dinosaurs

teacher's guide

University of Nebraska State Museum

The Dinosaurs Encounter Kit
has been generously funded by the
Nebraska Federation of Women's Clubs

This kit was developed by the Public Programs Division of the University of Nebraska State Museum.
It's development was made possible by the input and guidance of
Rosemary Thornton, Science Teacher, Lincoln Public Schools,
Dr. George F. Engelmann, University of Nebraska-Omaha,
and Curator of Paleontology, Mike Voorhies at the University of Nebraska State Museum.

UNIVERSITY OF NEBRASKA STATE MUSEUM

UNIVERSITY OF Nebraska Lincoln

Dear Colleague,

The goal of the Dinosaur Encounter Kit is to bring hands-on materials from the University of Nebraska State Museum and inquiry based activities to the classroom. It is designed to introduce some of the lesser-known aspects of the fascinating world of dinosaurs to students. It will complement and enrich existing dinosaur curricula.

The objectives of this Encounter Kit are for students to:

1. investigate the diversity among dinosaurs by developing different strategies for grouping dinosaurs;

2. explore how scientists use distribution of dinosaur fossils to understand the movements of the continents;

3. obtain a better grasp of geologic time and important events that happened in earth's history;

4. practice excavation skills and train their eyes to distinguish dinosaur bone from rock;

5. explore dinosaur behavior by creating dinosaur track records.

The activities range in **length from 45 to 60 minutes**. Some of the activities are more appropriate for younger students, while others are better for 4th grade and above. All can be adapted for any age. Any group size is possible, but **groups of fewer than 30 students** is recommended. Students should have a comfortable amount of space for viewing or working with materials.

Your input into the usefulness, effectiveness, and enjoyment of this kit is valuable. Please assist the University of Nebraska–Lincoln in insuring that our goal and objectives are met by completing the enclosed **Evaluation Form** in the kit. Your opinion is most important!

We hope that you and your students enjoy learning about rich diversity of the dinosaurs. If you have any questions feel free to call (402) 472-6302.

The University of Nebraska State Museum Education Staff

Table of Contents

Encounter Kits

Encounter Kits are organized around a teaching-learning framework, which guides teaching and learning through four main stages.

STARTING OUT:

Usually a full group discussion. This provides an opportunity for you to stimulate curiosity, set challenges, and raise questions. Students share their knowledge and previous experience on the topic.

Teacher:

- Probes for current knowledge and understanding
- Motivates and stimulates activity
- Sets challenges and poses problems

Student:

- Shares thoughts and ideas
- Raises questions

ACTIONS:

Groups of students look closely at the phenomena or actively participate in actual scientific work. They work directly with materials. It is important to allow enough time for this inquiry stage, so that they can explore materials and concepts that are new and fully experience trial and error. This can be an investigation time as students discuss ideas together, try out activities and manipulate materials.

Teacher:

- Facilitates
- Observes

Student:

- Explores
- Observes
- Works as a team member
- Problem solves
- Records

TYING IT ALL TOGETHER:

Usually a full group experience, this stage provides students with the opportunity to share their discoveries and experiences. You guide them as they clarify and organize their thinking, compare their different solutions, analyze and interpret results, and attempt to explain the phenomena they have experienced.

Teacher:

- Questions
- Guides
- Assesses student understanding

Student:

- Interprets and analyzes
- Synthesizes
- Communicates
- Questions

BRANCHING OUT:

This optional stage allows the students to connect and relate learning from the kit activity into other projects and activities.

Teacher:

- Facilitates
- Assesses understanding

Student:

- Applies
- Questions
- Integrates

Activity One – Dinosaur Diversity

Learning Objective:

Students investigate the diversity among dinosaurs by developing different strategies for grouping them together. This activity introduces students to scientific terms and dinosaurs that are used throughout the kit.

Activity One – Dinosaur Diversity

Group size:
Divide class into 16 teams of two or less students.

Time:
30 minutes

Materials Provided:

- Dinosaur Models (16)

Allosaurus	*Iguanodon*
Apatosaurus	*Maiasaura*
Cetiosauriscus	*Parasaurolophus*
Corythosaurus	*Plateosaurus*
Deinonychus	*Spinosaurus*
Dilophosaurus	*Stegosaurus*
Diplodocus	*Triceratops*
Euoplocephalus	*Tyrannosaurus*

- *Dinosaurs* poster series (4)
  - *Dinosaurs of the British Isles 115 million years ago*
  - *Dinosaurs of North America 140 million years ago*
  - *The End of the Dinosaurs 65 million years ago*
  - *Early Dinosaurs 200 million years ago*
- Dinosaur Groups activity sheet
- Dinosaur Information cards (16)
- *Dinosaurs Golden Guide*

Additional Materials Included in Kit:

- *Dinosaurs and How They Lived*
- *National Geographic* Vol. 183; January, 1993

Preparation:

- Place the posters around the room where students can use them.
- Make a copy of the Dinosaur Groups activity sheet for each student.
- Match the 16 models and information cards together to distribute to students (each model has its name printed on its stomach)

Background:

Dinosaurs are one of the many types of animals that lived during the Mesozoic Era from 250 to 65 million years ago. We think of this as the time of the dinosaurs, but there were also insects, fish, birds, mammals and reptiles. Dinosaurs are reptiles, but they are different from other reptiles because they walk and run with their legs under their bodies, not spread wide like a lizard's legs. Dinosaurs are also different because they lived on land. They did not live in the sea or fly. The amazing swimming and flying reptiles of the Mesozoic are not dinosaurs.

There were many different types of dinosaurs. Some were larger than five elephants, while others were as small as a chicken. Most were plant eaters, but some ate eggs or other animals. Some dinosaurs ran on two legs, while other used four. So far scientists have discovered more than 350 different kinds of dinosaurs, and there may be many more that we do not know about yet.

Paleontologists, scientists who study the plants and animals of the past, learn about dinosaurs by examining their bones, teeth, eggs, footprints, skin imprints, and coprolites (droppings) that have been fossilized. Recently paleontologists have discovered that soft tissue such as hearts and other internal organs may have been fossilized too. Every year scientists learn more about dinosaurs.

Part 1: Students Group Dinosaurs

- As a class, brainstorm descriptions of dinosaurs.
- Ask, "How could dinosaurs be divided into groups based on your descriptions?"
- Give each team a **dinosaur**, the **Dinosaur Information card** that describes it and a **Dinosaur Groups activity sheet**.

Action:

1. Read about your dinosaur and record its name on the activity sheet. (Each model has its name printed on its stomach.)
2. Join with another team and compare your two dinosaurs (This makes 8 groups.). Decide if the dinosaurs are alike. Record your decision on the activity sheet.
3. Join with another team and compare your dinosaurs. (This makes 4 groups.) Decide which dinosaurs are alike. Record your decision on the activity sheet.
4. Join with another team and compare your dinosaurs. (This makes 2 groups.) Decide which dinosaurs are alike. Record your decision on the activity sheet.
5. Now look at all eight of your team's dinosaurs. Create a system that groups similar dinosaurs together. Try to make at least three groups. Sometimes a dinosaur may be in a group all by itself.
6. Compare your system for grouping the dinosaurs with the other team. (There are no wrong answers. The goal is to group dinosaurs - it doesn't matter how it is done.)

Part 2: Scientists Group Dinosaurs

- Just like you, scientists have come up with a system for grouping dinosaurs. All scientists use the same system that divides all dinosaurs into six groups.
- Write the name of each group on the chalkboard as you introduce it.
- Use the chart on the next page as a reference if students have questions about which group a dinosaur belongs in. The small, brown Plateosaurus is an early Sauropod, but looks similar to some of the Theropods because those two groups are closely related. All the dinosaurs have their name on their stomach.

Action:

1. One group of dinosaurs is the Theropods. This group includes all meat-eating dinosaurs. Does your team have any theropods?
2. Most dinosaurs are plant eaters. The other five groups are all plant eaters. Sauropods are big, long necked dinosaurs. Do you have any sauropods?
3. The Ornithopods are called duck billed dinosaurs because they have wide flat noses. Do you have any ornithopods?
4. The Stegosaurs are dinosaurs with plates on their back. Do you have any stegosaurs?
5. The Ankylosaurs are armored dinosaurs. They are built like tanks. Do you have any ankylosaurs?
6. The Ceratopians are dinosaurs with horns on their heads. Do you have any ceratopians?
7. Decide which group the dinosaur you started with belongs in and record it on your Dinosaur Groups activity sheet.
8. With your team, put your dinosaurs into these six groups that scientists use. You may not have a dinosaur that fits each group. There are lots of dinosaurs in each group, but we only have sixteen today.
9. Hold up your Theropods . . . Sauropods . . . Ornithopods . . . Ankylosaurs . . . Stegosaurs . . . and Ceratopians.

