DOCUMENT RESUME

ED 468 213 SO 034 071

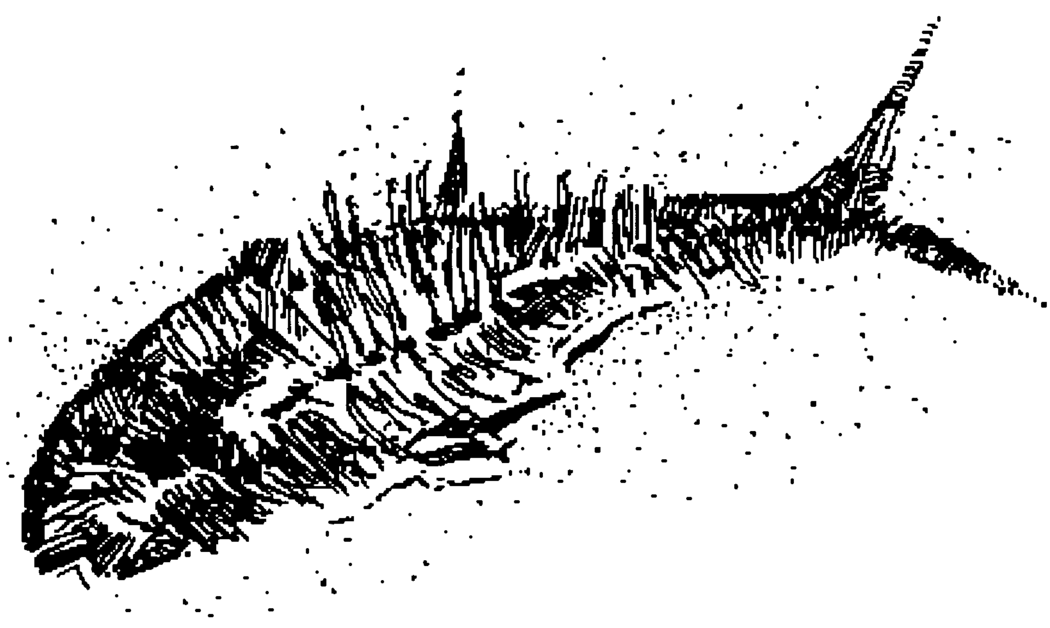
TITLE	Paleontology. A Curriculum and Activity Guide to Mammoth Cave National Park. [Grades] 1-12.
INSTITUTION	National Park Service (Dept. of Interior), Washington, D.C.
PUB DATE	2002-00-00
NOTE	96p.
AVAILABLE FROM	Mammoth Cave National Park, P.O. Box 7, Mammoth Cave, KY 42259. Tel: 270-758-2251; Fax: 270-773-2111; e-mail: MACA_Park_Information@nps.gov. For full text: http://www.nps.gov/maca/ learnhome/curricula.htm/.
PUB TYPE	Guides - Classroom - Teacher (052)
EDRS PRICE	EDRS Price MF01/PC04 Plus Postage.
DESCRIPTORS	Ecology; Elementary Secondary Education; Environmental Education; Heritage Education; *Natural Resources; *Paleontology; *Physical Environment; Physical Geography; Primary Sources; Social Studies; Student Educational Objectives
IDENTIFIERS	Kentucky; Site Visits

ABSTRACT

Mammoth Cave (Kentucky) was designated as a national park in 1941 because of its beautiful hills and valleys, scenic rivers, and the vast cave system located within its boundaries. Outstanding physiographic features include karst terrains, sandstone capped plateaus, and bluffs overlooking rivers and streams, which provide an unusually wide variety of ecological elements. The Park is part of what is believed to be the most diverse cave ecosystem in the world. This curriculum and activity guide for paleontological study (an examination of the remains of living things) in Mammoth Cave National Park provides information about the National Park Service. The unit is divided into the four parts: (1) "Our Geological Past" (Kitchen Geology, grades 4-6; Weathering and Erosion, grades 4-6; Paleo Time Line, grades 6-12; Time Lapse, grades 6-12); (2) "Fossilization" (Create a Fossil, grades 1-4; Tales of the Dead, grades 6-12; How Do You Become a Fossil? grades 1-6; Crinoid Race, grades 6-9; Fossil Identification, grades 6-12); (3) "Adaptations" (Race for Survival, grades 1-8; Survival of the Fittest, grades 6-12); and (4) "Human Influences" (Shoe Box Midden Dig, grades 6-12; Fossil Search, grades 4-9; Exploring the Past: A Field Trip into Mammoth Cave, grades 6-12). Contains a glossary. (BT)

PALEONTOLOGY

A curriculum and activity guide to Mammoth Cave National Park



The National Park Service

ParkNet

2002

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www.nps.gov/maca/learnhome/curricula.htm

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ACKNOWLEDGEMENTS

Appreciation is extended to

Science and Resource Management Division
Mammoth Cave National Park

Rick Toomey and Mona Colburn
Illinois State Museum

Lorraine Chure
Fossil Reproductions, Jensen, Utah

Florissant Fossil Beds National Monument

Fossil Butte National Monument

Petrified Forest National Monument

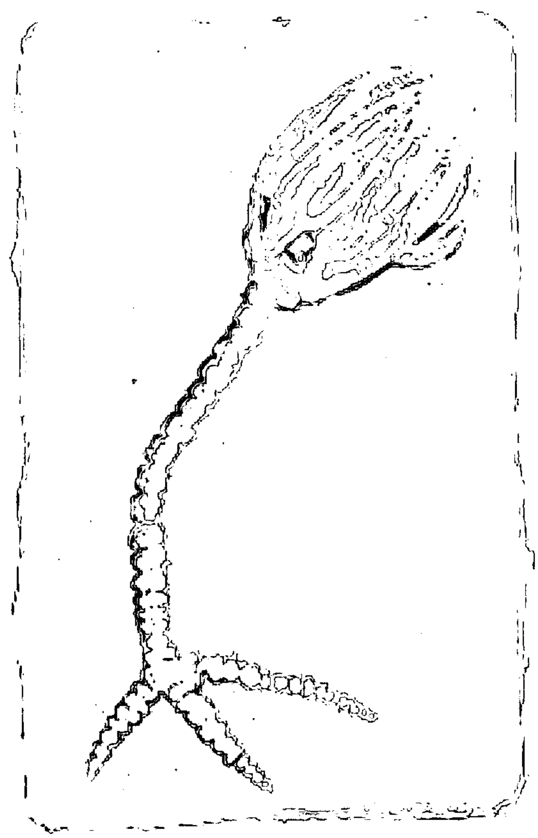
MISSION

The mission of the National Park Service:

To conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the public enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.

The mission of Parks as Classrooms:

Parks as Classrooms is an educational initiative of the National Park Service in partnership with the National Park Foundation. The goal is to use the resources of the parks for teaching and learning.



INTRODUCTION

Significance of Mammoth Cave National Park

Mammoth Cave was designated as a national park in 1941 because of its beautiful hills and valleys, the scenic rivers, and the vast cave system located within its boundaries.

Mammoth Cave National Park contains the world's longest known cave system and offers internationally renowned examples of karst topography. Many types of cave formations are present within this extensive 350-plus mile cave system. The park is part of what is believed to be the most diverse cave ecosystem in the world.

In addition to the cave system, the park is noted for its outstanding scenic rivers, valleys, bluffs, forests and abundant wildlife. Outstanding physiographic features include karst terrains, sandstone capped plateaus, and bluffs overlooking rivers and streams, which provide an unusually wide variety of ecological niches.

The geologic and cultural time line for the park extends prehistorically from the Middle Mississippian Period (300-350 million years ago) to the Paleo-Indian period (10,000 BC to 15 AD). The historic time frame begins with early settlement (1774-1825) and continues through the Depression Era (1929-1941). Representing these time periods are fossil remains, prehistoric and historic archaeological sites, and standing structures on the surface and in the cave.

On October 27, 1981, Mammoth Cave National Park became a World Heritage Site and on March 27, 1990 it was designated as an International Biosphere Reserve.

Paleontology

Paleontology comes from the Greek word for ancient life. Paleontology studies the remains of living things. The Earth is dynamic and nothing remains the same for long. The Earth has been changing for 4.6 billion years. Climates change, rivers and glaciers altar course, seas rise and fall. Animals and plants flourish and then die to make room for new forms. The sediments that are laid down change. To give order to these changes, the scientists developed a scale that divides time into meaningful periods. This time scale is called geologic time.

Fossils are a record of life as it has evolved through geologic time. Fossils are invaluable to scientists in reconstructing prehistoric environments. These life forms have been buried in the earth, buried in the sea, and captured in rock. They have been preserved in peat, tar, ice, and amber. They may be unchanged from the originals, or they may be a mineral replacement. They range in size from dinosaur skeletons to tiny plants and animals that can only be seen under a microscope. Most fossils are formed from the hard parts of plants and animals such as shells, bones, teeth, or wood. Eggs, footprints and burrows can also be fossilized. The study of fossils indicates that life originated on the earth 3 billion (3,000 million) years ago. Since that time there has been a succession of plant and animal species. Most are now extinct and only a few remain as fossils. When one considers how quickly organisms are destroyed after death it is remarkable that fossils are as common as they are. Remains that can be destroyed by scavengers, bacteria, chemical decay and erosion make the odds against preservation extremely high.

Paleontologists are scientists who seek to understand the succession of plants and animals through time. They try to determine how these creatures lived, how they grew and how they died. They try to answer questions concerning the web of life, interactions between organisms, and interactions between organisms and their environment. Around the world, researchers are studying thousands of sites, excavating fossils, and transporting them back to laboratories where they are reconstructed. The main clues for reconstruction come from comparisons with living plants and animals. The rules that govern how animals and plants cope with life are presumably the same today as they have always been. Some of the organisms that lived on earth left no descendants, but many are still represented. These "living fossils" can provide clues to the way long-dead organisms looked and functioned.

The world of fossils is never static. Paleontology is continually growing and evolving.

Paleontology and Geology

Geologic time is a measurement of the past. Without a measurement tool, objects and events could not be placed into proper relationships. The divisions of geologic time are made on the basis of life that existed at the time.

A geologic column indicates the types of rock that were deposited.

The rocks of Kentucky were laid down in water. Soft mud is often converted to shale. Loose sand and gravel become converted to sandstone and conglomerates. The third type of sedimentary rock is limestone, which is precipitated from seawater. Limestone is also formed from the shells of dead sea animals. Heat, pressure, and chemical action may change these three kinds of sedimentary rocks into a variety of metamorphic rocks.

The rocks of Kentucky belong to the Paleozoic Era. The periods within this era are: Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian. The Mammoth Cave region of Kentucky was primarily a result of events which occurred within the Mississippian period.

Paleontology and Mammoth Cave

Marine invertebrates existed in the Mississippian Sea that covered Kentucky 300-350 million years ago. Bits of shell, bone and dissolved carbonates combined to form the limestone strata of south central Kentucky. Fossil remains of these prehistoric marine organisms became exposed when water dissolved holes in the limestone layers and formed the caves we have today.

More recent fossils were also deposited after the caves formed. Vertebrate remains are often found in caves, including bones, teeth, and mummified remains. Bones accumulate in nests, under roosts, and in dens. Bones may be washed in during times of floods. Caves also serve as pitfalls for large animals. Guano, feces, footprints, scratchings, and other traces of animal activity (such as ceiling stains from hibernating bats, wood-rat middens, and bear dens) are also well-preserved in dry cave areas.

The interiors of caves provide a protected environment that naturally preserves deposited materials. The cave environment offers protection from wind, rains, and sun and this dry, protected environment yields materials not found elsewhere.

Goals of the Paleontology Curriculum Guide

Mammoth Cave and approximately another 300 caves located on park property are the repository of paleontological resources. Paleontological remains are nonrenewable and vulnerable. This curriculum was developed:

- to provide a variety of experiences to teach paleontological concepts.
- to teach about the rarity and conservation of paleontological remains.
- to foster an understanding of the importance of preserving fossils in situ.
- to communicate how paleontology relates to the conservation of the living cave system.

Use of the Paleontology Curriculum

This curriculum provides some lessons to be used before a park visit. These lessons will enhance the park visit by providing background information that will enable the student to understand concepts of paleontology before visiting the resource.

Some of the curriculum materials are designed to build on the park experience and re-enforce learning.

Each lesson contains information to help students understand paleontological concepts.

Environmental Education and Paleontology

The Environmental Education staff at Mammoth Cave National Park is committed to assisting you with your study of paleontology. If you have questions or need additional information, we urge you to call for assistance. The educators at Mammoth Cave National Park may be available to come to your classroom to assist with teaching many of these concepts. You may find that a trip to view the resource would be more beneficial to your students. Qualified educational groups are invited to take advantage of the Mammoth Cave extended classroom concept. Details of planning park participation in your curriculum can be found on the next page.

The Environmental Education Program

Qualified groups are invited to participate in the Mammoth Cave Environmental Education program. This is a tightly structured, hands-on experience designed to introduce and excite students about the unique surface and subsurface environments found within Mammoth Cave National Park.

By using the park's natural resources, this program strives to give each child a better understanding of his or her fragile world, and of the interdependency of all environments and their inhabitants. Each day's customized program will be structured to provide visual and tactile experiences, reinforcing the classroom curriculum of each group.

Who Can Participate?

Available on a first-come, first served basis, the Environmental Education program is open to any education or scientific group whose course of study can be enhanced and/or supplemented by a visit to Mammoth Cave. The park's resources must directly relate to your class curriculum and proof of your school curriculum or syllabus may be requested prior to your visit. Because there are a limited number of slots, your group will want to reserve early.

How Long Does the Program Last?

Participants should plan to devote a minimum of four (4) hours to the on-site program. This time will be equally divided between surface and cave activities. You will need to budget additional time for lunch, breaks, and gift-shop visits.

When Can I Come?

The Environmental Education program is offered on weekdays throughout the year.

What Do We Need to Bring?

Students are asked to wear jackets while on their cave tour, as subsurface temperatures are in the mid-50s. Good walking shoes should also be worn, as both surface and cave trails are uneven and occasionally rock-strewn. Because ticks and chiggers are prevalent in the area, insect repellent is suggested. Teachers will need to provide one supervisor for every ten students.

What Does the Program Cost?

There is no fee charged to groups who can show that their course of study directly relates to resources found within Mammoth Cave National Park. Visits for recreational purposes should follow the standard fee schedule.

How Can I Participate?

To make reservations, contact the Environmental Education coordinator Monday through Friday, between the hours of 8:00 a.m. and 4:30 p.m. Central Time. Please keep in mind that reservations are available on a first-come, first-served basis, so please make your plans early.

Contact:

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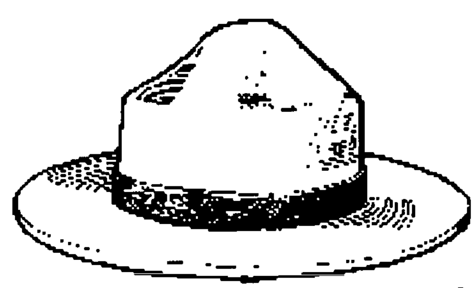
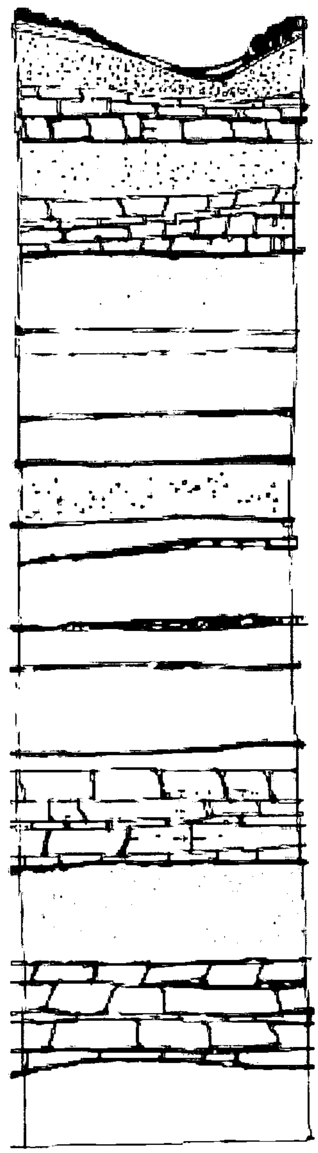
Environmental Education Coordinator
Mammoth Cave National Park
P.O. Box 7
Mammoth Cave, KY 42259
(270)758-2354 or (270) 758-2313
MACA_Environmental_Ed@nps.gov



PART 1: OUR GEOLOGIC PAST



KITCHEN GEOLOGY

GRADE LEVEL: 4-6

TIME REQUIRED: Two to three class periods

SETTING: Classroom

GOAL: To create a layered edible dish that demonstrates: (1) the layering of rock strata, and (2) the movement of rocks that expose fossils.

OUTCOMES: At the end of the lesson the student will:

- state the defining characteristic of sedimentary rock,
- define index fossil,
- define uplifting, overthrust, and faulting,
- and state how fossils are exposed.

KERA GOALS: Meets KERA goals 1.3, 1.4, 2.1, 2.2, 2.4, 2.6, 5.3, 5.4, 6.1, 6.2, 6.3

BACKGROUND INFORMATION

Sedimentary rocks are layered rocks. Chemicals in rivers, lakes, and oceans precipitate particles from water. This precipitate then mixes with organic remains (such as shells and skeletons) of organisms. Wind, rain, and ice wear down surface rocks into bits of sand, soil, mud, pebbles, clay, and loose sediments. All these various sediments eventually pile up layer upon layer. Over time, pressure exerted by the weight of the top layers compacts and cements the lower sediments to form solid rock. Younger rock is placed on older rock. Each layer captures life forms of that period in time. These preserved species are called index fossils. By observing these index fossils the geologist can determine the age of the rock.

Sandstone is a sedimentary rock made of layers of compressed and cemented sand grains. Shale is a sedimentary rock made of layers of silt and mud. Limestone is a sedimentary rock made of layers of carbonated sediments (sea life) that thrived in a warm shallow sea. Fossils can be found in any sedimentary rock, but in the Mammoth Cave area they are most typically seen in the layers of limestone.

Rock strata can stretch, bend, and break when they are subjected to heat and pressure. They are constantly worn away on the surface by wind, rain, and ice. As the rocks change, fossils become exposed.

MATERIALS NEEDED

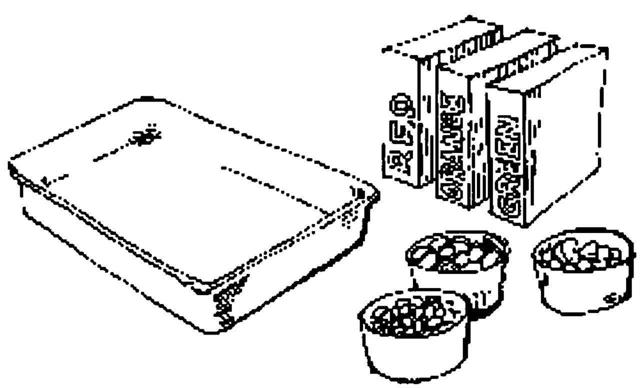
- Clear glass container 12" X 18"
- Three boxes of Jell-O of contrasting colors (red, orange, green)
- 1½ cup Coolwhip or cottage cheese (blended)
- ¼ - ½ cup each of carrots, nuts, pieces of apples (Avoid candies with food coloring such as M & M's)

PROCEDURE

ACTIVITY ONE: SEDIMENTARY ROCK

Create a series of rock strata with fossils.

1. Following the directions on the box, mix a box of one color Jell-O and allow to partially set-up (follow directions for soft-set or thickened Jell-O as shown on box).
2. When partially set-up, stir in Coolwhip or blended cottage cheese to make the Jell-O opaque. Add ¼ cup sliced carrots to represent fossils. Allow to set until firm.
3. Mix a box of the second color Jell-O and when partially set, stir in Coolwhip or blended cottage cheese. Add ¼ cup nuts to represent fossils. Pour this mixture on top of the first layer of Jell-O. Allow to set until firm.
4. Mix the third box of Jell-O and when partially set, stir in Coolwhip or blended cottage cheese. Add pieces of apples to represent fossils. Pour this mixture on top of the first two layers of Jell-O. Allow to set until firm.

