Dinosaurs, Sharks, and Woolly Mammoths:

Glimpses of Life in North Dakota's Prehistoric Past

NORTH DAKOTA STUDIES

STATE HISTORICAL SOCIETY OF NORTH DAKOTA

HISTORY FOR everyone.

ndstudies.gov | history.nd.gov | statemuseum.nd.gov

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Additional Resources:

- Prehistoric Life of North Dakota (Map)
- Geology, Geography, and Climate: A Unit in North Dakota Studies
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HOW TO GET NORTH DAKOTA STUDIES TRUNKS

Order forms can be found online at history.nd.gov. Submit a request for trunks well in advance of your needed dates. Trunks for popular topics are sometimes booked months in advance. Fill out the form with as much detail as you can, including the dates you wish to receive each trunk. Submitting the paper-work far enough in advance will make it easier to complete an order. Several trunks can be requested at a time. Trunks can be picked up/shipped at the same time or staggered for use at different times. If trunks are not available on your requested dates, staff will contact you. Either alternate trunks can be substituted, or trunks can be sent as soon as they become available.

Pickup or Shipping

Trunks may be picked up at the North Dakota Heritage Center on the North Dakota State Capitol grounds. You may arrange to pickup trunks before or after regular business hours, prescheduled.

Pick up and return trunks at the employee entrance and loading dock on the southwest side of the North Dakota Heritage Center (see map and directions following this section). To gain access to this entrance, call security at 701.328.3564 in advance to let them know why you need access to the loading dock, what time you will be there, who will be picking up the trunk(s), and the color and make of your vehicle. Entrance will not be permitted without advance notice. After gaining access, you may pull into the building garage for easier loading. North Dakota Studies trunks are cubes, 24” per side, and typically weigh between 40 to 60 lbs. Three trunks will fit in the back seat of a small car. There is a $25 fee for each trunk picked up at the North Dakota Heritage Center.

Alternately, trunks can be shipped for $100 per trunk to any location within the state of North Dakota. This fee includes shipping both to and from your location. When selecting this option, add a couple of days to your request to allow for delivery in a timely manner.

We encourage you to work with organizations, schools, or homeschool families in your community if you wish to share trunk costs with others. Make a note on the order form that you would like an extension for multiple sites to share the trunks, and staff will contact you for more information.

Payment

Payment is not required when the application is submitted, but trunk payments are required before trunks are picked up or shipped. Make checks payable to the State Historical Society of North Dakota and note “Trunks” on the memo line. Mail checks to North Dakota Studies Outreach Coordinator, State Historical Society of North Dakota, 612 East Boulevard Avenue, Bismarck, ND 58505. Do not leave cash or checks with staff; all payments must be mailed to this address.

STATE HISTORICAL SOCIETY OF NORTH DAKOTA

NORTH DAKOTA STUDIES

ORDER FORM

Use this form to reserve one or more trunks for your classroom or other educational program. Trunks are available on a first come, first served basis, so it is best to make requests early. They are generally available for two weeks at a time; however, we are happy to accommodate special requests when possible. Submit this form to dlstuckle@nd.gov or Outreach Coordinator, State Historical Society of North Dakota, 612 East Boulevard Avenue, Bismarck, ND 58505.

Contact Person: _____

Organization/School: _____

Shipping Address: _____ City: _____ Zip: _____

Work Telephone: _____ E-Mail: _____

Grade Level(s): _____ Approximate number of people who will view this trunk: _____

1. Check the box next to the trunk(s) you are requesting.
2. Note either the date you will pick trunk(s) up at the North Dakota Heritage Center in Bismarck, or the date you would like to receive it, if shipped. Shipped trunks are sent via UPS two to three business days before your requested date.

North Dakota Studies Topics	***Date***		***Date***
Geology, Geography, and Climate		Early Settlement of North Dakota	
☐ Fossils	_____	☐ Ethnic Traditions	_____
American Indians of North Dakota		North Dakota Agriculture	
☐ Early Peoples	_____	☐ Farming and Ranching	_____
☐ Chippewa/Métis	_____	☐ Great Depression	_____
☐ Dakota	_____		
☐ Mandan/Hidatsa/Arikara	_____	Additional Topics	
		☐ Archaeology	_____
Frontier Era		☐ Energy Development	_____
☐ Fur Trade	_____	☐ Water Resources	_____
☐ Frontier Military	_____	☐ Night Sky	_____

Please select delivery method:

☐ PICK UP OPTION $25 (per trunk). Please allow 4-5 business days for processing.
☐ SHIPPING OPTION $100 (per trunk). Please allow 5-7 business days for processing.

Make checks payable to the State Historical Society of North Dakota. Full payment must be received before the trunk can be shipped or picked up. To get an invoice, contact us for more information. E-mail dlstuckle@nd.gov or call 701.328.2794 if you have any questions.

Download copies of this form at history.nd.gov

HISTORY FOR everyone.

Copy: _____
Sent/Picked Up: _____
Returned: _____

CREDIT CARD PAYMENT AUTHORIZATION

To pay with a credit card, mail this form, along with the trunk order form, to Outreach Coordinator, State Historical Society of North Dakota, 612 East Boulevard Avenue, Bismarck, ND 58505.

NAME ON CARD			TELEPHONE NUMBER
ADDRESS	CITY	STATE	ZIP CODE
ACCOUNT NUMBER ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐			CARD EXPIRES (MMYY) ☐☐☐☐
CARD TYPE ☐ Visa ☐ MasterCard ☐ Discover ☐ American Express			CSC NUMBER* ☐☐☐☐
SIGNATURE (REQUIRED BY CREDIT CARD COMPANIES)			DATE

TOTAL AMOUNT	*Three-digit (Visa, MasterCard, or Discover) or four-digit (American Express) security code
☐☐☐☐.☐☐	

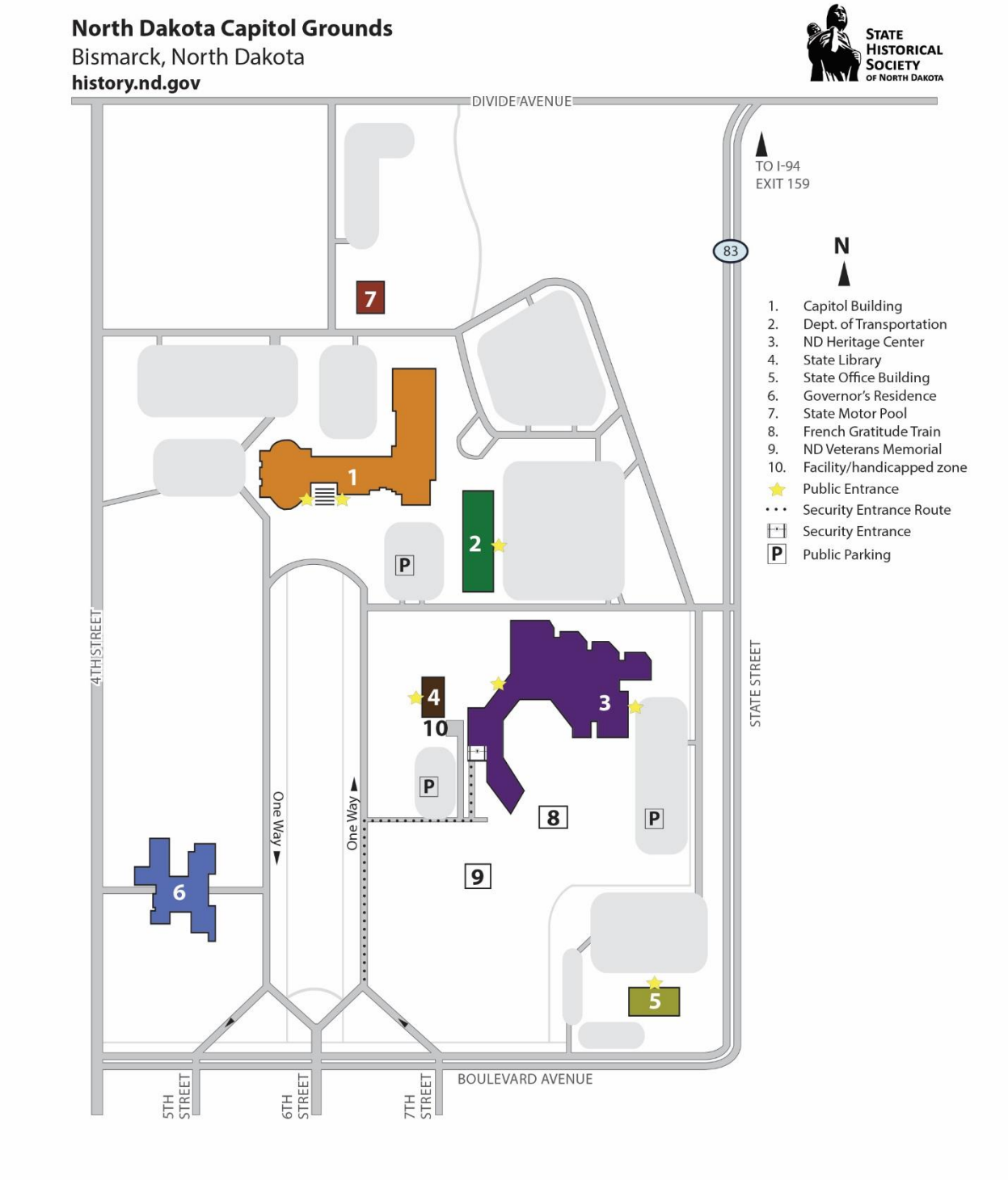
DIRECTIONS TO PICK UP TRUNKS

North Dakota Heritage Center & State Museum
Located on the North Dakota State Capitol Grounds
612 East Boulevard Avenue, Bismarck, ND 58505-0830

Contact security staff at 701.328.3564 to get access to the loading dock at the security entrance (see symbol on map) and pick up North Dakota Studies trunks. They will ask for your name; reason for access to this entrance; your expected arrival time; and the make, model, and color of your vehicle.

- From Interstate 94, take exit 159 south onto State Street.
- Driving south on State Street, continue past the first entrance to the North Dakota Heritage Center & State Museum.
- Follow the curve on State Street to the right, where State Street merges into East Boulevard Avenue.
- Continue driving west on East Boulevard Avenue to the second light, at the intersection with Seventh Street.
- Turn right onto State Capitol Grounds.
- Following the loop, take the first right turn, which is for deliveries and parking.
- Continue past the parking lot, and you will see the North Dakota Heritage Center's loading dock. Drive up to the garage door and security staff, who should be expecting you, will open the door and allow inside access to load your vehicle.

MAP


North Dakota Capitol Grounds
Bismarck, North Dakota
history.nd.gov
STATE HISTORICAL SOCIETY OF NORTH DAKOTA
DIVIDE AVENUE
TO I-94
EXIT 159
83
N
1. Capitol Building
2. Dept. of Transportation
3. ND Heritage Center
4. State Library
5. State Office Building
6. Governor's Residence
7. State Motor Pool
8. French Gratitude Train
9. ND Veterans Memorial
10. Facility/handicapped zone
Public Entrance
Security Entrance Route
Security Entrance
Public Parking
4TH STREET
STATE STREET
One Way
One Way
BOULEVARD AVENUE
5TH STREET
6TH STREET
7TH STREET

HOW TO RETURN TRUNKS

Replace the artifacts, documents, photographs, and any other materials in the proper order included in the packing instructions. Return the trunk to your nearest UPS shipping center or return trunks to the ND Heritage Center & State Museum on the Capitol grounds (see "How to Get North Dakota Studies Trunks" for details). If you have questions, please call the North Dakota Studies Outreach Coordinator at 701.328.2794.

Shipping Instructions

Remove the old shipping label and as much of the plastic envelope as possible from the trunk. Place the self-stick envelope, containing the pre-paid return shipping label, on the front of the trunk where the old label had been. Close the lid and tighten the fasteners. Unless UPS already makes scheduled stops to your location, you will have to call them to pick up the trunk, or you will have to return the trunk to the nearest UPS shipping center.

Evaluation and Follow-up

Please share your thoughts about your North Dakota Studies trunk experience:

- Complete the evaluation form provided in the plastic envelope with the shipping label and packing list. Either send it back with the trunk or mail it to:

  North Dakota Studies Outreach Coordinator
  State Historical Society of North Dakota
  612 East Boulevard Avenue
  Bismarck, ND 58505

- Learn about additional educational resources in the North Dakota Studies teacher's guide including the North Dakota Studies program and National History Day in North Dakota. Consider using these resources, along with additional North Dakota Studies trunks. Find out more at history.nd.gov.
- Visit the State Museum and State Archives at the North Dakota Heritage Center to learn more about collections, exhibits, and programs available through the State Historical Society of North Dakota. Visit our websites at history.nd.gov, statemuseum.nd.gov, or ndstudies.gov for more information. Sign up for the e-newsletter at history.nd.gov/enews.
- Visit more than fifty historic markers and historic sites managed by the State Historical Society of North Dakota, including the Pembina State Museum in Pembina; Fort Abercrombie in Abercrombie; the Ronald Reagan Minuteman Missile Site in Cooperstown; Fort Totten near Devils Lake; the 1883 Stutsman County Courthouse in Jamestown; the Welk Homestead near Strasburg; the Missouri-Yellowstone Confluence Interpretive Center and Fort Buford near Williston; the Chateau de Mores in Medora; and the Former Governors' Mansion and Camp Hancock in Bismarck
- Follow our sites and museums on Facebook and other social media platforms.

PROGRAM OBJECTIVES

- Promote the use of primary source material in the study of North Dakota's history and culture.
- Enrich curriculum with participatory activities that relate to the study of North Dakota history.
- Extend social studies and history curricula by introducing history studies based on tangible evidence of North Dakota's past—objects, documents, photographs, and audio-visual materials.
- Complement and promote existing curriculum, including the North Dakota Studies program and National History Day in North Dakota.
- Encourage critical thinking skills by using the methods of historians.
- Develop respect for and familiarity with paleontological sites, archeological sites, and historic sites and structures within the state.
- Generate greater understanding about the resources of the State Historical Society of North Dakota and the work of its staff—historians, archaeologists, archivists, historic preservationists, museum curators and educators, anthropologists, and paleontologists.

