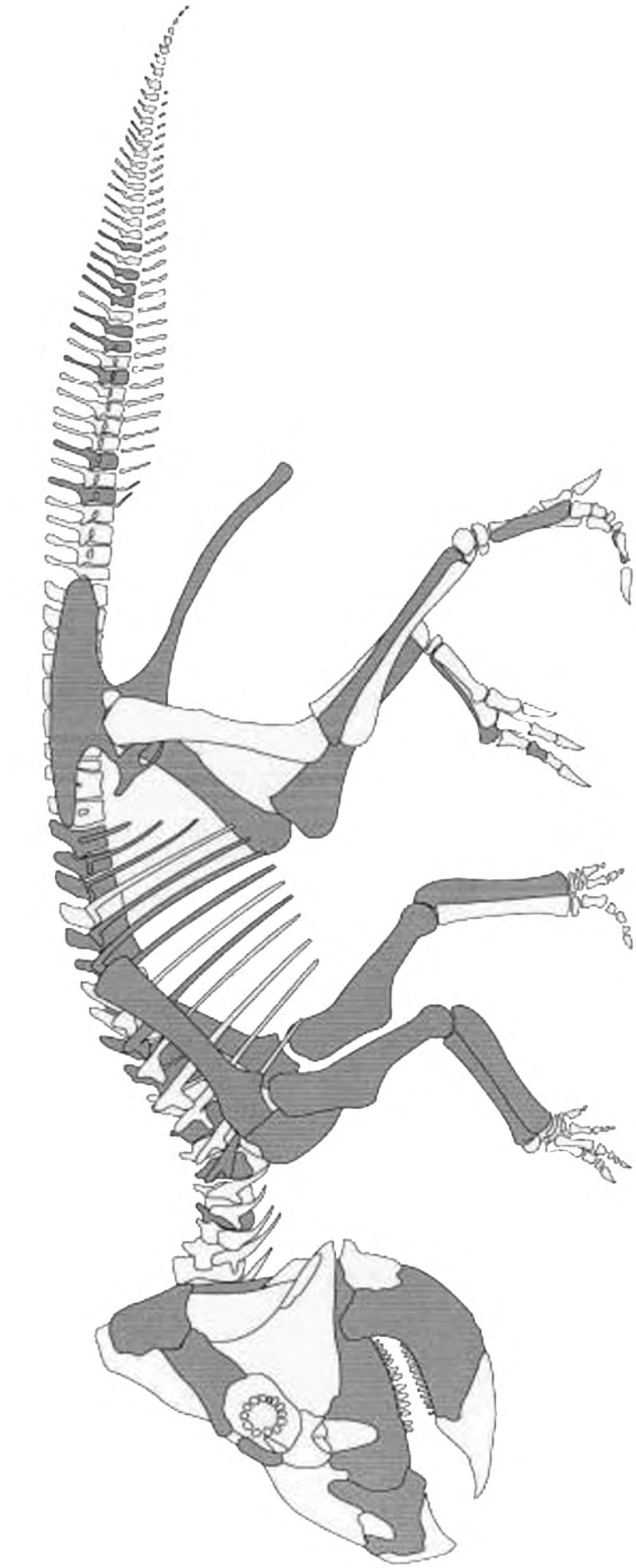
Kingdom	Animalia (animals)
Phylum	Chordata (animals with spinal nerve cords) Subphylum Vertebrata (chordates with backbones)
Class	Archosauria ("ruling reptiles") Subclass Dinosauria (extinct reptiles, "terrible lizards")
Order	Ornithischia (bird-hipped) Suborder Marginocephalia (fringed heads)
Family	Ceratopsidae (frilled dinosaurs)
Genus	*Leptoceratops* (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.*

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 hypacrosaurs 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 hypacrosaurs.

