DINOSPHERE

A K – 2 UNIT OF STUDY

The Children's Museum of Indianapolis

NOW YOU’RE IN THEIR WORLD.
Acknowledgments

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Rick Crosslin, teacher, writer
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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
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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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.

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.

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 \textit{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.

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 \textit{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 Vocabulosaur 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/).

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.

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.

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.
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.

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.
Experience 1 — Dinosaur Names

Join the Dinosaur Age

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.

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

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.

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.

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EXPERIENCE 1 — DINOSAUR NAMES

Common and Science Names

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.

Vocabulosaurs
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
- cephal – head
- cerat – horn
- rhino – nose
- tyrant – terrible
- vore – eats

Dig tools
Drawings of dinosaurs: Dino Diaries: The Littlest Dinosaurs by Bernard Most.

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

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.

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, 7.1I
Math — 6.2

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.

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.

Bucky Derflinger discovered Bucky, the teenage T. rex.
What’s in a Dinosaur Name?

Name: ____________________________________________

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

Word Parts

uni
one

cerat
horn

vore
eat

drom
three

rhino
nose

odon
tooth

tyrant
terrible

draco	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.

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

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 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.

Dino books

Classifying Kelsey — A Dinosphere Dinosaur

All Organisms
- Plant Kingdom
- Fungi Kingdom
- Animal Kingdom
  - Protists Kingdom
  - Bacteria Kingdom

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

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

Archosauria Class
- Living reptiles — Testudines/Chelonia (turtle/tortoise), Squamata (lizards/snakes), Crocodylia (crocodiles, alligators/caymans).
- Nonliving extinct reptiles — Pterosauria (winged reptiles), Plesiosauria and Ichthyosauria (marine reptiles), and other orders.

Dinosauria subclass (“terrible” lizards from the Mesozoic Era)
- Saurischia (lizard-hipped), Ornithischia (bird-hipped), and others

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

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

Ceratopsidae Family
- Psittacosaurus, Protoceratops, Pachyrhinosaurus, Styracosaurus, 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

<table>
<thead>
<tr>
<th><strong>Kingdom</strong></th>
<th>Kelsey - Animalia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phylum</strong></td>
<td>Kelsey - Chordata</td>
</tr>
<tr>
<td><strong>Subclass</strong></td>
<td>Kelsey - Dinosauria</td>
</tr>
<tr>
<td><strong>Order</strong></td>
<td>Kelsey - Ornithischia</td>
</tr>
<tr>
<td><strong>Family</strong></td>
<td>Kelsey - Ceratopsidae</td>
</tr>
<tr>
<td><strong>Genus</strong></td>
<td>Kelsey - Triceratops</td>
</tr>
<tr>
<td><strong>Species</strong></td>
<td>Kelsey - horridus</td>
</tr>
</tbody>
</table>

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](http://dinosauricon.com/main/index.html)

---

**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

---

**Bonuses:** 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 *Dinosauria* 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.**

---

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

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

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

*Dinosauria* visitors can help prepare fossilized bones from an Edmontosaurus that were collected during the 2003 teacher dig.
Experience 2

Lesson 1

EXPERIENCE 2 — DINOSAUR SIZE

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.

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

What might have caused the death of this maiasaur?
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.

Indiana Academic Standards — Kindergarten

Science — 11, 1.2, 21, 2.2, 61
Language Arts — 13, 1.3, 71, 7.2, 7.3
Math — 19, 31, 4.2, 51, 6.2,
Social Studies — 1.1

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.

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

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.

Vocabulosaurus

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

- skeleton
- wire
- sculpture
- scale
- model

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

Indonesia 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

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.

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.

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.

The Children's Museum of Indianapolis © 2004
EXPERIENCE 2 — DINOSAUR SIZE

Compare Dinosaur Body Parts

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

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

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.

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 by Byron Barton.

Indiana Academic Standards — Grade 2
Science — 11, 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 — 19, 1.11, 1.12, 5.1, 5.2, 5.3, 6.2,

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 by Byron Barton.
Experience 2

Grades K – 2 | Lesson 1

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

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

The Children’s Museum of Indianapolis © 2004
Dino books


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.