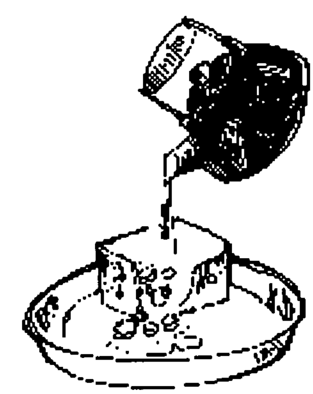


PROCEDURE

ACTIVITY TWO: EXTRUSION OF FOSSILS

Create movement of Jell-O that is characteristic of earth's movement to expose the fossils. Cut 4"x4" squares of Jell-O. Use one square for each of the following demonstrations:

1. **Uplifting.** Place a four- by four-inch square of Jell-O on a plate. Slide a knife under the piece of Jell-O and gently lift. First the strata will bend and then it will break. Once the pieces are standing on end, some of the fossils may be exposed.
2. **Overthrust**. Cut another four- by four-inch square of Jell-O. Gently and evenly push in from opposite sides of the square so the center rises up and one half flops over the other half. Geologists call this overthrust. Notice the older stratum is no longer under the younger strata.
3. **Faulting**. The surface of the earth is covered with cracks called faults. Sometimes the land on one side can be uplifted and raised above the land on the other side. Cut another 4" square of gelatin. Slice the gelatin into two parts. Use a spatula to raise one side. This will show the way rocks can move in relation to each other.
4. **Erosion.** Wind and rain constantly wears away sedimentary rocks, thus exposing fossils. This may be demonstrated in various ways. Allow hot water to run over a square of gelatin until fossils are exposed. Use a hair dryer to dissolve and expose the fossils in a second square.



NOTE: Examine how fossils are exposed with each type of earth movement. Hopefully, molds, imprints, as well as fossil pieces will be exposed

This activity adapted from *The Big Beast Book* by Jury Both

WEATHERING AND EROSION

GRADE LEVEL: 4 -6

TIME REQUIRED: One class period

SETTING: Classroom, science lab, or outdoors

GOAL: To create a landform by using weathering and erosion processes

OUTCOMES: At the end of this lesson the student will be able to:
- define and give an example of mechanical weathering,
- define and give an example of chemical weathering,
- define the process of erosion,
- and list at least two types of sedimentary rocks.

KERA GOALS: Meets KERA goals 1.3, 1.4, 2.1, 2.2, 2.4, 5.1,.5.3, 5.4, 6.2

BACKGROUND INFORMATION

The earth is a dynamic body. Earth movements cause elevation of the surface while opposing processes wear it down. The wearing down processes include weathering and erosion.

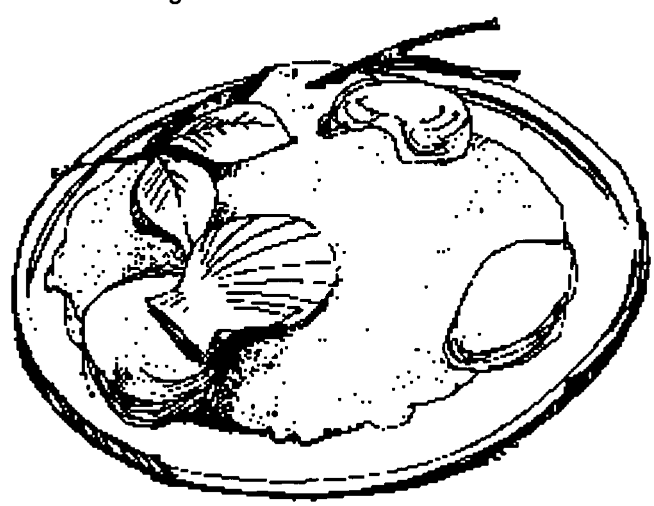
Weathering - is the disintegration and breakdown of rock near the earth's surface.
Mechanical weathering occurs when rocks are broken into smaller and smaller pieces. This process can occur when plant roots break rocks apart, or when freezing and thawing produce wedges in rocks.
Chemical weathering occurs as water combines with other elements to alter rocks. An example is carbonic acid. Water combines with carbon dioxide to produce a weak acid called carbonic acid. The carbonic acid then dissolves rock by chemical weathering.
Erosion - is the transportation of this material, usually by water, wind, or ice.

The products of mechanical and chemical weathering constitute the raw material for sedimentary rocks. Weathered debris is eventually deposited in lakes, river valleys, seas, and oceans. Over long periods of time these sediments are cemented together to form solid rock.

Since sediments accumulate at the earth's surface they contain indications of past environments. Layering is the most characteristic feature of sedimentary rock. As each layer accumulates it records the nature of the environment at the time. The layers are called strata and are separated by bedding planes. Generally, each bedding plane marks the end of one deposit period and the beginning of another.

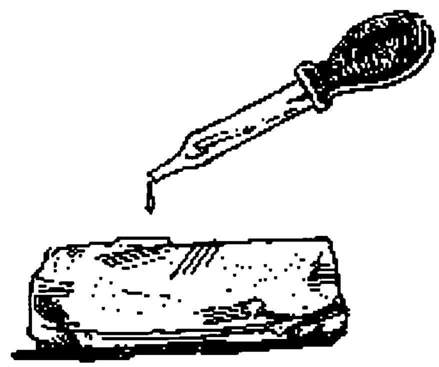
Sandstone is the name given to rocks when sand grains predominate. Limestone is the result of cemented shells and bone fragments. Shale consists of silt and mud.

MATERIALS NEEDED
- One frisbee for each group
- Two pieces of sandstone and two pieces of limestone for each group
- Small bottle of vinegar with dropper for each group
- Dirt and small rocks
- An assortment of leaves, rocks, shells, twigs
- Small plastic containers with holes punched in the bottom (to form a "rain cloud"). NOTE: Containers from frozen lunches make excellent clouds
- Water
- Paper and pencil
- "Weathering and Erosion Worksheet"



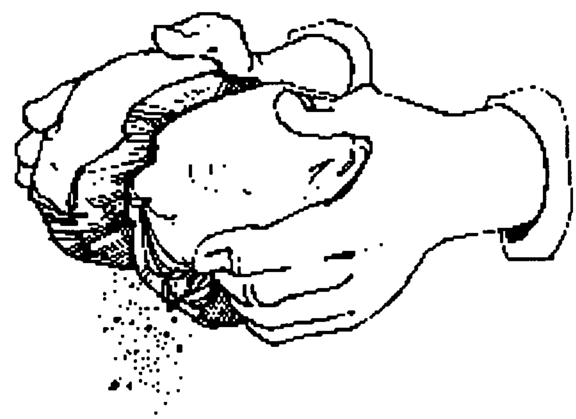
PROCEDURE

1. Divide students into small groups of 2-4 students each.
2. Give each group two sandstone rocks, two limestone rocks, a bottle of vinegar with a dropper, and one copy of the "Weathering and Erosion Worksheet."
3. *As a demonstration of chemical weathering:*



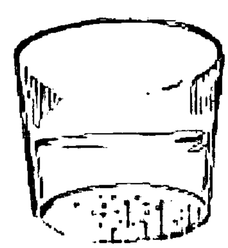
- Place several drops of vinegar on the sandstone and observe the action of acid on the rock. Record your observations.
- Place several drops of vinegar on the limestone and observe the action of acid on the rock.

4. *As a demonstration of mechanical weathering:*



- Give each group a frisbee in which to collect any rock particles or rock dust produced.
- Instruct students to take turns rubbing the limestone rocks together. Record your observations.
- Instruct students to take turns rubbing the sandstone rocks together. Record your observations.
- Discuss how long it took to produce the resulting particles. Which rock produced the most new soil?
- Estimate the total amount of soil produced by mechanical weathering.

5. Place a cup of dirt in the center of each frisbee. This represents the amount of soil necessary to grow a plant. Have students theorize the length of time it would take nature to produce sufficient soil to grow crops or support a forest.
6. Have students stabilize their landforms (soil mound) with rocks, leaves, and/or twigs.
7. Look at the effects of weathering. Pour water into each "rain cloud". Have students pass their rain cloud over their soil mound, allowing rain to fall onto their landform. Record the effects of erosion on the soil mound.



8. Compare the results of water on the various soil mounds. Did any withstand the erosional effects of water? Why were some more effective than others. Was there a correlation between the amount of "rainfall" and the amount of erosion? Was there a correlation between the type of ground cover and the amount of erosion?

EXTENSION

- Bury bits of shells or other fossil materials in the landform and discuss the process of extrusion.

WEATHERING AND EROSION WORKSHEET

Chemical Weathering

1. In the space below record the action of acid (vinegar) on sandstone rock.

2. In the space below record the action of acid (vinegar) on limestone rock.

Mechanical Weathering

1. In the space below record your observations after rubbing two pieces of limestone rock together. The frisbee will be used to collect rubbings.

2. The amount of "soil" produced by mechanical weathering of limestone rock was ______________.

3. In the space below record your observation after rubbing two pieces of sandstone rock together.

4. The amount of "soil" produced by mechanical weathering of sandstone rock was _____________.

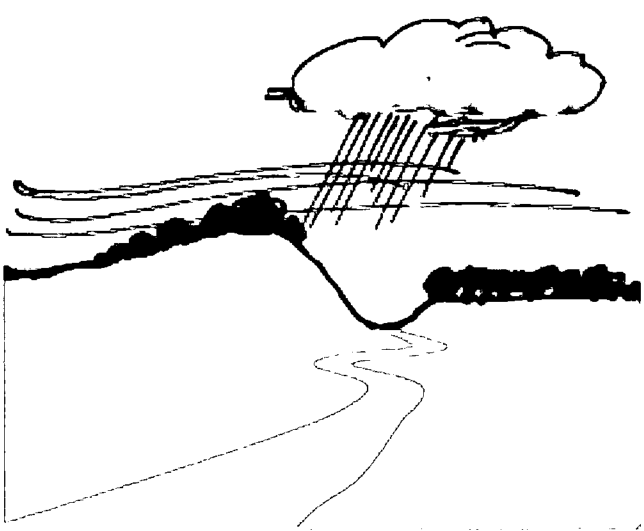
5. Amount of "soil" produced by mechanical weathering of both limestone and sandstone rocks was ____________.

6. After placing a cup of dirt in the Frisbee (enough to grow a small plant) record below your theory of the length of time it would take natural processes to produce sufficient soil to grow crops or support a forest.

WEATHERING AND EROSION WORKSHEET

Effects of Weathering

1. Stabilize your "landform" (cup of soil in Frisbee) with rocks, leaves and/or twigs.
2. Pour water into your "rain cloud" (small plastic container with holes punched in the bottom).
3. Pass your "rain cloud" over your "landform".
4. In the space below record the effects of erosion on your landform.



5. Compare the results of "rainfall" on the landforms of the other groups in your class by answering the following questions.

- Did any withstand the erosional effects of water? Which ones?
- Why were some more effective than others?
- Was there a correlation between the amount of "rainfall" and the amount of erosion?
- Was there a correlation between the type of ground cover and the amount of erosion?

PALEO TIME LINE

GRADE LEVEL: 6 - 12

TIME REQUIRED: Two class periods

SETTING: Classroom

GOAL: Create a time line

OUTCOMES: At the end of the lesson the student will be able to:
- visualize the passage of time through the use of familiar historical events,
- visualize the layering of artifacts and/or fossil remains with the oldest remains at the bottom and the youngest (newest) remains at the top,
- visualize the length of time which has passed since the appearance of various plant and animal species
- visualize the passage of time between major prehistoric events,
- and understand the number of evolutionary events that have occurred during the most recent geologic time periods.

KERA GOALS: Meets KERA goals 1.1, 1.6, 1.7, 1.8, 1.9, 1.15, 2.2, 2.4, 2.6, 2.20, 4.2, 4.5, 5.3, 6.2, 6.3

BACKGROUND INFORMATION

The natural history of our earth is told on countless "pages" of rocks. Each rock layer is like a page of a novel. Fossils litter various rock layers and provide the ever-changing story of life on our planet. The positioning of fossils in respect to each other provides a clue to the passage of time. Geologists have used these rock and fossil records to divide pre-historic time into four large time frames called eras. Boundaries between these eras are not always clear, but each era has a set of typical animals, plants, and geologic changes that set it apart.

The oldest and longest time period is called the Precambrian Era. It began when the earth was first formed, about 4.6 billion years ago. Little is known about life in this era because few fossils have been found.

The Paleozoic Era followed the Precambrian Era. Scientists believe that at the beginning of this era there was only one large continent on earth called Pangaea. This continent, located near the South Pole, was covered with ice. About 400 million years ago, the huge

continent drifted towards the equator, causing the ice sheet to melt. During this period of time the available fossil record becomes more complete.

It was during the Mesozoic Era, which began about 225 million years ago, that the continent of Pangaea slowly separated into the seven present-day continents. Variations in temperature and climate occurred. Reptiles of many shapes and forms lived during this era. For over a 100 million years during this time period giant dinosaurs roamed the earth. Very small mammals, birds, and some flowering plants developed near the end of this period.

The Cenozoic Era began about 65 million years ago. This is the era in which we currently live. The climate during this era has ranged from hot and humid to prolonged periods of cold. The strange pre-historic creatures of old have developed into the life forms with which we are so familiar today.

The geologic eras are further divided into shorter time spans called periods. Various periods are separated by important geologic events. The list of eras and periods, with their major environmental events and changing forms of life, is called the Geologic Column.

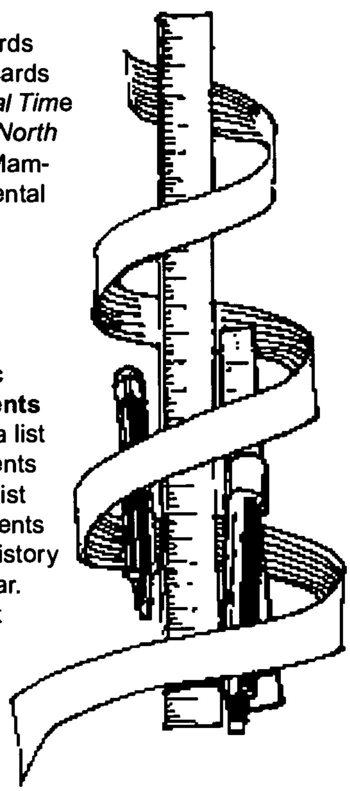
This Geologic Column provides us with a view of the planet's history. It shows the enormous span of geologic time and the multitude of living creatures that have come and gone.

Background information taken from Petrified Forest National Park, "Dividing the Earth's Chapters", found in *Fascinating Fossil Factory.*

PALEO TIME LINE

MATERIALS NEEDED

- Two rolls of adding machine tape
- Yardstick
- Ruler
- Marking pens
- Special Events activity cards
- Paleo Time Line Activity cards
- Optional Chart: *Geological Time and the History of Life in North America* (available from Mammoth Cave NP Environmental Education Program)



PROCEDURE

ACTIVITY ONE:
Make a time line of historic events known by the students

1. Have the students make a list of important historical events they have studied. Their list should include several events from ancient to modern history with which they are familiar. The list could include (but should not be limited to):
   - *ancient history* – the first humans; the Tigris-Euphrates River cultures; ancient Egypt; building of the Great Wall of China; the Roman Empire,
   - *early history* – the Middle Ages; Shakespeare; Columbus discovers the New World; westward expansion in America,
   - *modern history* – the California Gold Rush; the invention of the phonograph, automobile, airplane; World War I or II; Space Travel; your school classroom.
2. Have each student or pair of students choose a different event from your list. Have them produce a visual image that illustrates their event. They may find or draw a picture or they may use one of the drawings from the "Special Events" activity sheet. Have the students perform research in order to determine the year or time frame in which their event occurred. How long ago was that? In calculating time, remind them to add 2,000 years to any events that are listed as a time B.C. (For example, an event which occurred in 1,500 B.C. would be 3,500 years old.)
3. Have the students determine an appropriate scale of time for their list of historical events. NOTE: A scale of 1-inch equals 100 years would produce a time-line over 20 feet long to record the oldest Homo sapiens remains found in North America – dating back to 22,000 BC from Los Angeles – or 250 feet long to reach back 300,000 years ago to the first confirmed Homo sapiens remains found in Hungary! Using this scale, cut a piece of adding machine tape the necessary length. You will now paste or tape the Special Events pictures vertically along this section of tape.
4. Explain that when scientists search for clues to our history, they must search through many facts, they must read lots of documents, and sometimes they must literally dig down into the earth to look for discarded items from early civilizations. When excavating a site, the newest events (and artifacts) would be found at the top of the hole. The oldest artifacts and the remains of the oldest civilizations will be found at the bottom of the hole. As an example, the clothes you wore last week would be at the bottom of the clothes hamper. The clothes you are wearing today would be at the top of the hamper. With this in mind, begin with the oldest event chosen by the class. Because it is the oldest, we would find it at the bottom of an excavation site. Therefore, that picture will be found at the very bottom of the tape. Draw a vertical line across the width of the tape at the very bottom. Write the date of your earliest historic event next to the line. Now paste or tape the picture which shows that event on or next to the line.
5. Next you are ready to record the second oldest event. How many years passed between these two events? Using your scale, how much distance must you measure up the tape? Measure the distance and draw a vertical line across the width of the tape in the appropriate place. Write the new date next to this line. Now paste or tape the picture of that event on or next to this new line.
6. Proceed to the third oldest date and repeat steps 4 and 5 for this and all other events until you get to your classroom (today's date) at the very top of the tape.
7. Have a discussion of the time line of events:
   - How far down would a scientist have to "dig" to find information about the pyramids? About knights in shining armor? About man walking on the moon?
   - What do you notice about the number of events and their distance apart on your tape? Which part of our history seems to be the most crowded? Why are the events at the bottom of the tape so far apart? Do you

think this is because people didn't do as much a long time ago, or do you think it is because it is harder for scientists to find artifacts and information about older events?
- What do you predict your time line may look like in the next 100 years?

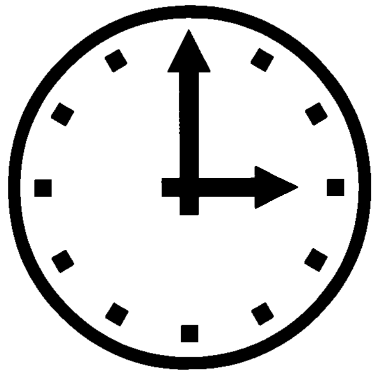
ACTIVITY TWO:
Make a time line of pre-historic history

1. Tape or otherwise fasten the adding machine tape horizontally to the classroom or hallway wall, approximately eye-level for your students. Draw a vertical line across the width of the tape one inch from the beginning edge of the tape. This line should be labeled "TODAY".
2. OPTIONAL INSTRUCTION FOR YOUNGER STUDENTS: Instruct students to measure the length of the tape, placing a vertical line every 10-inches. Label the distance at the bottom of each vertical line (10, 20, 30, etc). This will provide a scale of one-inch equals one million years. The length of the tape should equal the distance back in time you would like to represent. NOTE: The tape will be 42.5 feet long to trace back to the first marine hard-shell animals; or 250 feet long to trace back to the first signs of life.
3. Pass out the "Paleo Time Line" cards, one to each student or pair of students.
4. Using the ratio of 1 inch = 1 million years, each student or pair of students should calculate how far their time period will be from "Today." They may calculate their answer in inches or convert their answer to feet and inches. In turn, allow them to measure, mark and label their "Special Event" along the adding machine tape at the appropriate distance from the vertical "Today" line.
5. Tape the top of the "Historic Time Line" over the vertical "Today" line so that it is within the first inch (first one million years) of the "Paleo Time Line."
6. With each student/pair of students standing at their location, point out how much time has passed between primary geological and paleontological events. Point out the great number of events that occurred during historic time. Compare the frequency of historic events to the vast amounts of time between paleo events.