HOW TO USE TRUNKS

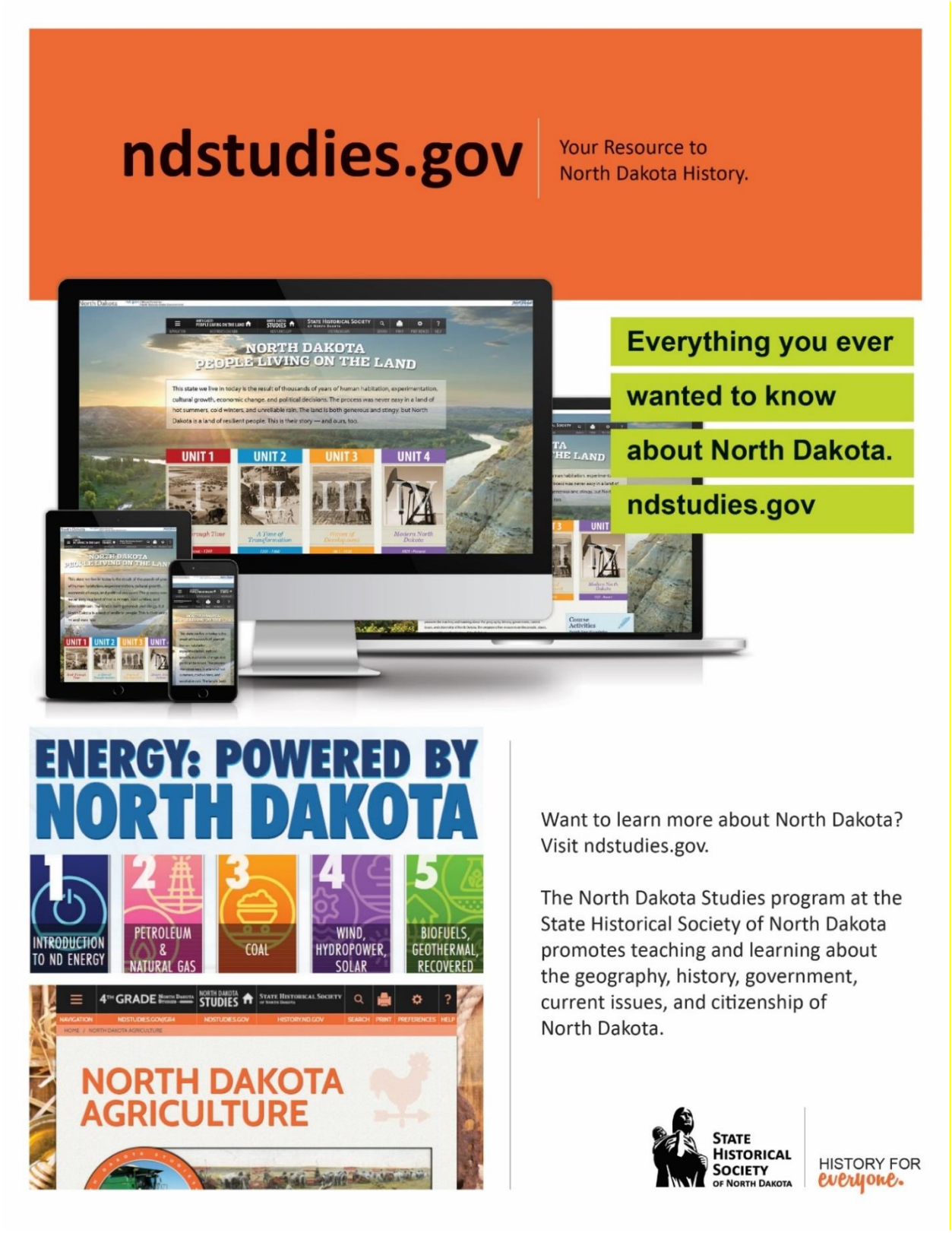
Purpose
North Dakota Studies trunks provide hands-on experiences for learning about the heritage of North Dakota and its people.

Intended Audiences
While the North Dakota Studies trunk program is developed for use at the fourth grade level, it can easily be modified to suit other audiences and purposes. These materials are a great resource for interdisciplinary content and can be used in language arts, visual arts, and music classes as well as science, technology, engineering, and math (STEM). Other organizations that might enjoy using the North Dakota Studies trunk program include libraries, historical societies, museums, hospitals, senior citizen centers, retirement homes, nursing homes, state and city parks, recreational groups, civic groups, youth camps, and youth organizations.

Contents of North Dakota Studies Trunks:

Objects	Scientific specimens or three-dimensional artifacts that can be analyzed to discover the stories they can reveal. Objects in each trunk include both authentic historic items and reproductions. These items have been donated or purchased specifically for use in educational programming. Encourage students to touch and examine the objects, but do stress respect for historical materials and the importance of preservation. Descriptions of each object are listed in the *Teacher's Guide* along with instructions and worksheets for examining objects.
Documents	Illustrate events, people, and concepts relating to a specific topic. Documents lend themselves especially well to developing critical thinking and analytical skills. The documents included in each trunk have been selected for visual appeal and thought-provoking content. They can include a wide variety of materials from handwritten letters to magazine advertisements. A list of the documents included in each trunk can be found in the *Teacher's Guide* along with instructions and worksheets for examining documents.
Audio-Visual Materials	Incorporate a variety of media formats including photographs, CDs, and DVDs. These items deliver a range of content from period appropriate music, to oral history interviews, to videos. Photographs contain details and historical information about social life, clothing, everyday activities, architecture, and technology. A description of each audio-visual media item is listed in the *Teacher's Guide* along with instructions and worksheets for examining these resources.
Teacher Guides	Provide lessons and activities for each topic. Additional information may include topic overviews, suggested readings, glossaries, timelines, maps, and explanations of primary and secondary sources and how to use them. Users are encouraged to review individual trunk objectives and the topic overview before using the objects, documents, and audiovisual materials.

NORTH DAKOTA STUDIES ONLINE



DINOSAURS, SHARKS, and WOOLLY MAMMOTHS

TOPIC OVERVIEW

PACKING INSTRUCTIONS

***Teacher's Guide* (3-ring binder):** Place on top of the foam trays before closing the trunk.
Photograph Boards (16): Place against back wall of trunk.
Media: *Dinomummy* book and *Dinosaurs Unearthed* DVD—place against left wall of trunk.

TRAY 1 – Cretaceous Underwater World

- Otolith, fish ear stone (box #5)
- Mosasaur tooth (#6)
- Cephalopod (#1)
- Cephalopod, ammonite (#2)
- Gastropod, snail (#3)
- Bivalve, clam (#4)

TRAY 2 – Dinosaurs and the Hell Creek Formation

- Conifer cone (#7)
- Freshwater bivalve, clam (#13)
- Tooth (#9)
- Claw (unnumbered box)
- Vertebra (#10)
- Coprolite, feces (#12)
- Dinosaur skin impression

TRAY 3 – Swampy Everglades

- Fern leaf (#15)
- Walnut nut (#16)
- Gastropod, snail (#17)
- Leaf (#14)
- Crocodile tooth (#18)
- Turtle shell fragment (#19)

TRAY 4 – North Dakota's Last Sea, the Cannonball Sea

- Shark Tooth (#20)
- Coral (#21)
- Crab (#22)
- Shrimp burrow (#24)
- *Teredo*-bored petrified wood, North Dakota state fossil (#23)

TRAY 5 – North Dakota Savanna

- Horse tooth (#26)
- Rabbit jaw with teeth (#27)
- Lower jaw fragment with teeth (#25)
- Terrestrial snail (#28)
- Beetle pupal cell (#29)
- Maidenhair tree seeds

TRAY 6 – The Great Ice Age

- Woolly mammoth tooth
- Ground sloth claw
- Bison tooth (#33)
- Freshwater clam (#34)

SHIPPING ENVELOPE – Place white plastic envelope on top of foam trays

- Packing List
- Pre-Paid Return Shipping Label (if required)
- Evaluation Form
- Outreach Coordinator's Business Card

Returning a North Dakota Studies trunk:
Remove the old shipping label, and as much of the clear plastic envelope as possible from the outside of the trunk. Place the pre-paid return shipping label in its self-stick envelope on the trunk where the old label had been. Make sure to close the lid and tighten the fasteners. Unless UPS already makes scheduled stops to your location, you will have to call them to pick up the trunk, or you will have to return the trunk to the nearest UPS shipping center.

TOPIC OBJECTIVES

- Describe what geologists and paleontologists are, and how each is different from archaeologists.
- Identify and describe the four geologic eras and how changes through time have created the landscape of North Dakota.
- Discuss the various types of plants and animals that existed during each geologic era, and what type of environment they lived in.
- Identify fossil fuels and explain how they formed in North Dakota.
- Explain the effect of glaciers on the landscape of North Dakota.

INTRODUCTION TO PALEONTOLOGY IN NORTH DAKOTA

There are many resources included in the *Teacher's Guide* to help teachers and students better understand the scope of the geologic story of what is now the state of North Dakota. The North Dakota Studies unit included here, *Geology, Geography, and Climate*, is written at a fourth grade level. This unit, along with units written for the eighth graders, can be found online at ndstudies.gov. The *North Dakota History: Journal of the Northern Plains* features *Dinosaurs, Sharks, and Woolly Mammoths: Glimpses of Life in North Dakota's Prehistoric Past*. While written at a higher level, includes a variety of images, maps, and other graphics that will interest students of all ages. The North Dakota Geological Survey also has a number of websites for both teachers and students including: the main website, www.dmr.nd.gov/ndgs; the Paleontology Division, www.dmr.nd.gov/ndfossil; and a fossil newsletter for kids, www.dmr.nd.gov/ndfossil/kids.

The North Dakota Studies trunk comes with a number of objects and photo boards that can be used to touch and see history beyond the book. Included in the trunk are more than thirty natural history specimens that can be handled by students. Real fossils are in clear boxes, and casts can be held directly. Sixteen photo boards depict artistic renderings of what prehistoric creatures and their environments might have looked like. Also included are the book *Dinomummy* and a forty-five minute National Geographic DVD, both about Dakota the mummified hadrosaur found near Marmarth, North Dakota.

No study of the natural history of North Dakota is complete without a trip to the North Dakota Heritage Center & State Museum in Bismarck. This is a unique opportunity to see full-scale dinosaur skeletons and other natural history fossils in the Adaptation Gallery: Geologic Time. Learn more at history.nd.gov and statemuseum.nd.gov. Educators will recognize the content of the trunk matches the content and layout of the exhibits in the gallery. The trunk can be used before or after a fieldtrip to help strengthen connections between North Dakota Studies classroom materials and the museum exhibits.

Following is a brief overview of the units of time that are the focus of telling the geologic story of North Dakota. This trunk focuses on the Mesozoic Era (the age of reptiles and dinosaurs) and the Cenozoic Era (the age of mammals). Spend a few minutes studying the strati-graphic column photo board. The column on the left is an example of the geologic time scale (also known as a geologic time table or geologic time calendar). This calendar divides the scope of 4.5 billion years of geologic history of Earth into four main time periods: the Precambrian Eon, and the Paleozoic, Mesozoic, and Cenozoic eras. Several activities in the *Teacher's Guide* are designed to help students understand the massive scale of geologic time. An internet image search will also reveal a variety of creative ways to visually depict a calendar of geologic time. A smaller portion of the geologic time scale is blown up here, in the column on the right, to show greater detail of the portion of the geologic time scale that we focus on in North Dakota Studies. This column zooms into the end of the Cretaceous Period of the Mesozoic Era starting with the Niobrara and Pierre Formations (the oldest rocks exposed on the surface in North Dakota) to the modern Quaternary Period. This column also shows what type of rock is commonly found in each formation, or rock layer (claystone, sandstone, etc.).

UNDERSTANDING GEOLOGIC TIME

The history of Earth is divided into many segments of time, four of which are commonly used. These four segments are the Precambrian Eon and the Paleozoic, Mesozoic, and Cenozoic eras. This trunk focuses mostly on the Mesozoic Era (the age of reptiles and dinosaurs) and the Cenozoic Era (the age of mammals).

Precambrian Eon:

- 4.5 billion years ago to about 540 million years ago
- Only microscopic plants lived during this era

Paleozoic Era: Age of Fish

- 540 million years ago to about 248 million years ago
- Shallow seas covered all of North Dakota
- Sharks and fish lived in these seas
- The oil and natural gas found in the Williston Basin dates from this era

Mesozoic Era: Age of Reptiles

- 248 million years ago to about sixty-five million years ago
- Called the "Age of the Reptiles" because of the reptile-like animals found in the water, air, and on land
- The era in which dinosaurs existed

Cenozoic Era: Age of Mammals

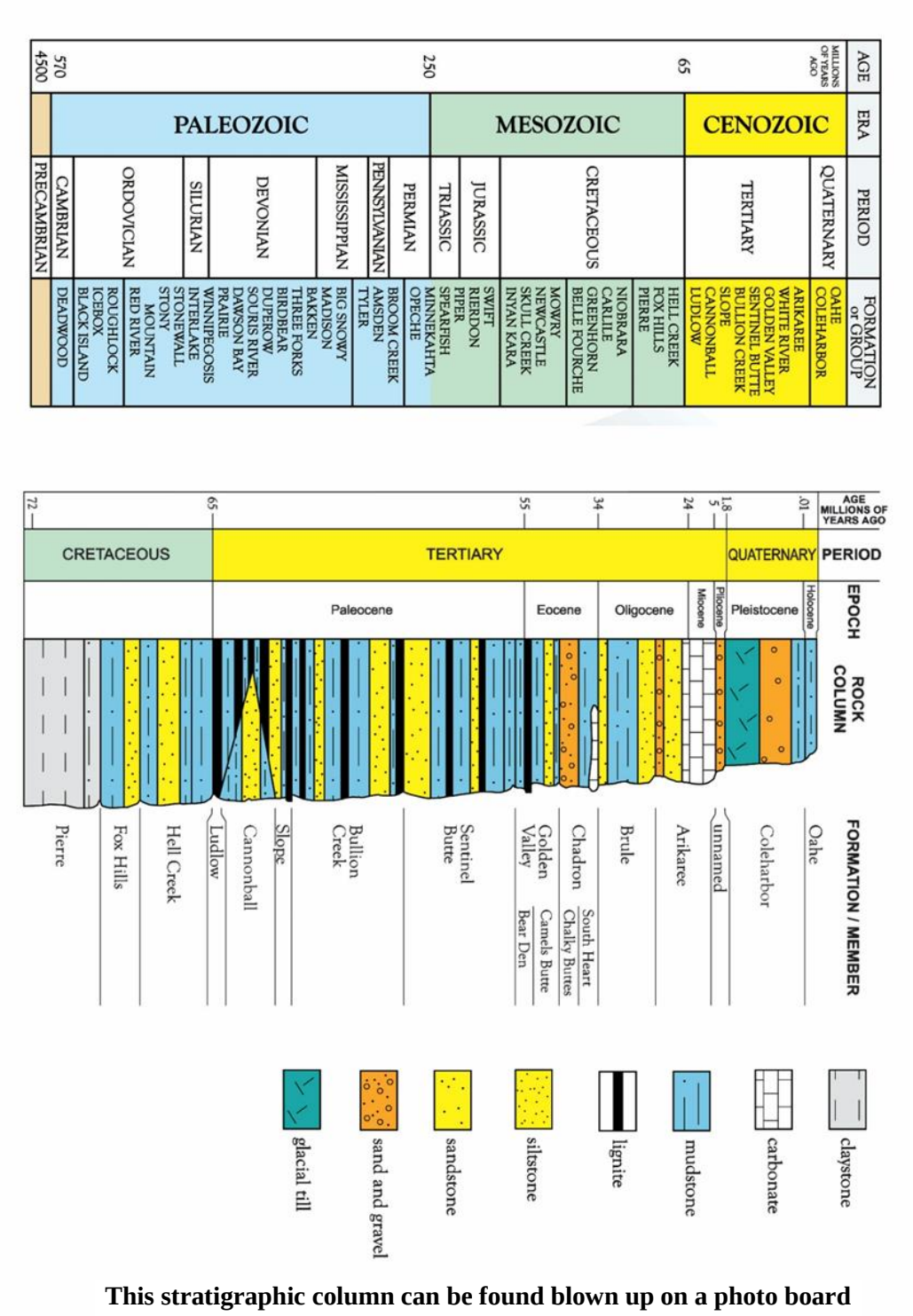
- Began about 65 million years ago to current day
- Coal reserves developed during the Tertiary Period
- The early part of the Quaternary is sometimes called the "Ice Age" because glaciers covered almost the entire state

Breaking down geologic time:

- Eon: largest chunk of time the geologic timescale measures—hundreds of millions to billions of years
- Era: hundreds of millions of years long, boundaries marked by mass extinctions
- Period: tens of millions of years long
- Epoch: divisions of the most recent periods, several million years long

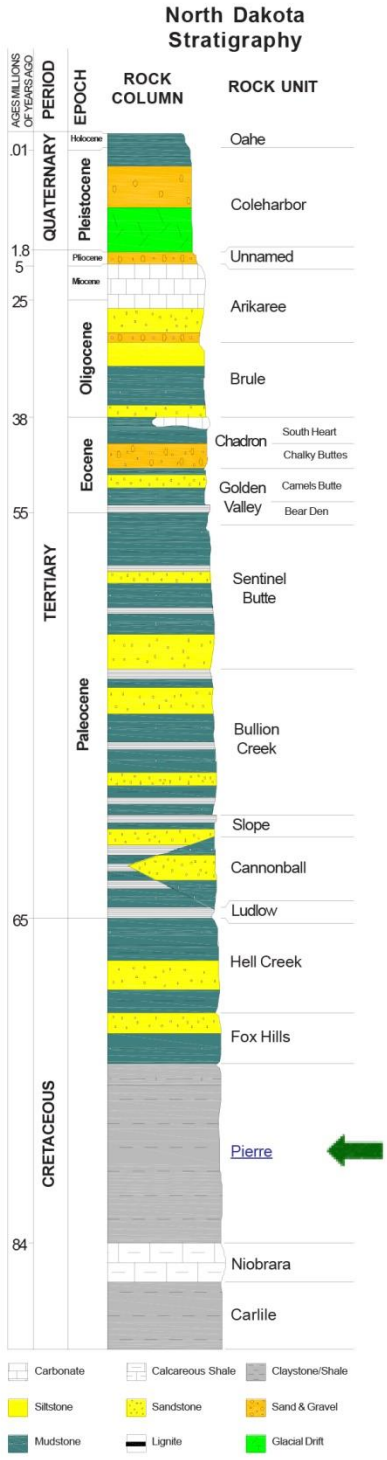
Study the stratigraphic column on the next page or on the photo board from the trunk to better understand how geologic time has been broken down and classified. There are several activities at the end of this teacher guide to help students better understand the scale of geologic time.