<table>
<thead>
<tr>
<th>Dinosaur</th>
<th>Tally</th>
</tr>
</thead>
<tbody>
<tr>
<td>T. rex</td>
<td>12</td>
</tr>
<tr>
<td>Triceratops</td>
<td>8</td>
</tr>
<tr>
<td>Maiasaura</td>
<td>4</td>
</tr>
</tbody>
</table>

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

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.

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.
**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.

**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

**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.
EXPERIENCE 1 — WHY DO ANIMALS LIVE IN GROUPS?

Animals Groups

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?
- 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.

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.

Vocabulosaurs

- 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

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.

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.

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.
EXPERIENCE 1 — WHY DO ANIMALS LIVE IN GROUPS?

**Dinosaur Interaction**

**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.

**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

**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.

**Vocabulosoarsaur**
- **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.

**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.*
Experience 1

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.search4dinosaurus.com/pictures.html#about

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

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

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

Dino books


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.)


Dino video Walking With Dinosaurs. BBC and Discovery Channel, 1999.

Bonuses: 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.search4dinosaurus.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 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.

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!

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.

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?

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

Indiana Academic Standards — Kindergarten
Science — 1.1.2, 2.2
Language Arts — 1.3, 4.3, 5.1, 5.2, 7.2, 7.3
Math — 11, 3.1, 3.2, 6.2, 6.3

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.

The molds made from these bones will be used to make replicas of the originals.
EXPERIENCE 1 — HOW A DINOSAUR FOSSIL FORMS

Layered Fossil Parfait: Deeper Is Older

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.

Vocabulaurus

- 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

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.

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

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

**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.

**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.

**Dig tools**
- Claw resin cast — *T. rex*
- Tooth resin cast — *T. rex*

**Experience 1**

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

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**How to make a fossil cast**

1. Make an impression.
2. Fill the impression with plaster of paris.
3. Remove the cast from the mold.
EXPERIENCE 1 —
HOW A DINOSAUR FOSSIL FORMS

BONUS — Kelsey:
Clues of the Dig Site Map

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.

Indonesia 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

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

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


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**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.

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Each layer of a dinosaur excavation site has secrets to share like these fossilized rib bones.
Experience 1

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

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Life</td>
</tr>
<tr>
<td>2</td>
<td>Death</td>
</tr>
<tr>
<td>3</td>
<td>Sediments</td>
</tr>
<tr>
<td>4</td>
<td>Time</td>
</tr>
<tr>
<td>5</td>
<td>Fossilization</td>
</tr>
<tr>
<td>6</td>
<td>Exposure</td>
</tr>
</tbody>
</table>

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.

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

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.”

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 fleshted-out dinosaurs with skeletons of dinosaurs.
EXPERIENCE 2 — FOSSIL SKELETONS: OBSERVING, MAKING AND LEARNING

Dinosaur Flesh and Bones

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.

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

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.

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.

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

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.

Indiana Academic Standards — Grade 1
Science — 11, 2.4, 2.5, 2.6, 2.7, 5.2, 6.1
Language Arts — 7.9, 7.11
Math — 4.3, 6.2

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.

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

This giant plant-eater was named Triceratops (“three-horned face”) by Othniel Marsh in 1889.
EXPERIENCE 2 — FOSSIL SKELETONS: OBSERVING, MAKING AND LEARNING

Make a Dinosaur Model

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.

Vocabulosaursaurus
- 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

Dinosaur sites at Kid Sites
[http://www.kidsites.com/sites-edu/dinosaurs.htm](http://www.kidsites.com/sites-edu/dinosaurs.htm)

Dinosphere Paleo Prep Lab link on The Children's Museum Web site shows how a fossil is prepared.
[http://www.childrensmuseum.org](http://www.childrensmuseum.org)

Zoom Dinosaurs skeletons link

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.

Dino books


- **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.

Bucky, a *T. rex.* The shaded bones are real fossils.
**Bonus: Digging Deeper!**

After completing the activities in these lessons, some students can explore more about dinosaur skeletons and fossil 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?

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

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.

Indiana Academic Standards — Kindergarten

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

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 Franklin Branley and The Magic School Bus in the Time of the Dinosaurs by Joanna Cole.

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.

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.
EXPERIENCE 1 — QUESTIONS AND CLUES

What Happened to the Dinosaurs?

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 backbones).
- 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

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.

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

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.