Site

The fossilized bones of these hypacrosaurs 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 hypacrosaurs, 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 hypacrosaurs 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 hypacrosaurs 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 hypacrosaurs 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

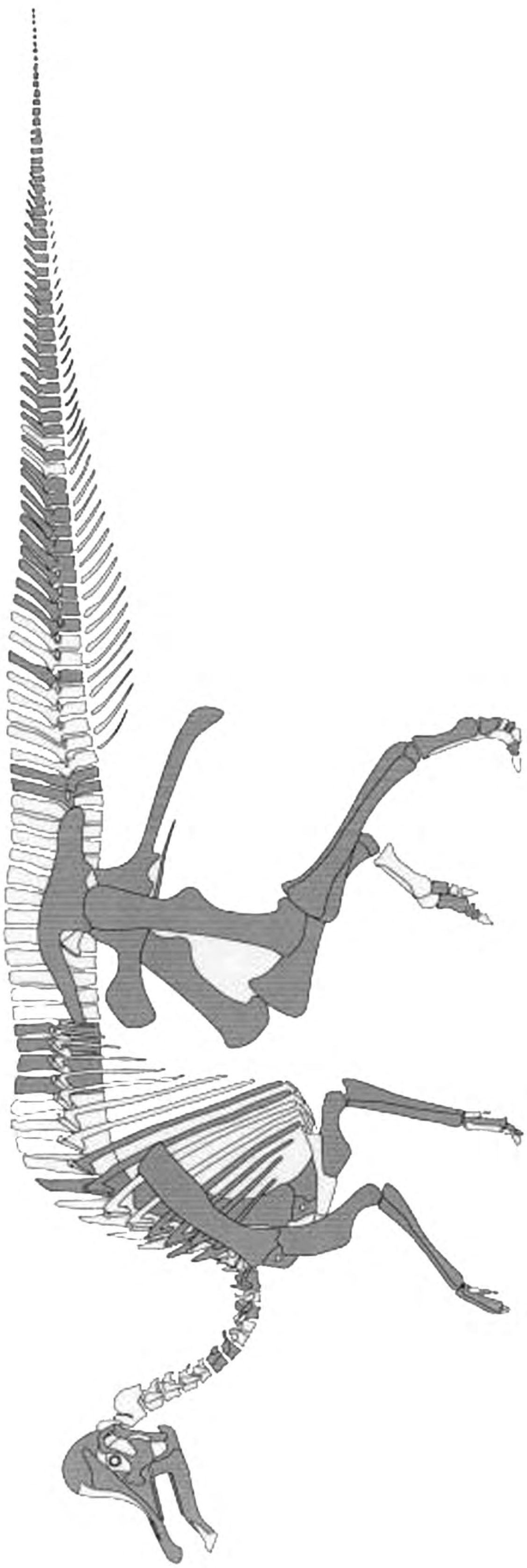
Kingdom — Phylum — Class — Order — Family — Genus — Species

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

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	*Hypacrosaurus* (almost the highest lizard)
Species	*stebingeri (after Eugene Stebinger, who found the first specimens)*

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.

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

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	*Bambiraptor* (baby raptor)
Species	*feinbergi* (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