Part 2: Scientists Group Dinosaurs (cont.)

Groups Scientists Use

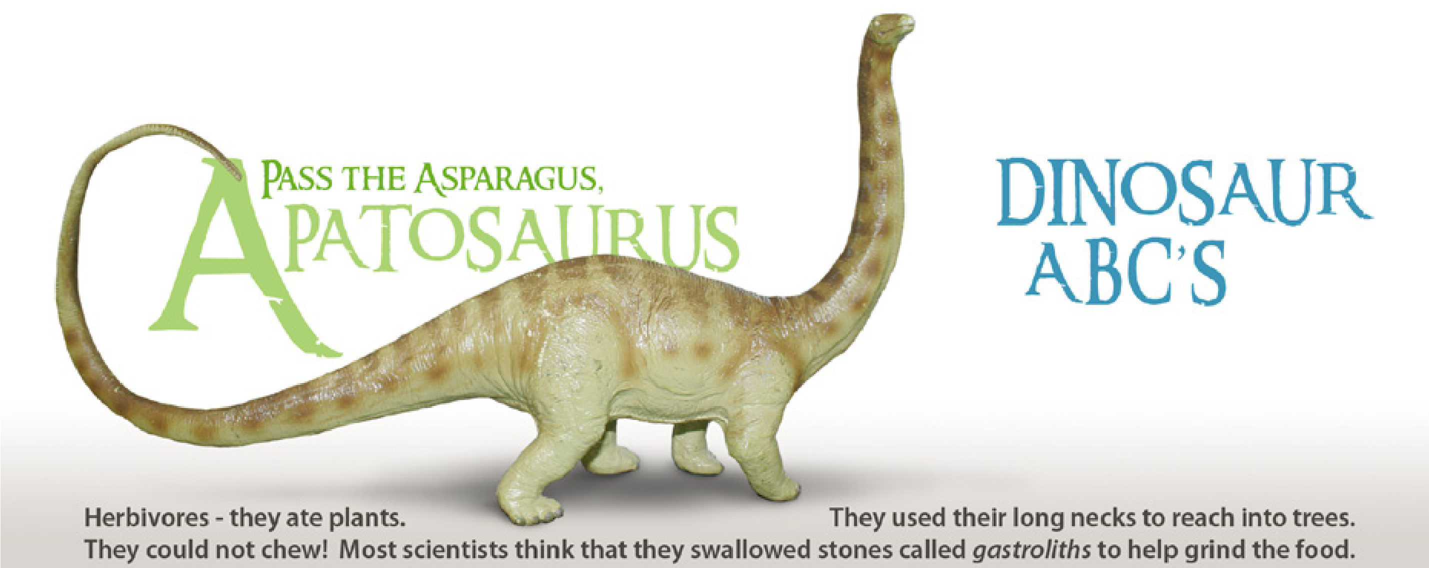
Sauropods	Theropods	Ornithopods	Ankylosaurs	Stegosaurs	Ceratopians
Plateosaurus	*Dilophosaurus*	*Corythosaurus*	*Euoplocephalus*	*Stegosaurus*	*Triceratops*
Diplodocus	*Deinonychus*	*Iguanodon*			
Apatosaurus	*Allosaurus*	*Maiasaura*			
Cetiosauriscus	*Spinosaurus*	*Parasaurolophus*			
	Tyrannosaurus				

Tying It All Together:

- Do all the dinosaurs in each group look like they belong together?
- All of the dinosaurs in a group have things in common about how they behaved and how their bodies worked, but they don't always look the same.
- Scientists group dinosaurs by the similar ways they lived rather than by how they looked

Branching Out:

1. Create a learning center with the dinosaur models, Dinosaur information cards, and the books included in the kits. Let students find new ways to group the dinosaurs and investigate how the dinosaurs lived.
2. Make a classroom book of Dinosaur ABC's. Have students select their favorite dinosaur names and facts. Arrange them alphabetically, challenge students to come up with creative ideas for difficult letters like "Quacky Dinosaurs: All about Duckbills". When the class has decided what to put in their book, have each student make one or two pages, then bind them all together and share the book with others in your school library.



Dinosaur Groups Activity Sheet

This dinosaur is ____

First Group

This dinosaur is like ____________________ because ____________________ .

This dinosaur *is not* like ____________________ because ____________________ .

Second Group

This dinosaur is like ____ because

____ .

This dinosaur *is not* like ____ because

____ .

Third Group

This dinosaur is like ____ because

____

____

____ .

This dinosaur *is not* like ____ because

____

____

____ .

Scientists put this dinosaur in the ____ group,

because it is ____ .

Activity Two – Dinosaurs on the Move

Learning Objective:
Students explore how scientists use the distribution of dinosaur fossils to understand the movements of the continents.

Activity Two – Dinosaurs on the Move

Group size:

Divide the class into groups of two.

Time:

45 minutes

Materials Provided:

- Map Puzzle Activity Sheet (template)
- Small dinosaur models (6)

  Triceratops — *Parasaurolophus*

  Brontosaurus — *Stegosaurus*

  Tyrannosaurus — *Brachiosaurus*
- Moving Continents Model
- *North America in the Age of Dinosaurs* poster
- *National Geographic* Vol. 183; January, 1993

Supplies Needed Per Student:

- Scissors

Additional Materials Included in Kit:

- *Dinosaurs and How They Lived*

Preparation:

- Make copies of the Map Puzzle Activity Sheet for each student
- Hang up the *North America in the Age of Dinosaurs* poster.

Background:

The land we live on is very slowly moving and changing. Three hundred twenty-five million years ago there were three continents. Two hundred million years ago they came together in one gigantic continent called Pangaea (*pan* means all, *gaea* means earth). Today there are seven continents.

Studying dinosaur fossils can help us understand this movement because dinosaur fossils have been found throughout the world on every continent. The fossil record shows us where dinosaurs lived millions of years ago.

It shows us that the dinosaurs living 200 million years ago were able to roam freely across Pangaea. Then, about 180 million years ago, Pangaea began to split up. Eventually two new continents formed; one in the north and one in the south. Laurasia was the name of the continent in the north and Gondwanaland was in the south. Because these two continents were divided by an ocean, dinosaurs could not travel between them. From this time, scientists have found fossils of the same kind of dinosaur in Asia and North America, but not in South America.

By the end of the age of the dinosaurs the continents were divided much as they are today. The dinosaurs that lived then could not travel between the continents. The dinosaurs who lived on different continents 65 million years ago, were very different from each other.

Part 1: Moving Continents

- Use the **Moving Continents Model** to demonstrate how the continents move. The laminated continents will slide smoothly along a table or desktop. As you move the continents around, talk to students about how they have moved through time.

Action:

1. The land we live on today is moving on the surface of the earth. It moves very slowly, too slowly for people to see. During the time of the dinosaurs the continents were moving just like today (place dinosaur models on the continents).
2. Studying dinosaur fossils helps us understand how the continents moved in the past. When the continents are connected, the dinosaurs can move from one to the other (move two continents together and move the dinosaurs between them).
3. At the beginning of the age of the dinosaurs, all the continents were together (group continents together). This big continent was called Pangaea, which means “all earth.” Where could the dinosaurs go then? (Move dinosaurs between continents.) What do you think happened to the dinosaurs when the continents moved apart (separate continents)?
4. By studying where a particular type of fossil is found, we can figure out if the continents were together or apart when that animal lived. It can help us understand what the world looked like at that time. Some types of dinosaurs are found all over the world, but others are found on only one or two continents. Now you use dinosaur models to figure out what the world looked like in the past.

Part 2: Puzzling Maps

- Have students work with a partner. Give each pair of students scissors and two copies of the **Map Puzzle Activity Sheet**.

Notes for the Teacher:

Here are some notes on the dinosaurs used in this activity.
Prosauropods were the earliest long necked dinosaurs. They lived from 210 to 190 million years ago all over the world. *Plateosaurus* is a prosauropod. **Stegosaurids** were plated dinosaurs. Most stegosaurids lived from 160 to 140 million years ago in North America, Europe, Asia and Africa. *Stegosaurus* is a stegosaurid. **Ceratopsid**s were horned dinosaurs. Ceratopsids lived from 80 million years ago to the end of the time of the dinosaurs, 65 million years ago and are found only in North America and Eastern Asia, which were connected by a land bridge. *Triceratops* was a ceratopsid.