Volcanic eruptions change the land and the atmosphere.

Vocabulosityaurus
- 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

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 Dinosaurs 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.
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.jpinstiute.com

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

- **Enchanted Learning — Comprehensive e-book about dinosaurs**
  http://www.zoomdinos.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**


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?

<table>
<thead>
<tr>
<th>Theory or idea</th>
<th>Evidence that supports theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dinosaurs were killed when:</td>
<td></td>
</tr>
<tr>
<td>A meteorite hit Earth</td>
<td>Layer of chemicals in soil</td>
</tr>
<tr>
<td>Great volcanoes erupted</td>
<td>Large lava fields around world</td>
</tr>
<tr>
<td>Geological changes occurred</td>
<td>Climate changes, seasonal changes, new plants and animals</td>
</tr>
<tr>
<td>Dinosaurs are not extinct:</td>
<td></td>
</tr>
<tr>
<td>Some dinosaurs evolved into modern birds</td>
<td>More than 60 similarities between birds and dinosaurs</td>
</tr>
</tbody>
</table>

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.
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.
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.

Dinosaurs

- 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.

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.

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

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.
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.

**Vocabulosaurs**

- **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**

**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.

**Tools**

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

A giant mold is needed to make a cast of a giant dinosaur.
EXPERIENCE 2 — PALEONTOLOGISTS

Paleontologists: Make Discoveries!

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.

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

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.

Vocabulosaurus

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

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

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

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Dino Web sites

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

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

**Stemberg Museum of Natural History (unofficial virtual tour)**
http://www.oceansofkansas.com/Stembrg.html

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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.

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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.

---

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.
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

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.

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.

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*. 

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


Models


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.

Dinosaur Webquests

- The Children’s Museum Dinosphere Webquests
  http://www.childrensmuseum.org

- 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.hnwm/science/si-science/biology/animals/burgess/dino/tour.htm

- Dino Web sites
  Artwork of Waterhouse Hawkins
  http://rainbow.ideo.columbia.edu/courses/v1001/dinodis3.html

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

- Sternberg Museum of Natural History (unofficial virtual tour)
  http://www.oceansoffkansas.com/Sternbq.html

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

Vince Vaccarella for CPE 542 — Technology in Education

http://www.lfelem.lfcs.edu/tech/DuBose/Webquest/Vaccarello/WQPS_VV.html

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

What are dinosaurs?

Dinosaurs are a special group of animals that were alive more than 65 million years ago. Dinosaurs are an extinct subclass of Archosauromorpha, 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.

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.

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 enormity 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.
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.

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 *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.

**Why focus on the Cretaceous Period?**

Ammonites are extinct mollusks from the Mesozoic Era. Their fossilized shells are found in great quantities and help to date other fossils found nearby.
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, horseshoe crabs, dragonflies and horseshoe crabs. The fossil record is rich in opportunities to learn about the past but much more lies buried, waiting to be uncovered. This helps to make digging for fossils an ongoing and exciting endeavor for adults and children.

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

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

An easy way to remember the different groups is with this phrase:
Kids Please Come Over For Great Science!

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

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

These pieces will need hours of preparation before the Gorgosaurus skull is ready for Dinosphere.
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 other large theropods may have banded together to attack and kill prey. Even grown 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.

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.

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.

The Children’s Museum of Indianapolis © 2004
Stan's pathologies
Stan has some interesting pathologies — or healed injuries — that create a picture of what life was like for such predators. The T. rex has several broken and healed ribs, as well as a scar that may match the size and shape of a T. rex tooth. At some point, Stan also suffered a broken neck. As it healed, two vertebrae fused together and a third was immobilized by extra bone growth. Even more spectacular is a hole in the back of the skull. A piece of fossilized bone 2 by 5 inches broke off inside the braincase. Pete Larson, of the Black Hills Geological Institute, speculates that the size of the hole matches a T. rex tooth. Whatever the immediate effect of these injuries, Stan lived through them to fight another day. Perhaps disease or old age finally killed the T. rex.

As Stan's carcass rotted in the sun, scavengers pulled apart much of the skeleton and skull. Spring floods eventually covered the bones, which remained buried for 65 million years.