EXTENSIONS:

1. Prior to this activity, have students calculate the length of adding machine tape they will need in order to reach back to the beginnings of prehistoric time. Have them calculate the distance back to the first marine hard-shell animals found 510 million years ago, going back in time three billion (3,000 million) years to the first signs of life, or going back 4.5 billion years to the beginnings of geologic time! They should use a scale of one-inch equals one million years. If a roll of adding machine tape is 160 feet long, how many rolls of tape will they need to complete this activity?
2. Change the scale for activity one. Go outside to the school football field and let the students measure and label the most recent million years of history. Use the scale 100 yards equals one million years. Ask them how far down the field they think that they would have to walk to reach their birth date. How far would they walk to reach the discovery of America? How much time is represented by one yard? (Answer: 10,000 years Can the students tell you what Kentucky was like 10,000 years ago? (One possible answer: Prehistoric Indians lived in the Mammoth Cave area at that time) Divide 10,000 years by the number of inches in a yard to discover the number of years represented by one inch. (Answer: 278 years. Round this number off and use 280 years for one inch) How many events can the students list that happened in the first inch of history?
3. Change the scale for your prehistoric time line. This time try using one-foot equals one million years. Have each student recalculate the new distances. Mark off your new time line outdoors in the school playground or along the school football field. Use flags or signs to show each event. NOTE: The older events may extend past the end of the football field. Instruct the students to find a landmark on their way home (from the bus or car window) that would be equivalent to the beginnings of life on earth! How far will they need to travel to find the first life forms or the start of geologic time?
4. Students could research and report on the evolutionary event depicted on their card prior to labeling the event on the time line tape.
5. Students could add sketches, photographs, or line drawings to the time-line tape, which show the species living during their time period.
6. Take a field trip to a rock quarry, to a road-cut, or to an expanse of exposed local rock to search for fossil remains. Ask permission of the landowners before you collect any fossils you see!

PALEO TIME LINE



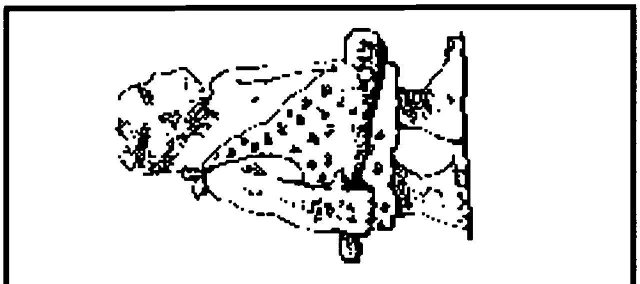
1 – 1 ½ Million Years Ago	Ice Ages Begin
2 Million Years Ago	First Humans Appear
10 Million Years Ago	Mammoth Cave Begins to Form
50 Million Years Ago	Modern Plants & Animals
65 Million Years Ago	Dinosaurs Are Extinct
130 Million Years Ago	First Flowering Plants Develop
150 Million Years Ago	Early Mammals
160 Million Years Ago	Early Birds
180 Million Years Ago	Bony Fish & Palm Trees
240 Million Years Ago	Start of Age of Dinosaurs
255 Million Years Ago	Early Insects & Seed Ferns
290 Million Years Ago	First Reptiles
300 Million Years Ago	Early Amphibians
350 Million Years Ago	First Land Animals (Scorpions)
410 Million Years Ago	Earliest Land Plants
450 Million Years Ago	First Fish
510 Million Years Ago	First Marine hard-shell Animals
3,000 Million Years Ago (3 Billion Years Ago)	Algae; First Signs of Life

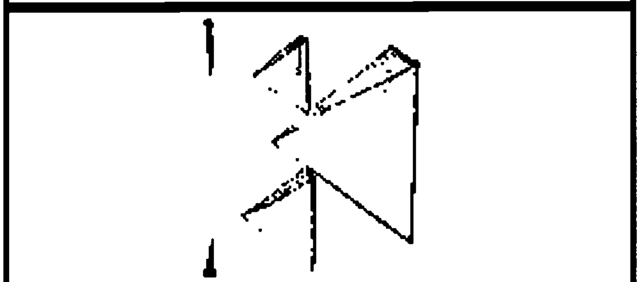
PALEO TIME LINE CARDS

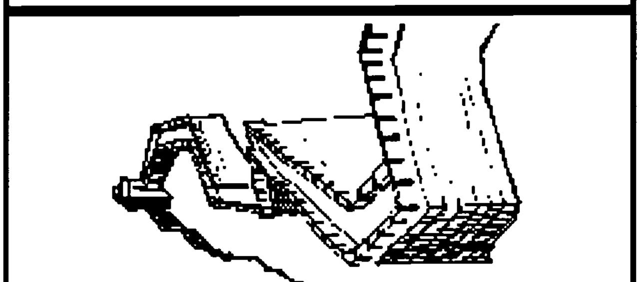
1 – 1½ Million Years Ago **Ice Ages Begin**	2 Million Years Ago **First Humans**
10 Million Years Ago **Mammoth Cave Begins to Form**	50 Million Years Ago **Modern Plants and Animals**
65 Million Years Ago **Dinosaurs Become Extinct**	130 Million Years Ago **Flowering Plants Develop**
150 Million Years Ago **Early Mammals**	160 Million Years Ago **Early Birds**
180 Million Years Ago **Bony Fish and Palm Trees**	240 Million Years Ago **"Age of Dinosaurs" Begins**

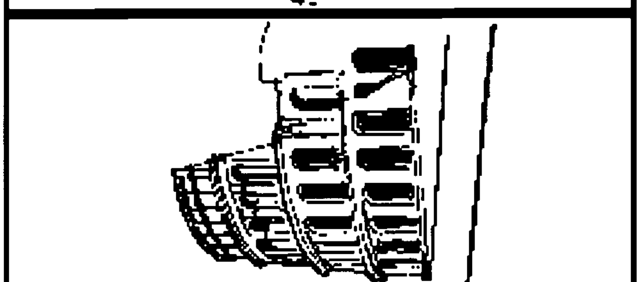
255 Million Years Ago **Early Insects and Seed Ferns**	290 Million Years Ago **First Reptiles**
300 Million Years Ago **Early Amphibians**	350 Million Years Ago **First Land Animals**
410 Million Years Ago **Earliest Land Plants**	450 Million Years Ago **First Fish**
510 Million Years Ago **First Marine Hard-Shelled Animals**	3,000 Million Years Ago (3 Billion Years Ago) **Algae** **First Signs of Life**

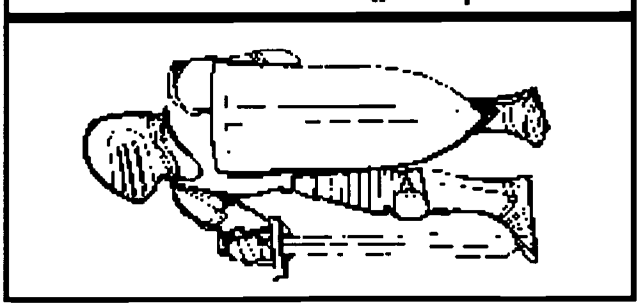
PALEO TIME LINE SPECIAL EVENT CARDS

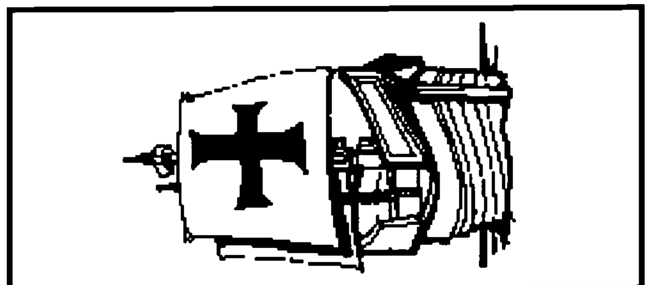


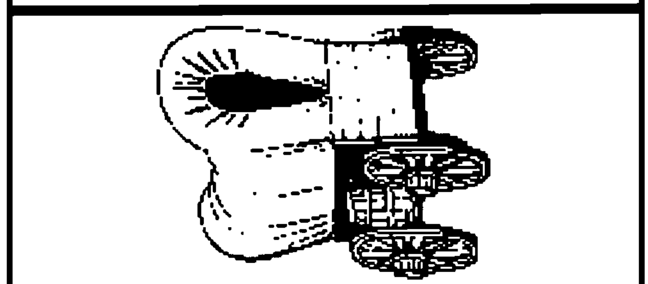


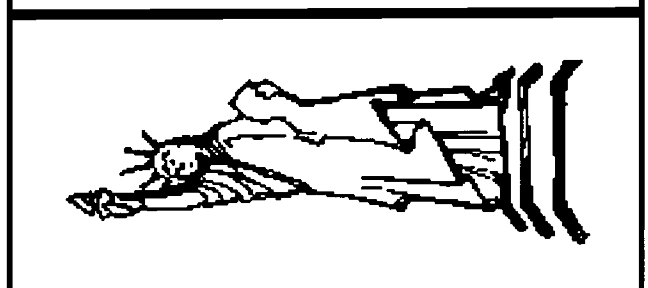


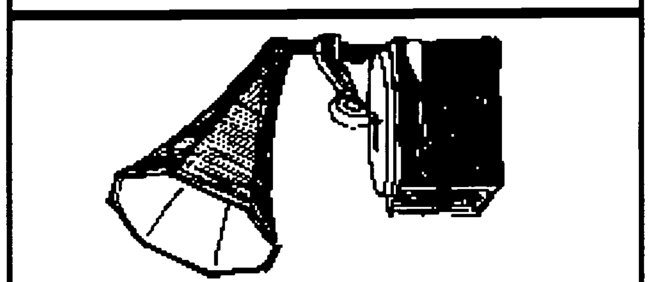


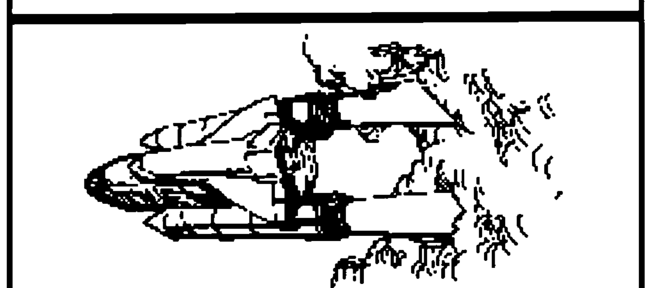












TIME LAPSE

GRADE LEVEL: 6 - 12

TIME REQUIRED: Will vary based on the project selected

SETTING: Classroom

GOAL: To prepare and present a visual interpretation of some aspect of change

OUTCOMES: At the end of this lesson the student will:

- prepare a visual demonstration of change,
- articulate this change by a presentation, and
- demonstrate the ability to manipulate the visual medium of his choice.

KERA GOALS: Meets KERA Goals 1.1, 1.2, 1.3, 1.4, 1.7, 1.8, 1.10, 1.11, 1.12, 1.13, 1.16, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.9, 2.11, 2.19, 3.3, 3.4, 3.7, 4.2, 4.6, 5.1, 5.2, 5.3, 5.4, 5.5, 6.1, 6.2, 6.3

BACKGROUND INFORMATION

Our earth is dynamic. The environment has changed and is still in the process of changing. Land and mountains rise and are destroyed by weathering and erosion. Climates change. Most change occurs slowly over a long period of time.

Succession is a term used to describe the ever-changing environment and the gradual process by which one habitat is replaced by another. Succession influences the characteristics and types of plants and animals that live in an area. As the plants change, the habitat available to animals changes. As the habitat and food sources change, the animals must change or migrate to a new location.

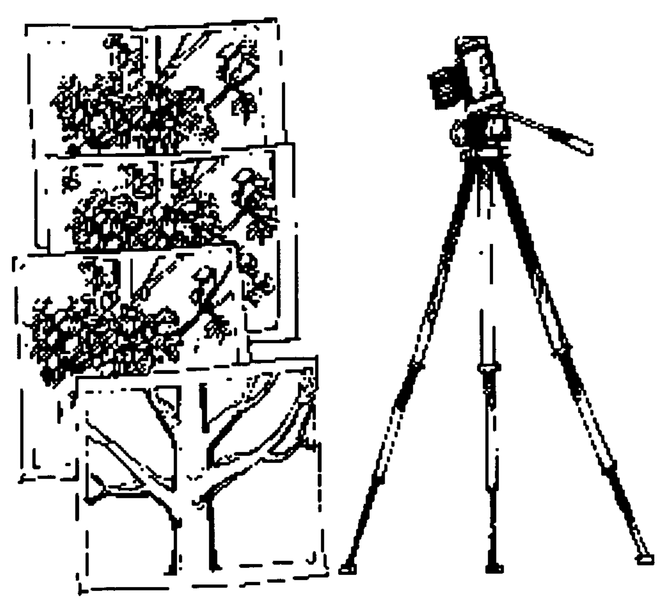
MATERIALS NEEDED

Materials will be determined by the medium chosen:

- Paper
- Crayons, markers, paints, pencils
- Video camera and film
- Still camera and film
- Magazines

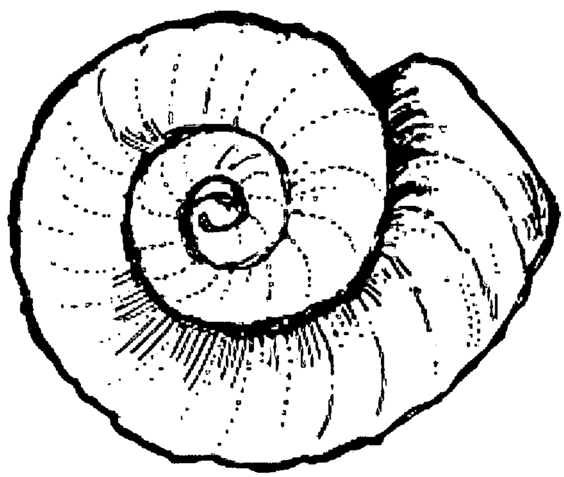
PROCEDURE

1. Students may work alone or in small groups.
2. The student should select a visual medium. Some possible mediums include: video, slides, magazine pictures, natural objects (i.e. live or decaying), or a drawing.
3. Using their chosen medium, the student should demonstrate a concept of variations, change, or adaptations by portraying the same scene over a period of time. Some examples the students might elect include:
   - Photographs of an eroding hillside over a period of time.
   - Seasonal changes – winter to spring
   - Succession:
     pond
     forest
     community
4. The time required for the project will vary according to the project selected. For example, a montage of magazine pictures will require less time than photographing the change of seasons.



This activity was adapted from "Time Lapse" found in *Project Wild*, a joint project of the Western Association of Fish and Wildlife Agencies and the Western Regional Environmental Education Council, Inc.

PART 2: FOSSILIZATION



CREATE A FOSSIL

GRADE LEVEL: 1-4

TIME REQUIRED: One class session

SETTING: Classroom or outdoors

GOAL: The student will create a fossil.

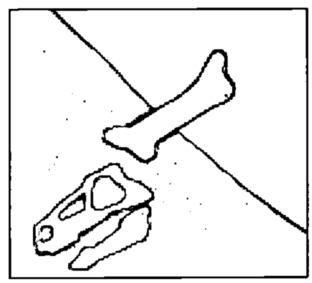
OUTCOMES: At the end of the lesson the student will be able to:
- list three conditions necessary for fossilization,
- state where fossils are usually found, and
- define at least two types of fossils.

KERA GOALS: Meets KERA goals: 1.1, 1.2, 1.3. 2.2, 2.5, 2.6, 5.1, 5.2

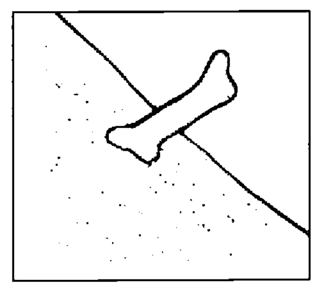
BACKGROUND INFORMATION

Fossils are the direct evidence of past life. They are the tools around which geologists and paleontologists reconstruct the history of the earth. They are found in sedimentary rocks. This type of rock is the result of the consolidation of sediment that has accumulated in layers. These depositional environments come from lake bottoms, river bottoms, river sandbars, beaches, and oceans. Some sediments result from weathering rocks, others originate from tissues and bones of plants and animals. It is within the depositional environment that plants and animals may become fossilized. There are three prerequisites that must be met before organic material can be preserved: (1) Organisms must contain hard parts such as bones, teeth, cartilage, or shells. (2) The organic material must be buried quickly in an oxygen-free environment protected from scavengers. (3) Conditions after burial must be favorable as the effects of heat and pressure that produce sedimentary rock may alter the composition and appearance of a potential fossil.

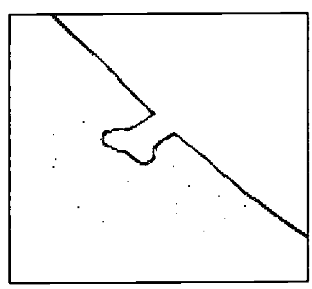
There are several types of fossils.
1. **Petrification** occurs when parts of the organism are saturated with minerals. Highly porous materials such as wood and bone are often petrified.
2. **Carbonization** occurs when the weight of surrounding sediments squeezes out the water and gas and leaves a residue of carbon (imprint).
3. **Molds and casts** are replicas of the construction of an organism. A good analogy is Jell-O. The Jell-O is poured into a mold and the finished dish is a cast of that mold.
4. **Trace** fossils are signs left behind by an organism. Examples include footprints, nests, and burrows.



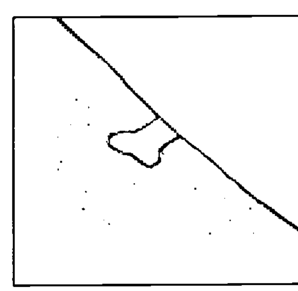
◀ **Original Remains**
The bones and teeth may be dug out unchanged



Petrified Fossil ▶
Minerals replace the original material. The fossil is now turned to stone



◀ **Mold Fossil**
The bones and teeth rot away slowly, leaving a hole in the rock in the exact shape of the original

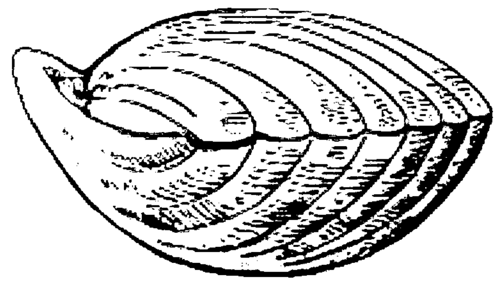


Cast Fossil ▶
After a mold forms, different chemicals fill the hole. They form a fossil the same shape as the original, but made of a different material

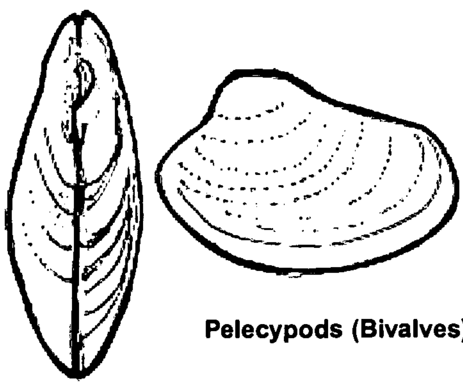
CREATE A FOSSIL

The rocks of South-central Kentucky began as sediments in a shallow tropical sea. Today, fossils of marine shell life are abundant, and the remains of bryozoans, brachiopods, trilobites, pelecypod (clams), gastropods (snails), and crinoids (sea lilies) are easily found.

A fossil that is always found in the same rock layer is called an index fossil. The index fossil of the Mammoth Cave St. Genevieve limestone is the crinoid. By finding this fossil the paleontologist can date the rock strata.