Action:

1. Cut out the five continents by following the dotted lines. Experiment with moving the continents around on your desk. You will be scientists exploring how the continents moved by studying dinosaur fossils.
2. The first fossils you will study are prosauropods. They lived 195 million years ago. Prosauropod fossils have been found on North America, South America, Africa, Australia, Europe and Asia.
3. How would the continents need to be placed so prosauropods could travel from one continent to another by walking? Arrange them on your desk. (Give students time to move their continents.) This is what the world may have looked like 195 million years ago. Compare your continents to your partner's. Are they the same? Scientists don't always agree.
4. Remember the continents are moving very slowly, but if we jump forward in time. We'll see what the world looked like 150 million years ago. From that time we find stegosaurid fossils in North America, Africa, Europe and Asia.
5. How would the continents need to be placed so stegosaurids could travel from continent to continent by walking? Arrange them on your desk the way the world may have looked 150 million years ago. Compare your map with your partner's. Pangaea is starting to divide into smaller continents.
6. Now we're going to jump forward in time to see what the world looked like 80 million years ago. From that time, we find ceratopsid fossils in North America and Asia.
7. How would the continents need to be placed so ceratopsids could travel from continent to continent by walking? Arrange them on your desk the way the world may have looked 80 million years ago. Compare your map with your partner's.

Discussion:

Did the world look the same for the different types of dinosaurs? Did Pangaea change into the continents we see today all at once? (It was a slow change. Not all the continents separated at the same time.)

How do scientists know that the earth looked like this in the past? (By studying the rocks and fossils of the earth's past.) Scientists believe that by the end of the time of the dinosaurs, 65 million years ago, the continents we know today had separated and were drifting towards their current locations.

If the continents continue to move slowly, what might happen in the distant future? (Some scientists predict that far in the future, all the continents will come back together in about 250 million years.)

Activity Three – Big Time Tour

Learning Objective:

Students explore the vast span of geologic time. First they consider big numbers, then take some guesses about important past events and locate them on an arm's length map of time.

Activity Three – Big Time Tour

Group size:
Any

Time:
Part I: Million Appreciation Lesson 20-30 minutes
Part II: Investigating All Time 45 minutes

Materials Provided:

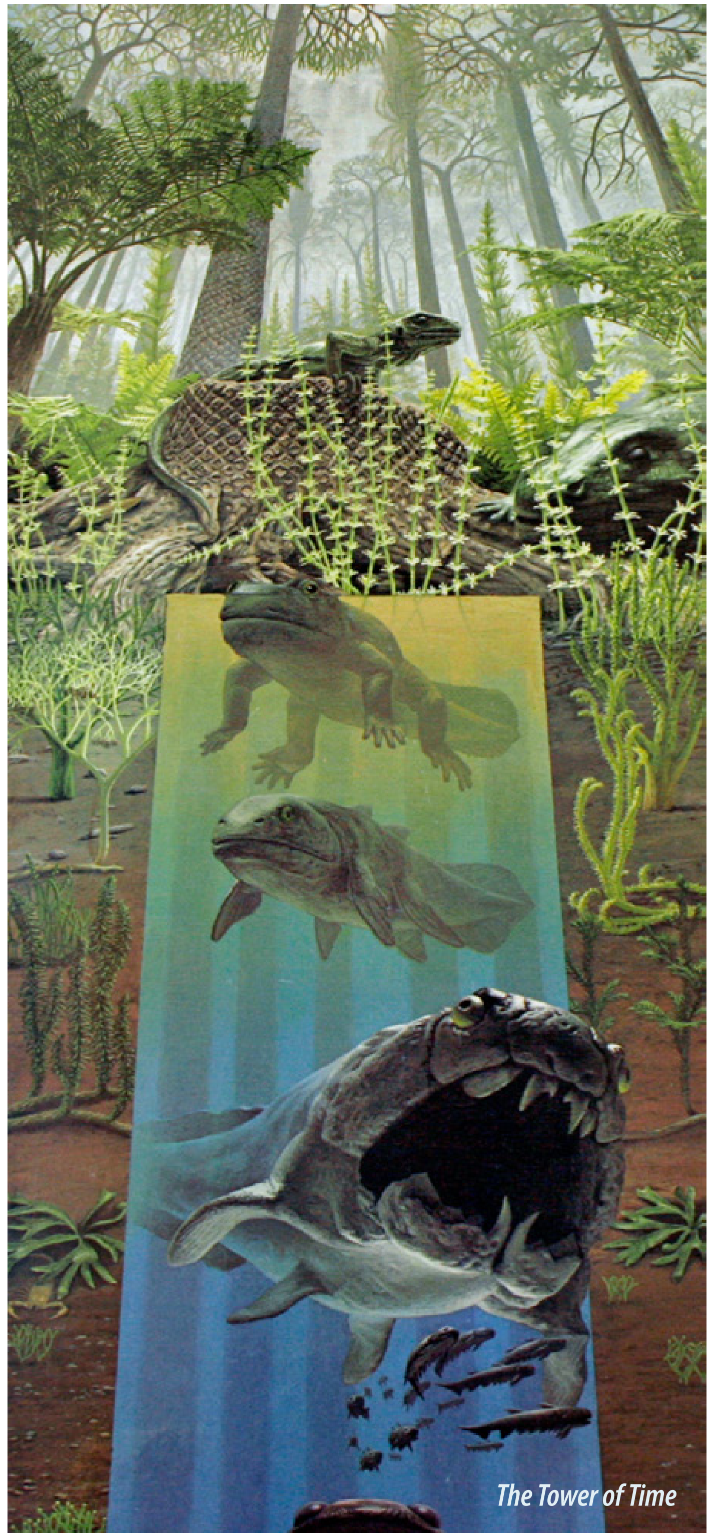
- *Million Appreciation Lesson* (template)
- *The Tower of Time* poster

Supplies Needed <u>Per Student</u>:

- Pencil or pen
- Sticky notes (at least 4)
- Fine point water soluble marker or a sharp pencil
- Colored water soluble markers
- 1 sheet of paper a little longer than an arm's length

Preparation:

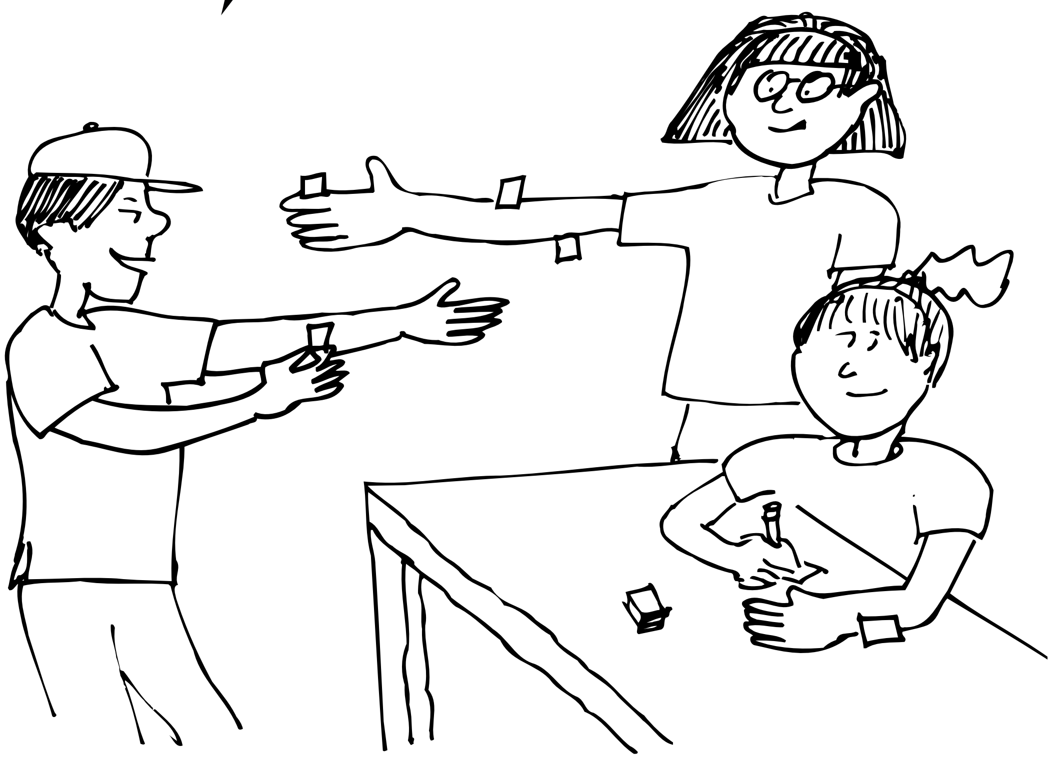
- Make a copy of *Million Appreciation Lesson* for each student.
- Post *The Tower of Time* time line in the classroom.