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

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

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

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

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

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

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

Stan — Tyrannosaurus rex

<table>
<thead>
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<td>Camarasauria (meat-eating lizard)</td>
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<td>Genus</td>
<td>Tyrannosaurus (tyrant lizard)</td>
</tr>
<tr>
<td>Species</td>
<td>rex (king)</td>
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</tbody>
</table>
Tyrannosaurus rex — Stan
Resource Materials

Drawing

*Tyrannosaurus rex — Stan*

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

Kingdom Animalia (animals)
Phylum Chordata (animals with spinal nerve cords)
Subphylum Vertebrata (chordates with backbones)
Class Archosauria (“ruling reptiles”)
Subclass Dinosauria (extinct reptiles, “terrible lizards”)
Order Saurischia (lizard-hipped)
Suborder Theropoda (beast-footed)
Family Tyrannosauridae (tyrant lizard)
Genus Tyrannosaurus (tyrant lizard)
Species rex (king)
The shaded bones are real fossils.

Scale: 1 cm = .5 m
Tyrannosaurus rex — Bucky
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 most complete ever. *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 7 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 Zerbst family’s granddaughter Kelsey Ann. John Bell Hatcher described the first *Triceratops* fossils in 1889. Othniel C. Marsh named the specimen “three-horned face.” The name refers to the two large brow horns and the smaller nose horn of these animals. This easily recognized dinosaur has become widely popular, particularly among children who have seen movies featuring the behemoth as a peaceful, plant-eating creature.

**Fossils**

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

**Dinosphere link**

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

**Dinosphere Dinosaur Classification**

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

Kids Please Come Over For Great Science!

**Kelsey — *Triceratops horridus***

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<td>Family</td>
<td>Ceratopsidae (frilled dinosaurs, including horned dinosaurs)</td>
</tr>
<tr>
<td>Genus</td>
<td>Triceratops (three-horned face)</td>
</tr>
<tr>
<td>Species</td>
<td>horridus (horrible — describing the horns)</td>
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</tbody>
</table>
Skeleton Diagram
*Triceratops horridus* — Kelsey

The shaded bones are real fossils.

Scale: 1 cm = 28 cm
Resource Materials

Drawing
Triceratops horridus — Kelsey
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 scopped 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, focusing 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.

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

*Oviraptor* embryo — Baby Louie

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

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

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 Homer a coffee can full of little fossilized bones. Homer 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 hatching. Though more recent research has challenged Horner’s hypothesis, the “good-mother lizard” moniker has stuck. Like the challenged Horner’s hypothesis, the “good-shells. Though more recent research has challenged Horner’s hypothesis, the “good-mother lizard” moniker has stuck. Like the challenged Horner’s hypothesis, the “good-mother lizard” moniker has stuck. Like the challenged Horner’s hypothesis, the “good-mother lizard” moniker has stuck.

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.

Dinosaur Classification

| Kingdom | Animalia (animals) |
| Phylum   | Chordata (animals with spinal nerve cords) |
| 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) |

| Kingdom | Animalia (animals) |
| Phylum   | Chordata (animals with spinal nerve cords) |
| 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) |

Dinosphere Dinosaur Classification

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

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.

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.

Size
Maiasauras 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.

Duckbill — Maiasaura peeblesorum

Duckbill — Edmontosaurus annectens
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**

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<tr>
<td>Genus</td>
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<tr>
<td>Species</td>
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**Resource Materials**

The Children’s Museum of Indianapolis © 2004
Skeleton Diagram

_Gorgosaurus sp._

The shaded bones are real fossils.

Scale: 1 cm = .5 m
Drawing
Gorgosaurus sp.
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 Flammend 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 Please Come Over For Great Science!

<table>
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<tr>
<th>Kingdom</th>
<th>Animalia (animals)</th>
</tr>
</thead>
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<tr>
<td>Phylum</td>
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</tr>
<tr>
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<td>Archosauria (“ruling reptiles”) Subclass Dinosauria (extinct reptiles, “terrible lizards”)</td>
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<tr>
<td>Order</td>
<td>Ornithischia (bird-hipped)</td>
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<tr>
<td>Suborder</td>
<td>Suborder Marginocephalia (fringed heads)</td>
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<tr>
<td>Species</td>
<td>not named at this time</td>
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</table>
Skeleton Photos