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

The Children's Museum of Indianapolis

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

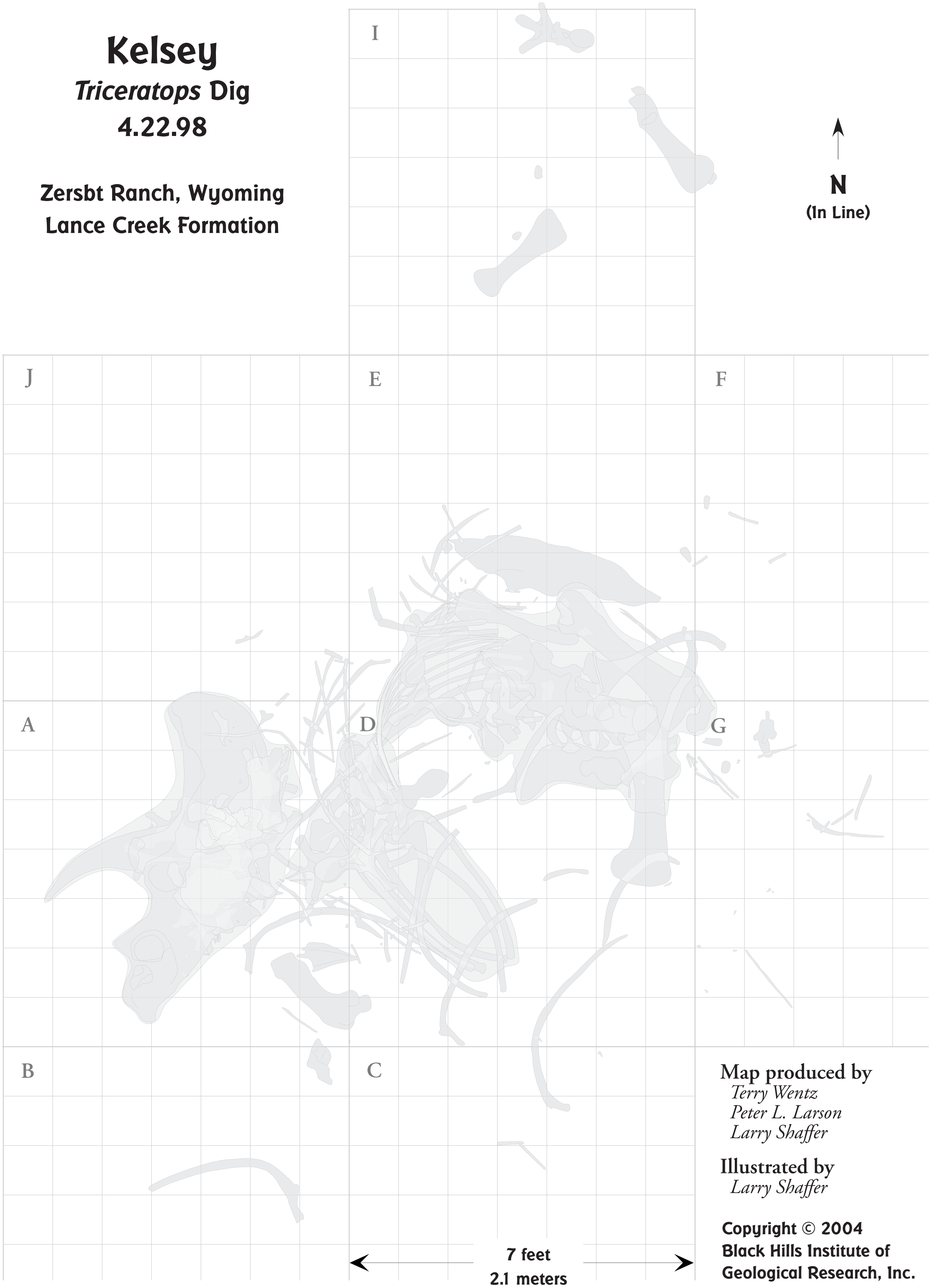
Didelphodon Vorax

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	*Didelphodon* (opossum tooth)
Species	*vorax*

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

Dinosphere Dinosaur Classification Chart

Saurischia — lizard-hipped

Sauropod

Saurpoda — lizard-footed

*****Barosaurus***
Camarasaurus
*****Diplodocus***
Aragosaurus
*****Saltasaurus***
Patagosaurus

Therapod

Therapoda — beast-footed

Allosaurus
*****Oviraptor*** **(Baby Louie)**
Ceratosaurus
*****Gorgosaurus*** **sp.**
Troodon
*****Tyrannosaurus rex*** **(Stan, Bucky)**
*****Bambiraptor feinbergi***

Ornithischia — bird-hipped

Ornithopoda

Ornithopoda — bird-footed

Camptosaurus
Corythosaurus
*****Edmontosaurus annectens***
Heterodontosaurs
*****Maiasaura peeblesorum***
Prosaurolophus
*****Hypacrosaurus stebingeri***