The Tower of Time

Big Time Tour

Explore the vast span of geological time. First, consider big numbers. Then take some guesses about some important past events and locate them on an arm's length map of time.



Before You Begin

Teams of 2

Length:
Part I - 20-30 minutes
Part II - 45 minutes

What You Need

For each team of 2:

- pencil or pen
- sticky notes
- fine point water-soluble marker
- a sheet of paper a little longer than arm's length (tape together lengths of legal-size paper)

What We Know. Our home planet Earth has been through many changes. Giant elephants once grazed the North American plains. Before that, dinosaurs roamed the Earth for millions of years, then disappeared. Many kinds of organisms lived in the early oceans of Earth. Much earlier, Earth was a fiery ball of molten rock. How do scientists know these things? They have learned to read the rocks. Geologists know that different rock types are formed in different ways, giving clues to different conditions in Earth's past. Studying the layers of rocks and the order in which they were formed gives clues about the changing climate and conditions. Fossils in the rocks help scientists actually see what life was like in the past. Scientists still have a lot to learn, but they do know that conditions and life forms have undergone huge changes over time . . . and that Earth is very, very old. How old? Today you will take an arm's length tour of all time.

Big Time Tour

Part One: Million Appreciation Lesson

Summertime, halftime, daylight savings time . . . we measure kinds of time in hours, days, and months. We measure Earth's past in geological time. This kind of time is measured in millions and billions of years. To really appreciate geological time you need to get a sense of just how big a million is. You might want to get out your calculator and do your own figuring. Otherwise, just check your guess. The math hints and answers are at the bottom of p.18.

1 Suppose you need to get your Mom's attention to ask her something really, really important, but she's on the phone. Usually Moms say something like "I'll be off in just a second." What if she said, "Wait just a million seconds, dear"?

Guess how long it would take for a million seconds to go by. Check one:

____an hour ____a day ____a week ____more

2 How much space does a million names take in phone book pages? The white pages of a big city phone book hold about 500 names on each page. How many pages would you guess it takes to hold a million names? Check one:

____10 pages ____100 pages ____1000 pages ____more

3 You have decided to take a hike . . . of a million steps. How far will you travel? Hint: one step equals 1 meter. There are 1,000 meters in 1 kilometer. Check one:

_____ around the Great Pyramid in Egypt (.8 kilometer)

_____ along the length of the Panama Canal (88 kilometers)

_____ across Florida from top to bottom (880 kilometers)

4 A pinch of salt is about 1,000 grains. Would you guess a million grains of salt would fill a . . .

_____cup _____bathtub _____your bedroom

Activity 3

Big Time Tour

Think It Over

Answer 1. You would be really annoyed. It would take 11.7 days for your mom to get off the phone if you had to wait a million seconds.

Answer 2. Hint: Divide 500 into a million. It takes about 2,000 pages to hold a million names. Big city phone books like San Francisco's are 1,000 pages. You would need two fat phone books worth of pages.

Answer 3. A million steps will take you about 900 kilometers. That is the length of Florida from top to bottom. A fair hiker covering ten kilometers a day would take about three months to walk this distance.

Answer 4. A cup holds about a million grains. You can pour a billion grains into a bathtub and pack a trillion into your bedroom.

Big Time Tour

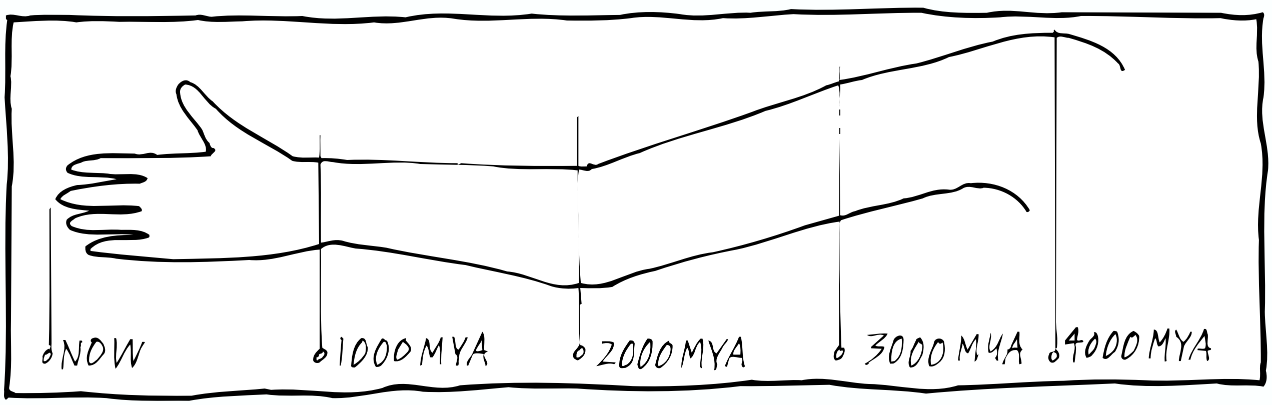
Part Two: Investigating All Time

Earth is old. It was formed about 4.5 billion years ago (4,500 million is another way to write this big number). Work in teams of 2 to investigate big time.

Take a Guess . . .

1 Imagine your arm is 4.5 billion years long. On your arm timeline imagine that now is located at your fingertips. Then imagine the beginning of Earth is located at your shoulder. MYA is another way of writing "a million years ago."

2 A lot has happened since Earth began. Just for fun, take a few guesses about where on the timeline some key events in Earth's history happened.



3 Bacteria were the first signs of life on Earth. Write "first life form" on a sticky note. Place it on one teammate's arm where you think bacteria first appeared.

4 Dinosaurs "ruled" the Earth for millions of years before they became extinct. Write "first dinosaurs" on a sticky note. Place it on your teammate's arm where in time you think dinosaurs first appeared. Write "last dinosaurs" on the next note and place it where you think the dinosaurs became extinct.

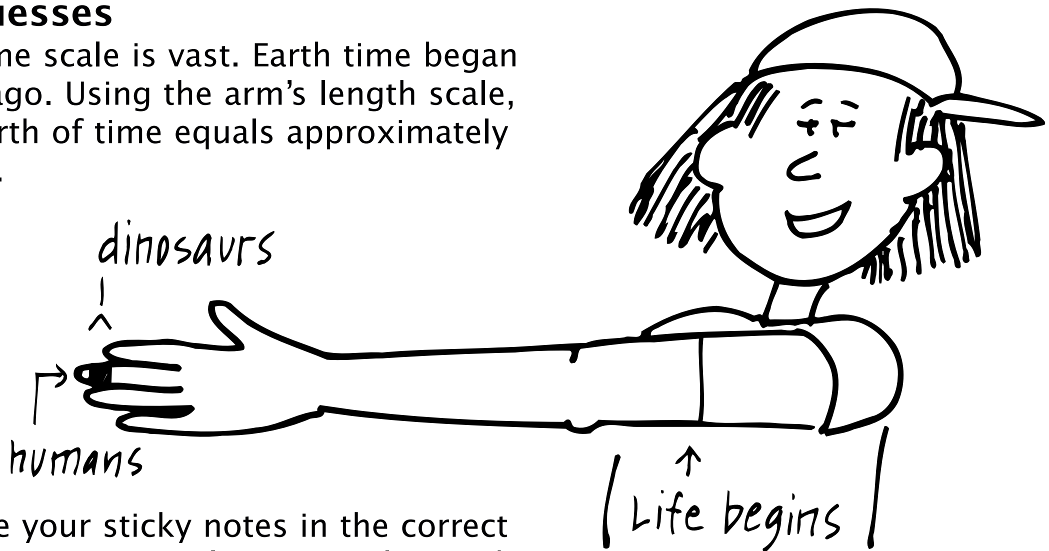
5 How far back do humans go? Write "first humans" on a note and place it to show where you think the first humans appeared.

Big Time Tour

Part Two: Investigating All Time (cont'd)

Check your Guesses

The geological time scale is vast. Earth time began 4.5 billion years ago. Using the arm's length scale, one fingernail worth of time equals approximately 100 million years.