*Leptoceratops* sp. — Frannie

*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

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<td>Subclass Dinosauria (extinct reptiles, “terrible lizards”)</td>
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<tr>
<td>Order</td>
<td>Ornithischia (bird-legged)</td>
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<tr>
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<td>Suborder Ornithopoda (bird-footed)</td>
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<td>Family</td>
<td>Hadrosauridae (bulky lizard)</td>
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<td>Genus</td>
<td>Hypacrosaurus (almost the highest lizard)</td>
</tr>
<tr>
<td>Species</td>
<td>stebingeri (after Eugene Stebinger, who found the first specimens)</td>
</tr>
</tbody>
</table>

Kids Please Come Over For Great Science!
Skeleton Diagram

*Hypacrosaurus stebingeri*

The shaded bones are real fossils.

Scale: 1 cm = 0.5 m
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

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<td>Subclass Dinosauria (extinct reptiles, “terrible lizards”)</td>
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<tr>
<td>Order</td>
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<td>Suborder Theropoda (beast-footed)</td>
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<tr>
<td>Family</td>
<td>Coelurosauridae (very advanced meat-eaters)</td>
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<tr>
<td>Genus</td>
<td>Bambiraptor (baby raptor)</td>
</tr>
<tr>
<td>Species</td>
<td>feinbergi (in honor of Michael and Ann Feinberg)</td>
</tr>
</tbody>
</table>
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**

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

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Black Hills Institute of Geological Research, Inc.
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<td>Dinosaur fossil bones in <em>Dinosphere</em></td>
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Dinosphere Floor Plan
**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 stalkling 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*. 

---

*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.*
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.
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.

*A family of hypacosaurs pause for a drink of water, but predators lurk nearby.*
Paleo-artist Michael Skrepnick’s “Watering Hole” scene is based on the most current research about dinosaur habits and interactions.
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.
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?
**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.
## 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.