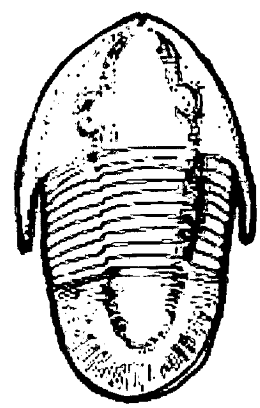


Brachiopods

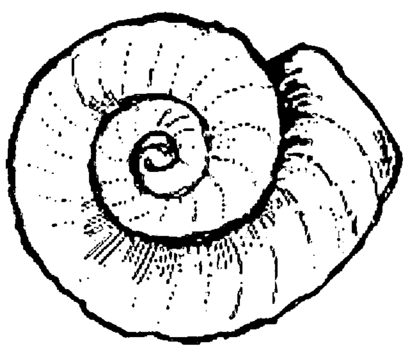


Pelecypods (Bivalves)

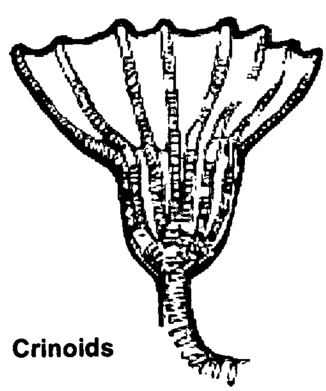
Bryozoans *(Archimedes)*



Trilobites



Gastropods



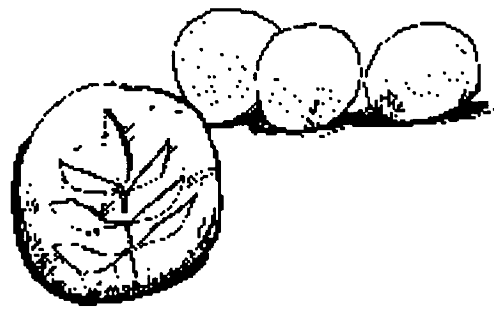
Crinoids

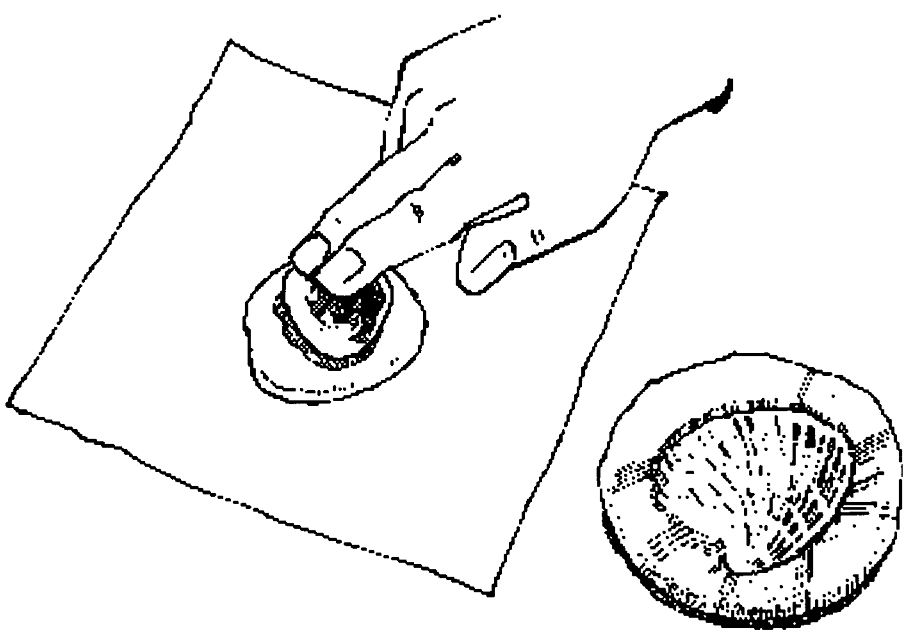
CREATE A FOSSIL

MATERIALS NEEDED
- Recipe for fossil dough
- Enough dough for each student to make a one-inch ball
- 4" X 4" square of wax paper for each student
- Leaf, shell, or other material from which to make an imprint
- Paint and paint brush

PROCEDURE
1. Provide each student with a square of wax paper.
2. Provide each student with enough dough to make a one-inch ball.
3. On the wax paper, press the dough ball into a disc. The disk should be about the size of a half-dollar.
4. Have each student select a piece of material (shell, bone, leaf, etc.) from which to make an imprint.
5. Press the selected material into the dough. Remove the material, leaving an imprint. Set aside to dry.
6. When dry, may be painted.

EXTENSION
- Discuss the types of materials that are presently being deposited. What can these potential fossils tell future paleontologists about our present day environment?
- Discuss the different types of fossils. Have the students find and/or describe examples of each.





CREATE A FOSSIL – FOSSIL DOUGH RECIPES

SMOOTH LIMESTONE:

This recipe will produce a "rock" which is white and smooth. It is preferred for making fossil impressions of leaves.

MIX:

1 cup cornstarch
2 cups baking soda (1 lb. Box)
1-¼ cups cold water

DIRECTIONS:

1. Stir all ingredients in a saucepan over medium heat for about 4 minutes until the mixture thickens to moist mashed potato consistency. Remove from the heat, turn out onto a plate and cover with a damp cloth until cool. Knead as you would dough.
2. Shape into balls, one for each student.
3. Store in the refrigerator in an airtight container or plastic bag until needed.

Yield: 25-30 one-inch balls

ROUGH LIMESTONE:

This recipe will produce a "rock" which is rough in texture. It is preferred for making fossil impressions of shells or acorns.

MIX:

2	cups flour
1	cup salt
1	tablespoon vegetable oil
1	teaspoon alum
½ - 1	cup water

DIRECTIONS:

1. Combine first four ingredients. Add a small amount of water at a time until the mixture is the consistency of bread dough. Knead until smooth.
2. Shape into balls one-inch in diameter, one for each student.
3. Store in an airtight container or plastic bag until needed. For long-term storage, keep in the refrigerator.

Yield: 25-30 one-inch balls

TALES OF THE DEAD

GRADE LEVEL: 6 - 12

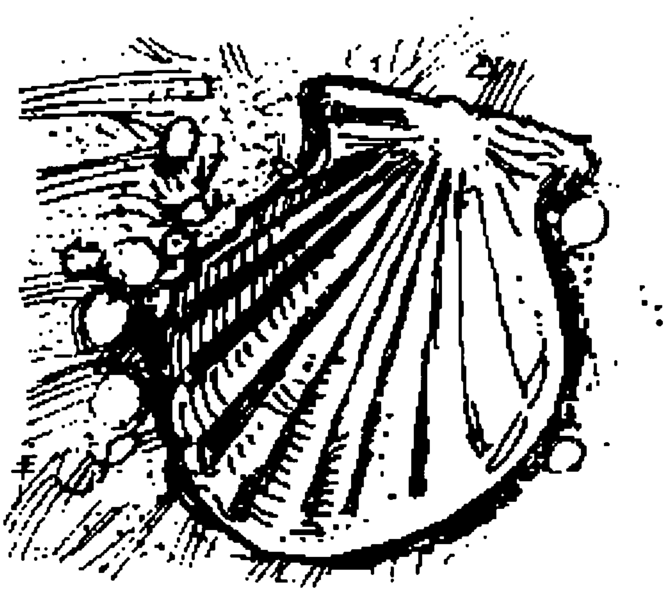
TIME REQUIRED: Two class sessions

SETTING: Classroom or outdoors

GOAL: Examine a fossil. Record several observations and inferences concerning the fossil and the environment in which it existed.

OUTCOMES: At the end of this lesson the student will:
- define paleontology,
- define observation and inference and give an example of each, and
- use knowledge of present environment to make inferences concerning the fossils.

KERA GOALS: Meets KERA goals 1.1, 1.2, 1.3, 1.4, 1.10, 1.11, 2.1, 2.2, 2.4, 2.5, 2.6, 2.11, 2.13, 3.4, 3.7, 4.1, 4.2, 4.6, 5.1, 5.3, 5.4, 5.5, 6.1, 6.2, 6.3



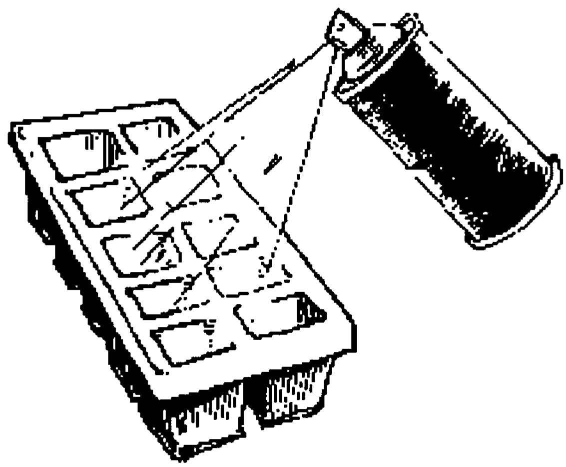
BACKGROUND INFORMATION

Fossils are strange and fascinating records buried within the earth. These records or pieces of the past are exposed through earth changes. Some fossils look like their modern relatives. Others look like something from outer space. Occasionally a rare find will produce the entire animal or tree. Unfortunately signs of ancient life are rare. Most life disappears without a trace. However, when conditions are right, bits and pieces are preserved.

Paleontologists = scientists who study fossils. They put the pieces together in a logical manner. By observing present-day environments they make inferences about the past.
Observation = seeing and recording a fact
Inference = assumption based on an observation

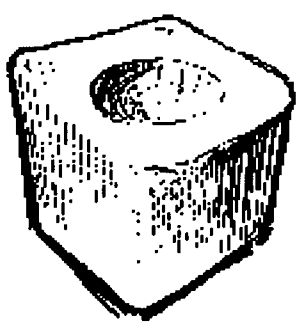
Paleontologists use two principles, observation and inference, to determine what the past was like. Most fossils are nothing more than fragments. Paleontologists reconstruct the missing parts by making inferences of how the whole plant or animal might have looked. They use their knowledge of modern plants and animals to draw conclusions about the ancient environment.

MATERIALS NEEDED
- Plaster of Paris
- Ice cube trays
- Non-stick spray or petroleum jelly
- Materials from which to create fossils: sea shells, leaves, nuts, cast of animal tracks, ferns, etc.
- Paper and pencil
- "Tales of the Dead - Student Worksheet"



PROCEDURE
Each student should create a fossil from modern-day materials. Note: the teacher may prefer to construct fossils ahead of time.

Make the fossils:
1. Spray an ice cube tray with a non-stick spray, or coat it with petroleum jelly.
2. Select a variety of materials found in our modern environment (sea shells, leaves, ferns, nuts, animal tracks, etc.). Coat the selected items with petroleum jelly, or spray with a non-stick spray, to prevent the item sticking to the plaster.
3. Prepare a stiff mixture of Plaster of Paris.
4. Place Plaster of Paris in ice cube trays.
5. Make a variety of casts, molds, and imprints. For example, some students may gently press a leaf, fern, or seashell into the plaster, gently remove the item, and leave behind an impression of the article. Other students should press and leave a small item in the plaster so only a section of the object can be seen. (Items might include the edge of a seed, the pattern of an acorn cap, the stem of a leaf, a small portion of a seashell, or a fragment of a chicken bone.) The remaining students might fill animal tracks with plaster to produce three-dimensional impressions.
6. Allow the plaster to harden.
7. Remove from trays.



Observations and Inferences: (using worksheet)
1. Divide students into small groups or allow them to work as individuals.
2. Give one fossil to each student or small group. Be certain that each group or individual has a fossil they did not make.
3. The students should:

- Describe in detail and make at least two observations of the type of fossil they are given.
- Make the following inferences:
  - What it might have been.
  - Where it lived.
  - Describe its environment.
- Draw a picture of their conclusion. This picture should contain elements of the environment as well as showing what the original plant or animal looked like.

TALES OF THE DEAD – STUDENT WORKSHEET

1. Describe your "fossil" in detail, making at least two observations. Determine the type of fossil you were given.

2. Make the following inferences:

- What might your fossil have been?

- Where might your fossil have lived?

- Describe you fossil's environment.

3. Draw a picture of your conclusion. The drawing should contain elements of your fossil's environment. It should also show what the original plant or animal looked like (use an additional sheet of paper if necessary).

HOW DO YOU BECOME A FOSSIL?

GRADE LEVEL: 1-6

TIME REQUIRED: One class period

SETTING: Classroom or outdoors

GOAL: To participate in a role-playing exercise designed to help children understand the fossilization process and to teach them how to "read" a fossil history

OUTCOMES: By the end of this activity students will be able to:

- list three conditions necessary for fossils to be preserved,
- tell where fossils are usually found,
- understand that only a representative selection of individuals or species from a time period actually become fossilized,
- conceptualize the statistical odds against becoming a fossil, and
- visualize the process of layering and stratification.

KERA GOALS: Meets KERA goals 1.1, 1.3, 1.4, 1.5, 1.8, 1.10, 1.15, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.13, 3.7, 4.2, 4.6, 5.1, 5.3, 5.4, 5.5, 6.1, 6.2, 6.3

BACKGROUND INFORMATION

It is not easy to become a fossil. Many plants and animals never leave a trace of having lived on this planet because their soft body parts (leaves, skin, feathers, muscles) do not survive over time. Hard body parts (bones and teeth) may decay or be eaten by other creatures. To become a fossil, the plant or animal must become buried quickly in an environment that keeps air away from the body. Fossilization can occur when the remains are buried in a mudslide, covered in a thick layer of leaves along the edge of a pond or lake, trapped in the ooze at the bottom of lakes or oceans, or sucked into a tar pit. Once covered, the remains may harden and the entire plant or animal will be preserved.

If the remains are slowly dissolved or washed away and replaced by minerals, it is said that they are **petrified**. The remains may also be seen as a **mold or cast.** This means the remains were dissolved but NOT replaced by minerals. Instead nothing is left but an outline in the surrounding rock. Finally, the remains may be seen as a **print or trace** fossil. A print or trace is a footprint or leaf print made when mud becomes solid rock.

After a plant or animal is preserved, sediment layers will constantly be added above the fossilized remains. Over time remains of other species may be preserved in these new layers of water, soil, or mud. Additional layers of sediments may build up on top of these newest remains. This means that the oldest fossil evidence will be found in the lowest layers of rock and sediment and the most recent (or youngest) fossils will be found closer to the surface in the top-most layers of rock and sediment.

Once the plant or animal is preserved its remains are not always discovered. Over a long period of time the fossil may be washed out of the surrounding rock and soils, or it may be so deeply buried that it is never discovered. Only when these early remains are eventually exposed by erosion, found, identified, recorded and compared to other fossils do they become valuable clues to our past.

We may not be able to make a complete and accurate list of all plants and animals that lived at any one particular time. As demonstrated in this activity, not every species became a fossil. However, we can describe the habitat and climate of a time period by looking carefully at the types of fossil remains that we do locate. By studying known fossils we can tell if the plant or animal lived in water or on land. If it lived in water, we can tell if the plant or animal lived in the ocean or in fresh water by comparing the fossil to similar species around us today. By comparing with living creatures, we should be able to tell if they lived in fast flowing water (streams or rivers) or in quiet pools (small lakes or ponds). If it is a land species, we can look at tooth remains to tell if it was a carnivore or herbivore. By looking at foot and leg bones we can tell if the animal was a good swimmer, fast runner, or climber. We can compare the temperature (climate) preferences to living creatures and make assumptions about the earlier climate of an area.

HOW DO YOU BECOME A FOSSIL?

MATERIALS

- Ten squares each of red, blue, green and brown paper
- Animal cards, one for each student
- 5"x 8" index card or piece of cardboard, one for each student
- 25" string, large safety pin, or masking tape, one for each student
- One blackboard, dry erase board, flip chart, or large piece of paper taped to the wall
- Marker or chalk
- One set of Situation Cards

PROCEDURE

1. Glue the animal card pictures onto 5"x 8" index cards or pieces of cardboard. Attach a piece of string 25" long to each card so the card can be worn around the neck (you may prefer to use a large safety pin or masking tape).
2. Give each student a completed animal card. They will become that animal for the duration of the game.
3. Place all the colored squares in a central location. Allow each student to choose a colored square. The color will be used to determine their fate.
4. The students will stand up and listen as the teacher reads from one of the Situation Cards. These cards describe what happens to each animal.
5. During Round 1, the teacher reads a scenario from one of the Situation Cards. As their color is called, the students will sit down if they did **not** become a fossil. They remain standing if they **do** become a fossil. At the end of the scenario, all student species that are still standing will be listed at the bottom of the board or flip chart. Draw a line above the list to represent the top of a sediment layer. This represents the oldest layer of rock and the species that became fossilized during that time period.
6. Students may trade colored squares if they desire.
7. All students stand up again and Round 2 of the game is played. At the end of this round all student species still standing should be listed on the board above the first list. Draw a line above this second list to represent the top of the second sediment layer. You have now created the next youngest layer of rock filled with younger fossils.
8. All students stand up and the game is played again for Round 3. Again list all student species remaining at the end of this round above the second list. This represents the youngest layer of fossil remains. Draw a line above this third list.
9. After all rounds are complete, go back and look at the types of plants and animals that survived as a fossil. Are all species represented? Why or why not? Look at the number of each species listed. Are these numbers proportionate to the number of living species alive during that time period? Why or why not?

DISCUSSION

Discuss the implications of fossil finds.

- What assumptions about early life would scientists make based on the fossil remains found in each sediment layer (and time period) listed on the board?
- What do fossils tell us about any particular era of time?
- Can scientists be absolutely certain which plant or animal was dominant during a particular time period? Why or why not?
- Was it possible to have other creatures or plants living during a particular time period that we don't yet know anything about?
- Is it possible for scientists to discover new, unknown plant or animal fossils?
- Is it possible for scientists to accurately describe the climate or habitat of a particular place during any one particular time period? How can they do that?

EXTENSION

- Conduct research on the plants and animals found during various pre-historic eras and time periods. After the research is completed, have each student draw a picture of his or her species. Use these drawings with the above activity.
- Using the results of the activity above, have students complete a graph that shows the number of each species before and after each round of the activity.

This activity adapted from Fossil Butte National Monument, *"The Fossilization Game"*, found in *Teaching Paleontology in the National Parks and Monuments and Public Lands: A Curriculum Guide for Teachers of the Second and Third Grade Levels*

SITUATION CARD ROUND 1: THE FOREST HABITAT

Green circles — These creatures died in the forest. Vultures ate their remains. We never knew they existed!

Red circles — These creatures were caught in a forest fire. They were burned up and we never knew they existed! Ouch!

Blue circles — These creatures were caught in a flood. They were washed down the river and out to sea. We never saw them again!

Brown circles — These creatures were covered in mud and became fossils. We thought they were the only ones that lived during this time period!

SITUATION CARD ROUND 2: THE LANDSCAPE DRIES OUT

Brown circles — These creatures lived in a desert. When they died their remains dried up and they were blown away by the wind. We never knew they existed!

Green circles — These creatures couldn't find water. The died of thirst and their remains rotted away. Ugh!

Red circles — These were eaten by carnivores. We never knew about them!

Blue circles — There was a sudden, welcoming rainstorm, which produced pools of water. The animals rushed over for a drink. These creatures fell into the pond and were covered by mud. Because their remains were protected from the water and air, they became fossils!

SITUATION CARD ROUND 3: A VERY WET LANDSCAPE

Blue circles — These creatures tried to swim across a fast-moving river and were washed away by the current. Large fish ate some and the others were carried so far downstream that we never knew they existed!

Brown circles — Dinosaurs swallowed these creatures. So long!

Green circles — These creatures lived and died in the over-grown forest along the riverbanks. Scavengers ate their remains! We never knew they existed!

Red circles — These creatures were caught in a mudslide. Because they were buried so quickly, they were able to become fossils!

SITUATION CARD ROUND 4: THE ICE AGE CAME

Red Circles — The climate was getting colder. These creatures were not able to adapt. Since they did not grow longer fur to stay warm, they decided to migrate to a warmer climate. We never saw them here again!

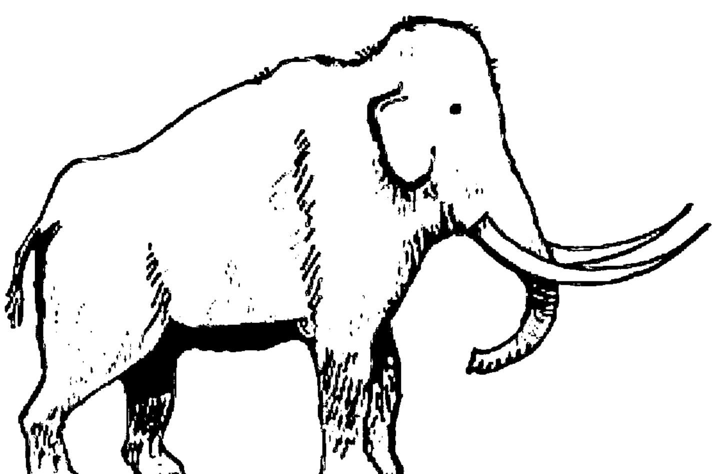
Green circles – These creatures depended upon the green plants for their food supply. When the ice and snows came the plants disappeared and so did these animals!