STRATIGRAPHIC COLUMN



This stratigraphic column can be found blown up on a photo board in the North Dakota Studies trunk.

THE CRETACEOUS UNDERWATER WORLD



Stratigraphic Time: 85 to 65 million years ago
Rock Formation: Pierre during the Cretaceous Period

During the Cretaceous, from about eighty-five to sixty-five million years ago, North Dakota was either completely or partially covered by subtropical to warm temperate, shallow inland seas. These seas occupied what was called the Western Interior Seaway, essentially the North American mid-continent. The seas were never very deep, perhaps a few hundred feet at most, and at their greatest extent they connected the Arctic Ocean with the Gulf of Mexico. During low sea level, the Hell Creek Delta covered western North Dakota and Fox Hills Sea shoreline habitats occurred in central North Dakota. Fine grained sediments, mostly silt and clay, deposited on the floor of these oceans are now rocks of the Carlile, Niobrara, and Pierre Formations. These are the oldest rocks exposed in North Dakota. Entombed in these rocks are fossils of the animals and plants that inhabited the seas. Remains of marine reptiles, including the mosasaur *Plioplatecarpus*, plesiosaurs, and the sea turtle, *Archelon*; fish (such as sharks, rays, and ratfish); birds; and invertebrates (including clams, cephalopods, snails, corals, and crabs) have been recovered from these rocks.

Tray 1:

- *Tylosaurus*: mosasaur tooth cast [Pierre Fm.]
- *Baculites*: cephalopod [Pierre Fm.]
- *Jeletskytes*: cephalopod (ammonite) [Fox Hills Fm.]
- *Euspira*: gastropod (snail) [Fox Hills Fm.]
- *Tancredia*: bivalve (clam) [Fox Hills Fm.]
- *Vorhisia*: otolith (fish ear stone) [Fox Hills Fm.]

Photo Boards:

Cretaceous Seafloor Mural: This diorama illustrates a Cretaceous seafloor community. Fossils of animals like those shown here have been found (*Dinosaurs, Sharks, and Woolly Mammoths,* p. 8).

Mosasaur *Plioplatecarpus* Mural: This painting depicts an animal community that lived in the shallow-water, subtropical Pierre Sea that covered North Dakota about seventy-five million years ago. The scene is based on fossils found in the Pierre Formation at a site near Cooperstown, Griggs County. The large, predatory mosasaur *Plioplatecarpus* is attacking the diving seabird *Hesperornis*, who has just captured a salmon-like fish, *Enchodus*. In the background the carcass of a decaying *Plioplatecarpus* is being scavenged by a frenzied group of dogfish sharks, *Squalus*. The mosasaur on exhibit at the North Dakota Heritage Center & State Museum was found in this position—with gnaw marks on some of its bones from feeding dogfish sharks. In the painting, the large sand-tiger shark *Carcharias* cruises near the sea floor. Shells of an ammonite, *Sphenodiscus*, with a snail crawling on it, and of the large clam *Inoceramus*, encrusted by oysters, litter the bottom (*Dinosaurs, Sharks, and Woolly Mammoths*, p. 11).

Additional Resources:

- **Trunk Resources:**
  - *Geology, Geography, and Climate: A Unit in North Dakota Studies*, pp. 1-25
  - *Dinosaurs, Sharks, and Woolly Mammoths,* pp. 6-15
  - *Prehistoric Life of North Dakota* (Map): Find the Pierre Formation on the map. You might see the color variations easier here: www.dmr.nd.gov/ndfossil/poster/poster.asp or ndstudies.gov/gr8/content/unit-iii-waves-development-1861-1920/lesson-1-changing-landscapes/topic-2-newcomers-view-land/section-3-environment, or in *Dinosaurs, Sharks, and Woolly Mammoths,* p. 5
  - *Prehistoric Life of North Dakota: Coloring and Activity Book*

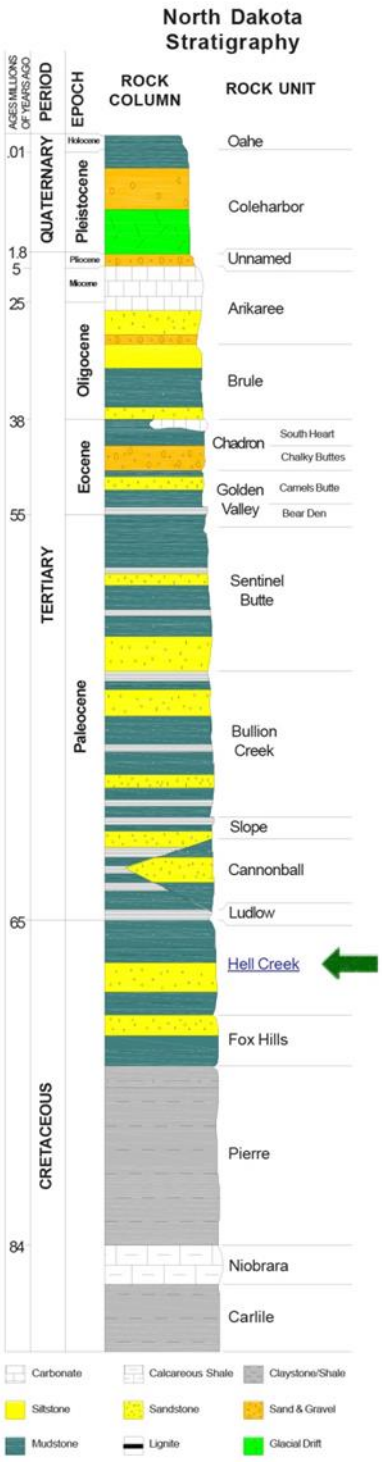
- **Online Resources:**
  - Mosasaur Fun Facts: history.nd.gov/activities/MosasaurFunFacts.pdf
  - *Plioplatecarpus* Coloring Activity: history.nd.gov/activities/plioplatecarpus.pdf

- **Adaptation Gallery: Geologic Time** at the North Dakota Heritage Center & State Museum in Bismarck. Featured in the *Underwater World* exhibit in this gallery are fossils of some creatures that inhabited the seas including the twenty-four-foot-long Cooperstown mosasaur (large, marine lizard-like predators) *Plioplatecarpus*, sixteen-foot-long tarpon-like fish *Xiphactinus*, twelve-foot-long giant sea turtle *Archelon*, five-foot-tall diving seabird *Hesperornis*, ammonites, and fossils of some smaller fish including sharks, invertebrates, and other animals.

WHEN DINOSAURS RULED HELL CREEK

Stratigraphic Time: 65 million years ago
Rock Formation: Breien Member, Fox Hills, and Hell Creek Formations during the Cretaceous Period

During the Cretaceous, about sixty-five million years ago, a well-drained lowland corridor existed between the rising Rocky Mountains and the Western Interior Seaway to the east. Sediments eroded from the Rocky Mountains were carried to this western North Dakota lowland by rivers and streams and were deposited in a huge delta, the Hell Creek Delta. These sediments, now turned into sandstone, siltstone, and mudstone, are called the Hell Creek Formation. Wood-lands, ponds, and swamps that existed on this subtropical, deltaic coastal plain provided habitats for many kinds of exotic plants and animals including several species of dinosaurs such as *Triceratops* and *Tyrannosaurus rex*. Freshwater fishes, salamanders, lizards, turtles, crocodiles, birds, snails, clams, and small mammals coexisted with dinosaurs. Fossils of animals, including sharks, rays, and mosasaurs (large marine lizards) that inhabited shallow marine waters next to the delta are found in the Fox Hills Formation and Breien Member of the Hell Creek Formation. The species of dinosaur that existed at this time were the last dinosaurs to ever live.



Tray 2 [All from the Hell Creek Formation]:

- *Metasequoia:* conifer cone
- Freshwater bivalve: clam
- *Tyrannosaurus rex:* tooth cast
- Dinosaur claw cast
- *Hadrosaur:* vertebra cast
- Coprolite: feces cast
- *Edmontosaurus:* Duck billed dinosaur skin cast

Photo Boards:
Cretaceous Mural: This mural depicts what the coastal forest on the Hell Creek Delta bordering the Western Interior Seaway may have looked like in North Dakota about sixty-five million years ago. Sediments deposited in the delta are known as the Hell Creek Formation (*Dinosaurs, Sharks, and Woolly Mammoths*, p. 16).

Edmontosaurus: This is a painting of *Edmontosaurus* in a coastal swamp. This duck billed hadrosaur was a common herbivore that resided in North Dakota at the end of the Cretaceous Period. A hadrosaur face was elongated into a broad, flattened snout with a toothless beak. This flattened snout looked rather like the bill of a modern duck, hence the popular name "duck billed dinosaur." *Edmontosaurus* used its beak for foraging, possibly to strip bark and leaves from trees. There were several species of hadrosaurs, and their skeletons are remarkably similar, so generally the skull must be found to identify the exact species of the animal (*Dinosaurs, Sharks, and Woolly Mammoths*, p. 19).

Tyrannosaurus rex: This is *Tyrannosaurus rex* in a Late Cretaceous habitat. No complete skeletons of this dinosaur have been found in North Dakota, but *T. rex* teeth and bones have been recovered. *Tyrannosaurus rex* lost teeth throughout its life, growing replacement teeth much like a shark does (*Dinosaurs, Sharks, and Woolly Mammoths,* p. 21).

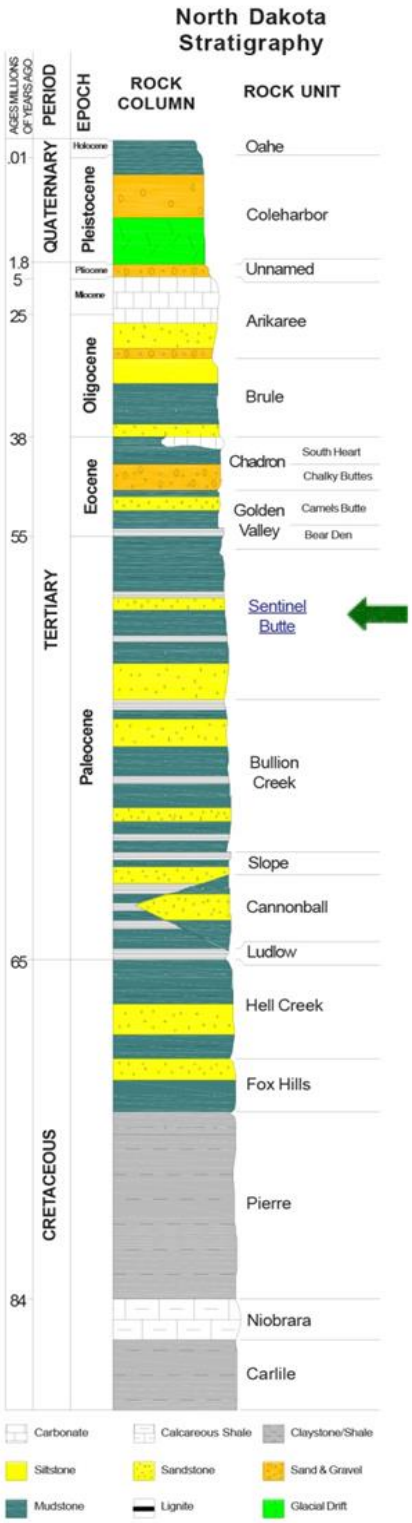
Additional Resources:

- **Trunk Resources:**
  - *Geology, Geography, and Climate: A Unit in North Dakota Studies*, pp. 1-25
  - *Dinosaurs, Sharks, and Woolly Mammoths,* pp. 16-25
  - *Prehistoric Life of North Dakota* (Map): Find the Fox Hills and Hell Creek rock Formations on the map. You might see the color variations easier here: www.dmr.nd.gov/ndfossil/poster/poster.asp or ndstudies.gov/gr8/content/unit-iii-waves-development-1861-1920/lesson-1-changing-landscapes/topic-2-newcomers-view-land/section-3-environment, or in *Dinosaurs, Sharks, and Woolly Mammoths,* p. 5
  - *Prehistoric Life of North Dakota: Coloring and Activity Book*

- **Online Resources:**
  - *Triceratops* Coloring Activity: history.nd.gov/activities/triceratops.pdf
  - *Tyrannosaurus rex* Coloring Activity: history.nd.gov/activities/trex.pdf
  - *The Day the Mesozoic Died*: A thirty-four minute video explaining the K-T Boundary that includes footage of paleontologists working in the North Dakota Badlands, digging in the Hell Creek Formation. www.hhmi.org/biointeractive/day-mesozoic-died

- **Adaptation Gallery: Geologic Time** at the North Dakota Heritage Center and State Museum in Bismarck, ND. The display *When Dinosaurs Ruled* features full scale casts of *Tyrannosaurus rex* (about thirty-five feet long) and *Triceratops* (about thirty feet long) skeletons facing each other in a combative pose. Other fossils in this display include a duck-billed dinosaur leg bone that shows gnaw marks caused from *T. rex* bites, a skull of *Triceratops*, a jaw of a duck billed dinosaur *Edmontosaurus*, a flying *Pteranodon* and its nest with babies, skeletons of small raptor dinosaurs, a mammal skeleton *Didelphodon*, and plants and invertebrates that lived along with the dinosaurs. In the hallway outside of the Adaptation Gallery, the fossil of Dakota, the mummified duck-billed dinosaur, is on exhibit.

NORTH DAKOTA EVERGLADES



Stratigraphic Time: 65 to 55 million years ago
Rock Formation: Ludlow, Slope, Bullion Creek, Sentinel Butte, and Golden Valley Formations during the Paleocene Epoch of the early Tertiary Period

During the Paleocene, between about sixty-five million and fifty-five million years ago, sediments eroded from the rising Rocky Mountains were carried to western North Dakota and deposited in rivers, floodplains, lakes, and swamps. These lithified sediments are the Ludlow, Slope, Bullion Creek, Sentinel Butte, and Golden Valley Formations. Mats of vegetation built up in the swamps and the vegetation was eventually transformed into lignite coal. This subtropical, swampy lowland contained extensive forests and provided habitats for exotic plants and animals. Invertebrates, including clams, snails, insects, and minute crustaceans, lived in the rivers, streams, ponds, and swamps. Many kinds of vertebrates also lived in and near these aquatic habitats including turtles, crocodiles, alligators, champsosaurs (crocodile-like reptiles), and fish. Exotic plants such as ferns, cycads, figs, bald cypress, ginkgo, magnolia, sycamore, giant dawn redwoods, and palm grew in the lush forests. Insects and birds lived on and ate these plants. Mammals were beginning to become established during this time after the extinction of the last of the dinosaurs a few million years earlier.

Tray 3:

- Fern leaf
- *Cyclocarya*: walnut nut [Sentinel Butte Fm.]
- *Campeloma*: gastropod (snail) [Bullion Creek Fm.]
- *Ginkgo*: leaf [Sentinel Butte Fm.]
- Crocodile tooth [Sentinel Butte Fm.]
- Turtle shell fragment [Sentinel Butte Fm.]