Thyreophora

Stegosauria — roofed or plated reptiles

Stegosaurus
Kentrosaurus

Ankylosauria — armored reptiles

Ankylosaurus
Hylaeosaurus

Marginocephalia

Ceratopsia — horn-faced

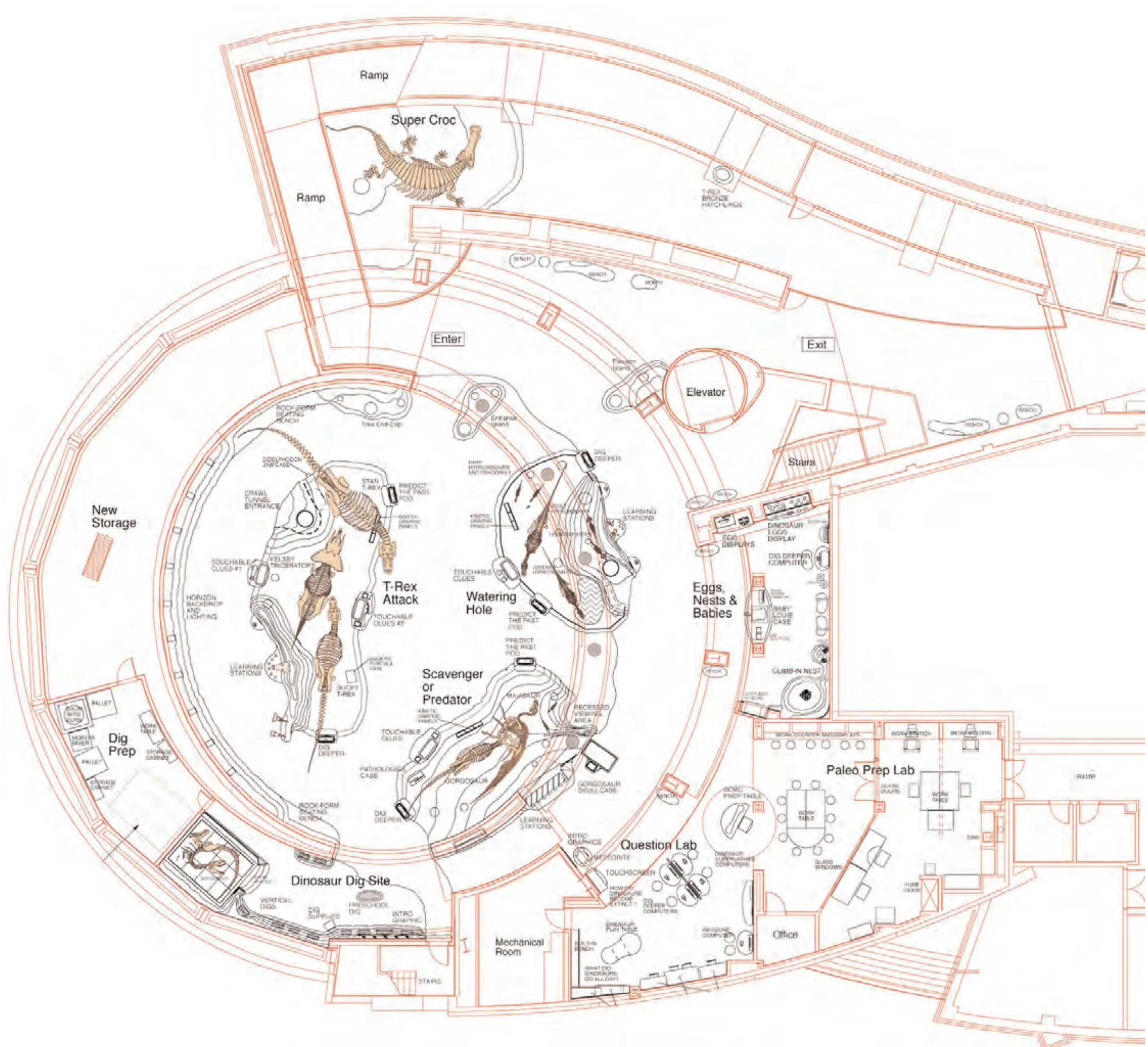
Protoceratops
*****Leptoceratops*** **sp. (Frannie)**
Brachyceratops
*****Triceratops horridus*** **(Kelsey)**