Brown circles — These creatures depended upon small reptiles for their lunch. When the climate became colder their food supply disappeared! These creatures slowly starved to death, dried up, and disappeared!

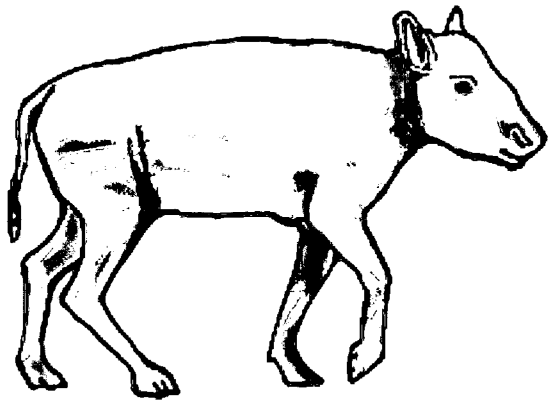
Blue circles – These creatures were walking along the edge of the glacier when they fell through the snow into a large crack. They froze quickly and became frozen fossils!

FREE-TAILED BAT

GIANT GROUND SLOTH



WOOLLY MAMMOTH



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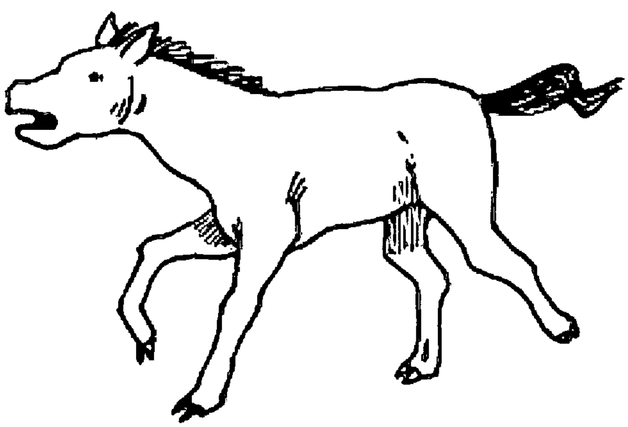

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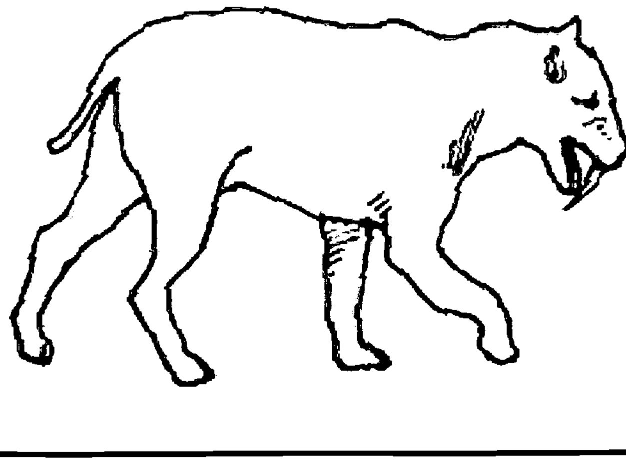


SABER-
TOOTHED
CAT

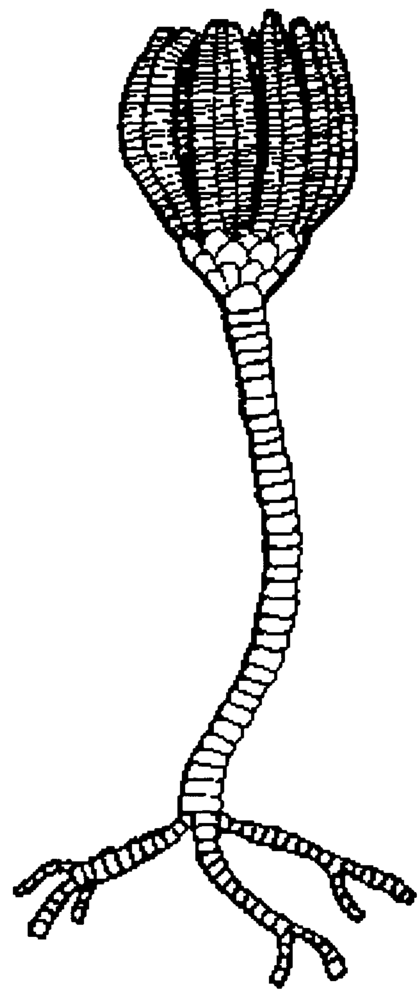
CRINOID RACE

GRADE LEVEL: 6 - 9

TIME REQUIREMENT: One class session

SETTING: Indoors in a gymnasium or outdoors

GOAL: To learn to identify fossils by participating in a relay race.



OUTCOMES: At the end of this lesson, presented with several choices, the student will:
- identify the type of rock in which fossils are found,
- identify at least three types of fossils,
- select a component of sandstone,
- select a component of limestone,
- select a component of shale,
- identify sandstone rock,
- identify limestone rock,
- identify an agent of change, and
- identify one thing needed for fossilization to occur.

KERA GOALS: Meets KERA goals 1.3, 3.3, 3.7, 4.1, 4.2, 4.4, 4.6, 5.1, 5.3, 5.4, 6.1, 6.2

BACKGROUND INFORMATION
This culminating activity is best used after students have gained some experience in identifying the different types of fossils found at Mammoth Cave National Park. They should also have some basic knowledge of the different types of sedimentary rocks.

MATERIALS NEEDED
1. Three boxes to hold the objects. Each box will contain:
- A selection of fossils (including crinoids, gastropods and brachiopods)
- A container of sand
- A container of water
- A piece of sandstone
- A piece of limestone.
- A container of mud
- An insect skeleton (or chicken bone)
- Several leaves
2. Crinoid Race Clue Sheet
3. Paper and pencil for keeping score

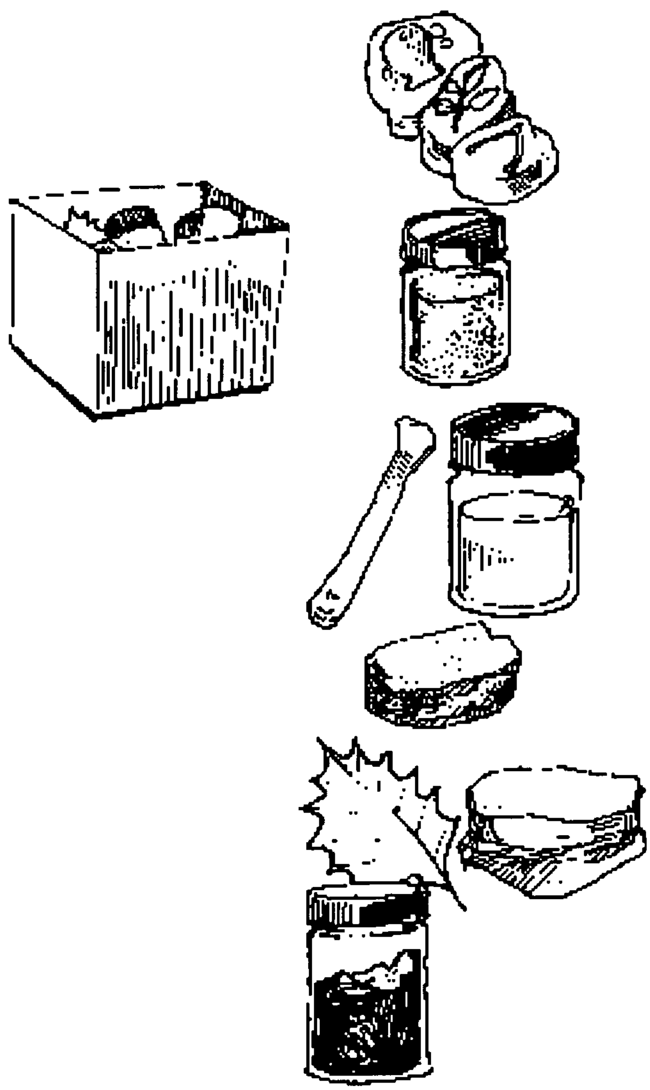
CRINOID RACE

PROCEDURE

1. Fill three boxes with an identical selection of items. Each box should contain a selection of fossils, a container of sand, a container of water, a piece of sandstone, a piece of limestone, a container of mud, an insect skeleton (or chicken bone), and several leaves. Place the filled boxes in a straight line at one end of the playing field.
2. Divide the students into three teams. Each team should line up single-file at the opposite end of the room or field. Each team should be facing one of the three boxes.
3. Explain to the students that they are about to participate in a relay race. The teacher will read a clue. Each clue will provide information on a type of rock, a component of a rock, a type of fossil, or a method of fossilization. After listening to the complete clue, the first student in each line will run to their team's box and choose the item described in the clue. Explain that scoring will be based on returning to their team with a correct solution to the clue. Every team with a correct answer will receive two points. The first person back with a correct answer will receive one extra point. A team with an incorrect answer gets one point. The team with the highest cumulative score will be declared the winner.
4. When everyone is ready and understands the rules the teacher will read the first clue. After the clue has been read, the teacher says, "Go" and the first person in each team will race to his or her team's box and will select the correct answer to the clue. Once the selection has been made, the runner races back to his or her team.
5. The teacher now reviews the answers. Beginning with the first team back, the runner shows and explains his or her selection. Note that occasionally there can be more than one correct answer to a clue. Next proceed to the second and third team back, awarding points for speed, correct, and incorrect answers.
6. The first runner now goes to the back of the line and the second person in line becomes the next runner.
7. The teacher will read the second clue card, the teacher says "Go", and the second set of runners race to their box to select their correct answer.
8. Continue in this manner until all students have had at least one chance to select an answer.
9. After each team member has a chance to run and collect a correct item, total the scores. The team with the highest total score will be declared the winner.

10. Review instructions:

- The teacher will read a clue card.
- On signal the students will race to their team's box, select the item referred to in the clue, and return to the starting point.
- The teacher will review what each team selected
- Award points after each round of play, awarding points as follows:
  - first to return with correct answer: 3 points
  - all others with correct answer: 2 points
  - any team with an incorrect answer: 1 point



CRINOID RACE CLUE SHEET

I am the BEST place for fossilization to occur.
I am often found upon the floor. *(mud)*

I am a rock found throughout the land.
I am made of tiny grains of sand. *(sandstone)*

To carve out a cave I was the first facet.
I produced the gas that created the acid. *(leaves)*

I have two shells not quite the same.
Figure it out, you win this game. *(brachiopod)*

I was alive in an ancient sea.
Rock was made by crushing me. *(shell)*

In a former life, like a flower I bloomed.
Now in stone I am entombed. *(crinoid)*

For millions of years I eroded away.
I am a part of the caprock seen at Mammoth Cave today. *(sand)*

Living on land or in the sea.
My spiral shell can protect me. *(gastropod)*

I am the stone made in the sea.
The cave exists inside of me. *(limestone)*

I ebb and flow and land gives way.
I erode those rocks that are in my way. *(water)*

I'm seen as a fossil of creatures long dead.
I can be part of a finger, a leg or a head. *(bone)*

I produce O_2 to keep you alive.
I'm collected, admired, or just pushed aside. *(leaves)*

I'm found in an ocean, a lake, or stream bed.
I'm best for preserving creatures – from their feet to their head! *(mud)*

I am made from tiny grains.
I wash away in times of rain. *(sandstone or limestone)*

In Fall I float to the ground, where roads I do pave.
I release CO_2 — which helps carve out a cave! *(leaves)*

The calcium in me made a strong bone.
Crushed after death I become a tan stone. *(bone or shell)*

Carbon dioxide in me can take its toll.
Eating away limestone, I produce a hole. *(water)*

Often I'm called the "Lily of the Sea,"
But the fossil stalk is what's left of me. *(crinoid)*

As the caprock erodes and produces lots of me,
I 'm found on the playground and next to the sea. *(sand)*

I held up a mammoth, a tapir, a sloth.
I'm found in **your** body wrapped in muscle and cloth. *(bone)*

I create acid by releasing a gas.
That mixes with water to carve a cave path. *(leaves)*

A head, a foot, a spiral shell.
Close my door and all is well. *(gastropod)*

In days long ago I was much larger and faster,
But now I'm a fossil that's found in a pasture. *(insect skeleton or bone)*

Eroded from rock, I'm found by the sea.
Do you think you can you remember the name of me? *(sand)*

I have two shells that look almost alike.
You can hold me. I would never bite! *(brachiopod, pelecypod, bivalve, seashell)*

FOSSIL IDENTIFICATION

GRADE LEVEL: 6-12

TIME REQUIRED: Two class sessions

SETTING: Classroom as a pre-site activity

GOAL: The student will identify types and frequency of fossils found in rocks at Mammoth Cave National Park.

OUTCOMES: At the end of the lesson the student will:
- identify fossils routinely found in the Mammoth Cave area, including:
  - gastropod
  - brachiopod
  - trilobite
  - bryozoan
  - horn coral
  - crinoid
- define an index fossil.
- state the index fossil for Mammoth Cave St. Genevieve limestone.

KERA GOALS: Meets KERA goals 1.1, 1.2, 1.3, 1.4, 1.5, 1.10, 2.1, 5.3, 6.1, 6.2

BACKGROUND INFORMATION

The Mississippian Period was named for the limestone bluffs along the Mississippi River where typical outcrops occur. Rocks formed during this time period are found in the states that make up the upper Mississippi Valley. During most of the Mississippian period a shallow sea covered Kentucky. As these seas receded they were replaced by river deltas and low coastal areas. These periods of coastal environments alternated with periods when the sea inundated the area. Life forms from this ancient ocean became our current fossil record.

Fossils are the remains or traces of ancient life that are preserved in rocks. Of the large numbers of organisms that once lived, only a small number became fossils. Most of these fossils are found in sedimentary rock. To become a fossil the organism must meet specific criteria. The organism must have hard body parts such as bones, cartilage, teeth, or shells. The organism needs to be protected from scavengers and decomposers. Therefore, when it dies it needs to be buried quickly. The best location for fossilization to occur is in mud. A riverbed, lake, or sea floor are ideal fossilization sites. As more and more layers of sediment cover the organism, the resulting pressure and heat hardens the sediments into rock, capturing the evidence of past history.

Because fossils are restricted to a certain time interval, a fossil can be used to determine the relative age of the rock in which it is preserved. If, for example, we find rocks that contain crinoids, we can conclude the rocks are Paleozoic in age. Such fossils are called index fossils. Some Mississippian rocks contain so many broken pieces of the crinoid fossil that the Mississippian era is known as the "Age of the Crinoid."

MATERIALS NEEDED
- Replicas or examples of Mississippian era fossils to include a gastropod, brachiopod, trilobite, bryozoan, horn coral, crinoid, and others as available*
- Rocks embedded with fossils
- *Fossil Identification Workbook* (included with this curriculum)
- "Fossil Identification Graph"
- Pencil

*fossil replicas available to borrow from Mammoth Cave Education Program.

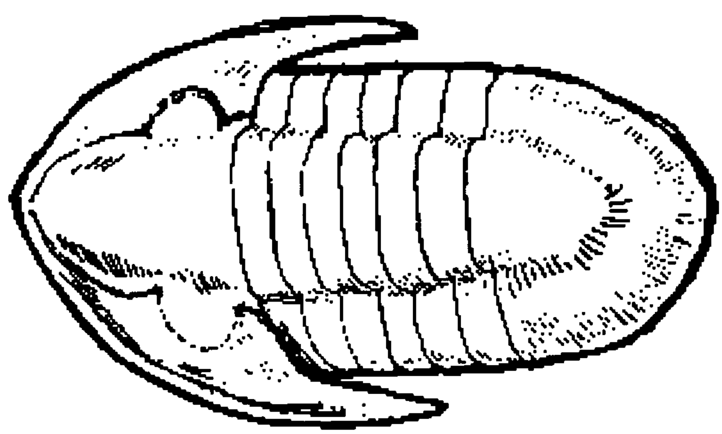
FOSSIL IDENTIFICATION

PROCEDURE

1. Divide the class into small groups of 2-4 students each. Give each group a set of fossil replicas and a copy of the Fossil Identifcation Workbook.
2. Have the students compare the drawings on the workbook with their fossil replicas.
3. Because each fossil has a different part exposed in real life, instruct the students to look at each fossil from various angles in order to practice seeing their fossils from different perspectives.
4. Discuss the identifying features of the various fossil types.
5. Give each group a selection of rock samples that contain embedded fossils and a copy of the "Fossil Identification Graph." Instruct students to examine their rocks carefully. They should use the *Fossil Identification Workbook* to identify the fossils found in their rocks.
6. Instruct the students to make a list of the fossils their group can identify. Count the number of each type of fossil. Represent this number as a bar graph on the "Fossil Identification Graph."

EXTENSION

- Ask each group to present an oral or written report that summarizes their findings.
- On the board, prepare a frequency graph representing the total numbers and types of fossils found by all the groups. Show the combined total as a bar graph.
- Have the students convert their findings into a line graph.
- Plan a field trip to identify types of fossils in situ. In south-central Kentucky, possible sites could include Mammoth Cave National Park, areas where ground excavations have left rocks littering the area, road-cuts, or the banks of rivers which have cut down through limestone layers.

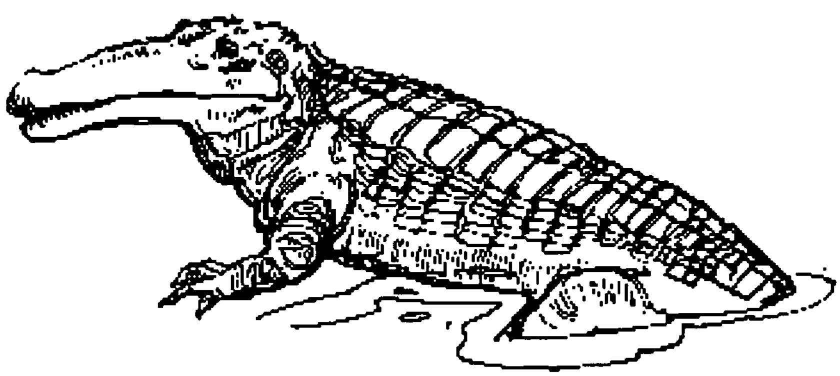


FOSSIL IDENTIFICATION GRAPH

Name:________________________

14									
13									
12									
11									
10									
9									
8									
7									
6									
5									
4									
3									
2									
1									
	Brachiopods	Pelecypods	Gastropods	Bryozoans	Trilobites	Corals	Echinoderms	Teeth	Plants

PART 3: ADAPTATIONS



RACE FOR SURVIVAL

GRADE LEVEL: 1-8

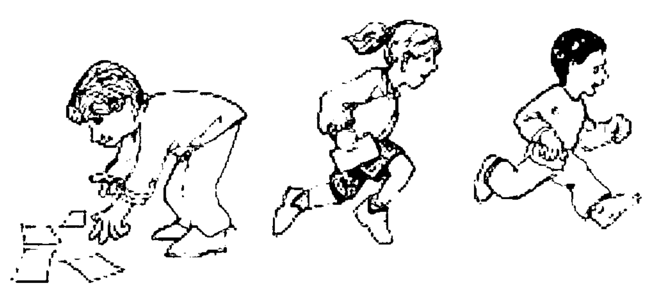
TIME REQUIRED: One class session

SETTING: Classroom or outdoors

GOAL: Given an environmental change the student will select a possible adaptation for survival.

OUTCOMES: At the end of this lesson the student will:
- define adaptation,
- define natural selection, and
- verbalize how life forms adapt.

KERA GOALS: Meets KERA goals 1.2, 1.3, 1.4, 1.5, 1.7, 1.10, 2.1, 2.2, 2.3, 2.4, 2.6, 2.11, 3.4, 3.7, 4.2, 4.6, 5.1, 5.2, 5.3, 5.4, 5.5, 6.3



BACKGROUND INFORMATION

Our planet contains a great variety of distinct ecosystems: dessert, pond, mountain top, forest, ocean, or cave, to name but a few. Within each of these environments lives a selection of plants and animals that have adapted to each other and to their surroundings. This has occurred by the development of a specific set of physical or sensual modifications that helps these plants and animals survive.