Poster Boards:

Paleocene Swamp Mural: This is a swampland habitat during the Paleocene sixty million years ago in western North Dakota. Crocodiles, crocodile-like champsosaurs, and several kinds of turtles, fish, insects, and mollusks lived in these swampy areas. Exotic plants such as bald

cypress, dawn redwood, magnolia, ginkgo, and palm grew here. Farther east in North Dakota the Cannonball Sea was inhabited by sharks, rays, and ratfish (*Dinosaurs, Sharks, and Woolly Mammoths*, p. 27).

***Borealosuchus* on a log:** This is the swamp habitat of the crocodile *Borealosuchus*, which was very large, growing to about fifteen feet long and similar in appearance to the living crocodile. There have been many fossils of this animal recovered in North Dakota, especially in Billings County at a site called Wannagan Creek. The remains of about eighty *Borealosuchus* skeletons have been found in an area roughly the size of an ice hockey rink (*Dinosaurs, Sharks, and Woolly Mammoths*, p. 30).

Additional Resources:

- **Trunk Resources:**
  - *Geology, Geography, and Climate: A Unit in North Dakota Studies*, pp. 1-25
  - *Dinosaurs, Sharks, and Woolly Mammoths*, pp. 26-36
  - *Prehistoric Life of North Dakota* (Map): Find the Cannonball, Ludlow, Slope, Bullion Creek, Sentinel Butte, and Golden Valley rock Formations on the map. You might see the color variations easier here: www.dmr.nd.gov/ndfossil/poster/poster.asp or ndstudies.gov/gr8/content/unit-iii-waves-development-1861-1920/lesson-1-changing-landscapes/topic-2-newcomers-view-land/section-3-environment, or in *Dinosaurs, Sharks, and Woolly Mammoths*, p. 5
  - *Prehistoric Life of North Dakota: Coloring and Activity Book*

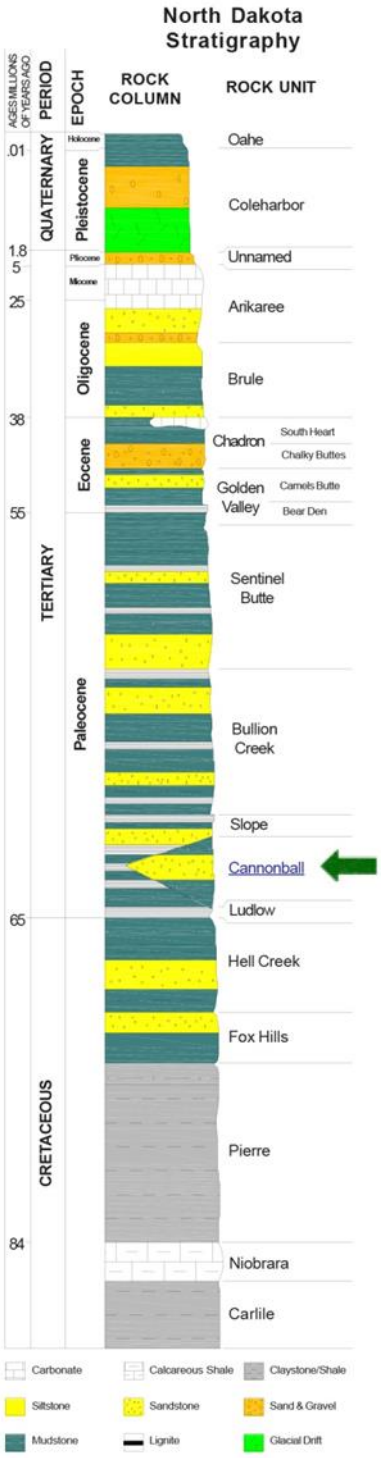
- **Online Resources:**
  - *Champsosaurus gigas* Coloring Activity: history.nd.gov/activities/champsosaurus.pdf

- **Adaptation Gallery: Geologic Time** at the North Dakota Heritage Center and State Museum in Bismarck. The *Everglades* exhibit, simulating swampland, illustrates this time in North Dakota's history right after the dinosaurs became extinct. This exhibit features the cast of a twelve-foot-long crocodile *Borealosuchus* skeleton, a three-foot-long salamander *Piceoerpteon* skeleton, an eight-foot-long skeleton of *Champsosaurus* (crocodile-like animal), turtles, the skeleton of a lemur-like mammal *Plesiadapis*, the skeleton of the bear-size mammal *Titanoides*, and fossils of invertebrates. Fossils of many plants from this time are displayed on a twenty-foot-long wall. Also on this wall are examples of North Dakota's state fossil, *Teredo*-bored petrified wood.

CANNONBALL: NORTH DAKOTA'S LAST SEA

Stratigraphic Time: 60 years ago
Rock Formation: Cannonball Formation during the Paleocene Epoch of the early Tertiary Period

The last sea to cover North Dakota was the Cannonball Sea. About sixty million years ago, during the Paleocene, that sea receded from North Dakota. Sediments deposited in the Cannonball Sea are called the Cannonball Formation and consist mostly of sandstones and mudstones. Fossils found in these rocks provide information about the kinds of animals that inhabited the sea. Remains of large marine reptiles, mosasaurs, and plesiosaurs that lived in Cretaceous seas are not found in the Cannonball Formation because they had become extinct at the end of the Cretaceous at the same time that dinosaurs became extinct. The main predators in the Cannonball Sea were sharks. Remains of several species of sharks, including the sand tiger shark, *Carcharias*, have been found. Many other kinds of fish including stingrays, eagle rays, and ratfish also lived in the sea. Invertebrate animals inhabited the shallow water areas and shorelines including cephalopods, clams, snails, crabs, shrimp, and lobsters. *Teredo*-bored petrified wood, North Dakota's state fossil, occurs in the Cannonball Formation. This is driftwood that had been bored into by shipworms (clams) before becoming petrified.



Tray 4 [All from the Cannonball Formation]:

- *Carcharias*: shark tooth
- *Paracyathus*: coral
- *Camarocarcinus*: crab
- *Ophiomorpha*: shrimp burrow
- *Teredo*: bored petrified wood, North Dakota's state fossil

Photo Board:
Carcharias painting: The shark *Carcharias* was the most common predator of the Cannonball Sea in North Dakota. Fossil teeth of *Carcharias* and other sharks have been found in the Cannonball Formation. These teeth are identical to those of the modern sand-tiger shark (*Dinosaurs, Sharks, and Woolly Mammoths*, p. 33).

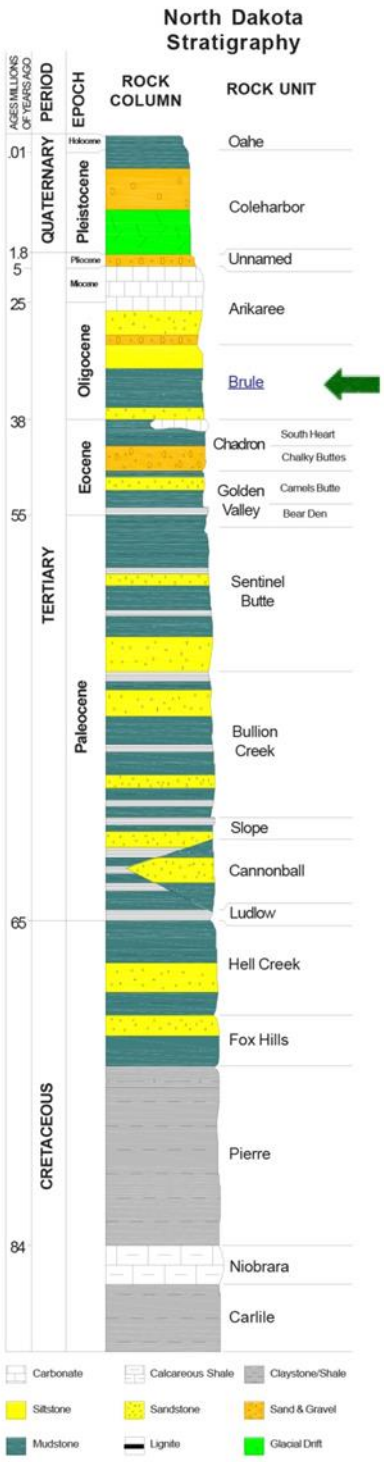
Additional Resources:

- **Trunk Resources:**
  - *Geology, Geography, and Climate: A Unit in North Dakota Studies*, pp. 1-25
  - *Dinosaurs, Sharks, and Woolly Mammoths,* pp. 33-36
  - *Prehistoric Life of North Dakota* (Map): Find the Cannonball Formation on the map. You might see the color variations easier here: www.dmr.nd.gov/ndfossil/poster/poster.asp or ndstudies.gov/gr8/content/unit-iii-waves-development-1861-1920/lesson-1-changing-landscapes/topic-2-newcomers-view-land/section-3-environment, or in *Dinosaurs, Sharks, and Woolly Mammoths,* p. 5
  - *Prehistoric Life of North Dakota: Coloring and Activity Book*
  - Request the North Dakota Studies Energy Development trunk

- **Online Resources:**
  - North Dakota Studies Online Energy Units: Learn more about the fossil fuels and coal found in North Dakota by exploring the North Dakota Studies Energy Units online: ndstudies.gov/energy/level2. How and when were these resources created, and how does the industry affect our state today?

- **Adaptation Gallery: Geologic Time** at the North Dakota Heritage Center & State Museum in Bismarck. Fossils of animals that lived in the last sea to cover North Dakota, the Cannonball Sea, are displayed including teeth of sharks, fish, and many invertebrates.

NORTH DAKOTA SAVANNA



Stratigraphic Time: 50 20 million years ago
Rock Formation: Brule and Arikaree Formations during the Oligocene and Miocene Epochs of the early Tertiary Period

About fifty million years ago, the climate became cooler and drier compared to earlier in the Paleocene. The swampy environments and the plants and animals that lived during the early Paleocene began to disappear. A mostly treeless plain, or savanna, became established by about forty million years ago. Rivers flowing across the savanna deposited sands and gravels in the river channels and silts and muds on the floodplains. Gallery woodlands grew along the stream margins, and lakes occupied some areas. The rich assortment of fossils found in the Chadron, Brule, and Arikaree Formations indicate the kinds of animals that inhabited the savanna. Life during the Eocene, Oligocene, and Miocene was much different than in the Paleocene. A diverse group of mammals resided on the savanna, many of which were members of families that still exist today including ancestral dogs, cats, camels, deer, squirrels, beavers, horses, rabbits, rhinoceroses, and mice. Large tortoises, some as large as the modern Galapagos turtles, lived near the rivers. Several species of fish, amphibians, turtles, lizards, and birds lived in and near the lakes and rivers.

Tray 5 [All from the Brule Formation]:

- *Mesohippus:* horse tooth
- *Palaeolagus*: rabbit jaw with teeth
- *Merycoidodon:* oreodont jaw fragment with teeth
- *Skinnerelix:* terrestrial snail
- *Pallichus:* beetle pupal cell
- *Celtis:* maidenhair tree seeds

Photo Boards:

Oligocene Mural: About thirty million years ago, during the Oligocene, the subtropical, swampy forests had given way to a mostly treeless plain, similar to a savanna. This open plain was a scrubland consisting of shrubs, herbaceous plants, and some grasses. The Oligocene

climate was seasonal and temperate, with an annual rainfall similar to that found in North Dakota today. Fossils recovered from the Brule Formation show that the number of mammal species, mostly adapted for grazing, and the abundance of mammals dramatically increased in the warm-temperate, dry, open-plain Oligocene habitats in North Dakota following the Eocene extinctions. The most spectacular mammals that lived during this time in North Dakota were the brontotheres, or titanotheres "thunder beasts," because of their immense size. They were like today's rhinoceroses, but more the size of elephants, about eight feet tall at the shoulder. However, true savanna habitats, dominated by grasslands like parts of Africa today, did not become established in the state until the Miocene (*Dinosaurs, Sharks, and Woolly Mammoths*, p. 37).

***Mesohippus* Painting:** This was one of the early species of horses. It was about the size of a greyhound dog, with slender limbs adapted for trotting and running. Many people are under the false impression that horses did not inhabit North America until introduced by Spanish explorers. However, horses are indigenous to North America. Fossil remains of the earliest horse, *Hyracotherium* (or sometimes *Eohippus*), date to about fifty million years ago. In fact, horses were some of the most abundant mammals that lived during that time. The oldest fossils of horses found in what is now North Dakota are from about thirty million years ago, when the diminutive horse, *Mesohippus* roamed western North Dakota. *Mesohippus* was tiny. The adults were only about twenty inches tall at the shoulder. They had three toes on each foot compared to the modern horse *Equus* that has one. *Mesohippus* was probably more of a browsing herbivore compared to the modern grazing horse.

Paleontologists have also found the remains of 50,000-year-old horses in North Dakota indicating that horses lived here during the last Ice Age. By that time, horses had attained the size and aspect of modern-day horses and are placed in the modern horse genus, *Equus*. Horses did become extinct in North America some time near the end of the Ice Age, several thousand years ago. Why they became extinct in North America and not in the Old World is a matter of debate. Spanish conquistadors brought horses with them when they arrived in the southwestern part of what is now the United States in the 1500s, but Native Americans in North Dakota didn't acquire horses until the mid-1700s. The importance of the horse to Plains Indians cannot be overstated. The period from the time Native People first obtained horses until the near extermination of the buffalo in about 1880 is known as the "Horse Culture Period." The importance of the horse on the Great Plains extends to the days of pioneers and settlers and is equally prominent today, especially in cowboy culture (*Dinosaurs, Sharks, and Woolly Mammoths*, p. 41).

***Palaeolagus* Painting:** The *Palaeolagus* is in the Lagomorpha family, which includes pikas, rabbits, and hares. Because of their small size and continually growing incisors (gnawing teeth), lagomorphs are much like rodents, except that they have two pairs of upper incisors as compared to one pair in rodents. They were similar in appearance to the modern rabbit except that its hind legs were shorter, suggesting being better adapted for scampering than hopping (*Dinosaurs, Sharks, and Woolly Mammoths*, p. 42).

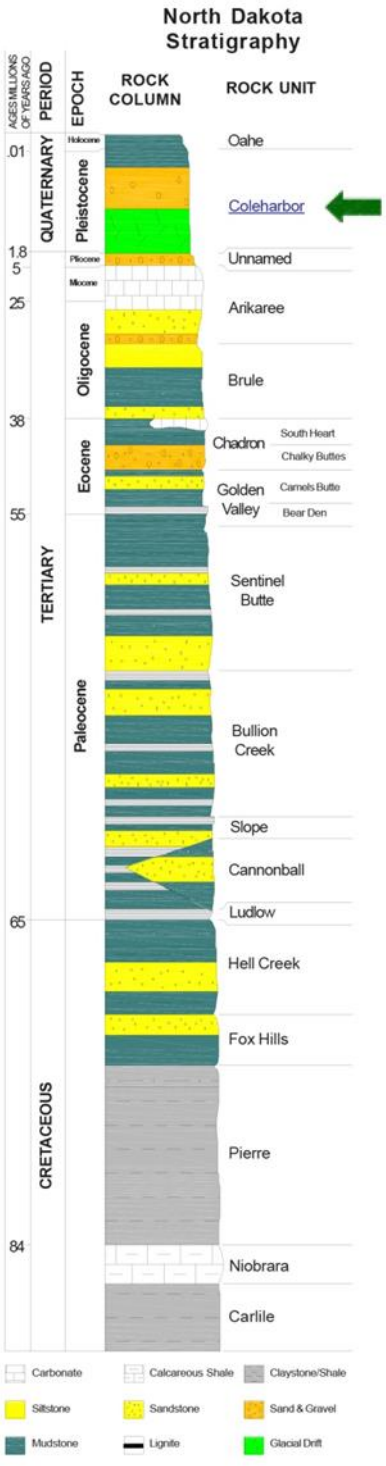
Additional Resources:

- **Trunk Resources:**
  - *Geology, Geography, and Climate: A Unit in North Dakota Studies*, pp. 1-25
  - *Dinosaurs, Sharks, and Woolly Mammoths,* pp. 37-47
  - *Prehistoric Life of North Dakota* (Map): Find the Arikaree and Brule Formations on the map. You might see the color variations easier here: www.dmr.nd.gov/ndfossil/poster/poster.asp or ndstudies.gov/gr8/content/unit-iii-waves-development-1861-1920/lesson-1-changing-landscapes/topic-2-newcomers-view-land/section-3-environment, or in *Dinosaurs, Sharks, and Woolly Mammoths,* p. 5
  - *Prehistoric Life of North Dakota: Coloring and Activity Book*

- ***Adaptation Gallery: Geologic Time*** at the North Dakota Heritage Center & State Museum in Bismarck. The *Mammals on the Savanna* section of the exhibit features fossils of many mammals from this period including the remains of the elephant sized brontothere *Megacerops*, giant pig-like *Archaeotherium*, rhinoceros *Subhyracodon*, early horse *Mesohippus*, weasel-like canid *Hesperocyon*, insectivore *Leptictis*, sheep-like *Merycoidodon*, rabbit *Palaeologus*, predatory cat-like mammals *Dinictis* and *Hoplophoneus*, and others. Shells of the huge tortoise *Stylemys* and other turtles and a fish skeleton are also displayed.