Pachycephalosauria — thick-headed reptiles

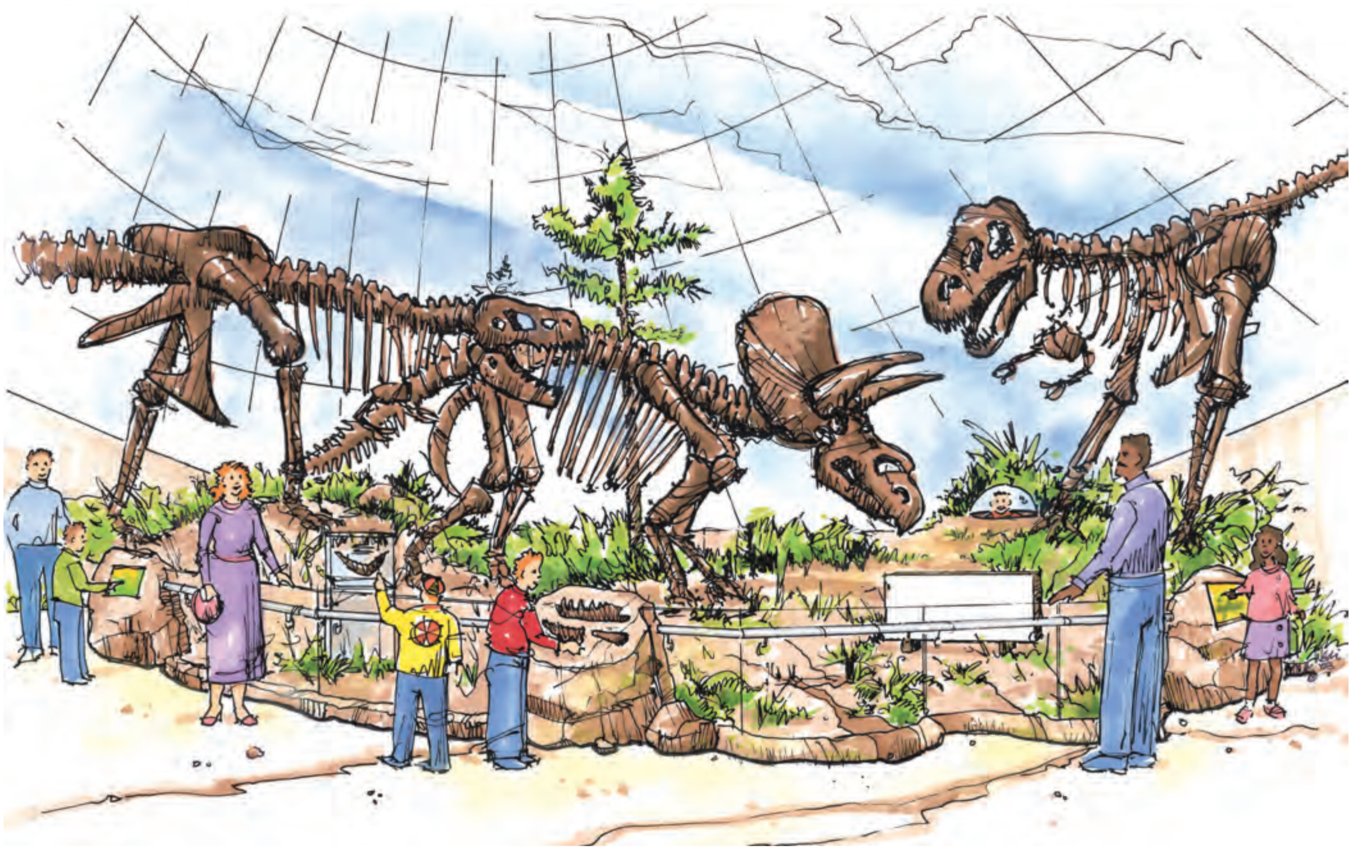
Pachycephalosaurus

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?