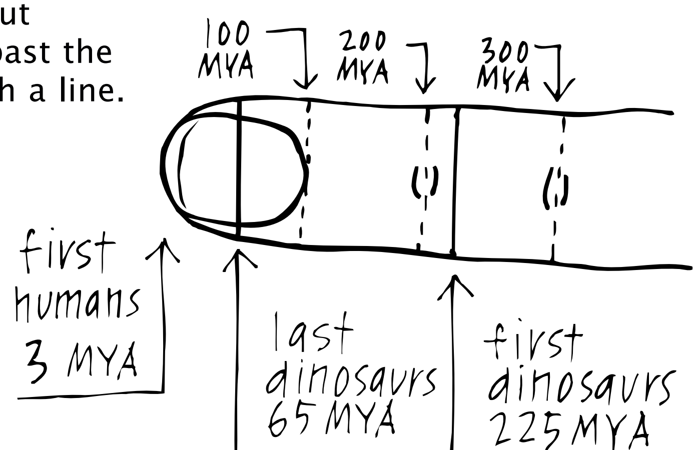
6 Ready to place your sticky notes in the correct place along your teammate's arm timeline? The first life forms (bacteria) appeared about 3,500 million years ago (mya). Place your sticker midway between the elbow and the shoulder.

7 Most life forms happened at your fingertips. Using a water-soluble marker, draw a line at the base of the fingernail of the third finger. This is 100 mya (million years ago.) Draw a line across the first knuckle to mark 200 mya. Draw another line across the next knuckle to mark 300 mya.

8 The dinosaurs appeared 225 million years ago. This is one quarter of the way between your nail and knuckle. Draw a line here.

9 The dinosaurs became extinct about 65 million years ago. This is just past the halfway mark on your nail. Mark it with a line.

10 Humans appeared over 3 million years ago. Draw a thin line on the tip of the nail. (This fraction of time probably takes up less space on the timeline than the dirt under your fingernails.)



Big Time Tour

Part Two: Investigating All Time (cont'd)

11 Work with your partner to make an arm's length timeline. Label your timeline with some important events in Earth's history. You need paper and a marker or pen. Choose one person to be the tracer, the other will be the arm model.

12 Find a flat surface for your paper. Lay an arm on the paper. Position it so there will be room to write around the arm. Let your partner trace around the arm to make an outline.

13 Mark the time zones along the bottom of the page:

Present time	fingertips
4,000 mya	shoulder
2,000 mya	elbow
1,000 mya	midway between fingertips and elbow
3,000 mya	midway between elbow and shoulder

14 Now place these events on your timeline:

MYA (Million Years Ago)	**Event**
over 3 mya	first humans
65 mya	dinosaurs become extinct
225 mya	first dinosaurs, first mammals
500 mya	first fish
570 mya	first shelled animals
3,500 mya	bacteria (first life forms)
4,500 mya	Earth begins as a mass of melted rock

Big Time Tour

Think It Over

Some moments in the geological record show surprising changes. One of these places is at 65 mya. It is called the K-T boundary and marks the end of one era and the beginning of another. Mark this boundary on your timeline. What other events are close to this boundary?

Activity Four – Digging Dinosaurs

Learning Objective:
Students will practice excavation skills and train their eyes to distinguish dinosaur bone from rock.

Activity Four – Digging Dinosaurs

Group size: Divide the class into five groups.
Time: 50 minutes

Materials Provided:

- Grid Map Activity Card (template)
- 5 Specimen sets each containing:
  - 1 chicken bone
  - 1 mammal bone fragment
  - 1 piece of petrified wood
  - 1 horn coral fossil
  - 1 crinoid fossil
  - 1 dinosaur fossil cast
  - 1 dinosaur fossil bone fragment
  - 2 small rocks
- 5 Tool kits each containing:
  - 1 small screwdriver
  - 2 hand lenses
- *Geological Bedrock Map of Nebraska*
- 10 Dinosaur bone fragments
- 15 Small rocks
- *Fossils Tell of Long Ago*

Supplies Needed Per Student:

- Pencil

Supplies Needed Per Group:

- Fossil Pie
- 2 Pieces of yarn 18 inches long (put with the toolkit)
- Masking tape (put with the tool kit for each group)

Supplies Needed Per Class:

- 1 Box of Plaster of Paris
- 1 Small bag of clay kitty litter
- Newspaper
- Sponge
- Old toothbrush (1 or 2 for class – for washing fossils)
- Bucket of warm water (1 for class – for washing fossils)
- 5 Small aluminum baking pans

Additional Materials Included in Kit:

- *Dinosaurs and How They Lived*
- *National Geographic* Vol. 183; January, 1993

Preparation:

- At least one day before the class, prepare a fossil pie for each group.
  1. Set out five small aluminum baking pans, one for each group.
  2. In a large container, combine equal parts cat liter and Plaster of Paris.
  3. Add water to the Plaster of Paris mixture until it is the consistency of pancake batter.
  4. Pour some of the mixture into each tray.
  5. Drop in a dinosaur bone fragment and three rocks into the plaster.
  6. Add more plaster mixture to cover the bone fragments and rocks.
  7. Let stand 15 minutes.
  8. Pour off any excess water.
  9. Let the mixture set until it can hold its shape without the tray.
  10. Remove from tray and let dry. The plaster must dry at least overnight. If allowed to dry longer, it will continue to set for the next 3-4 days
- Make a copy of the "Grid Map" activity card for each student.

Background:

Fossils are the evidence or remains of once living things and they are usually made of minerals. To understand fossilized bone, consider a bone that is not fossilized. Bones are not solid. They are porous and blood passes through them all the time. Fossil bones have the same structure as the original bone. The difference is that organic material has been lost and minerals have been added to them as the years pass. Paleontologists, scientists who study ancient animals and plants, train their eyes to recognize the structure of fossilized bones. By using a magnifying glass you can see a pattern, like a honeycomb, that indicates it is a fossil.

The first step in finding fossils is to decide where to look. Good places to find dinosaur fossils are where sedimentary rocks from 250 to 65 million years ago are on the surface of the ground. The best places are where no one has looked for dinosaurs before. Paleontologists find these places using maps and satellite pictures. Sometimes they get hints from people who have found fossils by accident. If you think you have found a fossil, you can take it to a museum and ask a paleontologist; but the best place for a fossil is in the ground. When you pick up a fossil, everything paleontologists could learn from the area around the fossil is lost. Also, it is against the law to remove fossils from private or government land without permission.

When they find a fossil, paleontologists are very careful to record all the important scientific information about it. They keep a field notebook just to record this information. They make a square grid around the fossil and take careful measurements. Then they try to remove the rock and dirt around the fossil to see how big it is, always watching for more fossils, even very small ones. As they work, they make careful notes in their field notebook recording the size and shape of the fossil, its position in the ground, and any other fossils found nearby. Information about the general area and the rocks where the fossil was found are also recorded. When their investigation is complete, the fossil can be moved.

Inside a Museum excavation:

Local students assist Shane Tucker, University of Nebraska State Museum Highway Salvage Paleontologist, as he applies a plaster and burlap field jacket to a turtle specimen. Numerous other specimens (sorry, no dinosaurs) have already been jacketed and mapped and are ready to be removed. A five foot section of fossil log was also discovered in this excavation square in the Wildcat Hills south of Gering, Nebraska.

Part 1: Finding Fossils

- Divide the class into small groups (up to five groups) and give each group a **specimen set**.

Action:

1. Place your specimens in the center of the group and sort them. You can sort them in any way that makes sense to your group. Be prepared to explain your sorting system.
2. Choose one person from your group to explain your system to the rest of the class. How did you decide which was which?
3. Find the bone fragment in your set. Have each person examine the specimens and try to see the honeycomb pattern found in bones.

Part 2: Doing the Dig

- Paleontologists must determine whether fossils are likely to be found in an area. They carefully observe and investigate a dig site and keep detailed records of what they find and where. During your excavation, you will use a grid map to record where your fossils are found.
- Give each group some **newspaper**, a **fossil pie**, a **tool kit** and two **Grid Map Activity Cards**.
- Spread the newspaper on your desks before you begin working.
- As students work, move from group to group to help them identify and map each item they excavate.

Action:

1. Using the yarn and tape in your took kit, mark four equal sections on your fossil pie. Sketch the fossil pie and grid sections on your map. This sketch will be used to record where the fossils are found.
2. Using the tools or your fingers, carefully excavate the objects in the plaster mixture and record their locations on the "Grid Map". Be careful, this is real dinosaur bone.
3. When you are finished, wash the specimens in the bucket of warm water. Use the toothbrush to wash the plaster off. Do not rinse plaster down the drain.
4. Decide which specimens are dinosaur bones. Label your sketch. Collect the rocks and dinosaur bones together.