The ecosystems in which organisms live are dynamic and ever changing. Fire, flood, drought, earthquakes, or changes in the climate may alter these environments. A new organism may be introduced into the environment that alters the inter-relationship of the original inhabitants. As the environmental system changes, organisms are forced to change and adapt in order to survive.

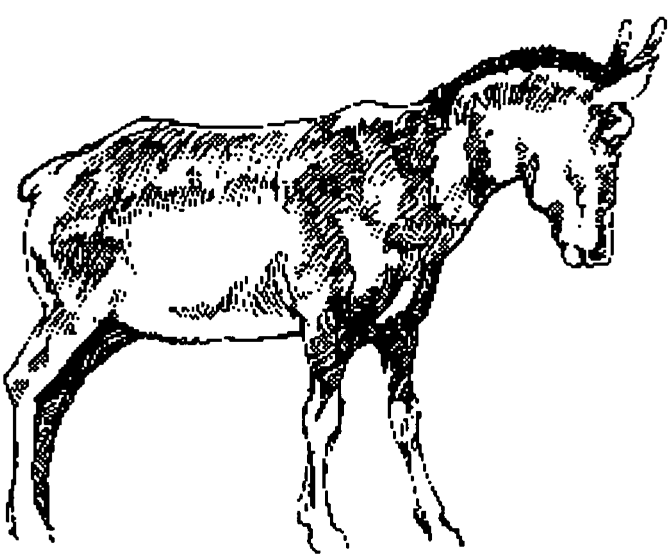
When change occurs in the environment, individual characteristics of a species may help or hinder the survival of that population. If the characteristic helps, the species survives the changing situation and passes on the genes that give those characteristics to their offspring. If the animals are hindered by a particular characteristic, the species must either adapt or face possible extinction.

Most plants and animals exist because they have successfully adapted to changes in their environment. When an organism is unable to change or deal with evolving environmental stress, it will die and the species may be threatened with extinction. Organisms able to cope with the new stress tend to survive. Over time, natural selection and evolution enhance adaptations. These adaptations to a changing environment can take varying amounts of time to occur. Some adaptations happen quickly. The immunity of insects to pesticides is one example. Other adaptations can take thousands of generations or even millions of years to occur. The loss of eyes by true cave dwellers (troglobites) is an example of a slow adaptation.

RACE FOR SURVIVAL

MATERIALS NEEDED

- One set of "Adaptation" cards
- List of "Changing Situations"
- 5" x 8" index cards or poster board
- Score card



PROCEDURE

1. Photocopy the "Adaptation" cards. Cut out the adaptations. Paste each adaptation onto a 5" x 8" index card or onto poster board that has been cut to the appropriate size. Set aside.
2. Review the list of "Changing Situations" with the students. Have students brainstorm possible adaptations for each situation. How many ways can an organism change to survive each new situation?
3. Review the list of possible adaptations to familiarize students with possible choices.
4. Place the "Adaptation" cards face up on the ground at the far end of the playing field.
5. Divide the students into teams of 5-10 students each. Each team should form a line along the edge of the playing field at the opposite end from the "Adaptation" cards.
6. Read one of the "Changing Situations".
7. On a signal, the first student in each line will race to the far end of the field and select one "Adaptation" card that will help his or her team cope with the change. Once they have selected their adaptation they should return to the starting line.
5. Once all the runners have returned, review what each team has selected. Have the students justify their selection and come to a consensus as to whether this adaptation would lead to survival.
6. Award points for correct or creative answers that can be justified. The team with the highest score will be declared the winner. Award points as follows:
   - first team to return with a reasonable choice: 3 points
   - all other teams with reasonable choices: 2 points
   - selections which would **not** lead to survival: 1 point

This activity adapted from Florissant Fossil Beds National Monument, *"Adaptation Game"*, found in *Teaching Paleontology in the National Parks and Monuments:* A Curriculum Guide for Teachers of the Fourth, Fifth and Sixth Grade Levels

RACE FOR SURVIVAL – CHANGING SITUATIONS

Your predators become camouflaged.

Your prey becomes camouflaged.

The plants you eat become extinct.

Your predators begin to run faster.

The area where you live turns into a desert.

The plants you eat develop spines.

Humans use pesticides to kill you.

The animals you eat begin living underground.

Disease and insects kill the trees you depend on for food.

The climate becomes very cold.

The animals you eat develop armor.

Other animals learn to find and eat your eggs.

The ocean you live in dries up.

Your food supply becomes seasonal.

The animals you eat start to come out only at night.

The plants you eat develop a bad taste.

RACE FOR SURVIVAL – ADAPTATIONS

Become camouflaged.

Develop better night vision.

Hibernate.

Learn to store food.

Build your home underground.

Develop muscles and claws for digging.

Shed more fur to keep cooler.

Develop longer legs.

Develop lungs for breathing.

Sleep in the day and hunt at night.

Migrate.

Develop Armor.

Incubate eggs within your body (mammals).

Lay camouflaged eggs.

Grow quills.

Shed less fur.

Grow fangs.

Develop claws for climbing trees.

Develop a better sense of hearing.

Develop a better sense of smell.

Develop a way to store water in your body.

Become immune to pesticides.

Develop new teeth and digestive system so you can eat different plants.

Live with others of your kind and take turns keeping watch for predators.

Change your external color.

Grow faster.

Give birth to live babies.

Eat meat.

Become an omnivore so you can eat both plants and other animals.

Become warm-blooded.

54

RACE FOR SURVIVAL – ADAPTATION CARDS

BECOME CAMOUFLAGED	DEVELOP BETTER NIGHT VISION
EAT MEAT	DEVELOP MUSCLES AND CLAWS FOR DIGGING

53

RACE FOR SURVIVAL – ADAPTATION CARDS

SHED MORE FUR TO KEEP COOLER	BECOME WARM-BLOODED
MIGRATE	INCUBATE EGGS WITHIN YOUR BODY (MAMMALS)

RACE FOR SURVIVAL – ADAPTATION CARDS

DEVELOP LUNGS FOR BREATHING	SLEEP IN THE DAY AND HUNT AT NIGHT
DEVELOP LONGER LEGS	DEVELOP ARMOR

57

RACE FOR SURVIVAL – ADAPTATION CARDS

DEVELOP NEW
TEETH AND
DIGESTIVE SYSTEM
SO YOU CAN EAT
DIFFERENT PLANTS

LAY
CAMOUFLAGED
EGGS

DEVELOP
A BETTER
SENSE OF
HEARING

DEVELOP CLAWS
FOR CLIMBING
TREES

RACE FOR SURVIVAL – ADAPTATION CARDS

DEVELOP
A BETTER
SENSE OF SMELL

DEVELOP
A WAY TO STORE
WATER IN YOUR
BODY

GROW QUILLS

CHANGE YOUR
EXTERNAL COLOR

61

RACE FOR SURVIVAL – ADAPTATION CARDS

GROW FASTER	BECOME IMMUNE TO PESTICIDES
GIVE BIRTH TO LIVE BABIES	SHED LESS FUR

66

RACE FOR SURVIVAL – ADAPTATION CARDS

HIBERNATE

GROW FANGS

BECOME AN
OMNIVORE
SO YOU CAN EAT
BOTH PLANTS
AND
OTHER ANIMALS

BUILD YOUR
HOME
UNDERGROUND

65

LEARN TO
STORE FOOD

LIVE WITH
OTHERS OF YOUR
KIND AND TAKE
TURNS KEEPING
WATCH FOR
PREDATORS

SURVIVAL OF THE FITTEST

GRADE LEVEL: 6 - 12

TIME REQUIRED: One class session

SETTING: Classroom or outdoors

GOAL: The students will create a graph depicting protective coloration as an element of survival.

OUTCOMES: At the end of the lesson the students will:
- define protective coloration and
- demonstrate the relationship of coloration and environment to survival.

KERA GOALS: Meets KERA goals 1.3, 1.4, 1.7, 1.8, 1.9, 1.10, 1.11, 2.1, 2.2, 2.4, 2.6, 2.8, 2.11, 2.13, 3.3, 3.7, 4.2, 4.4, 4.6, 5.1, 5.2, 5.3, 5.4, 6.2, 6.3

BACKGROUND INFORMATION

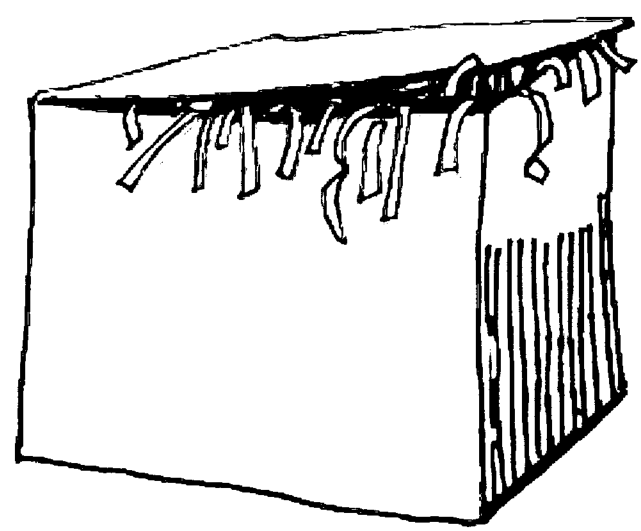
Since the beginning of time, thousands of plants and animals have evolved, lived, and become extinct. Our ecosystem is dynamic and ever changing. Fire, flood, drought, earthquakes, or changes in the climate may alter the environment. As the system changes, organisms are forced to change in order to survive. Those that are best suited to the environment survive. Evolution is a process by which populations change over time. Individuals unable to deal with the environmental stresses die, while others able to cope with the stresses survive. This is the process of natural selection. Each distinct environment (desert, pond, mountain top, or cave) supports a more or less distinct population. Plants and animals within each of these environments exist because they have adapted to their specific environmental conditions. Those unable to cope with the environment become extinct.

Organisms interact with each other constantly. Many of their contacts result in an energy flow through the ecosystem. There are three basic types of interactions within a community: predation, symbiosis and competition.

Predation may be defined as the behavior of capturing and feeding on another organism. The two components of predation are the predator and the prey. The predator is the organism that feeds on another living organism, and the prey is the organism that is eaten. Animal coloration has arisen through natural selection in response to the predator-prey relationship. Protective coloration allows the prey to resemble some object in its environment, thus providing potential escape from predation.

Symbiosis occurs when two very different organisms live together and each receives what it needs to survive from the other. Lichens are an example. Lichens are formed from algae and a fungus living together. The alga is green and produces food for the fungus through the process of photosynthesis. The fungus provides a thread base that protects the algae from receiving too much ultra-violet light and from drying out.

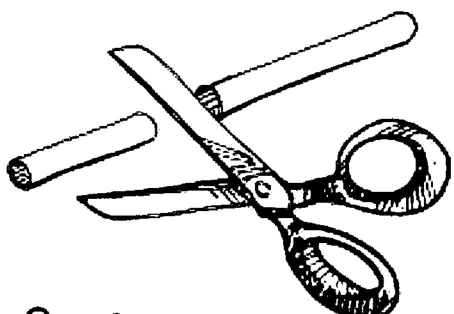
There is great **competition** within any community for both food and shelter. No two species in any community can occupy exactly the same niche and therefore even closely related species will differ slightly in their survival requirements. The swallow and house martin are good examples. Both these birds capture their insect food on the wing, but the martins tend to fly slightly higher than the swallows and direct competition is avoided.

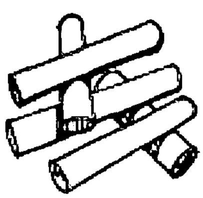


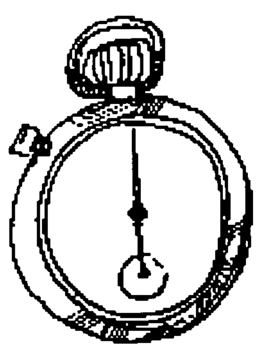
SURVIVAL OF THE FITTEST

MATERIALS NEEDED

- One box with a hinged lid for each pair of students
- Stopwatch or watch with second hand
- White tissue paper cut into ¼-inch strips
- Drinking straws in 5 colors, cut into 2-inch lengths
- Graph paper
- Pencil







PROCEDURE

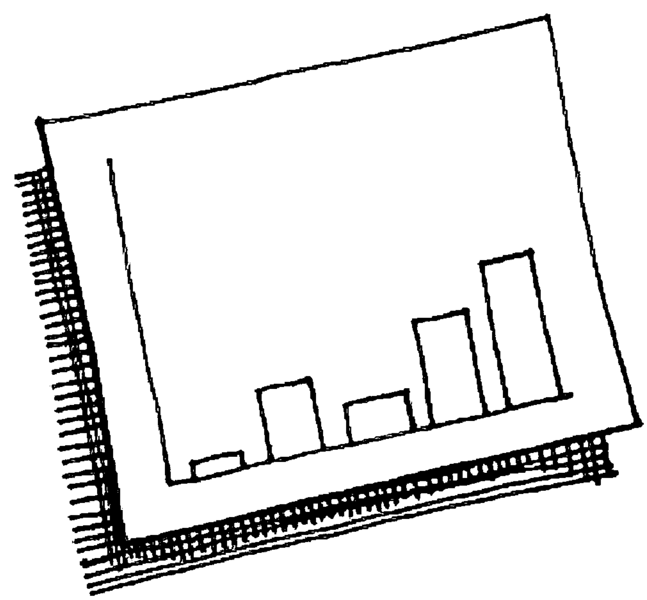
1. Cut white tissue paper in ¼-inch widths. Fill a hinged box with the cut paper, making a "bed" of tissue paper. You will need one box for each pair of students.
2. Cut drinking straws into 2-inch lengths. You will need 8 pieces each of five different colors. One of the colors must be white. These straws represent five different species living in a habitat. Mix these straws into the bed of tissue paper.
3. Divide students into teams of two. Give one student in each team a habitat box and a stopwatch or a watch with a second hand. This student will open the box and keep time for three seconds. At the end of the three-second interval the box lid will be rapidly closed.
4. The second student will pick one straw at a time from the box during the three-seconds that the lid is open.
5. At the end of the three-second round the students will reverse roles.
6. The activity will continue for ten rounds.
7. At the end of the ten rounds the students will tabulate the results by adding up the number of straws of each color they have collected.
8. Have each team produce three bar graphs. Have each **student** create a bar graph that shows the number of each color straw he or she "captured" during the 10 rounds of play. Instruct the students to combine their results and produce a bar graph that reflects the total of each color captured by the **team.**
9. Create a graph that reflects the combined results from the class as a whole. Compare your graphs.
10. The following questions are to be addressed:
    - Which color straw was most frequently selected?
    - Why was that color selected?
    - Which color was least represented on the chart? Why?

- What is the correlation of survival to the environment?

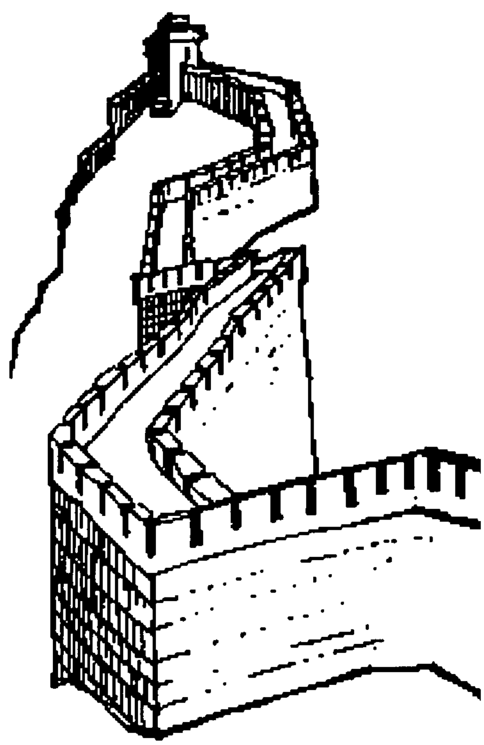
EXTENSION:

1. Read and discuss the peppered moth experiment conducted in England in 1950. H.B.D. Kettlewell (*Scientific American*, March 1959, page 48) details this experiment in "Darwin's Missing Evidence". How do the results of this experiment compare to the above straw activity?
2. Conduct a second camouflage activity which looks at the blending ability of a species. To conduct this experiment you will need 10 sheets of newspaper, 5 sheets of white construction paper, 5 sheets of black construction paper, scissors, and a large container. Directions:

- You will need to produce five habitat areas. Each habitat area will require one open sheet of newspaper and a total of 192 rectangles that measure 1"x 1 ½ " each cut from black paper, white paper and newsprint. Cut 64 rectangles out of the white construction paper. Cut 64 rectangles out of the black construction paper. Cut 64 rectangles out of the second sheet of newspaper.
- Place all the cut papers in a container and shake to mix thoroughly.
- Dump the mixed papers onto the open sheet of newspaper, being certain that the pieces are scattered across the top surface of the newspaper. You have now prepared a classroom habitat. Prepare five of these habitats and space them around the outer edge of the classroom or down the length of a hallway.
- Have the students line up. At your signal, have them walk quickly past each classroom habitat and quickly "capture" one paper creature from each habitat area.
- Instruct the students to compute their results. How many of each type paper animal were captured? How many of each type paper animal survived? Graph the survival rate of the different animals.
- Which coloration offered the best protection? Why? How could a change in pollution (more soot covering the habitat, for example) affect the numbers and kind of animals in the population? How would this same population be affected if a "Clean Air" regulation was enacted and enforced? Predict the new results. Test your predictions by placing your populations (cut rectangles) on a solid black habitat surface or on a solid white habitat surface.



PART 4: HUMAN INFLUENCES



SHOEBOX MIDDEN DIG

GRADE LEVEL: 6 –12

TIME REQUIRED: Two class periods

SETTING: Classroom

GOAL: To create and excavate a fossil/archaeology site

OBJECTIVES: At the end of this lesson the student will be able to:

- define the Principle of Superposition,
- define the Principle of Original Horizontality,
- state how these two principles apply to paleontology,
- describe the process of stratification,
- differentiate the roles of the archaeologist, paleontologist, and the historian, and
- describe some techniques used by archaeologists and paleontologists.

KERA GOALS: Meets KERA goals 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.10, 1.11, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.9, 2.10, 2.11, 2.19, 2.20, 2.23, 3.4, 3.7, 4.1, 4.2, 5.1, 5.2, 5.3, 5.4, 6.1

BACKGROUND INFORMATION

The 4.6 billion-year history of the earth is divided into eras, periods, and epochs that are based on the type of life that existed during each of these time frames. The geologic processes and scientific laws operating today also operated in the past.

The Earth's atmosphere and surface water act together to decompose and wear away the rocks on the surface of the planet. The sediments formed by this erosional process are deposited in horizontal layers. This process is called the **principle of horizontality**. Over time, these sediments harden and bond together and become the rock layers of today. Because the first, or oldest, sediments are found on the bottom layer, the age of sediments and rocks becomes progressively younger from bottom to top. This is called the **principle of superposition**. Sedimentary rocks tell the story of destruction and rebuilding. Geologists study sedimentary rocks to understand the past. They use a relative time scale which places rocks and events in the chronological order in which they formed. Using these principles, scientists can use fossils to establish the age of the rock.

Archaeologists and paleontologists are scientists who look at the early history of our planet. **Paleontologists** study the fossil remains of various organisms and use the clues they find to describe the earliest plant and animal life found in an area. By comparing these early species to those found today, the paleontologist can draw some conclusions about the prehistoric climate of that era.