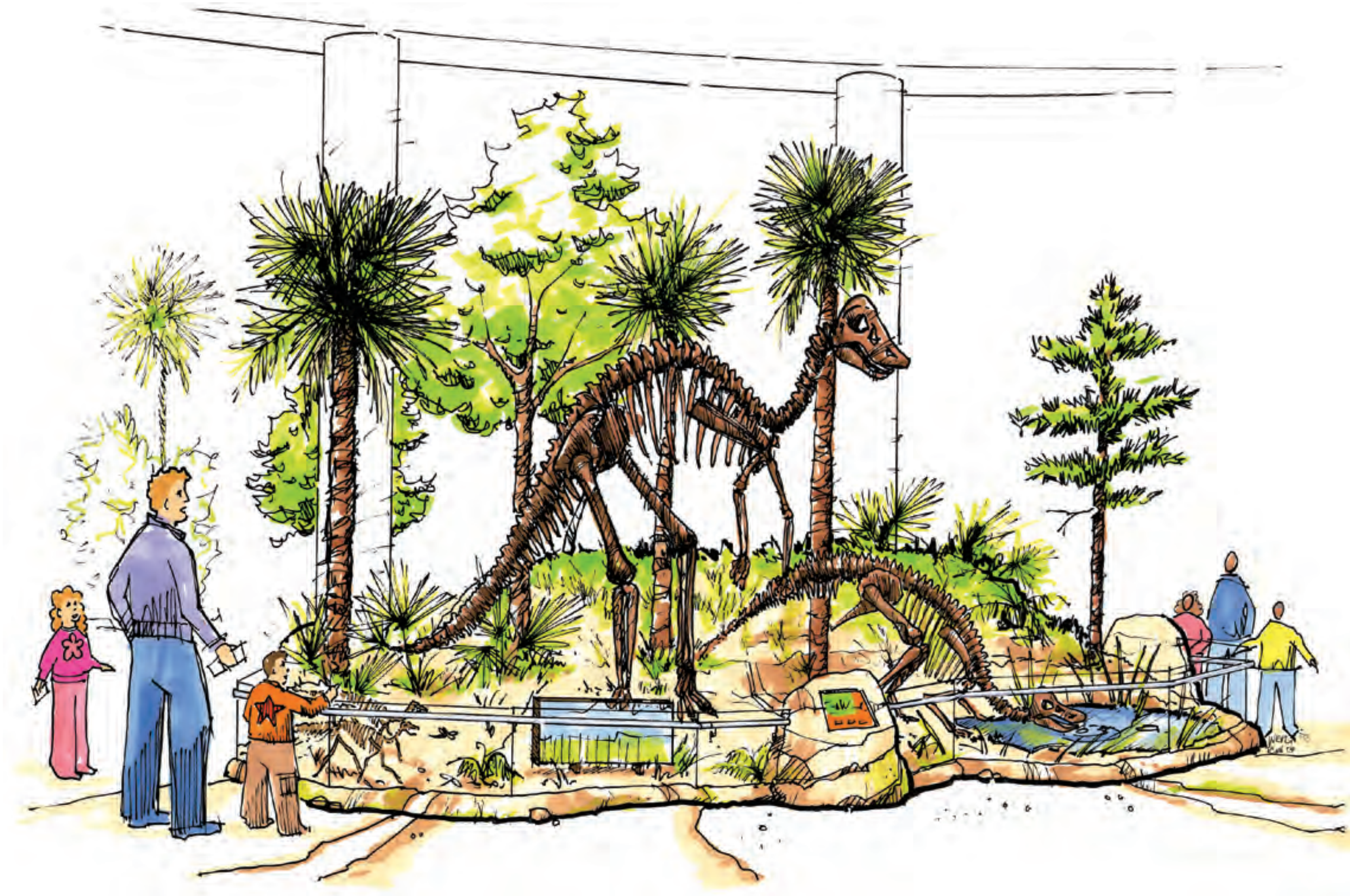
The noise and movement have terrorized two opossum-size didelphodons hiding inside a nearby burrow. They are nocturnal animals and this afternoon skirmish has interrupted their nap. Because they could be trampled, they stay hidden, hoping the predators will be chased away.

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?

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

Dinosphere Watering Hole Scene



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A family of hypacrosaurs 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?