Tying It All Together

- When everyone is finished with their excavation, gather the class together for a discussion.

  What structures made it easier to tell rock from fossil? How can a bone become fossilized?

  How do paleontologists know where to look for fossils?

  What would you do if you found a fossil bone? What kind of information would you tell a scientist about the bone? Why is it important to record where a fossil is found?

Grid Map Activity Card

Use the grid below to map out the shape of your fossil pie. Carefully sketch all the things you find in the pie on your map. You may want to write notes to help you remember important facts about what you find.

Activity Five – Tracks and Traces

Learning Objective:
Students explore dinosaur behavior by creating dinosaur track records.

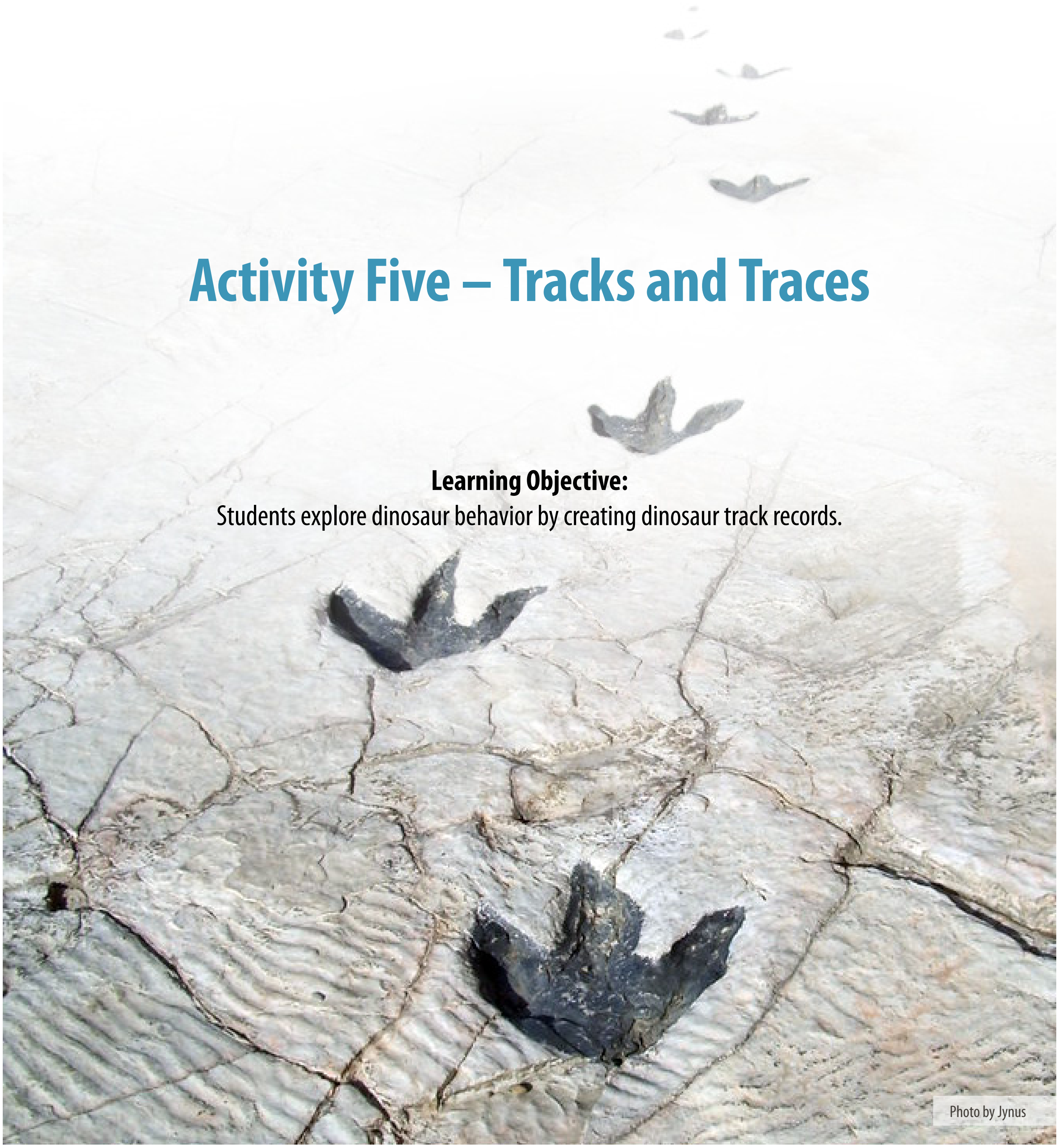


Photo by Jynus

Activity Five – Tracks and Traces

Group size: Divide the class into five groups.
Time: 60 minutes

Materials Provided:

- Dinosaur Track Challenge Activity Card (template)
- 5 Dinosaur Footprints Activity Card (templates)
- *A Glimpse of the Past* poster
- *On the Tracks of Dinosaurs*
- Trace fossils included in the kit
  - *Lambeosaurus* skin impression cast (2)
  - Small carnivorous dinosaur footprint cast (2)
  - Carnivorous dinosaur footprint cast (2)
  - *Oviraptor* egg cast (2)
  - Coprolites (2)

Supplies Needed Per Group:

- Pencil
- Scissors
- Meter or yard stick
- Sidewalk chalk
- Several pieces of cardboard 8″ x 10″ or larger

Additional Materials Included in Kit:

- *National Geographic* Vol. 183; January, 1993
- *Dinosaurs of the British Isles 115 million years ago* poster
- *Dinosaurs of North America 140 million years ago* poster
- *Dinosaurs and How They Lived*

Preparation:

- Set up a work space for each group and place the books and resources in a location easily available to all groups.
- Select a large flat area to make track puzzles where students can trace footprints (a large concrete slab works best).
- Hang the posters on a wall in the classroom.

Background:

A dinosaur track is an impression left by a dinosaur's foot in the earth. Tracks of ancient animals like dinosaurs preserved in rocks are trace fossils. Skin and leaf impressions, eggs, gastroliths (stomach stones) and coprolites (fossilized animal droppings) are other types of trace fossils. They are different from other fossils, which are actual parts of plants or animals preserved in rock.

Millions of dinosaur tracks have been found throughout the world. They are found in sedimentary rock, primarily in areas that once were wet, such as beaches, stream banks, or the shorelines of lakes - similar to where we find animal tracks today.

All dinosaur tracks are not the same. They differ by size, shape, depth, and length between strides. Some of the tracks are single footprints while others show how the dinosaur walked and with whom. Trackways (more than one footprint) can tell paleontologists whether the animal was large or small; whether it walked on two feet or four feet; what kind of dinosaur it was, and whether it was walking or running.

Behavior is harder to interpret from tracks, but they do give clues. Some trackways seem to show herds, such as when many similar tracks lead in the same direction. Family life may be indicated when larger prints are found with smaller prints of the same kind of dinosaur.

Hunting is a possibility when meat-eating dinosaur tracks follow another kind of dinosaur. When paleontologists examine dinosaur trackways to investigate movement, behavior, ecology, or habitats, they must use common sense and careful consideration of all the possibilities. Usually a simple explanation is more accurate than a complex or fanciful story.

Part 1: Looking for Tracks

Action:

1. Discuss: Have you ever seen animal tracks? Where have you seen them? Why do you think you see tracks in mud, snow, or sand?
2. Draw a diagram on the board of two sets of different tracks coming towards the same spot and only one of the tracks going away. Ask, "What might have happened here?" Allow the class to pose a variety of possibilities.
3. When dinosaurs left tracks behind in the mud, sometimes those tracks fossilized, or turned into rocks. Fossilized tracks are called trace fossils. (Show students dinosaur tracks and other trace fossils included in the kit.) What kind of story do you think tracks like these could tell a scientist? What sort of things do dinosaurs do? (eat, drink, walk around, protect themselves, etc.) How can tracks show what dinosaurs were doing?

Part 2: Making Tracks

- Divide the class into small groups.
- Assign each group a **dinosaur** (the kit includes Dinosaur Footprint Activity Cards for five types of dinosaurs), and give them a **Dinosaur Tracks Challenge** and **Dinosaur Footprints Activity Card**.
- Assign each group an area to put their footprint puzzle.