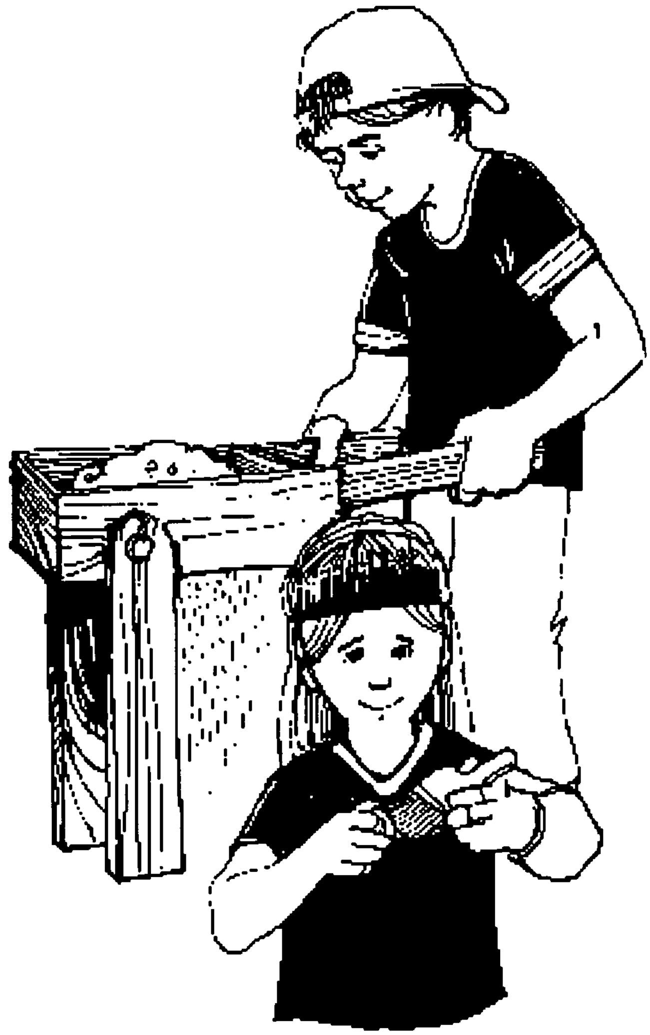
Archaeologists look at the life of early human beings. Starting approximately 12,000 years ago, early humans left behind objects, or artifacts, which tell about the daily life and environment of the people who inhabited this area of Kentucky. These ancient trash piles are called middens. The clues that archaeologists uncover tell us how these early people survived, what they ate, what their homes were like, and what games and jobs they enjoyed. Both archaeologists and paleontologists use similar techniques to uncover clues of the past.

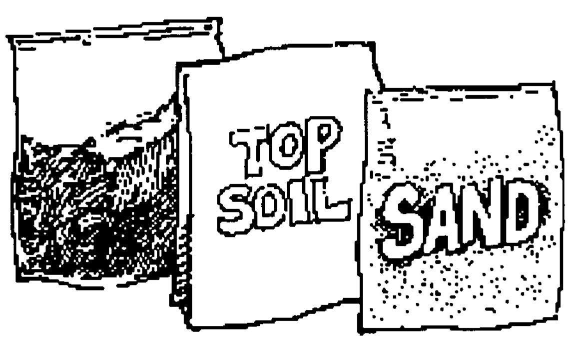
An archaeological or paleontological survey is a systematic examination of the land. When a site is discovered the boundaries are defined and mapped. All specimens within these boundaries are mapped and recorded. Specimens are then collected and taken to a laboratory where they are cleaned and analyzed. It is important for these scientists to keep detailed notes about the surrounding landscape and to note exactly where each specimen was located because the surroundings and relative location of various artifacts can often be a more important clue than the item itself.

SHOEBOX MIDDEN DIG

MATERIALS NEEDED
Each group of three students will need one set of the following items:

- 2 cups of dirt found locally
- 2 cups of bagged topsoil
- 2 cups of sand
- Spray bottle of water
- Permanent marker
- Ruler marked in millimeters
- Graph paper, 3 sheets per group
- "Curator Work sheet," 3 per group (two-sided)
- Pencil
- Paper plates, 3 per group
- One styrofoam tray
- Clear plastic shoebox marked in millimeters on the side (starting with "1" at the top)
- Plastic spoon
- Small paintbrush
- "Prehistoric" fragments, including: Shells or coral fragments, fish bones
- "Ancient" artifacts, including: Small chicken bones, pieces of charred wood, burnt rocks, arrowheads, or rocks which look like scrapping stones
- "Modern" artifacts, such as: Ticket stubs, small toys, fast-food, gum, or candy wrappers





SHOEBOX MIDDEN DIG – ACTIVITY ONE

PROCEDURE

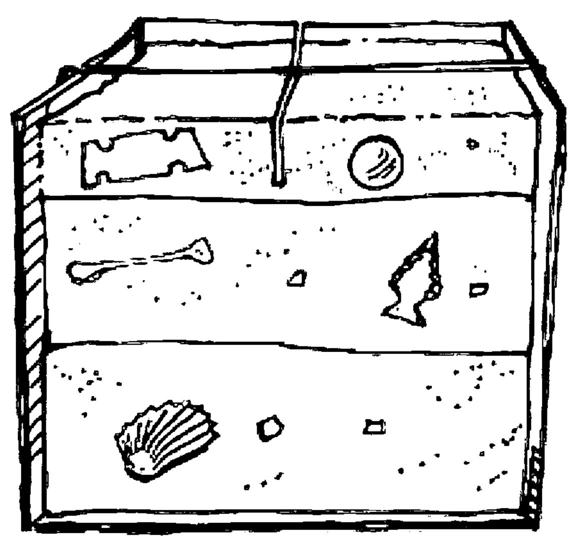
MAKING THE BOXES:

1. Divide the students into groups of three.
2. Provide each group with the materials needed to construct a shoebox midden: a clear plastic shoebox; black permanent marker; a ruler marked in millimeters; 2 cups each of local dirt, topsoil and sand; spray bottle of water; and three collections of artifacts. Each artifact collection will represent an activity or event during each of three different time periods.
3. Tape or draw a millimeter ruler down one side of the box. If drawing, have the students mark horizontal lines spaced one millimeter apart down one corner of their box. Label each line. The number 1 should be located at the top of the box.
4. Instruct the students to place a small amount of the local dirt on the bottom of the shoebox. Place the "Prehistoric" fossil remains on the top of the soil and cover the remains with the rest of the locally obtained dirt.
5. Spray water over this layer until it becomes sticky and adheres to the "fossils".
6. Begin the next layer by placing a small amount of topsoil over the previous layer. Place the "Ancient" artifacts on the topsoil and cover these artifact pieces with the rest of the topsoil. Spray lightly with water to compact the soil.
7. Spread a small layer of sand on top of the topsoil. Place "Modern" artifacts in the shoebox and cover with additional sand. Spray lightly with water to compact the sand.
   NOTE: Each layer should be approximately 2-inches deep.
8. Place two pieces of colored string or tape across the top layer of the sand to produce a grid that divides the shoebox into fourths.
9. **NOTE:** Choose articles for each layer which will "tell a story". For example, the bottom, or "Prehistoric", layer should consist of shells (sea environment) or bones (landmass). The middle layer of "Ancient" artifacts could consist of items found in a rockshelter, a hunting area, or a cave. The rockshelter artifacts may include cooking items, charred wood or stone, scrapping stone, bone fragments, or pottery fragments. In a hunting area there might be arrowheads, bones, sharp stones, or rock tools. In a cave environment there could be twine fragments, cane reed fragments, and pieces of gourds. Students might also use sunflower seeds, hickory nut shells, or mussel shells. The top layer of "modern" artifacts could represent a movie theatre area and include ticket stubs, and wrappers of fast food, gum, or candy. A playground area might include small toys, Popsicle sticks, and a penny. What could they use for a classroom, bedroom, or summer camp area? Encourage each group to be creative in developing their time capsule activities.

NOTE: The assembled boxes will be exchanged so that each group will have a different box to excavate than the one they assembled.

Questions to be answered:

1. Which is the oldest layer? How did you arrive at that answer?
2. What are the principles demonstrated in this model?



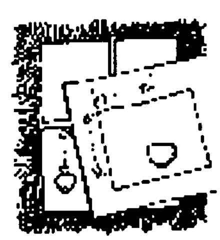
SHOEBOX MIDDEN DIG - ACTIVITY TWO

PROCEDURE

THE MIDDEN DIG:

1. Have the class get back into groups of three. Each group should be given three sheets of graph paper, 3 copies of the Curator Worksheet, a pencil, three paper plates, one styrofoam tray, a plastic spoon, and a small paintbrush. Have the groups exchange midden boxes.
2. Explain that each group is made up of three professionals: An excavator, a mapper, and a curator. Explain the duties of each. The excavator will patiently uncover any artifacts found only in the top layer of soil. Once the top layer of soil is removed and all artifacts have been mapped and curated, the students should exchange professions prior to excavating the second layer. Once the second layer has been excavated, the students exchange jobs a third time. In this way each student has an opportunity to experience each profession.

Excavator – in charge of uncovering the remains. The plastic spoon is to be used to carefully remove dirt from the site. Once an artifact is noticed, the excavator should use the paintbrush to remove the surrounding sand or dirt. The excavator must be extremely careful not to damage, tear, break, or mar the discovered artifact. The excavator continues working until the item is completely exposed. Each layer of excavated sand or dirt is to be placed on a separate paper plate. Once a large artifact is uncovered, the surrounding dirt or soil is usually sifted to find smaller artifacts or fossil remains which will present a more complete picture of the site. (NOTE: Students can be instructed to sift their dirt piles if you have fine mesh wire frames available. Charcoal fragments, charred wood, or small seeds should be saved.)



Mapper – in charge of mapping the excavation site and noting the exact location of each item uncovered. Two maps will be made. The first map will be a top view of the excavation site and will show the exact location of each artifact as it is uncovered. This map will use the surface grid for guidance. The second map will be a stratigraphic cross-section and will show the elevation (depth) of each artifact. The second map will use the millimeter ruler on the side of the shoebox for guidance. The two maps may be drawn on the same sheet of paper. The top view should be shown on the top half of the paper. The cross-sectional (side) view should be shown on the bottom half of the paper.

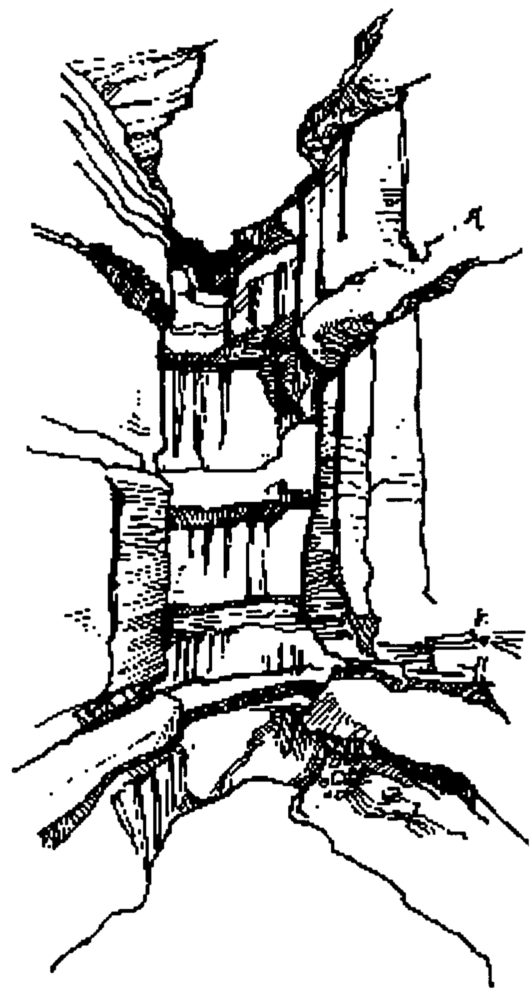
Curator – removes the artifact from the excavation site, cleans the specimen with the paintbrush, and displays it on a styrofoam tray. Each artifact should be recorded on the Curator Work Sheet. The work sheet will have a space for description, measurement, grid number and a drawing of the fossils your group finds.

3. Each group will excavate, map and curate as detailed, exchanging occupations each time the sediment layer changes.
4. Each group will develop a site report. This report should describe the different levels excavated and draw some conclusions concerning the environment of each. For each level, the report should describe, explain, and draw conclusions from the assembled facts. Each report should include: 1) the types and descriptions of remains; 2) the activities that occurred at this site; 3) a list of inferences that can be drawn from the artifacts collected at each level; and 4) predict what future historians will be able to tell us about the modern era based upon the artifacts discovered in the top layer.
5. Have the students respond to the following questions either orally or within their report:

- In which of the three rounds is the excavator called an archaeologist?
- In which of the three rounds is the excavator called a paleontologist?
- In which of the three rounds would you call the excavator a historian?
- What is the difference between an archaeologist and a paleontologist?
- Which occupation appealed to you the most? The least? Why?
- Would you have the patience to be an archaeologist or paleontologist?

EXTENSION

1. At scientific conventions, written reports are always available for further study. Have each group write up a site report describing their excavations and conclusions. Produce a book of convention proceedings by placing the written reports and site drawings in a loose-leaf binder. Make the "Proceedings" available for the class to review.
2. Conduct a "Paleo-Research Convention." At this convention, each group orally presents their site report before the class. Encourage questions. Have the presenters defend their techniques and conclusions. Require explanations of conditions and events surrounding the deposition of their specimens. Questions can be written out ahead of time.
3. Visit an archaeological or paleontological site. Possibilities include Wickliffe Mounds (Wickliffe, KY), Falls of the Ohio (Clarksville, IN), or Crystal Onyx Cave (Cave City, KY).
4. Obtain information on sites that contain artifacts or fossil remains by writing for brochures, by reading newspaper articles and books obtained from your local library, or by conducting research on the Internet.
5. Attend an archaeology weekend at Mammoth Cave National Park or other site. Archaeology Weekend is held at Mammoth Cave National Park during the middle of October of each year. This is an excellent chance to listen to archaeologists and/or a paleontologists as they present information about their most recent work at the national park. This is also a chance to watch archaeologists demonstrate crafts and skills of prehistoric people from the Mammoth Cave region.
6. Caves are a wonderful refuge for prehistoric and historic artifacts. The constant temperature and humidity levels work in conjunction with nitrates in the cave soil to preserve materials left behind by previous visitors. Some of this material may be very old. Plan a field trip to a cave. Notice the rock and sediment layering. Look closely at the rock layers for evidence of fossil remains. Ask about remains from people. How old are the artifacts found in this cave? Would you consider these artifacts to be "treasures" or "trash"? How would these artifacts be viewed by an archaeologist 1,000 years from now? Should these materials be preserved or cleared out of the cave? Why?



SHOEBOX MIDDEN DIG – MAPPING GRID

SHOEBOX MIDDEN DIG – CURATOR WORKSHEET

Descrip-
tion:______________________________

Measurements:___________________________

Grid #:________________________________

Drawing of fossil:

Description:______________________________

Measurements:___________________________

Grid #:________________________________

Drawing of fossil:

Descrip-
tion:______________________________

Measurements:___________________________

Grid #:________________________________

Drawing of fossil:

Description:______________________________

Measurements:___________________________

Grid #:________________________________

Drawing of fossil:

- Do you think all of the fossils you found are from one animal or location?

  Why or why not?

- What do these remains have in common?

- Do these remains present clues to the environment of this area?

- HYPOTHESIS: Name of animal or how site was used:

FOSSIL SEARCH

GRADE LEVEL: 4 - 9

TIME REQUIRED: Two class periods

SETTING: Outdoors

GOAL: Use math skills to follow an orienteering course to locate a fossil and to analyze the object located.

OUTCOMES: At the end of this lesson the student will:

- demonstrate the correct use of a compass,
- demonstrate the ability to determine the length of his or her stride,
- use a compass to locate a specific location,
- apply observation skills to analyze an object, and
- make inferences about a specific object: what it might have been, where it might have lived, and the environment in which it survived.

KERA GOALS: Meets KERA goals 1.2, 1.3, 1.4, 1.6, 1.7, 1.8, 1.9, 1.11, 2.1, 2.9, 2.10, 3.4, 3.7, 4.1, 4.2, 4.4, 4.6, 5.1, 5.4, 6.1, 6.2, 6.3

BACKGROUND INFORMATION

As one proceeds on a fossil hunting expedition, one needs to know how to meet the challenge of traveling into unknown territories. The ability to follow little known trails, to read maps, to move cross-country and to return safely is critical to success. The use of a compass and the ability to calculate pacing are instrumental in transferring map information to a specific location within the landscape.

Pacing is a simple method of measuring linear distance by walking. A pace equals two normal steps, beginning and ending on the dominant foot. It is measured from the heel of the foot to the heel of the same foot in the next stride. Pacing can be used anywhere: indoors, outdoors, in the woods, or in open fields. The use of pacing as a measurement dates back to Roman times. The original Roman pace was 58.1 inches long. This has become known as the geometric pace, which measures about 5 feet. Today pacing is commonly used in forestry to pace off 66 feet from a tree in order to determine tree height.

A **compass** tells you the direction you are headed relative to magnetic north. In order to use a compass successfully you must first find magnetic north. The red needle on the compass (the one that moves) always points to magnetic north. Next, you need to know where you are in relation to where you want to be and set your bearings for where you want to go next. The circular part of the compass is measured in 360 degrees. By following these degree markings, you should be able to find your next location.

You can combine the use of a compass and pacing to find your way in an area where there may not be any paths or roads. Using a compass and pacing with a topographic map that shows mountains, streams and other landmarks is called **orienteering**.

FOSSIL SEARCH

MATERIALS NEEDED

- One compass for each group of students
- 100 foot tape measure
- Pencils and paper
- One copy of "Fossil Search Clue List" for each team
- One set of "Fossil Search Clue Cards"
- Antique treasure or artifact to be analyzed, to be determined by the teacher

PROCEDURE

1. Set up the orienteering course:
- Prior to the first class session, copy one set of "Fossil Search Clue Cards" and one "Fossil Search Clue List" for each team.
- Copy and place the appropriate "Fossil Search Clue Card" at the correct location along the course. As an alternative, place markers at the appropriate locations. These cards or markers will tell the students they have arrived at the correct spot.
- Place the treasure to be found at the end of the trail.

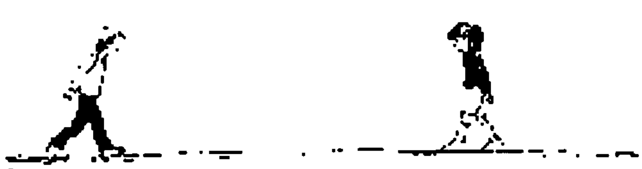
2. Determine student's average stride:
- Mark off a straight line that is one hundred feet long.
- Each student will walk along this line at his or her normal stride. While walking, each student should count the number of paces they take to cover the distance. Remember that a pace equals two normal steps, beginning and ending on the dominant foot. Repeat two more times.
- The students will calculate the total number of paces walked during their three tries and divide this total by three. This will give the average number of paces per hundred feet.
- Divide the 100 feet by the average number of paces. This will determine the length of the stride.
- For example: A student walks the hundred-foot distance in 47 paces one try, 52 paces the second time, and 51 paces the third time. The total number of paces walked is 150 paces. Divide by 3 for an average of 50 paces. Divide one hundred feet by 50 paces and you have an average stride of 2-feet. The students will need to know the length of their stride in calculating the distances and problems.

3. Review the use of a compass:
- Hold the compass steady at chest level so you can look down and read it easily. The compass housing should be held level - parallel to the ground, and the housing should be turned so that north is pointing away from you.
- Slowly turn your body so that the North (red) compass needle rests over or points to the North marking of the compass face.
- Sight across the compass to locate the direction of travel.
- Follow the direction of travel for the calculated number of paces.

4. Divide the students into groups, three students to a group:
- One student will read the clues and perform the necessary math
- One student will use the compass to determine the direction of travel
- One student will walk the required paces in the correct direction

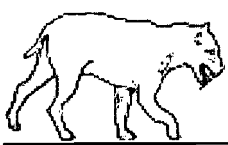
5. Students will calculate the distances and begin walking the course:
- After walking the required number of paces in the correct direction, the walking student will stand in the destination spot while the student holding the compass takes a second reading to make certain that the direction is correct. If an error is found, the walking student should return to the starting spot and repeat the pacing for that clue prior to advancing to the next clue.
- The group will read the second clue and follow the same procedure to the second site.
- When the students reach the mystery item, they will return to the beginning area to analyze their find.