THE GREAT ICE AGE

Stratigraphic Time: 1.6 million years ago
Rock Formation: Coleharbor and Oahe Formations during the Quaternary Period



The last Great Ice Age, which began about 1.6 million years ago, dramatically affected the geology and life of North Dakota. Glaciers advanced into North Dakota from Canada on numerous occasions and extended as far south as the Missouri River during the last major glacial advance. When the glaciers melted, the sediment incorporated in the melting ice was deposited. Fossils of the animals that lived during the Ice Age are found in these deposits including remains of mammoths, mastodons, giant bison, ground sloths, and horses. Spruce-aspen forests grew in North Dakota between 13,000 and 8,500 years ago. Fossils found in pond and bog sediments indicate that cold-adapted frogs, fish, insects, crustaceans, mollusks, plants, and small mammals, including beavers, inhabited the area. Artifacts indicate that the first people to live in North Dakota were here by 11,000 years ago. They were big game hunters preying on mammoths and other large mammals. Climate became warmer and drier between 8,500 and 4,500 years ago, and the spruce-aspen forests were replaced by prairie habitats. The kinds of plants and animals that live in North Dakota today became established at that time.

Tray 6:

- *Mammuthus:* woolly mammoth tooth cast [Coleharbor Fm.]
- *Megalonyx jeffersonii*: ground sloth claw cast [Coleharbor Fm.]
- Bison tooth [Oahe Fm.]
- Freshwater clam [Oahe Fm.]

Photo Boards:

Mastodon Mural: This painting of mastodons is in a spruce-aspen forest. Much of North Dakota appeared like this about eleven thousand years ago. Mastodons were elephant-like and elephant-sized, about as large as the Indian elephant that lives today, but they were neither true elephants nor very closely related to mammoths. Mastodons were covered with long, shaggy hair for insulation against the Ice Age cold (*Dinosaurs, Sharks, and Woolly Mammoths,* p. 51).

Woolly Mammoth: Fossils of woolly mammoths, *Mammuthus primigenius,* (migrants from Eurasia across the Bering land bridge), particularly teeth, are fairly common in North Dakota. They are in the same family as modern elephants. Woolly mammoths

used their tusks for brushing away snow, digging up roots, debarking trees, and fighting. The pointed tips were used for grasping. They ate grass and had a thick coat of shaggy, black-brown hair, an undercoat of fine hair and a layer of fat for insulation against the severe Ice Age climate (*Dinosaurs, Sharks, and Woolly Mammoths*, p. 50).

Megalonyx: The *Megalonyx* was a giant ground sloth. The first fossil of one in North Dakota was a claw, found south of Bismarck in 2000. Almost two centuries before its discovery, the Lewis and Clark Expedition, which had been specifically instructed by President Jefferson (also a paleontologist) to look for fossils, passed by the spot on what is now US Army Corps of Engineers-administered land where the fossil was found (*Dinosaurs, Sharks, and Woolly Mammoths*, p. 52).

Ice Age Horse: Horses like this Ice Age *Equus* ranged across North Dakota about fifty thousand years ago (*Dinosaurs, Sharks, and Woolly Mammoths*, p. 53).

Additional Resources:

- **Trunk Resources:**
  - *Geology, Geography, and Climate: A Unit in North Dakota Studies*, pp. 1-25
  - *Dinosaurs, Sharks, and Woolly Mammoths*, pp. 48-56
  - *Prehistoric Life of North Dakota* (Map): Find the Pierre Formation on the map. You might see the color variations easier here: www.dmr.nd.gov/ndfossil/poster/poster.asp or ndstudies.gov/gr8/content/unit-iii-waves-development-1861-1920/lesson-1-changing-landscapes/topic-2-newcomers-view-land/section-3-environment, or in *Dinosaurs, Sharks, and Woolly Mammoths*, p. 5
  - *Prehistoric Life of North Dakota: Coloring and Activity Book*

- **Online Resources:**
  - *Mammut americanum* Coloring Activity: history.nd.gov/activities/mammut%20americanum.pdf
  - Prehistoric Hunting: history.nd.gov/activities/hunting.pdf

- **Adaptation Gallery: Geologic Time** at the North Dakota Heritage Center & State Museum in Bismarck. *The Great Ice Age* display includes video animations depicting how these glacial advances affected North Dakota's landscape. Fossils of animals and plants that existed in North Dakota near the end of the Ice Age are also exhibited including the skull of the giant bison *Bison latifrons*, a skeleton of *Bison latifrons* being attacked by two saber-toothed cats *Smilodon*, and a skeleton of the huge, eight-foot-tall, ground sloth *Megalonyx*. Other fossils of Ice Age animals displayed include remains of woolly mammoth, frog, muskrat, insects, snails, clams, and plants. The Highgate Mastodon, *Mammut americanum*, skeleton is displayed in the hall outside the gallery.

GLOSSARY

Cenozoic Era: Known as the "Age of Mammals." The last part of this era is sometimes called the "Ice Age" for the glaciers that at one time covered almost the entire state of North Dakota.

Eon: Largest chunk of time the geologic timescale measures—billions of years long.

Epoch: Divisions of the most recent periods, several million years long.

Era: Hundreds of millions of years long, boundaries marked by mass extinctions.

Fossils: Evidence of past life that can include: plants, fish, mammals, and dinosaurs. An index fossil is one that helps identify the relative age of a rock formation.

Geologist: Scientists who study rocks. They work to understand our planet, Earth—how it was made; what it is made of; and how it has changed over time.

Mesozoic Era: Known as the "Age of Reptiles." This is the era in which dinosaurs existed.

Paleontologists: Scientists who study fossils. Most paleontologists have college degrees in geology as well as extensive training in biology. Knowledge of the anatomy, behavior, and habitat preferences of living plants and animals is critical for interpreting the appearances and life ways of species that are extinct and represented only by fossils. **Archaeologists** study *human* history and prehistory. Paleontologists and archaeologists have different professional backgrounds and academic focuses from each other.

Paleozoic Era: Known as the "Age of Fish." The oil and natural gas found in the Williston Basin dates from this era.

Period: Divisions of Eras, tens of millions of years long.

Precambrian Eon: The oldest era of Earth's history when only microscopic plants lived.

See also: *Geology, Geography, and Climate: A Unit in North Dakota Studies*, pp. 25-30.

BOOKS AND RESOURCES

North Dakota Studies Materials:

Fourth Grade: ndstudies.gov/gr4/geology-geography-and-climate/part-1-geology
Energy Units: ndstudies.gov/energy/level1

Eighth Grade: ndstudies.gov/gr8/node/292
Energy Units: ndstudies.gov/energy/level2

See also: *Geology, Geography, and Climate: A Unit in North Dakota Studies*, pp. 31-32.

North Dakota Geological Survey: www.dmr.nd.gov/ndgs
Paleontology Division: www.dmr.nd.gov/ndfossil
Fossil Newsletter for Kids (FIND): www.dmr.nd.gov/ndfossil/kids
Additional Educational Resources: www.dmr.nd.gov/ndfossil/education/Education.asp

Field Trips:

North Dakota Heritage Center and State Museum: statemuseum.nd.gov
Fossil Digs: www.dmr.nd.gov/ndfossil/digs

National Fossil Day: nps.gov/subjects/fossilday/index.htm

North Dakota Studies Trunks: Several other trunks relate to the topic explored in this trunk including Energy Development, Archaeology, Early Peoples, Chippewa/Métis, Dakota, and Mandan/Hidatsa/Arikara.

North Dakota Blue Book: history.nd.gov/bluebook/index.html

Dinosaurs, Sharks, and Woolly Mammoths

ACTIVITIES

ACTIVITIES

This section includes suggested activities designed to be used at a fourth grade level to correspond with North Dakota Studies curriculum. Most of the activities vary in complexity, time needed to complete, and skills required. Teachers are encouraged to change the activities to what works best for their particular situations. Even the simpler activities can be engaging and thought-provoking for older students. Some activities may extend over several class periods. There are also some suggested enrichment activities and independent study projects included. It should also be noted that several activities are trans-disciplinary. This holistic approach to North Dakota Studies seeks to connect arts and sciences in an engaging approach.

WHAT IS A PALEONTOLOGIST?

Objectives: Understand what paleontologists do for a living, what kind of education they need, and career prospects for the field. Describe the differences between paleontologists and archaeologists.

Materials:
- *Teacher's Guide*: "Paleontologist—A Job Description"
- *Dinosaurs, Sharks, and Woolly Mammoths* "Fossils and Fossil Hunters" (pp. 4-5)
- Student access to library materials including books and the internet

Preparation: Review the "Paleontology—A Job Description" handout from the *Teacher's Guide*. People who study rocks are called ***geologists***. They work to understand our planet, Earth—how it was made, what it is made of, and how it has changed over time. **Paleontologists** study fossils, which are evidence of past life that can include plants, fish, mammals, and dinosaurs. Paleontology is an interdisciplinary science that blends geology and biology. Most paleontologists have college degrees in geology as well as extensive training in biology. Knowledge of the anatomy, behavior, and habitat preferences of living plants and animals is critical for interpreting the appearances and life ways of species that are extinct and represented only by fossils. It should be noted that an **archaeologist** studies *human* history and prehistory. Paleontologists and archaeologists have different professional backgrounds and academic focuses from each other.

Activity: Have students read the "Paleontology—A Job Description" handout. Have them do additional work to research the history of paleontology, biographies of famous paleontologists, or paleontologists who have lived and worked specifically in North Dakota. Have them write a paper, or create a website, documentary, exhibit, or performance to share their research. Students of all ages will need help in understanding how to do an internet search, how to critically evaluate online sources, and how to cite sources. Even younger students can learn how to create an **annotated** bibliography. An annotated bibliography gives a summary and evaluation (about a paragraph long) of each source. This is an excellent exercise in internet literacy and critical thinking for students in all grade levels. This activity can be done individually or in groups.

Discussion: What is the difference between a paleontologist and an archaeologist? Which one studies natural history specimens like dinosaurs and other fossils? Which one studies people? Where can people go to find fossils on public display in North Dakota? Can they go on a dig in North Dakota?

Extend the Experience: Have students take part in National History Day in North Dakota. Learn more at history.nd.gov.

PALEONTOLOGIST—A JOB DESCRIPTION

Career Outlook: Good, medium to high earnings

Subjects to Study: Geology, biology, chemistry, mathematics, computer science, physics

Education: Paleontologists need to complete four years of college to receive a bachelor's degree, and most need to continue on for an additional two to five years to complete either a master's degree or a doctorate.

Job Description: Paleontologists are both scientists and detectives. They study fossils of animals to learn about what Earth was like many years ago. They find fossils by digging into layers of rock. Paleontologists use scientific methods to find out more about the life form that the fossil came from such as how old a fossil is, and whether the fossil was formed on land or under water. They use this and other information to learn more about the history of our planet.

Working Conditions: Paleontologists typically spend summers in the field at dig sites. During the colder months, when the weather doesn't allow for active field work, most paleontologists work in laboratories, do additional research, write publications, teach in college classrooms, or work in museums developing exhibits and public programs. They use a variety of tools including computers, picks, chisels, shovels, magnifying glasses, and other tools to help uncover and preserve fossils.

Related Jobs: Geologist, soil scientist, engineering and science technician, mathematician, university or college instructor, or museum curator. Some paleontologists have backgrounds as artists to help illustrate what fossils and their environments may have looked like, for use in publications and museum exhibits and programs.

Additional Information: It should be noted that an **archaeologist** studies *human* history and prehistory. Paleontologists and archaeologists have different professional backgrounds and academic focuses from each other.

Assignment: Go to the library and/or access the internet to look for jobs in the geology and paleontology fields. Find five to ten job descriptions for paleontologists. What type of degree is required? What types of organizations do they work for? How much money do they make? What kind of work experience do they need to have for different types of jobs within the field? Report back to your class in a paper or presentation what you have discovered. Be sure to include an annotated bibliography.

FOSSIL TALK

Objectives: Students synthesize their learning about paleontologists to write a news story or conduct an interview. They will present their work in a television talk show, podcast, or vlog format.

Materials:
- *Teacher's Guide:* "Paleontologist—A Job Description"
- *Dinosaurs, Sharks, and Woolly Mammoths* "Fossils and Fossil Hunters" (pp. 4-5)
- Student access to the internet and video creation and editing technology

Preparation: Review the "Paleontology—A Job Description" handout from the *Teacher's Guide*. This activity should be done in groups.

Activity: After learning about paleontologists, have students create a news story or an interview for a fictional television talk show, podcast, or vlog, *Fossil Talk*. Assign roles similar to a real talk show such as producers, hosts, moderators, guests, and film crew. Arrange to have students talk to one or more paleontologists either in person, or using an online service such as Skype. If students have access to technology, they can create and edit their own videos for this project. Have them present their videos in person or via an online format (such as the school website).

Discussion: Why did the paleontologist(s) they talked to choose to go into this line of work? What do they enjoy the most? What is the most surprising thing about their work? Why do they think science is fun? Why is it important to study dinosaurs?

Extend the Experience: Have students take part in National History Day in North Dakota. Learn more at history.nd.gov.

PERSONAL TIMELINE

Objectives: To understand how to create timelines, select milestones, and better understand concepts of time, students will chart a personal timeline of their lives.

Materials:

- Roll of paper
- Variety of art and craft supplies
- Old newspapers and magazines that can be cut up
- Photos from home
- Student access to library materials including books and the internet

Procedure: Determine significant events, people, and places and other milestones you would like to have students represent on a timeline. Encourage students to think of their own noteworthy events, but have some suggestions prepared to get them started. Some suggested milestones: When where you born? When did you start school? If you have siblings, when were they born? What major news events happened in your lifetime—people tend to remember where they were for major events like the assasination of JFK, the *Challenger* space shuttle explosion, the 9/11 attacks, etc.—what major news events resonate with your students? Other things students might want to include on their timelines are big life events like moving to a new place, taking a big family trip, the wedding of a close friend or relative, or beginning a new hobby. They may need to take this home to ask their families for more information or even find photos. They might also need to do some online research for information and images about major news stories that happened during their lives.

Activity: Have students work individually to create labels for each milestone or note-worthy event in their lives. Encourage them to be creative, using text, drawings, and photos. Have them write, draw, or attach labels, photos, and their other information to the paper in chronological order. This is an opportunity to let students be creative, and possibly move around a bit as they work. Have students present their timelines in class, explaining what some of the highlights have been in their personal lives.

Variations: Suspend string between two points and have students attach photos and drawings to it in clothesline fashion with binder clips or clothespins. Use a timeline app or website such as time.graphics. A variety of templates and other software suggestions to create timelines can be found on Pinterest. Students can share their timelines with their class through interactive whiteboards.

Extend the Experience: Have students build out their personal timelines by adding parents, siblings, grandparents, or other family members.

GEOLOGIC TIMELINE

Objectives: To grasp the great span of geologic history, and how Earth has changed over time, students will create a timeline to visualize the scope of geologic time.