Action:

1. Today you are going to work in groups to make a footprint puzzle that shows what a dinosaur was doing. The other groups will try to solve your puzzle and figure out what happened.
2. Before you can make your puzzle, you have to figure out how footprints can show what your dinosaur was doing. Then you will make your puzzle. Your group will have ______ minutes to make your puzzle.
3. Begin by describing a brief event that could have happened to your dinosaur. Have one or two members of the group act out the event while the others observe. Watch where their feet move. Can the event be described using footprints? How many footprints will you need to create your puzzle?
4. Gather the resources you need and make footprints. Your challenge is to make your puzzle simple enough to tell the other groups about your dinosaur. Can you use tracks to show:
   - How big your dinosaur is?
   - How your dinosaur moves and what it is doing?
   - What type of dinosaur it is?
5. Create your puzzle by tracing the footprint patterns you made with sidewalk chalk.

Part 3: Solving Puzzles

- When everyone is finished making their puzzle, have the groups visit each other's puzzles.
- Gather the class together for a discussion. Talk briefly about each puzzle

Action:

1. Visit the other puzzles and make predictions about:
   How big is the dinosaur?
   How did it move? What is it doing?
   What type of dinosaur is it?
2. Was it hard to show whether your dinosaur was running or walking? How did you do it?
3. What clues did you use to figure out the other puzzles? Were your predictions correct?
4. It isn't easy for people to interpret dinosaur tracks today because there are many possible answers. Think about your puzzle. Did the rest of the class understand your puzzle? Did they think of other things that might have left similar footprints?
5. Which tells a paleontologist more about dinosaur life - fossil bones or fossil tracks? (Really both types of fossils work together to help paleontologists understand how dinosaurs lived.)

Branching Out

Using the poster that depicts the dinosaurs from Dinosaur National Monument, have the students follow the trackways and figure out what the dinosaurs might have been doing. What would it mean if a dinosaur trackway had a line running down the middle of it? (The dinosaurs tail is dragging on the ground.) How many of the dinosaurs in the poster drag their tails on the ground? Discuss why paleontologists have redrawn dinosaurs with their tails high off the ground. Can the students figure out why it might be to the dinosaur's advantage to keep its tail high?

Discuss other types of trace fossils. What other impressions or traces might dinosaurs leave behind. Show the eggs and coprolites and discuss what scientists can learn about diet from fossilized eggs or droppings.

Dinosaur Tracks Challenge

1. Get to know how your dinosaur lives.

- ☆ What does it eat?
- ☆ How does it move around?

2. Describe a brief event that could have happened to your dinosaur, such as:

- ☆ Finding water.
- ☆ Finding food.
- ☆ Protecting itself or its group.

3. Think about how you would show the event using tracks. (If you can't come up with a plan, then pick a different event.)

- ☆ Have one or two people in your group act out the event while everyone else observes.

Watch their feet and decide:

- ☆ What tracks you will need.
- ☆ How many tracks you will need.
- ☆ How much space you will need.

4. Gather the resources you need and make the track patterns for your puzzle.

- ☆ What does it eat?
- ☆ How does it move around?

5. Present the track puzzle to the other groups. Ask them to predict:

- ☆ How big the dinosaur is.
- ☆ How the dinosaur moves (on two feet or four).
- ☆ What type of dinosaur it is.

Dinosaur Book References

Dinosaur Diversity

Berger, Melvin and Berger, Gilda. *Did Dinosaurs Live in Your Backyard?* Scholastic Inc: New York. 1998.
Charlesworth, Liza and Sachatello-Sawyer, Bonnie. *Dinosaurs*. Scholastic Inc: New York. 1995.
Lambert, David. *A Field Guide to Dinosaur*s. Avon Books: New York. 1983.
Norman, David. *The Illustrated Encyclopedia of Dinosaurs*. Crescent Books: New York. 1985.
Relf, Pat. *A Dinosaur Named Sue: The Story of the Colossal Fossil*. Scholastic Inc: New York. 2000.
Weishampel, David, P. and Dodson, H. Osmolska eds. *The Dinosauria*. University of California Press. 1990.
Gaffney, Eugene S. *Dinosaurs*. Golden Books Publishing Company, Inc.: New York. 1990.

Dinosaurs on the Move

Lambert, David. *A Field Guide to Dinosaurs*. Avon Books: New York. 1983.
Norman, David. *The Illustrated Encyclopedia of Dinosaurs*. Crescent Books: New York. 1985.
Parker, Steve. *Dinosaurs and How they Lived*. Dorling Kindersley: New York. 1991.
Plummer, Charles C. and McGeary, David eds. *Physical Geology* 7th ed. Wm. C. Brown Publishers: 1996.
Thurman, Harold V. and Trujillo, Alan P. eds. *Essentials of Oceanography* 6th ed.. Prentice Hall: New Jersey. 1999.
Weishampel, David, P. and Dodson, H. Osmolska eds. *The Dinosauria*. University of California Press. 1990.

Dino Munching

Davis, Lee. *Dinosaur Dinners*. DK Publishing, Inc: London: 1998.
Braus, Judy ed. *Nature Scope: Digging Into Dinosaurs*. National Wildlife Federation: Washington, DC: 1992.

Digging Dinosaurs

Aliki. *Fossils Tell of Long Ago*. HarperCollins Publishers: New York. 1990.
Aliki. *Digging Dinosaurs*. HarperCollins Publishers: New York. 1988.
Charlesworth, Liza and Sachatello-Sawyer, Bonnie. *Dinosaurs*. Scholastic Inc: New York. 1995.
Norell, Mark, Gaffney, Eugene and Dingus, Lowell. *Discovering Dinosaurs: Evolution, Extinction, and the Lesson of Prehistory*. University of California Press: Berkley. 2000.

Tracks and Traces

Farlow, James O. *On the Tracks of Dinosaurs: A Study of Dinosaur Footprints*. Franklin Watts: New York, 1991.
Lambert, David. *A Field Guide to Dinosaurs*. Avon Books: New York. 1983.
Lauber, Patricia. *Dinosaurs Walked Here: and Other Stories Fossils Tell*. Bradbury Press: New York, 1987.
Lockley, Martin. *Tracking Dinosaurs: A New Look at an Ancient World*. Cambridge University Press: Cambridge. 1991.

Nebraska Science Standards

Activity 1: Dinosaur Diversity

Objectives: Students investigate the diversity among dinosaurs by developing different strategies for grouping them together. This activity introduces students to scientific terms and dinosaurs that are used throughout the kit.

Grades K-2

SC K-12.1 **Inquiry, the Nature of Science, and Technology**

1. Abilities to do Scientific Inquiry

SC 2.1.1 Students will ask questions and conduct investigations that lead to observations and communication of findings.

Scientific Questioning: SC 2.1.1.a Ask questions that relate to a science topic.

Scientific Investigations: SC 2.1.1.b Conduct simple investigations.

Scientific Data Collection: SC 2.1.1.e Collect and record observations.

Scientific Communication: SC 2.1.1.f Use drawings and words to describe and share observations with others.

SC K-12.3 **Life Science**

1. Structure and Function of Living Systems

SC 2.3.1 Students will investigate the characteristics of living things.

Grades 3-5

SC K-12.1 **Inquiry, the Nature of Science, and Technology**

1. Abilities to do Scientific Inquiry

SC 5.1.1 Students will plan and conduct investigations that lead to the development of explanations.

Scientific Investigations: SC 5.1.1.b Plan and conduct investigations and identify factors that have the potential to impact an investigation.

Scientific Data Collection: SC 5.1.1.e Collect and organize data.

Scientific Communication: SC 5.1.1.g Share information, procedures, and results with peers and/or adults.

2. Nature of Science

SC 5.1.2 Students will describe how scientists go about their work.

SC K-12.3 **Life Science**

1. Structure and Function of Living Systems

SC 5.3.1 Students will investigate and compare the characteristics of living things.

Activity 2: Dinosaurs on the Move

Objectives: Students explore how scientists use the distribution of dinosaur fossils to understand the movements of the continents.

Grades K-2

SC K-12.1 **Inquiry, the Nature of Science, and Technology**

1. Abilities to do Scientific Inquiry

SC 2.1.1 Students will ask questions and conduct investigations that lead to observations and communication of findings.

Scientific Investigations: SC 2.1.1.b Conduct simple investigations.

Grades 3-5

SC K-12.1 **Inquiry, the Nature of Science, and Technology**

2. Nature of Science

SC 5.1.2 Students will describe how scientists go about their work.

Scientific Knowledge: SC 5.1.2.a Recognize that scientific explanations are based on evidence and scientific knowledge.

Science and Society: SC 5.1.2.b Recognize that new discoveries are always being made which impact scientific knowledge.

SC K-12.4 **Earth and Space Sciences**

4. Earth's History

SC 5.4.4 Students will describe environments based on fossil evidence.