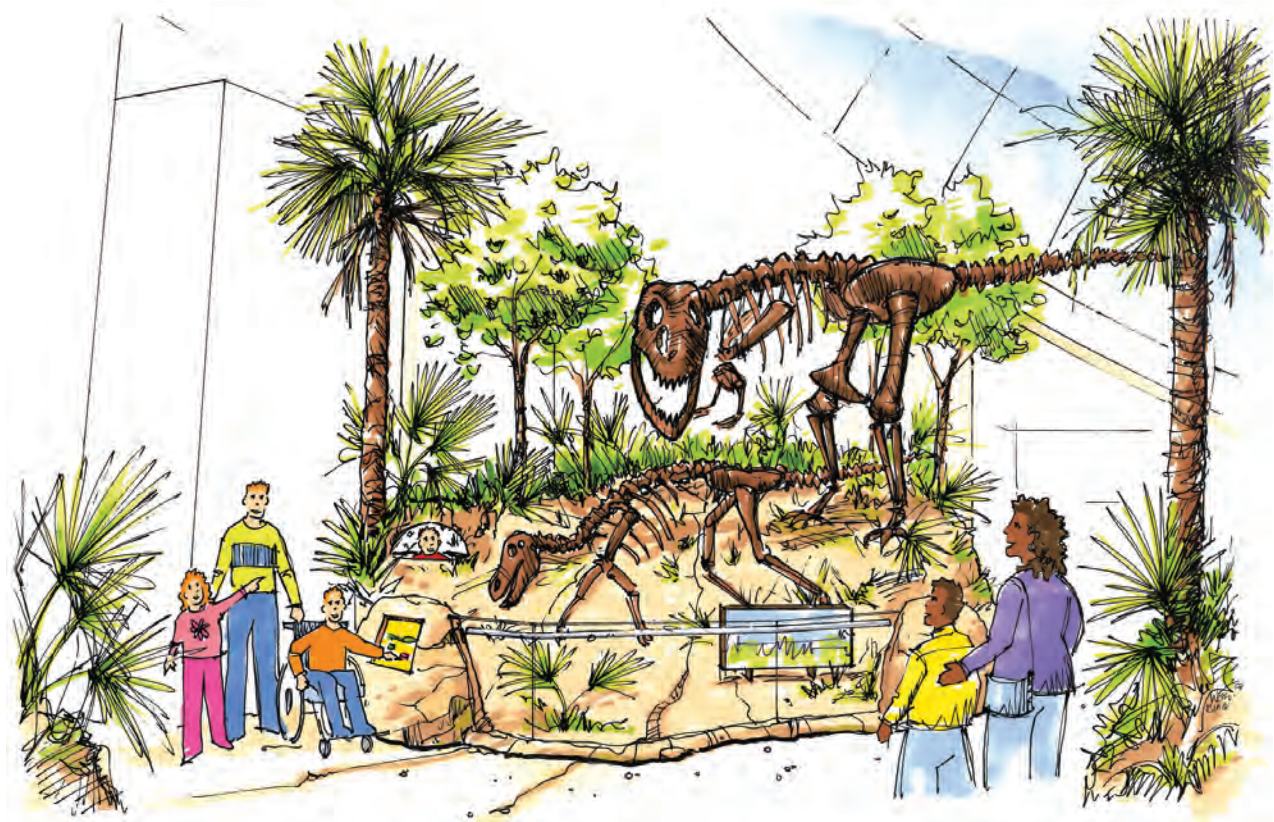
There's a crunching noise in some low-lying bushes by the water. One *Leptoceratops* snips and swallows leaves and twigs, while another slowly backs into a shallow hole to watch for predators.

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

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

Dinosphere Predator or Scavenger Scene



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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?

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?*

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

Important Dates in Dinosaur Discovery

600 B.C.	Central Asian traders bring stories of griffins, based on the fossil record of *Protoceratops,* to the ancient Greeks.
300 A.D.	Chinese scholars record the presence of "dragon bones."
1677	Robert Plot illustrates a thighbone, possibly of *Megalosaurus.*
1824	William Buckland names *Megalosaurus,* the first dinosaur to be scientifically described.
1825	Gideon Mantell and his wife find a dinosaur tooth and name the genus *Iguanodon.*
1842	Richard Owen coins the term **dinosauria**.
1850– 1851	Models of *Iguanodon, Megalosaurus* and *Hylaeosaurus,* 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 *Iguanodon* 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 *Deinonychus,* 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.

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 InstituteTeacher 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

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- Branley, M. Franklyn. *What Happened to the Dinosaurs?* New York: Thomas Y. Crowell, 1989.
- Cohen, Daniel. *Tyrannosaurus Rex.* Mankato, Minn.: Bridgestone Books, 2001.
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- 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.
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- Paul, Gregory S., ed. *The Scientific American Book of Dinosaurs.* New York: St. Martin's Press, 2000.
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- 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.

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.
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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.ldeo.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.jpinstitute.com

Museum of Paleontology, University of California, Berkley
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.zoom dinosaurs.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.

Resource Materials

Imprint — to leave a mark by means of pressure.