<table>
<thead>
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<th>Exhibit</th>
<th>Fossil</th>
<th>Exhibit</th>
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<td><strong>Tyrannosaurus rex</strong></td>
<td>Gastroolith</td>
<td><strong>Gastroolith</strong></td>
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<tr>
<td>Skeleton</td>
<td><strong>Triceratops horridus</strong></td>
<td>Bronze egg</td>
<td><strong>Troodon</strong></td>
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<tr>
<td>Skeleton</td>
<td><strong>Gorgosaurus sp.</strong></td>
<td>Bronze egg</td>
<td><strong>Therizinosaurus</strong></td>
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<tr>
<td>Skeleton</td>
<td><strong>Malasaura peeblesorum</strong></td>
<td>Bronze egg</td>
<td><strong>Tyranosaurus rex</strong></td>
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<tr>
<td>Skeleton</td>
<td><strong>Leptoceras sp.</strong></td>
<td>Bronze egg</td>
<td><strong>Hadrosaurus</strong></td>
</tr>
<tr>
<td>Skeleton</td>
<td><strong>Hypacrosaurus stebingeri</strong></td>
<td>Bronze egg</td>
<td><strong>Titanosaurus</strong></td>
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<tr>
<td>Skeleton Cast</td>
<td><strong>Bambiraptor feinbergi</strong></td>
<td>Egg fragments</td>
<td><strong>Oviraptor</strong></td>
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<tr>
<td>Furcula</td>
<td><strong>Tyrannosaurus rex</strong></td>
<td>Raptor embryo and nest</td>
<td><strong>Unidentified</strong></td>
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<tr>
<td>Mandible</td>
<td><strong>Tyrannosaurus rex</strong></td>
<td>Gorgosaur skull &amp; mandible</td>
<td><strong>Gorgosaurus</strong></td>
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<tr>
<td>Tooth</td>
<td><strong>Tyrannosaurus rex</strong></td>
<td>Water bug</td>
<td><strong>Hemiptera</strong></td>
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<tr>
<td>Horn Core</td>
<td><strong>Triceratops</strong></td>
<td>Camarasaur egg</td>
<td><strong>Camarasaurus</strong></td>
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<tr>
<td>Teeth</td>
<td><strong>Triceratops</strong></td>
<td>Hadrosaur egg</td>
<td><strong>Hadarosaurus</strong></td>
</tr>
<tr>
<td>Femur</td>
<td><strong>Triceratops horridus</strong></td>
<td>Copal with inclusions</td>
<td><strong>Agathis australis and others</strong></td>
</tr>
<tr>
<td>Mandible</td>
<td><strong>Triceratops</strong></td>
<td>Ammonite</td>
<td><strong>Rhondiceras sp.</strong></td>
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<tr>
<td>Amn</td>
<td><strong>Gorgosaurus</strong></td>
<td>Ammonite in nodule</td>
<td><strong>Promicraceras planicosta</strong></td>
</tr>
<tr>
<td>Skull and mandible</td>
<td><strong>Monoclonius</strong></td>
<td>Jurassic ammonite</td>
<td><strong>Dactylioceras sp.</strong></td>
</tr>
<tr>
<td>Skull and mandible</td>
<td><strong>Protoceratops andrewsi</strong></td>
<td>Archaeopteryx</td>
<td><strong>Archaeopteryx</strong></td>
</tr>
<tr>
<td>Skull and mandible</td>
<td><strong>Ankylosaurus</strong></td>
<td>Allosaurus hand</td>
<td><strong>Allosaurus fragilis</strong></td>
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<tr>
<td>Skull and mandible</td>
<td><strong>Camarasaurus</strong></td>
<td>Amber</td>
<td><strong>Agathis australis and others</strong></td>
</tr>
<tr>
<td>Skull and mandible</td>
<td><strong>Duckbill</strong></td>
<td>Pinecone fossil</td>
<td><strong>Araucaria mirabilis</strong></td>
</tr>
<tr>
<td>Skin cast</td>
<td><strong>Edmontosaurus annectens</strong></td>
<td>Dinosaur track</td>
<td><strong>Anchisaurus sp.</strong></td>
</tr>
<tr>
<td>Teeth</td>
<td><strong>Edmontosaurus annectens</strong></td>
<td>Seed fern</td>
<td><strong>Atelepteriis grandini</strong></td>
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<tr>
<td>Eggshell</td>
<td><strong>Saltasaurus</strong></td>
<td>Lioening leaf</td>
<td><strong>Cladus sp.</strong></td>
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<tr>
<td>Egg</td>
<td><strong>Oviraptor</strong></td>
<td>Foot</td>
<td><strong>Apatasaurus louisae</strong></td>
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<tr>
<td>Egg</td>
<td><strong>Hypselosaurus priscus</strong></td>
<td>Fossil wood</td>
<td><strong>Cycadales</strong></td>
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<tr>
<td>Jaw</td>
<td><strong>Didelphodon</strong></td>
<td>Ginkgo leaf</td>
<td><strong>Ginkgoites sibrica</strong></td>
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<tr>
<td>Dragonfly</td>
<td><strong>Cordulagomphus tuberculatus</strong></td>
<td>Gallator trackway</td>
<td><strong>Ichnogenus Gallator</strong></td>
</tr>
<tr>
<td>Dragonfly</td>
<td><strong>Aeschnidium cancella</strong></td>
<td>Triassic petrified wood</td>
<td><strong>Araucaria sp.</strong></td>
</tr>
<tr>
<td>Dragonfly</td>
<td><strong>Aeschnidium cancella</strong></td>
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<td><strong>Araucaria sp.</strong></td>
</tr>
<tr>
<td>Dragonfly Lava</td>
<td><strong>Dragonfly</strong></td>
<td>Jurassic horseshoe crab</td>
<td><strong>Mesolimulus walchi</strong></td>
</tr>
<tr>
<td>Dragonfly Lava</td>
<td><strong>Dragonfly</strong></td>
<td>Keichousaurus</td>
<td><strong>Keichousaurus yuwanenensis</strong></td>
</tr>
<tr>
<td>Pinecones</td>
<td><strong>Sequoya dakotensis</strong></td>
<td>Anomoza leaf</td>
<td><strong>Anomoazmites inconstans</strong></td>
</tr>
<tr>
<td>Ammonite</td>
<td><strong>Desmoceras sp.</strong></td>
<td>Rhamphorhynchus</td>
<td><strong>Rhamphorhynchus gemmingi</strong></td>
</tr>
<tr>
<td>Ammonite</td>
<td><strong>Scaphites</strong></td>
<td>Pinecone fossil</td>
<td><strong>Araucaria mirabilis</strong></td>
</tr>
<tr>
<td>Ammonite</td>
<td><strong>Lemuroceras sitampikyense</strong></td>
<td>Petrified wood</td>
<td><strong>Araucaria mirabilis</strong></td>
</tr>
<tr>
<td>Crab</td>
<td><strong>Grapsoideus</strong></td>
<td>Jurassic shrimp</td>
<td><strong>Aeger tipularis</strong></td>
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<tr>
<td>Baculite</td>
<td><strong>Baculites</strong></td>
<td>Sycamore leaf</td>
<td><strong>Ficus sycomorus</strong></td>
</tr>
<tr>
<td>Guitarfish</td>
<td><strong>Rhombopentygia rajoides</strong></td>
<td>Trilobites</td>
<td><strong>Dalmanites limulus</strong></td>
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<tr>
<td>Coprolite</td>
<td><strong>Coprolites</strong></td>
<td>Apatasaur vertebra</td>
<td><strong>Apatasaurus</strong></td>
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</table>
### Important Dates in Dinosaur Discovery