Past/Present Earth: SC 5.4.4.a Describe how slow processes (erosion, weathering, deposition, uplift) and rapid processes (landslides, volcanic eruptions, earthquakes, violent storms) change the Earth's surface.

Activity 3: Big Time Tour

Objectives: Students explore the vast span of geologic time. First they consider big numbers, then take some guesses about important past events and locate them on an arm's length map of time.

Grades K-2

SC K-12.1 **Inquiry, the Nature of Science, and Technology**

1. Abilities to do Scientific Inquiry

SC 2.1.1 Students will ask questions and conduct investigations that lead to observations and communication of findings.

Scientific Investigations: SC 2.1.1.b Conduct simple investigations.

Scientific Observations: SC 2.1.1.d Describe objects, organisms, or events using pictures, words, and numbers.

Mathematics: SC 2.1.1.g Use appropriate mathematics in all aspects of scientific inquiry.

SC K-12.3 **Life Science**

4. Biodiversity

SC 2.3.4 Students will recognize changes in organisms.

Grades 3-5

SC K-12.1 **Inquiry, the Nature of Science, and Technology**

1. Abilities to do Scientific Inquiry

SC 5.1.1 Students will plan and conduct investigations that lead to the development of explanations.

Scientific Observations: SC 5.1.1.d Make relevant observations and measurements.

Mathematics: SC 5.1.1.i Use appropriate mathematics in all aspects of scientific inquiry.

SC K-12.3 **Life Science**

4. Biodiversity

SC 5.3.4 Students will describe changes in organisms over time.

Activity 4: Digging Dinosaurs

Objectives: Students will practice excavation skills and train their eyes to distinguish dinosaur bone from rock.

Grades K-2

SC K-12.1 **Inquiry, the Nature of Science, and Technology**

1. Abilities to do Scientific Inquiry

SC 2.1.1 Students will ask questions and conduct investigations that lead to observations and communication of findings.

Scientific Investigations: SC 2.1.1.b Conduct simple investigations.

Scientific Tools: SC 2.1.1.c Select and use simple tools appropriately.

Scientific Observations: SC 2.1.1.d Describe objects, organisms, or events using pictures, words, and numbers.

Scientific Data Collection: SC 2.1.1.e Collect and record observations.

Scientific Communication: SC 2.1.1.f Use drawings and words to describe and share observations with others.

Grades 3-5

SC K-12.1 Inquiry, the Nature of Science, and Technology

1. Abilities to do Scientific Inquiry

SC 5.1.1 Students will plan and conduct investigations that lead to the development of explanations.

Scientific Tools: SC 5.1.1.c Select and use equipment correctly and accurately.

Scientific Observations: SC 5.1.1.d Make relevant observations and measurements.

Scientific Data Collection: SC 5.1.1.e Collect and organize data.

2. Nature of Science

SC 5.1.2 Students will describe how scientists go about their work.

Activity 5: Tracks and Traces

Objectives: Students explore dinosaur behavior by creating dinosaur track records.

Grades K-2

SC K-12.1 Inquiry, the Nature of Science, and Technology

1. Abilities to do Scientific Inquiry

SC 2.1.1 Students will ask questions and conduct investigations that lead to observations and communication of findings.

Scientific Questioning: SC 2.1.1.a Ask questions that relate to a science topic.

Scientific Investigations: SC 2.1.1.b Conduct simple investigations.

Scientific Observations: SC 2.1.1.d Describe objects, organisms, or events using pictures, words, and numbers.

Scientific Data Collection: SC 2.1.1.e Collect and record observations.

Scientific Communication: SC 2.1.1.f Use drawings and words to describe and share observations with others.

Grades 3-5

SC K-12.1 Inquiry, the Nature of Science, and Technology

1. Abilities to do Scientific Inquiry

SC 5.1.1 Students will plan and conduct investigations that lead to the development of explanations.

Scientific Questioning: SC 5.1.1.a Ask testable scientific questions.

Scientific Investigations: SC 5.1.1.b Plan and conduct investigations and identify factors that have the potential to impact an investigation.

Scientific Observations: SC 5.1.1.d Make relevant observations and measurements.

Scientific Data Collection: SC 5.1.1.e Collect and organize data.

Scientific Interpretations, Reflections, and Applications: SC 5.1.1.f Develop a reasonable explanation based on collected data.

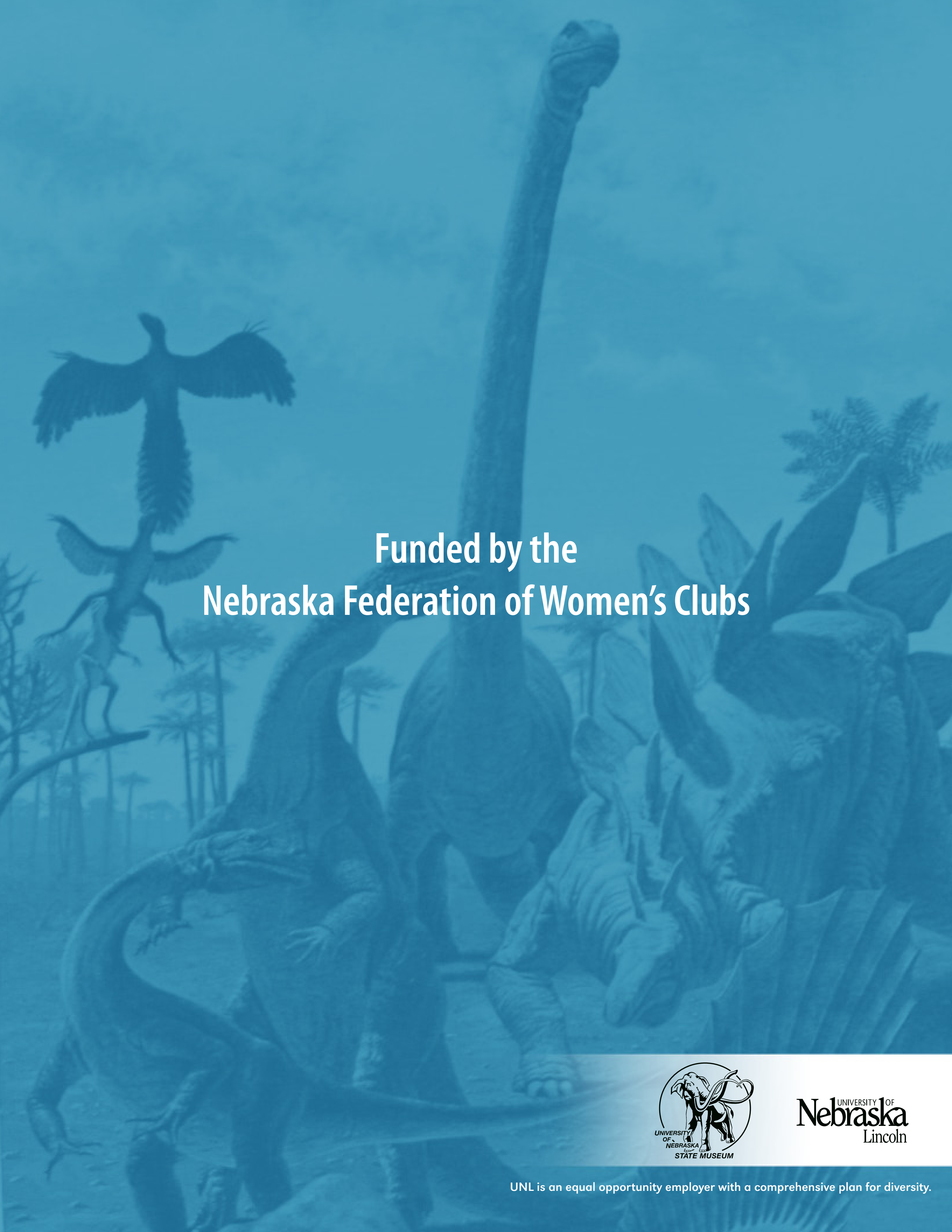
Scientific Communication: SC 5.1.1.g Share information, procedures, and results with peers and/or adults.

Scientific Communication: SC 5.1.1.h Provide feedback on scientific investigations.

2. Nature of Science

SC 5.1.2 Students will describe how scientists go about their work.

Scientific Knowledge: SC 5.1.2.a Recognize that scientific explanations are based on evidence and scientific knowledge.



Funded by the
Nebraska Federation of Women's Clubs

University of Nebraska State Museum

University of Nebraska Lincoln