Materials:

- Plenty of space to build timelines forty-six feet long (hallway, gym)
- Variety of art and craft supplies to mark and label a timeline
- Painters tape
- Measuring tools for each group (measuring tape, yard sticks, rulers)
- *Teacher's Guide:* "Milestones" and "Discussion Answer Key"

Procedure: For this activity, students will work in groups to make a timeline converting time to meters to better visualize the great span of geologic time. This concept can be used to compress geologic time into different formats: a calendar year, a day, the length of a television show, the length of a football field, etc.… Older students will be able to make calculations themselves, while younger students may not have the math skills for that yet. Teachers should alter this exercise as needed. See attached "Discussion Answer Key."

Activity: Using the "Milestones" handout as a reference for significant events and when they occurred, have students work in groups to create labels for the timeline. Make a forty-six foot line on the floor for each group with the painters tape. Using markers, divide the line into 46 one-foot sections, each representing 100 million years. Have students measure out the correct distance for each milestone in chronological order, placing the labels along the timeline where they belong.

Discussion: How long has there been life on Earth? In what period did fish, plants, amphibians, reptiles, dinosaurs, and mammals each appear on Earth? Did humans and dinosaurs exist on Earth at the same time? How do we know? When did modern man appear? Have the plants and animals that we know and are familiar with always been on Earth? What do you notice about the complexity of fossils as we move through the geologic time scale from the Precambrian Time to the Quaternary Period? What is the purpose of making a geological timeline? See "Discussion Answer Key" handout for more information.

Variations: Work outside if the weather is nice. Use chalk or paint that can be used on sidewalks or concrete pads, or paint on canvas or duck cloth.

MILESTONES

Relative to Calendar Year	Era, System, or Event	Million Years Ago (mya)
1/1	**Precambrian Eon Begins** Earth formed	4600
2/25	Inferred origin of life (first cells)	3900
3/5	Oldest dated rocks on Earth	3800
9/3	First multi-celled organisms (seaweed and algae)	1500
11/18	**Paleozoic Era "Age of Fish"** Cambrian Explosion	544
11/21	First fish	505
11/24	First fossil evidence of land plants	470
12/1	First insects	385
12/2	First land animals	375
12/3	First seed plants (ferns)	365
12/5	First reptiles	330
12/12	**Mesozoic Era "Age of Reptiles"**	245
12/13	First dinosaurs	228
12/14	First mammals (shrew-like mammals)	221
12/19	First bird	155
12/22	First flowering plants	115
K-T Boundary		
12/26	**Beginning of Cenozoic Era "Age of Mammals"**	65
12/27	Grasses become widespread. Rocky Mountains begin forming (80 to 55 mya).	60
12/31	Colorado River begins cutting down through rock layers to form the Grand Canyon	6
12/31 at 5:20 p.m.	Oldest, human like ancestors (hominids)	4
12/31 at 10:05 p.m.	First of four ice ages	1
12/31 at 11:48 p.m.	First modern man (*Homo sapiens*)	0.1
12/31 at 11:59 p.m.	Revolutionary War started	More than 240 years ago
1/1 at 0:00*	World War II ended	More than 70 years ago

*When geologic time is compressed to the scale of a calendar year, 1 second equals about 146 years. At this scale, World War II began about 0.4 second before midnight on December 31; because of rounding, this is shown as midnight of the New Year.
Source: www.uky.edu/KGS/education/geologictimescale.pdf.

DISCUSSION ANSWER KEY

1. Approximately how old is Earth? How do we know?

   The geologic time scale is currently estimated to be 4.6 billion years old. This estimate is based on scientific research that can be tested and supported by evidence found in the geologic record, rock formations, and fossils through relative and absolute dating methods.

2. In what period did fish, plants, amphibians, reptiles, dinosaurs, and mammals each appear on Earth? Did humans and dinosaurs exist on Earth at the same time? How do we know? When did modern man appear? How do we know? Have the plants and animals that we know and are familiar with always been on Earth? How do we know?

   See "Milestones" handout to see how life has changed on Earth over time.

3. What do you notice about the complexity of fossils as we move through the geologic time scale from Precambrian time to the Quaternary Period?

   Fossils have become increasingly complex and have changed over time with some periods of massive extinctions.

4. What is the purpose of making a geological timeline?

   To better understand the great span of the history of Earth.

5. When geologic time is compressed to the scale of a calendar year, 1 second equals about how many years?

   To calculate when a particular event happened, figure out at what fraction of time it happened in Earth history. For example, the first reptiles appeared 350 million years ago: 350 million/4600 million (age of Earth) = 0.076. To use the example of one day, find the number of seconds in a day (24 hours x 60 minutes x 60 seconds = 86,400 seconds in one day). Multiply 86,400 seconds by 0.076 = 6,566 seconds before present, or 109 minutes, or 10:11 pm. Use the following chart to help students make calculations.

YEARS IN A …	SHOW YOUR WORK	ANSWER
Second	1 sec = 146 years	146 years/sec
Minute	146 years/ 1 sec x 60 sec/ 1 min	8,760 years/min
Hour	8,760 years/ 1 min x 60 min/ 1 hour	525,600 years/hour
Day	525,600 years/ 1 hour x 24 hours/ 1 day	12,614,400 years/day
Month (30 days)	12,614,400 years/day x 30 days/ 1 month*	378,432,000 years/month
Year	12,614,400 years/day x 365 days/year	4,604,256,000 years in one calendar year

*Remember that the number of days in a month can vary. You could lose over 12 million years by miscalculating by one day.

MAPPING

Objectives: To better understand where different rock layers are exposed in North Dakota, and what kind of fossils are typically found in those layers.

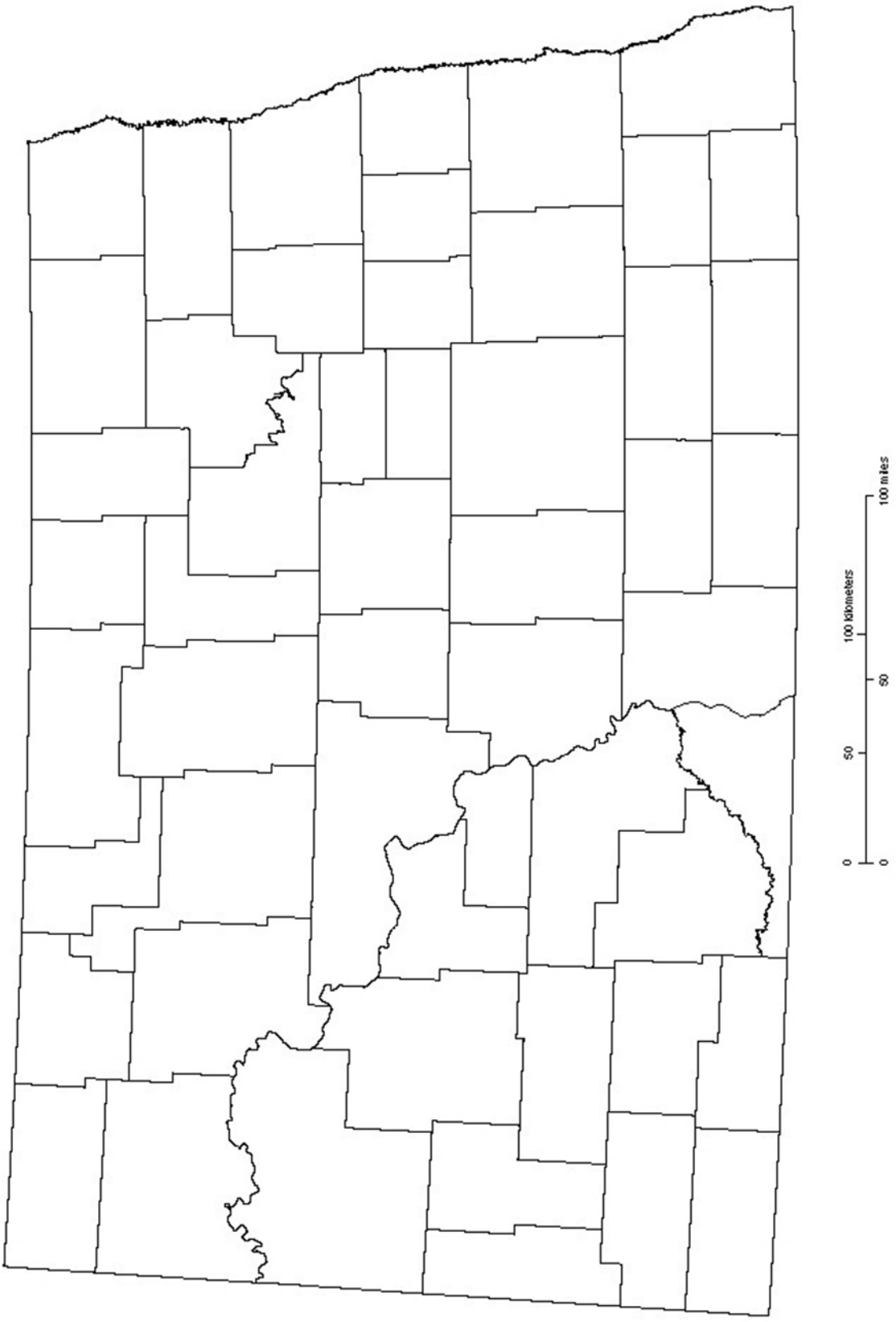
Materials:

- Blank map of North Dakota
- "Prehistoric Life of North Dakota" Map from the *Teacher's Guide,* also available here: www.dmr.nd.gov/ndfossil/poster/poster.asp
- Variety of colored pencils

Procedure: Using the "Prehistoric Life of North Dakota" map, have students draw where different landforms can be found in North Dakota (the Hell Creek Formation, the Fox Hills Formation, etc.). Have them create a map key to identify which color represents which land form.

Discussion: Which plants and animals have been found as fossils in North Dakota? Where do those species tend to be found? Why have some species only been found in certain parts of the state? What can it tell us if we only find bits and pieces of an organism, but not the whole thing?

Extend the Experience: Read about fossil digs in North Dakota at www.dmr.nd.gov/ndfossil/digs. While not all classrooms can take part in a dig as there are age limits and time constraints—it is an opportunity some students and educators might be interested in pursuing.


0
50
100 kilometers
0
50
100 miles

GOING ON A DIG

Objectives: Students learn how paleontologists find fossils.

Materials:

- *Dinosaurs, Sharks, and Woolly Mammoths* "Fossils and Fossil Hunters" (pp. 4-5).
- Paleo Primer, "Digging Etiquette" (pp. 6-7), www.dmr.nd.gov/ndfossil/paleo_primer
- *Dinomummy* (pp. 26 to 43).
- *Dinosaurs Unearthed* (forty-five minute DVD)

Preparation: Read the "Digging Etiquette" section of *Paleo Primer*. This contains important information for understanding if a dig is following the law or not. Paleontologists begin their work by researching and identifying landforms that might contain fossils. They walk along, looking at the surface of the ground **prospecting**, or looking, for fossils. They identify who owns the land where they'd like to dig, and get required permission and permits. After they find fossils, they map the location, take photographs of the site and the fossils, and make notes and sketches of their work. As they excavate dirt with picks and brushes, they protect fossils in plaster **jackets**, if necessary. They transport the fossils back to their lab where they continue to clean them and ensure they are stable and prepared for research, exhibit, or storage. Finally, they create reports, publications, exhibits, and public programs to share the information they've learned.

Paleontologists use lots of tools in their work including maps and GPS data, cameras, notebooks, picks, shovels, knives, ice picks, small brushes, and dental tools. They use wet paper towels, burlap, plaster, plastic, and a frame to support the plaster to create jackets that protect large and/or fragile fossils.

Activity: The *Dinomummy* book and *Dinosaurs Unearthed* DVD will help students understand the basics of what happens on a dig. Working individually or in groups, have students write a paper, or create a website, documentary, exhibit, or performance to share their research into how paleontologists find fossils.

Discussion: What is the process paleontologists follow to find and collect fossil remains? Can people dig wherever they want? What steps do you have to take to legally dig in a particular place? Where are some locations of digs in North Dakota? What tools do you need on a dig? How are they used? What happens to fossils after they are collected?

Extend the Experience: Read about fossil digs in North Dakota at www.dmr.nd.gov/ndfossil/digs. While not all classrooms can take part in a dig as there are age limits and time constraints—it is an opportunity some students and educators might be interested in pursuing.

SEDIMENT SURPRISE

Objectives: Students learn about determining the relative age of rocks and fossils by using the law of superposition and principle of original horizontality.

Materials: Before starting this activity, be aware of any food allergies or dietary restrictions your students may have.

- Clear food storage containers, spoons
- Food of different colors or textures that will make distinct "sedimentary" layers such as whipped cream, pudding, chilled gelatin, crushed cookies, shredded coconut, rice crispy bars, cookies, cake, etc.
- Items to use as "fossils": M&Ms, chocolate chips, raisins, gummy candies, vanilla wafers, hard candy, marshmallows, etc.
- *Teacher's Guide*:
    - "Topic Introduction" sections (Underwater World, Hell Creek, Everglades, Cannonball: Last Sea, Savanna, and Ice Age)
    - Worksheet: "Sediment Surprise"

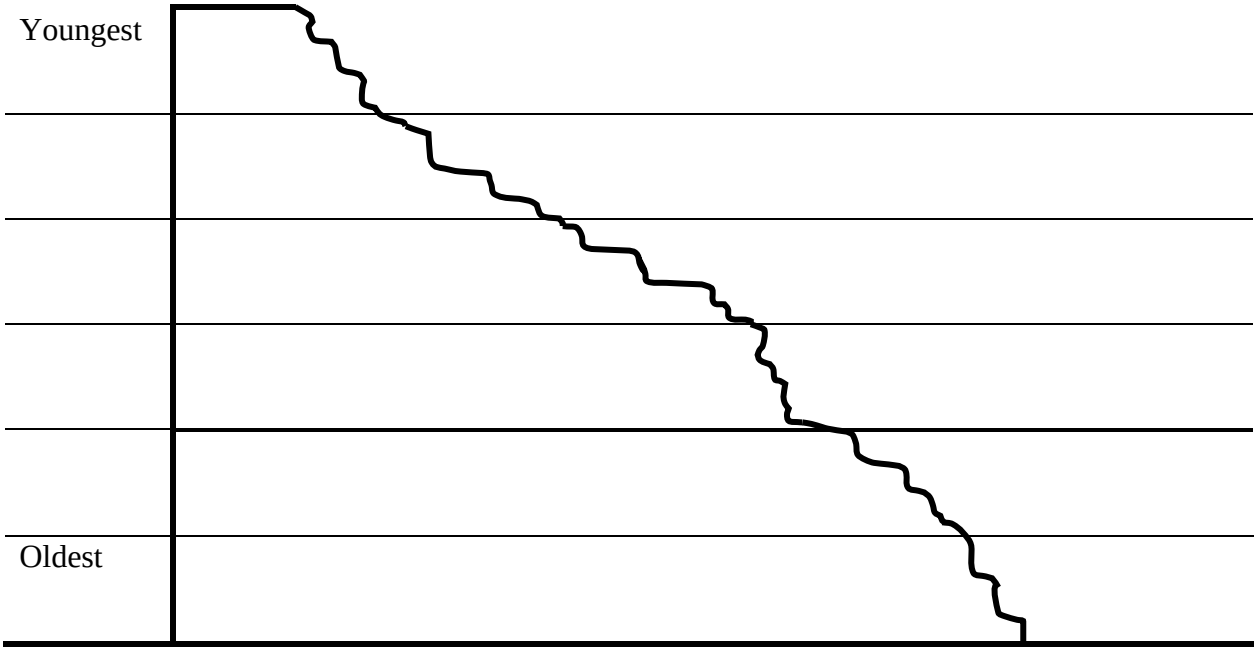
Preparation: The **law of superposition** states that in unaltered layers of sediment, the oldest layer will be at the bottom of the sequence. The **principle of original horizontality** states that gravity affects layers of sediment and results in relatively horizontal layers. These two concepts help geologists and paleontologists use **relative dating techniques** to identify the ages of rocks and fossils. Relative dating determines the order of objects or events, without necessarily knowing the specific, or *absolute*, age of each. For this activity, make sure to have food layers prepared before class if necessary (pudding, gelatin, cake, etc.).