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>600 B.C.</strong></td>
<td>Central Asian traders bring stories of griffins, based on the fossil record of <em>Protoceratops</em>, to the ancient Greeks.</td>
</tr>
<tr>
<td><strong>300 A.D.</strong></td>
<td>Chinese scholars record the presence of &quot;dragon bones.&quot;</td>
</tr>
<tr>
<td><strong>1677</strong></td>
<td>Robert Plot illustrates a thighbone, possibly of <em>Megalosaurus</em>.</td>
</tr>
<tr>
<td><strong>1824</strong></td>
<td>William Buckland names <em>Megalosaurus</em>, the first dinosaur to be scientifically described.</td>
</tr>
<tr>
<td><strong>1825</strong></td>
<td>Gideon Mantell and his wife find a dinosaur tooth and name the genus <em>Iguanodon</em>.</td>
</tr>
<tr>
<td><strong>1842</strong></td>
<td>Richard Owen coins the term <em>dinosauria</em>.</td>
</tr>
<tr>
<td><strong>1850–1851</strong></td>
<td>Models of <em>Iguanodon</em>, <em>Megalosaurus</em> and <em>Hylaeosaurus</em>, made by Waterhouse Hawkins, are displayed in the Great Exhibit at the Crystal Palace in London.</td>
</tr>
<tr>
<td><strong>1856</strong></td>
<td>The first dinosaur remains from the United States are described.</td>
</tr>
<tr>
<td><strong>1867</strong></td>
<td>Thomas Henry Huxley is the first scientist to suggest that birds are the direct descendants of dinosaurs.</td>
</tr>
<tr>
<td><strong>1877–1895</strong></td>
<td>&quot;The Bone Wars,&quot; 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.</td>
</tr>
<tr>
<td><strong>1878</strong></td>
<td>Miners discover dozens of <em>Iguanodon</em> skeletons at Bernissart, Belgium.</td>
</tr>
<tr>
<td><strong>1920s</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>1930s</strong></td>
<td>The Chinese scientist C.C. Young begins a series of expeditions to excavate dinosaurs in China.</td>
</tr>
<tr>
<td><strong>1969</strong></td>
<td>John Ostrom, of Yale University, publishes a description of <em>Deinonychus</em>, beginning a revolution in the way scientists and the public perceive dinosaurs.</td>
</tr>
<tr>
<td><strong>1970–present</strong></td>
<td>Increasing evidence suggests that dinosaurs are indeed the ancestors of birds. Continued study of specimens shows that dinosaurs were active, complex animals.</td>
</tr>
</tbody>
</table>

### Sources:
**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 Tyrell 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 Organismic Biology and Anatomy at the University of Chicago and considered one of the brightest minds in the research of South American and African dinosaur material. He also led the team to excavate and bring back the Super Croc fossils that serve as the basis for the replica in *Dinosphere*.

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

**Dinosaur Hunters**
Adapted from “Great Fossil Hunters of All Time”
http://www.enchantedlearning.com/subjects/dinosaurs/

**Roy Chapman Andrews** (1884–1960) was a biologist. U.S. fossil hunter and director of the American Museum of Natural History from 1935 to 1942. Andrews led five expeditions into Mongolia’s Gobi desert from 1922 to 1930, where he discovered the first dinosaur eggs known to science; identified many new species of dinosaurs; made important finds about now-extinct mammals, including the largest known land mammal, *Baluchitherium*; and found evidence of early Stone Age humans in Central Asia.