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 read 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
hypa — very
hyper — over, above
hypo — under, below
i — plural
ia — pertaining to
ic — having
icthy — 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 — inflamation
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, 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 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 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, 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.

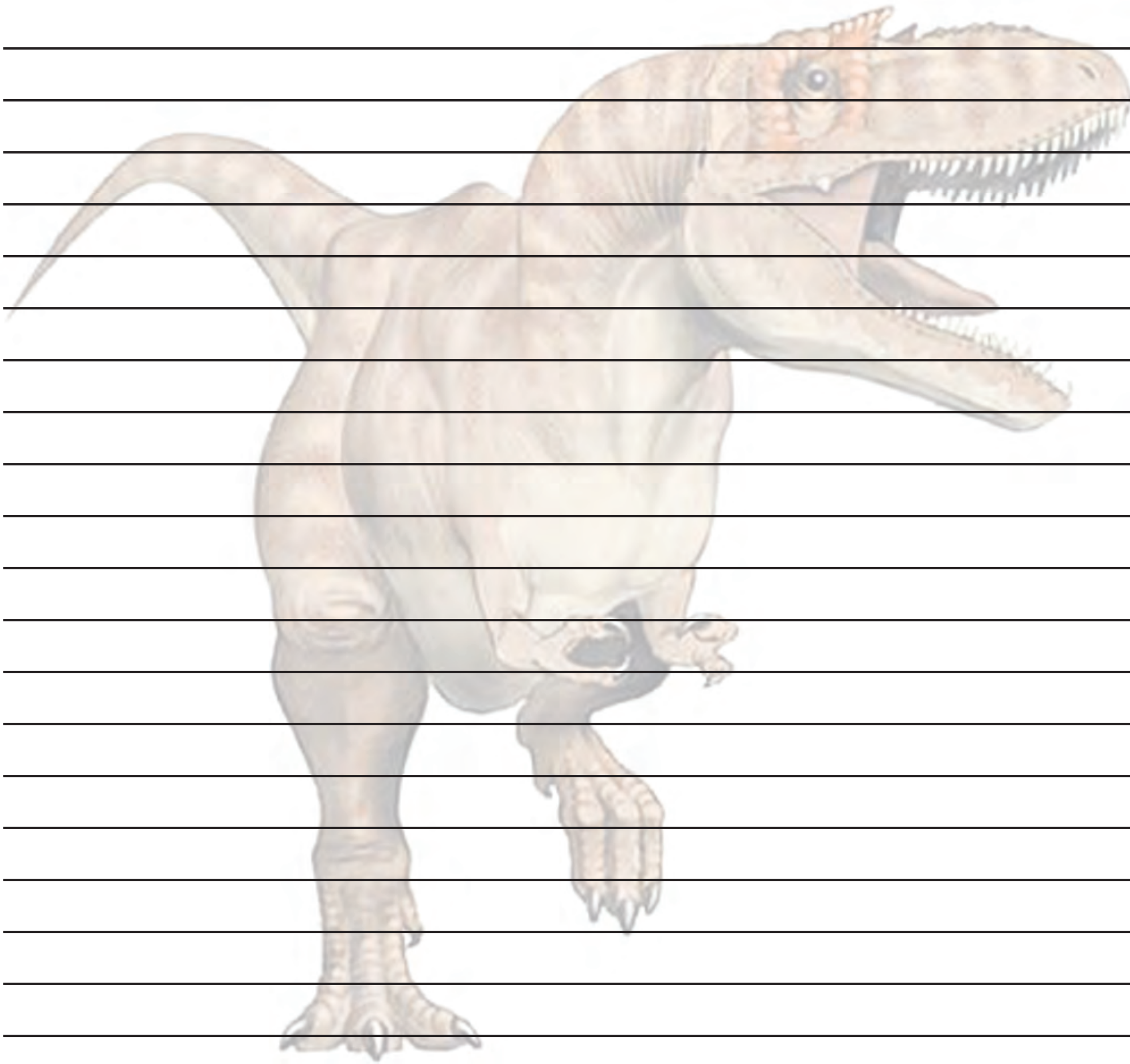
Content Standard G — History and Nature of Science (Grades K – 8)
Fundamental concepts and principles that underlie this standard include **History and Nature of Science:**

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

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Written by: ________________

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