Activity: Working individually or in groups, have students use the "Sediment Surprise" worksheet and the "Topic Introduction" sections (Underwater World, Hell Creek, Everglades, Cannonball: Last Sea, Savanna, and Ice Age), to identify which of these time periods would be oldest (on the bottom) and which would be youngest (on the top). Using the worksheet as a guide, have them select food to represent "sedimentary" layers and the "fossils" they would like to add to each layer. Let students build their model by spreading a layer of "sediment" and adding "fossils" as appropriate. Repeat, using different materials for each layer. Have students discuss how relative dating techniques help identify the order of sedimentary rock deposits. Have fun building and eating these models.

Discussion: Which layer is the oldest? How do you know? Which layer is the youngest? How do you know? How do paleontologists determine the age of rocks and fossils?

SEDIMENT SURPRISE

Using the information from the North Dakota Studies trunk, identify and label each of the following events or time periods on the line for the associated sedimentary layer, putting them in the proper chronological order: Ice Age, Savanna, Underwater World, Cannonball Sea, K-T Boundary, Hell Creek Delta, Everglades.



Identify fossils that might be found in each sedimentary layer. List them in the space below (continue on the back as needed).

Rock Layer	**Fossil**

Using the ingredients your teacher has provided for this activity, label each layer with a different ingredient you can use for each sedimentary layer and a couple of fossils for each layer. Make sure to share the ingredients with your classmates so everyone has enough to finish their project.

PALEO DIG GRID

Objectives: Students dive deeper into learning how paleontologists use grids to track how many and what kind of fossils they find in different locations at a dig site.

Materials: Before starting this activity, be aware of any food allergies or dietary restrictions your students may have.

- Paper plates and toothpicks for each student.
- Large pan of rice crispy bars with an assortment of four different types of identifiable "chunky" pieces mixed throughout to represent fossils such as: M&M's, chocolate chips, raisins, gummy candies, hard candy, etc.
- Graphic Organizer from the *Teacher's Guide*: "Paleo Dig Grid."

Preparation: Using a grid helps paleontologists systematically study a plot of soil or bone bed at a fossil dig. To demonstrate this concept, students will search a section of rice crispy bar for fossils to plot on a grid. Prepare rice crispy bars with an assortment of four identifiable types of "fossil" pieces mixed in. Cut the pan of bars up evenly so each student gets a piece roughly the same size (the accompanying grid is designed for twenty-five sections). Make sure to keep track of which section each student receives so they can fill out the associated square on the "Paleo Dig Grid." Give each student a paper plate or sheet of paper to work on and a toothpick to dig with. Have them dig apart their square of the rice crispy bar to find the four different types of fossils. Draw or project the paleo dig grid onto a white board.

Activity: Working on paper plates to help contain the mess, have students carefully pick apart their section of the rice crispy bar using toothpicks. Have each student organize their fossil pieces into groups of like items, e.g. all raisins together, all M&Ms together, etc. After digging apart their sections and grouping like items, students then count how many of each type of material they have. Finally, have the class complete the grid together to show how many of each fossil was found in each section. For example, a student with a corner section might fill out "four chocolate chips and two raisins" in the square located at 5-E on the grid while a student with a middle section might mark "five skittles and three raisins" in the square located at 3-B on the grid. Have students analyze the grid to see if all the sections were the same or different. Have fun eating what's left of the rice crispy bars.

Discussion: Why might a paleontologist use a grid during a fossil dig? How would this help them understand a fossil bed? Why might it be important to know where fossils were found during the dig? What are some of the risks of digging for fossils? Can a dig be destructive? What happens if fossil material is destroyed during a dig?

PALEO DIG GRID

5					
4					
3					
2					
1					
	A	**B**	**C**	**D**	**E**

HOW ARE FOSSILS FORMED?

Objectives: Students learn fossilization is a rare occurrence, takes certain conditions to happen, and that fossils can be difficult to find. They are an important part of our natural heritage and should be preserved whenever possible for all human-kind.

Materials: Images of horse and *Stegosaurus* skeletons (see figures 1 and 2 on the next page).

Preparation: Fossil formation is a rare event. When a plant or animal dies, usually the remains simply rot away or are scavenged, leaving no trace that it ever existed. Forces such as weathering and water currents can separate or destroy fossils before they are found. A fossil toe bone might be found at one place and a fossil rib at another. This is known as **disarticulation**, or to be spread out. It is especially rare to find a complete fossilized skeleton. If anything is left at all, it is usually only bones and teeth, although in rare cases, such as Dakota the hadrosaur dinomummy, soft tissue has been found. Paleontologists estimate only one percent of all species that ever lived, have left a fossil record. Therefore, fossils should be viewed as objects of great scientific value.

Activity: Create a class list of facts about horses. Include size, running ability, physical traits like teeth, skin and hair color, the types of food they eat, sounds made, etc. How do horses socialize? Do they live together or alone? Make a complete list of all the things about horses that students can think of. What would we know about horses if they were extinct and we only had fossilized bones and teeth?

Have the students divide the list into two groups: the traits evident from fossilized teeth and bones and traits we would not be able to deduce from the teeth and bones. For example, we can tell from teeth that they had grinding teeth and ate some sort of tough vegetation like grass. The shape of foot bones tells us they had hooves. The skeleton would tell us they were fast runners. How do we know? What more can we learn? What kinds of things would we **not** be able to learn from the bones and teeth? For example: What would they look like with muscle and soft tissue? What was the color of skin and hair? How did they behave? What sounds did they make? These traits would all have to be guessed.

Using their imaginations, students should put muscles and skin on the diagram of *Stegosaurus*. Skin color and texture can be the choice of the student, since fossil bones are of little help in determining these characteristics. Finding a dinomummy like Dakota helps paleontologists have a better idea of how the skin of the hadrosaur may have looked like and even felt.

Discussion: How does a living thing become a fossil? Why is it so rare for fossils to be formed and found?

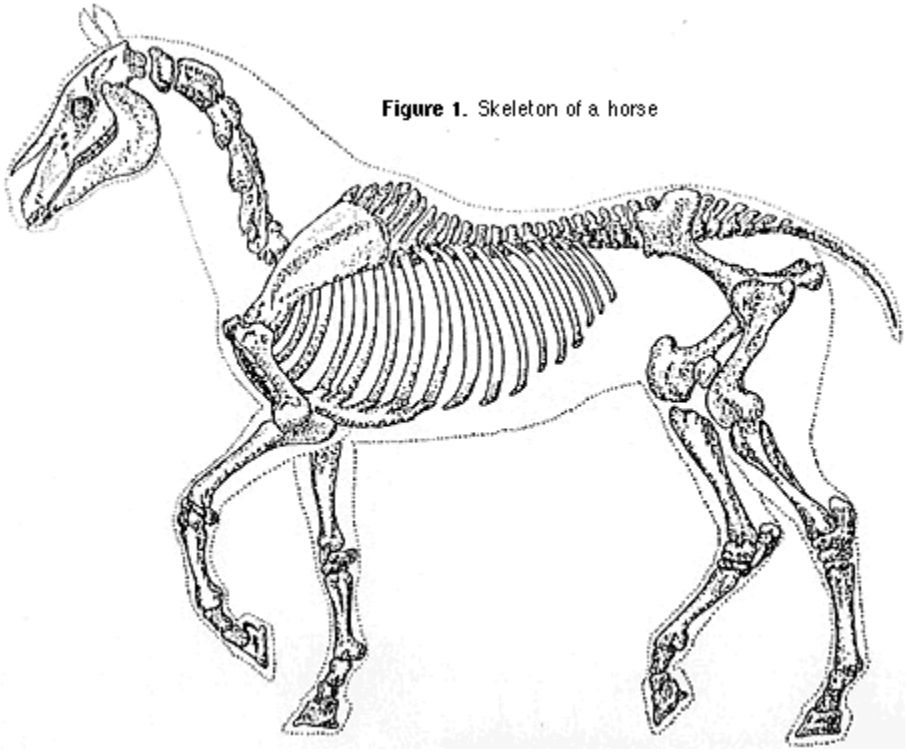


Figure 1. Skeleton of a horse

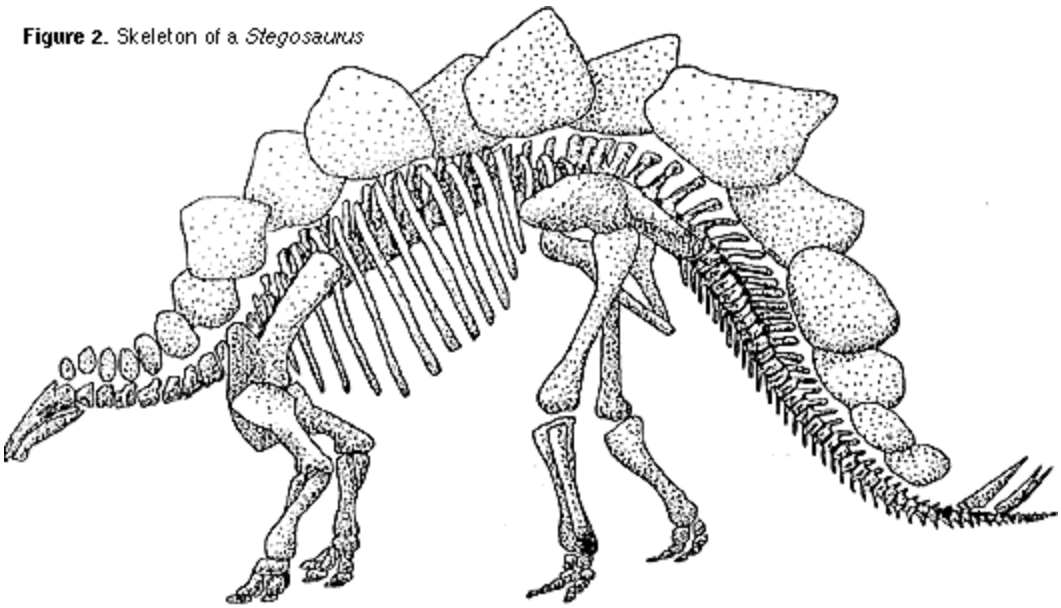


Figure 2. Skeleton of a *Stegosaurus*

FOSSILIZATION GAME

Objectives: Students learn fossilization is a rare occurrence, takes certain conditions to happen, and that fossils can be difficult to find. They are an important part of our natural heritage and should be preserved whenever possible for the benefit of all human-kind.

Materials: *Teacher's Guide*: "Fossilization Game Cards"

Preparation: Fossils should be viewed as objects of great scientific value. Fossil formation is a rare event. When a plant or animal dies, usually the remains simply rot away or are scavenged leaving no trace that it ever existed. Forces such as weathering and water currents can separate or destroy the remains before fossilization and the fossils before they are found. It is especially rare to find a complete fossilized skeleton. Paleontologists estimate only one percent of all species that ever lived has left a fossil record. To demonstrate how rare fossilization is, copy or print the "Fossilization Game Cards" from the next page. Cut the cards along the dotted line, making more as needed so there are enough for all participants. There should only be a couple of the "You become a fossil!" cards per class. Laminate the cards or glue/tape them on index cards to help them last longer.

Activity: Find a place where students have room to run like a gym or a playground. Have them choose an environment in which fossils could be buried such as a lake, pond, stream, river, or sea floor. Pretend the space you are in is that environment, and have students pretend to be plants or animals that would have lived in that environment: snails, clams, fish, turtles, alligators, seaweed, lily pads, rabbits, birds, horses, etc. Let students act out their plants and animals living in that environment for a few minutes: rabbits eating along a pond's edge, fish swimming up a river, snails crawling along the bottom of a sea. At any time determined by the teacher or class leader, action freezes and the time for possible fossilization begins. Students draw cards, determining their fate. Play the game as many times as desired, thinking up new environments, plants, and animals for each round. Remember, the only plants and animals future paleontologists will know anything about are the ones that became fossils.

Discussion: What was the role of the plant or animal each student portrayed? What happened to each organism after it died? Which ones became fossils? Which were destroyed? Compare the number of fossils at the end of each game to the number of students who participated. Is this a good representation of that community?

Variations: Use this game as a prompt for a writing exercise. Have students work individually to develop a scene and the story of a plant or animal within that scene. Choose a card to determine the fate of the plant or animal they are writing about.

FOSSILIZATION GAME CARDS

DRY UP	**DRY UP**	**DRY UP**	**DRY UP**
ROT AWAY	**ROT AWAY**	**ROT AWAY**	**ROT AWAY**
SWALLOWED BY CROCODILE	**SWALLOWED BY CROCODILE**	**SWALLOWED BY CROCODILE**	**SWALLOWED BY CROCODILE**
SWALLOWED BY BIG FISH	**SWALLOWED BY BIG FISH**	**SWALLOWED BY BIG FISH**	**SWALLOWED BY BIG FISH**
EATEN BY SCAVENGERS	**EATEN BY SCAVENGERS**	**EATEN BY SCAVENGERS**	**EATEN BY SCAVENGERS**
ERODED AWAY BY THE WIND	**BURIED IN SOFT MUD** **YOU BECOME A FOSSIL!**	**BURIED IN SOFT MUD** **YOU BECOME A FOSSIL!**	**ERODED AWAY BY THE WIND**
WASHED AWAY BY WAVES	**WASHED AWAY BY WAVES**	**WASHED AWAY BY WAVES**	**WASHED AWAY BY WAVES**
WASHED AWAY BY CURRENT	**WASHED AWAY BY CURRENT**	**WASHED AWAY BY CURRENT**	**WASHED AWAY BY CURRENT**

MAKING A FOSSIL

Objectives: Students learn the difference between **trace** and **body** fossils, learn how molds and casts are made naturally, and why and how paleontologists make molds and casts.

Materials:

- Air dry clay
- Natural materials like bark, leaves, shells, or small plastic toys—anything that will leave an interesting shape and texture in clay.
- *Teredo*-bored petrified wood specimen from the North Dakota Studies trunk.

Preparation: This project helps students understand how molds and casts, types of **trace** fossils, are created. Trace fossils are indirect evidence of life in the past, such as footprints, tracks, burrows, borings, and coprolites (feces), as opposed to a **body** fossil, the fossilized remains of part of an organism's body. A **mold** is an impression of an organism, such as a shell or a leaf, left in a soft surface that eventually hardened into a rock, such as mud that eventually became a layer of shale. A **cast** occurs when a mold impression gets filled in by another substance, such as a worm burrow filled with mud that hardens into a rock. Study the *Teredo*-bored petrified wood specimen from the trunk. Worm-like clams, *Teredo*, drilled into drift wood in the Cannonball Sea, which covered most of the state about sixty million years ago. Later the wood was fossilized into petrified wood, retaining the trace fossils of the *Teredo* burrows. This is the state fossil of North Dakota. Paleontologists also make their own molds and casts for many reasons such as making a replica of a fragile fossil to display in an exhibit or be handled by a classroom of students.

Activity: Give each student about a golf ball sized piece of clay to start with. Have them roll the clay into a ball, and then flatten it down on a hard surface into a round disk like a pancake. Take the objects and press them firmly into the clay, carefully peeling them back out again. What is left behind in the clay?

Discussion: How can trace fossils be used to help understand life in the past? Trace fossils can sometimes indicate behavior—footprints can show how an animal stood and how it walked. What limitations are there from trace fossils? It can be difficult to determine what specific type of plant or animal created an impression. Why do you think some of the fossils in the North Dakota Studies trunk are real fossils while others are casts?

Variations: Create molds and casts using ingredients found around the house: a mix of potting soil and white glue, plaster mixes, salt dough, playdough, etc. Bury small objects (shells, small plastic toys, etc.) in plaster and let it dry. Give kids tools like dental picks to dig out the "fossils."

"READING" SPECIMENS

Objectives: Observe, examine, and analyze natural history specimens.