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

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

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

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

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

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


**Resource Materials**

**Dinosaur Hunters continued**

**Philip Currie** is one of the world’s leading dinosaur paleontologists and curator at the Royal Tyrell 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 lifesize 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 Tyrell Museum of Palaeontology in Alberta, Canada. She studies the microfossils left behind by pollen grains and spores from ancient plants, and writes dinosaur books with her husband, the paleontologist Philip Currie.

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

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

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

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

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

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

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

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


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


Dinosaur Books for the Classroom

Dinosaur Videos


Models

Dinosaur Web Sites*
Artwork of Waterhouse Hawkins
http://rainbow.ideo.columbia.edu/courses/v1001/dinodis3.html

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

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

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

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

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

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

The Dinosauricon, by Mike Keesey

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.jspinstitute.com

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

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

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

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

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

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

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

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

Dinosaursia — “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.

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 horse-shoe crabs.

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

**Maiasaura** — a heading 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 upon 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 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.

**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
# Resource Materials

## What's in a Dinosaur Name?

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

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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 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 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.

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.

3.1.4 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
3.4.9 Explain that some diseases are caused by germs and some are not. Note that organisms living today.
3.4.8 Explain that some things people take into their bodies from the environment can hurt them and give examples of such things.
3.4.7 Explain that eating a variety of healthful foods and getting enough exercise and rest help people to stay healthy.
3.4.6 Explain that people need water, food, air, waste removal, and a particular range of temperatures, just as other animals do.
3.4.5 Give examples of some kinds of organisms that have completely disappeared and explain how these organisms were similar to some organisms living today.
3.4.4 Describe that almost all kinds of animals’ food can be traced back to plants.
3.4.3 Observe that and describe how offspring are very much, but not exactly, like their parents and like one another.
3.4.2 Explain that features used for grouping depend on the purpose of the grouping.
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.
3.3.1 Recognize that models are different from the real thing but can be used to help people to see things that are hard to see and/or record.
3.3.2 Investigate how and describe that something may not work if some of its parts are missing.
3.3.3 Explain how a model of something is simpler than the real thing but can be used to learn something about the real thing.
3.3.4 Take, record, and display counts and simple measurements of things over time, such as plant or student growth.
3.3.5 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 ask 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.
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.
5.1 Explain that telescopes are used to magnify distant objects in the sky including the moon and the planets.

5.2 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 Observe the stars and identify stars that are unusually bright and those that have unusual colors, such as reddish or bluish.

5.4 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.

5.5 Observe and explain that clouds and fog are made of tiny droplets of water.

5.6 Demonstrate that things on or near the Earth are pulled toward it by the Earth's gravity.

5.7 Describe that, like all planets and stars, the Earth is approximately spherical in shape.

5.8 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.

5.9 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.

5.10 Investigate that some materials conduct heat much better than others, and poor conductors can reduce heat loss.

5.11 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.

5.12 Explain that objects move at different rates, with some moving very slowly and some moving too quickly for people to see them.

5.13 Demonstrate that the Earth's gravity pulls any object toward it without touching it.

The Mathematical World

5.1 Make precise and varied measurements and specify the appropriate units.

5.2 Show that mathematical statements using symbols may be true only when the symbols are replaced by certain numbers.

5.3 Classify objects in terms of simple figures and solids.

5.4 Compare shapes in terms of concepts, such as parallel and perpendicular, congruence, and symmetry.

5.5 Demonstrate that areas of irregular shapes can be found by dividing them into squares and triangles.

5.6 Describe and use drawings to show shapes and compare locations of things very different in size.

5.7 Explain that predictions can be based on what is known about the past, assuming that conditions are similar.

5.8 Realize and explain that predictions may be more accurate if they are based on large collections of objects or events.

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.

5.10 Explain the danger in using only a portion of the data collected to describe the whole.

Common Themes

5.1 Recognize and describe that systems contain objects as well as processes that interact with each other.

5.2 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.

5.3 Recognize and describe that almost anything has limits on how big or small it can be.

5.4 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, 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.
Today I discovered …
Today I discovered