Materials:
- One or more specimens from the North Dakota Studies trunk.
- From the *Teacher's Guide*:
  - "Learning from Objects—How to 'Read' Specimens"
  - "Topic Introduction" (Underwater World, Hell Creek, Everglades, Cannonball: Last Sea, Savanna, or Ice Age)
- *North Dakota Studies: Geology, Geography, and Climate*
- *Dinosaurs, Sharks, and Woolly Mammoths*
- Stratigraphic Column Photo Board

Preparation: Review the handout from the *Teacher's Guide* about how to "read" specimens along with the appropriate sections from the "Topic Introduction." This information will help guide students through the process of analyzing specimens. This activity can be done either individually or in groups. It can be oral or written.

Activity: Without giving away the identity of individual items, lay specimens out on a table. While the objects should be handled carefully, the students should all get turns touching, holding, and examining the items. Students can work individually or in groups to figure out what the specimens are, how they were formed (for example, are they a body or a trace fossil?), and what more they can tell us about prehistoric lifeforms and environments. Use the questions from "Learning from Objects—How to 'Read' Specimens" to help guide students through their observation and analysis. Have them discuss or write a description of the physical appearance of the specimens. Encourage them to be as specific as possible.

After students have speculated what all the objects are, use the information from the *Teacher's Guide* "Topic Introduction;" *North Dakota Studies: Geology, Geography, and Climate*; and *Dinosaurs, Sharks, and Woolly Mammoths* to determine how accurate the students were in their analysis. After specimens have been identified, use the Stratigraphic Columns Photo Board to identify what era, period, epoch, and rock formation each fossil came from.

Discussion: Lead a class discussion about the specimens. What are you looking at? How do you know? What more can you see? How is this activity similar to the way a geologist or paleontologist works?

Extend the Experience: Have students read about the history of the North Dakota State Fossil Collection in this article by paleontologist Jeff Person: www.dmr.nd.gov/ndgs/documents/newsletter/nl2010/TheNDStateFossilCollection.pdf or the folklore of fossils in this article, also by Jeff Person: www.dmr.nd.gov/ndgs/documents/newsletter/2012January/FolkloreofFossils.pdf.

LEARNING FROM OBJECTS—HOW TO "READ" SPECIMENS

There are millions of objects on display and in storage at theNorth Dakota Heritage Center & State Museum in Bismarck. Each of these objects requires special handling, care, and preservation. These objects represent evidence of the past and can be classified as either specimens or artifacts. Specimens are natural history materials used in the scientific research of geology and paleontology. Artifacts are objects that are man-made or have been modified by humans in some way.

The objects in the North Dakota Studies trunks are meant to be touched, held, and examined. Some of these objects will be lost, broken, and worn out over time; however, the point of this program is to get real things from history into students' hands. Please caution students about careful handling of objects, but do not hesitate to encourage them to explore the contents of the trunk. We have used authentic items where possible, but some items are casts. Specimen descriptions clarify which are fossils and which ones are casts. Please do not remove objects from plastic cases or vials.

When we begin to examine objects they can reveal many clues about the world around us. Depending on the object and what can be learned from it, volumes can be discovered about the life and death of natural history specimens through different periods of time. Students should try thinking like a geologist or a paleontologist. Encourage them to do some detective work to figure out what they are looking at, how they know that, and what more they can find out. When studying collections and the objects in them, encourage students to use discovery or inquiry learning methods to ask questions and hypothesize about the objects. Some objects will naturally raise more questions and generate more answers than others. The following questions will help get you started:

Physical Features: Use your five senses to describe the object.	What does it **look** like? What **color** is it? What **size** is it? What does it **feel** like (texture--soft, rough, hard, smooth, light, heavy)? Does it have a **smell?** What might it **taste** like? Bone, and some types of rock, will stick to your tongue. Some rocks also have a distinctive taste—halite tastes like salt.	**What** is it? A plant, animal, or mineral? Is there enough material to determine what species it came from? **Who** found it? **When** was it was found? **Where** it was found? Where did it come from? Do you know what rock formation it was found in? Study the stratigraphic column poster board to understand where it fits into the stratigraphic column, and the scale of geologic time.

WHAT'S IN A NAME?

Objectives: Students learn how scientists use Greek and Latin words and scientific conventions to name plants and animals, both living and historic.

Materials:

- *Teacher's Guide*: "What's in a Name?" worksheet
- Student access to library materials including books and the internet
- Blank paper and art supplies

Preparation: Scientists name plants and animals in one of three ways: to reference the location where it was found, in honor of a person with some connection to the discovery, or to reference a unique body part or behavior. An example would be the Cretaceous clam, *Crassatellina hollandi*, named after F.D. Holland Jr., a paleontologist at the University of North Dakota. Scientific names of plants and animals are italicized.

Most dinosaurs are named after unique physical characteristics based on Greek and Latin word origins. The word "dinosaur" derives from two Greek words: *deinos*, meaning "terrible," and *sauros*, meaning "lizard." The word became popular after biologist and paleontologist Sir Richard Owen coined the term "Dinosauria" in 1841.

Activity: Having students work in groups or individually, give them the "What's in a Name?" worksheet. They will need access to a library media center or computer lab to look up the meanings and origins of the provided root words. Using the resources available in the North Dakota Studies trunk, have students analyze the names of a variety of specimens to decipher their meanings.

Discussion: What might be **inferred**, or deduced, from understanding the meaning of the root word that makes up a dinosaurs name? What does the name tell you about the animal? Share the dinosaur you created with your class. Does the name of your dinosaur describe the creature you drew?

WHAT'S IN A NAME?

1. Using a dictionary, library resources, or the internet, find the meaning and origin for each of the following words. Is the word a root word, a suffix, or a prefix?

WORD	MEANING	ORIGIN
Allo	Other	Greek
Ankylo		
Apato		
Archaeo		
Bi		
Brachio		
Bronto		
Campylo		
Ceno		
Cephalo		
Cerat		
Coelo		
Compso		
Daspleto		
Derm		
Di		
Dino		
Diplo		
Echino		
Elasmo		
Euoplo		
Ichthy		
Kristos		
Maia		
Man		
Mega		
Micro		
Mosa		
Nodo		
Notho		
Odon		
Ops		
Ornithos		
Ovi		
Pachy		
Paleo		
Ped		

WHAT'S IN A NAME? (*Continued*)

WORD	MEANING	ORIGIN
Placenti		
Platy		
Post		
Proto		
Pteryx		
Raptor		
Rex		
Rhychus		
Saur		
Spino		
Stego		
Struthio		
Suchus		
Tri		
Tyrano		
Uni		
Veloci		
Vore		
Xiph		

2. Using some of the above words as inspiration, create a dinosaur of your own. Write the name of your dinosaur in the space provided below with a brief description of what it is like. What does it eat? How big is it? What makes it special or unique? On a blank sheet of paper, draw a picture of it.

ADAPTATIONS

Objectives: Students learn about adaptations, changes in body parts or behavior, that helped prehistoric plants and animals survive.

Materials:

- Specimen from the North Dakota Studies trunk
- *Teacher's Guide*:
  - "Plant and Animal Adaptations" worksheet
  - *Dinosaurs, Sharks, and Woolly Mammoths*
- Access to library and internet resources

Preparation: Paleontologists are constantly trying to determine how the form of a fossil relates to its function. How do the characteristics of a fossil show how that plant or animal lived its life? How did dinosaurs use their claws? How did they use their teeth? How about dinosaurs with horns, spikes, clubs, or bony heads? These are just a few questions paleontologists try to answer using fossils. For example, it was thought that some dinosaurs used beaks for eating small prey, protecting themselves, or stripping bark from trees. However, recent studies have shown beaks probably were used to sieve food rather than as a weapon to attack predators. Understanding how the forms of dinosaurs bodies functioned helps paleontologists better understand how adaptations to those forms allowed plants and animals survive the conditions they lived in. Adaptations can occur through either modified behavior (e.g., working in groups, swimming in schools to avoid predators) or modified body parts (e.g., chemical defense, camouflage, different limb shapes).

Activity: Using resources from the North Dakota Studies trunk and access to library and internet sources, have students work individually or in groups to identify information to complete the "Plant and Animal Adaptations" worksheet from the *Teacher's Guide*.

Discussion: What are some other examples of body or behavioral modifications from either modern or prehistoric plants and animals? For example: Modified body parts such as eyes (ability to see at night, far away, under water); a keen sense of smell; or large/many teeth, claws, or body size. Modified behaviors such as playing dead, food selection, migration, traveling in a herd, defending themselves with armor, finding food by scavenging, etc. How is a dinosaur different from a reptile? Reptile legs are splayed out to the side while dinosaur legs are directly below them. Why might dinosaurs have adapted different types of legs than reptiles?

Variations: Using information from the "Topic Introduction" from the *Teacher's Guide*, create a Venn diagram comparing the behavioral and body adaptations of woolly mammoths and modern elephants.

PLANT AND ANIMAL ADAPTATIONS

PLANT OR ANIMAL	CLASSIFICATION	WHERE IT LIVED	WHAT IT ATE	BEHAVIOR OR BODY PART ADAPTATIONS	HOW ADAPTATIONS HELPED IT SURVIVE
Example: Mastodon, *Mammut americanum*	Mammal	Boggy spruce woodlands throughout North America	Tree branches and bark	Long shaggy hair, large tusks	Long hair helped protect them from the cold during the ice age. Long tusks helped break branches and bark off of trees to eat.

DESIGN-A-SAURUS

Objectives: Students learn how scientists and artists work together to recreate realistic depictions of what prehistoric plants and animals and their environments might have looked like.

Materials:

- Variety of art supplies
- Access to library and internet resources

Preparation: How do we know what ancient plants and animals looked like? Artists who work in paleontology need to understand both anatomy and biology, and how to balance what is known through science with what can creatively be imagined. Paleoartists base their work on fossil evidence (which are incomplete by their very nature) and current scientific research. This can be challenging when nobody knows what muscle structures and other soft tissue looked like. This can give reconstructions a "shrink wrapped" appearance. As paleoartists piece fossil clues back together, like a puzzle, their work changes over time based on new research and discoveries. There are many things still not known about prehistoric life. What did plants and animals look like with all their soft tissues? What kind of muscle structure did they have? Were they camouflaged to match their habitat, or brightly colored to attract a mate? What did their skin look like? Did they have hair or feathers? As paleontologists better understand the forms and functions of fossils and how plants and animals adapted and behaved, paleoartists incorporate new research into how they depict these ancient life forms.

Activity: To help students understand the work of paleoartists, have them find images of skeletons of modern living animals. Have them draw what those animals might look like based only on their skeletons. For example, what evidence is there on an elephant skeleton to show that it has a trunk? Does the skeleton of a camel indicate that it might have humps? What does a milk cow look like if you don't know what its soft tissue looks like? Have students draw where they think muscles, flesh, and other details should be. They should not add details to their drawing that aren't supported by evidence from the skeleton. Have students create posters and present them to their class. Can other students figure out what animal was the basis for each drawing?

Discussion: How is this activity similar to the way a paleoartist works? Explain the process used to select and draw the animals. What was the biggest challenge?

Variation: Find skeletons of prehistoric life forms and have students embellish them with plausible, yet fanciful depictions of soft tissue. What are the large holes in some skulls for? What tissue structures might have been supported by different bony structures?

ENRICHMENT ACTIVITIES AND INDEPENDENT STUDY PROJECTS

Reading, writing, and vocabulary: Use the resources in the North Dakota Studies trunk to create your own activities including word searches, crossword puzzles, a bingo game, and creative writing prompts (poems, short stories, etc.).

Who's who in North Dakota geology? Have students identify and research a geologist or paleontologist who was famous or who lived or worked in North Dakota. Have students write a paper, or create a website, documentary, exhibit, or performance to share their research.

Project based learning: Have students research and report on ethics and new issues in the field. What problems and solutions are geologists and paleontologists discussing in news from the field? How is the study of paleontology relevant to people's daily lives? Does the work of geologists affect public policy? Have students write a paper, or create a website, documentary, exhibit, or performance to share their research. Consider having students compete in National History Day in North Dakota. Learn more at history.nd.gov.

Find and visit a paleo-related site: There are many museums throughout North Dakota that have rock and fossil collections available for public viewing. Some museums and universities have laboratories where students and volunteers can see more of the work that goes on in the paleontology field. Check with labs in your area to see what type of age restrictions they have for volunteers. There are also lots of natural areas that are known for their rich geologic resources. Many state and national park areas in North Dakota have fossil-bearing exposed rock formations. Remember that it is illegal to remove objects from state and federal lands. Have students read "Why Do We Collect?" by paleontologist Jeff Person: www.dmr.nd.gov/ndgs/documents/newsletter/2013Winter/WhydoweCollect.pdf and "Paleontology Lab—Then and Now" by paleontologist Becky Barnes: www.dmr.nd.gov/ndgs/documents/newsletter/Summer%202015/Paleontology%20Lab%20-%20Then%20and%20Now.pdf.

Participate in a dig: The Paleontology Division of the North Dakota Geological Survey leads several public digs each summer. Learn more about how to get involved in fossil digs in North Dakota at www.dmr.nd.gov/ndfossil/digs. While not all students can take part in a dig (there are age limits and time constraints), it is an opportunity some students and educators might be interested in pursuing. Fossils found during public digs belong to all the people of North Dakota. These collections are managed by state and federal agencies.

Prospect for fossils: Before you go, know what the law says you can and cannot do. The North Dakota Geological Survey has a handy publication on how to get started: *Paleo Primer*, "Digging Etiquette" (pp. 6-7), www.dmr.nd.gov/ndfossil/paleo_primer. Emerging geologists and paleontologists will need to understand accepted practices for their new hobby. Encourage students to explore for fossils, but only after they know what laws they need to follow and what permissions they need to have. Private property owners own fossils found on their land. It is illegal to trespass on private property. It is also illegal to dig and/or keep fossils found on public lands. Fossils found on public lands in North Dakota belong to all the people of the state.

EARLY PEOPLES OF NORTH DAKOTA

Your next step in exploring North Dakota leads from the end of the Great Ice Age to discovering the Early Peoples of North Dakota.

Innovation Gallery at the North Dakota Heritage Center &State Museum in Bismarck:
The Innovation Gallery: Early Peoples, is devoted to the Native people of North Dakota. The gallery highlights the beauty and breadth of the State Museum's collections. Encounter the tribes of North Dakota, both as they were before contact with European-Americans, and also as the sovereign nations they are today. The story of the early peoples in North Dakota begins more than thirteen thousand years ago when people first began to migrate into North Dakota. This journey through time begins with the Paleoindians, the first hunters. See the *Bison antiquus* skeleton, an example of the mammals these big-game hunters killed using spears and creative hunting practices. View the exquisite workmanship in their stone tool technology. Learn about the hallmarks of human innovation during this time, including the invention of the bow and arrow and creation of clay pottery. Envision North Dakota's earliest cities. Look inside a tipi and imagine it as your home.

State Historic Sites:
Visit state historic sites that tell the story of early peoples in North Dakota including Double Ditch Indian Village, Huff Indian Village, Menoken Indian Village, and Writing Rock State Historic Site.

North Dakota Studies:
Explore the North Dakota Studies online content at ndstudies.gov to learn more about Native Americans in North Dakota. Request additional North Dakota Studies trunks including Early Peoples, Archaeology, Chippewa/Mètis, Dakota, and Mandan/Hidatsa/Arikara.

North Dakota Native American Essential Understandings Project:
The Essential Understandings project is a new approach to incorporating Native American curriculum into the classroom. It is based on the idea that Native American history and culture informs, and is informed by, all the other topics students study in the classroom. For example, to incorporate more Native American content into daily curriculum, students learning math can learn about the geometry of a tipi. Students in physical education class can assemble a tipi. Literature classes can spend more time on books written by Native American authors. Non-Native teachers can work with both Native and non-Native students to learn together what Native elders have to share about history and tradition: teachingsofourelders.org/ndnaeu-aligned-lessons.

Visit the North Dakota Heritage Center in Bismarck which includes the State Museum, the State Archives, and Museum Store with a wide selection of North Dakota specific books.