6. Analyze the treasure: Using the techniques of observation and inferences the students should attempt to provide the following:
- An accurate description of the article
- Exactly where it was found
- What might it have been
- How it might have been used
- What was the time frame of its existence
- Describe the environment in which it existed



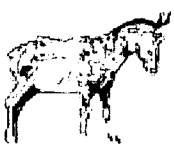
This activity adapted from Florissant Fossil Beds National Monument, *"Ancient Treasure Hunt"*, found in Teaching Paleontology in the National Parks and Monuments: A Curriculum Guide for Teachers of the Fourth, Fifth and Sixth Grade Levels

FOSSIL SEARCH – CLUE LIST



The Sabertooth Cat was a fierce predator whose remains were found in John Day Fossil Beds National Monument in Oregon. These animals had canine teeth nearly 6 inches long. ***Go 240 degrees for 240 fangs.***

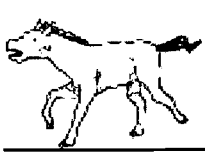
The bones of the Giant Sloth *(Megalonyx jeffersoni)* were discovered in Short Cave, which is located within Mammoth Cave National Park. The Giant Sloth stood 19 feet tall. ***Go 110 degrees for 3.8 lengths of the Giant Sloth.***



At Hagerman Fossil Beds National Monument in Idaho are found the fossil remains of a Pronghorn Antelope that lived nearly 3.4 million years ago. Modern pronghorns are the fastest land animal in North America and can run 60 miles an hour, or one mile per minute. ***Using the scale 1 foot=1 mile, go 200 degrees for the distance the Pronghorn would travel in 2.5 hours.***

The fossil bark of the Lepidodendron has been found in sandstone at Mammoth Cave National Park. This club moss reached a height of 105 feet. ***Go 360 degrees for two Lepidodendron heights.***

The fossil of a fish, a gar, that is five feet long was discovered at Fossil Butte National Monument in Wyoming. ***Go 260 degrees for 6 gar lengths.***



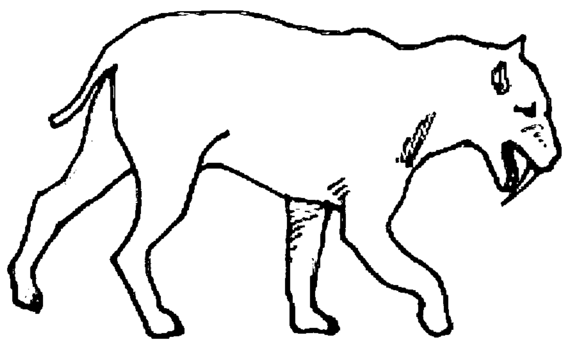
Fossil remains of a *Mesohippus* are found at Badlands National Park in South Dakota. *Mesohippus* was an ancestral horse. It had three toes instead of one (hoof). ***Go 10 degrees for a number of feet equal to the total number of toes found on 23* Mesohippus *feet.***

Phytosaurs were crocodile-like reptiles that lived 220 million years ago in what is now the Petrified Forest National Park in Arizona. The average length of a Phytosaur was 15 feet. ***Go 320 degrees for 5 Phytosaur lengths.***

In Dinosaur National Monument in Colorado are found the fossil remains of *Apatosaurus*. It got its name, which means "deceptive lizard," because of its unbelievable size. Adults were 75 feet long from nose to tail. ***Go 160 degrees for two* Apatosaurus *lengths.***

At Mammoth Cave National Park, a 38,000-year-old *Tadarida brasiliensis* was found. A *Tadarida brasiliensis* is a free-tailed bat. Its wingspan measured 12 inches. ***Go 100 degrees for 81 wingspans.***

FOSSIL SEARCH – CLUE NO. 1



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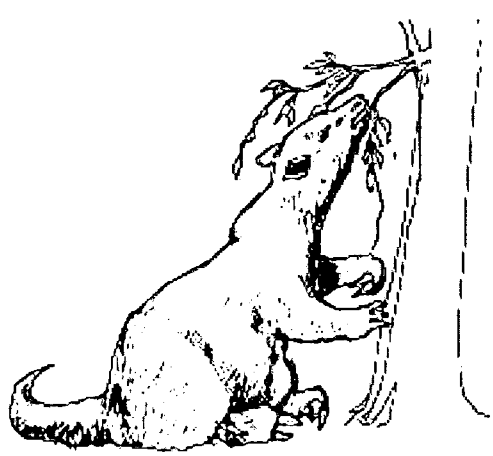

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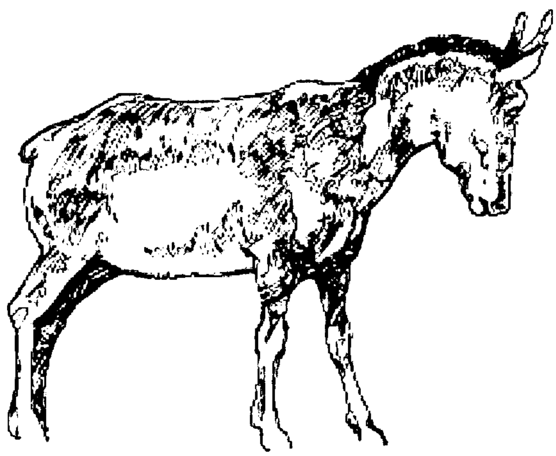
FOSSIL SEARCH – CLUE NO. 3



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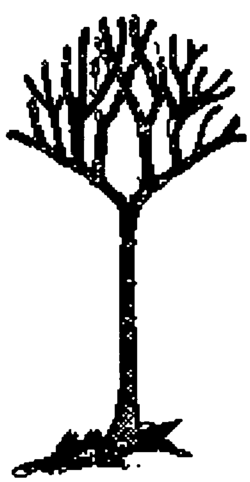
FOSSIL SEARCH – CLUE NO. 4



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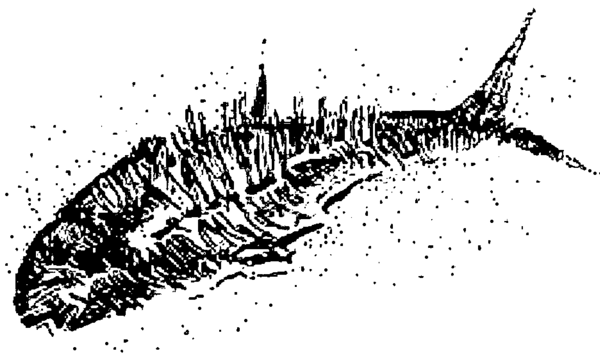

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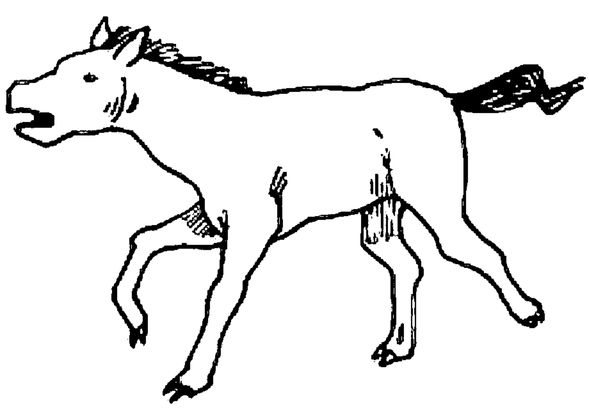

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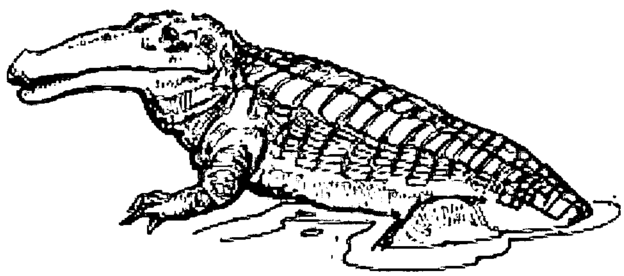
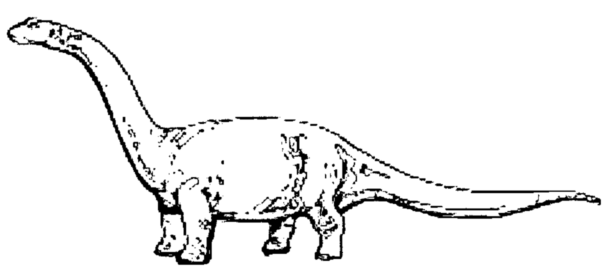
FOSSIL SEARCH – CLUE NO. 7



Phytosaurs were crocodile-like reptiles that lived 220 million years ago in what is now the Petrified Forest National Park in Arizona. The average length of a Phytosaur was 15 feet. ***Go 320 degrees for 5 phytosaur lengths.***

FOSSIL SEARCH – CLUE NO. 8



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FOSSIL SEARCH – CLUE NO. 9

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EXPLORING THE PAST

A FIELD TRIP INTO MAMMOTH CAVE

GRADE LEVEL: 6 – 12

TIME REQUIRED: Depends upon the methodology selected

SETTING: Mammoth Cave, Mammoth Cave National Park

GOAL: A field trip into the Mammoth Cave system or a computer simulated field trip into the cave to locate, photograph and identify marine and vertebrate fossils

OBJECTIVES: At the end of the lesson the student will:

- Develop an appreciation of fossils as a non-renewable resource
- Articulate the value of preserving fossils
- Locate and photograph a fossil for identification
- Document where the fossil was found
- Theorize an ancient environment for the fossil
- Identify the fossil

KERA GOALS: Meets KERA Goals 1.1, 1.2, 1.3, 1.4, 1.7, 1.10, 1.11, 1.13, 1.16, 2.1, 2.3, 2.4, 2.6, 2.9, 2.11, 2.13, 2.23, 3.4, 3.6, 3.7, 4.2, 4.3, 4.6, 5.1, 5.2, 5.3, 5.4, 5.5, 6.1, 6.2, 6.3

This lesson is a summation activity based upon knowledge acquired through previous lessons and learning situations. ***Students need to have*** *an understanding of the basic concepts of paleontology and an understanding of the geology of the Mammoth Cave region in order to successfully complete this activity. Specifically, they will need to understand the concepts of deposition, fossilization, and erosion prior to their field trip. Students need to be able to identify the primary rocks found in the Mammoth Cave area and be familiar with the types of fossils found in South-central Kentucky.*

A FIELD TRIP INTO MAMMOTH CAVE

BACKGROUND INFORMATION

Fossils provide valuable information about ancient environments. They are a vital link to our past. A fossil is a non-renewable resource. These resources are fragile and threatened by both natural forces and the impact of humans. As fossils are collected and/or destroyed, a part of the earth's history is lost. A collector needs to be responsible in the search for and the collection of fossils. In order not to destroy important information, fossils should not be disturbed without the assistance of an expert in the field of paleontology. Careful documentation is vital to provide the necessary clues to understanding the time in which the fossil might have lived. Documentation includes where the fossil was found, the type of rock in which it was found, and how the surrounding area looked. The surrounding rock is often the best clue as to when the fossil lived. Vertebrate fossils need to be left in situ (in their original location) until they have been evaluated and photographed. It is important to know how the bones lay in relation to one another and in relation to the environment.

The rocks of the Mammoth Cave area are sedimentary rocks. A broad shallow sea covered this part of North America with rivers entering from the northern land area. The rivers picked up fragments of weathered rock and deposited them in areas where the rivers emptied into the sea. These areas are called deltas. Soluble rocks, such as limestone, were dissolved by water and carried in solution. When the concentration of the dissolved materials was great enough, it precipitated as sediment on the sea floor, forming new layers of sedimentary rock. Plants and animals used some of this calcite to form hard body parts. When these organisms died, these parts accumulated as sediment that solidified into sedimentary rock.

Today, shells and other preserved hard parts of ancient plants and animals can be found in the rock. These preserved hard parts (fossils) tend to resist weathering and often extrude from cave walls.

Vertebrate remains are often found within caves. Most bone remains are found near an entrance. The entrance may be one that is used today, or it could be an old entrance that was destroyed long ago by the earth's movement.

During times of flooding bones might be washed into the cave, or floods may trap animals such as hibernating bats. Flooding or a change in surface drainage patterns may also redeposit bones far from their original deposition site.

An animal may wander into a cave, become lost, and die far from a cave entrance. Vertical shafts leading into cave passages may act as pitfalls for unsuspecting animals.

Species that are found in cave deposits may now be extinct, still living in the area, or extralimital (no longer living in the local area). Bones, tracks, trails, nests, scratch marks, and burrows may also be found in the cave environment.

A FIELD TRIP INTO MAMMOTH CAVE

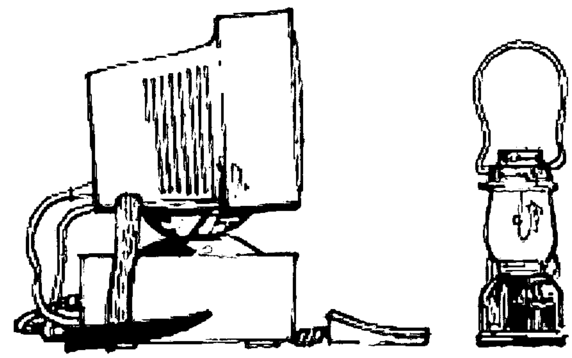
PROCEDURE
Schedule a field trip to Mammoth Cave. You may schedule a trip to the resource or you may elect to have a member of the Environmental Education staff come to your classroom to share fossil replicas. In either case, plan ahead. You will need to make arrangements several months before your trip.

OPTION ONE –
A TRIP TO THE CAVE
A trip to Mammoth Cave National Park requires that students come with some basic background knowledge. Students need to understand the concepts of deposition, fossilization, erosion, and the process of extrusion prior to their field trip. Students need to be able to identify the primary rocks found in the Mammoth Cave area. Students need to be familiar with the types of fossils found in South-central Kentucky.

During their visit, students will experience fossil hunting within the cave environment. Students will use photography to document their fossil find. Each student will keep detailed notes about the depositional environment, identify the type of rock in which the fossil is located, and theorize how the fossil was deposited in its present site. Students will either identify the fossil in situ or they will take photographs to aid in later research. The photographs will become part of the student's written report.

OPTION TWO –
A RANGER VISITS YOUR CLASSROOM
An instructor from the park will bring fossil replicas to your classroom. Each student needs to have some prior understanding of the basic concepts of geology and paleontology to have a meaningful experience. The computerized walk through the cave will not only include a three-dimensional view of the cave, but it will also allow the student to view each fossil from several angles. All students will make the same observations as were expected in the walk through the cave.

To schedule either method of presentation, you should call the Office of Environmental Education at Mammoth Cave National Park. Please follow the directions for scheduling located in the front of this guide.



EXTENSION
1. The student could research and write a paper on the ethics of fossil hunting.
2. The student could research the fossil he or she photographed or identified either in the cave or on the computer screen. This research should include information of the geologic era and the environment in which the fossil lived.
3. The student could present findings about his or her fossil orally at a classroom "science conference". At this time students may present background information on the geologic era and prehistoric environment along with the type or species of fossil found, details of the species life cycle, food preferences, predators, life expectancy, and other details uncovered through research and/or observation. These presentations could be enhanced by the use of visual aids.

GLOSSARY

Adaptations – Characteristics that give an organism a better chance of survival.

Archaeologist – A scientist who studies remains of past cultures, both prehistoric and historic.

Archaeology – Study of past cultures through material remains.

Articulated – Joints still connected.

Artifact – An object made and used by humans.

Biped – Any two-footed animal.

Bivalves – An animal (such as a clam) that has a two-valved shell where both valves are the same size and shape. Also called Pelecypods.

Blastoids – A Mississippian fossil consisting of a ½- to 1-inch cuplike body that was attached at the base to a short stem. Each of these bodies were five-sided and had arms radiating from it. Usually only the fossilized bodies are seen today.

Brachiopods – (Lampshells) These sea creatures have two shells (called valves). One valve is usually larger than the other. The top of one valve will curl over the top of the second. This gives them an "oil lamp" shape. Some shells are smooth while others have ridges and grooves that radiate out from the middle of the hinge. Brachiopods are common in rocks of Cambrian to Carboniferous age.

Bryozoans – Aquatic, colonial animals with branching, mossy or fan-like growth. They resemble corals but have more complex nervous, muscular and digestive systems.

Calamites – A Mississippian to Permian fossil plant. A scouring rush that grew to be 40-feet high, it had a ribbed, jointed trunk with leaf whorls at the joints.

Calcium carbonate – A compound, $CaCO3$, found in plant ashes, bones, shells, limestone, chalk, and marble.

Carbon – An element. Atoms of carbon are the building blocks of living cells.

Carbonization – A process of forming fossils in which the weight of the sediments squeezes out the water and gas and leaves a residue of carbon (imprint).

Carnivore – A flesh eating or predatory animal or plant.

Cast – A replica of an organism created when minerals use the organism as a mold to create the replica. For example, a shell fills with minerals, the shell dissolves away and the cast (inside of the shell) is left behind.

Cenozoic – The "Age of Mammals". This geologic era is the most recent.

Climate – The history of rain, snow, and temperature for an area. The average weather.

Compass – A device for determining directions. It uses a magnetic needle that points to magnetic north.

Competition – Two or more organisms attempting to occupy or use the same niche or resource in an environment at the same time.

Coral – A small, soft-bodied animal that secretes a hard exterior skeleton. Corals can be found individually (solitary) or in huge colonies that form coral reefs. Corals thrive in warm, shallow seas. One species of coral looks like the horn of a cow. Another species looks like a human brain. Their common names are derived from these images.

Continental Drift – The theory that continents have moved in relation to one another.

Core sample – Cylindrical core retrieved from a hollow steel pipe that is drilled into rock or sediment and brought to the surface for study.

Corprolite – Fossilized dung.

Crinoids – (sea lilies) Flower-like echinoderms. They have a stalk made of calcite disks stacked on top of each other. The disks can be circular or star-shaped. The tops contained a circle of colorful arms that resembled the head of a flower. Fossil remains are found in limestone from Ordovician to Recent times. Whole fossils are rare.

GLOSSARY

Cycads – A fossil plant from Permian to Recent times. Cycads had short, squat trunks with a crown of large, palm-like leaves

Datum – Something used as the basis for reasoning, inference, calculating, or measuring. A reference point or origin for mapping.

Echinoderms – (crinoids, blastoids, starfishes, sea lilies, and sea urchins) Sea animals covered with calcite plates or spines. They could be free-swimming or found attached to the sea bottom. They usually have a five-fold radial symmetry.

Ecology – The study of organisms and their interactions with their environment.

Ecosystem – A system made up of a community of animals, plants, and bacteria and their interrelated physical and chemical environment.

Element – A substance made up of only one kind of atom.

Era – An interval of geologic time shorter than an eon. An era includes two or more periods. There are four major eras: Precambrian, Paleozoic, Mesozoic, and Cenozoic.

Erosion – The gradual wearing away and transportation of materials, usually by water, wind, or ice.

Eon – The largest formal unit of geologic time. There are three eons: the Archean, Proterozoic, and Phanerozoic.

Epoch – A division of geologic time less than a period and greater than an age.

Extinct – When all members of a species have died out.

Extralimital – No longer living in the local area.

Extrusion – Something (rock, fossil, etc.) that is forced, pressed, or pushed out.

Faulting – A fracture in the earth's crust (fault) that causes the land on one side of the fault to be raised above the land on the other side.

Fauna – The animals of a specified region or time.

Flora – The plants of a specified region or time.

Food Chain – a sequence of organisms in a community where each member of the chain feeds on the member below it. The chain moves from plants that make their own food to herbivores to carnivores.

Food Web – How plants, predators and prey interact. The interaction of all food chains found in an ecological community.

Fossil – A remnant, impression, or trace of an animal or plant from a former geologic time that has been preserved in the earth's crust.

Fossilization – The process of becoming a fossil.

Gastropod – (snails) Most gastropods have coiled shells, either flat (like a wheel) or spiral (like a garden snail).

Giant Ground Sloth – With a body the size of a cow, they pulled leaves and twigs to their mouths with their long-clawed hands and long tongues. Found from the Pliocene to Pleistocene epoch.

Geologic Column – A column representing the eras and periods of time with their major events and changing life forms.

Geologic time – The total time involved since formation of the earth to the present time.

Geologist – A scientist who studies rocks, including how and when they were formed, the minerals they contain, and how they have changed through time.

Geology – The science dealing with the physical nature and history of the earth.

Graptolites – Tiny sea creatures that lived in little cups joined together into strings. They are usually found in shales and slates of Cambrian to Carboniferous age.

Habitat – The place or type of site where a plant or animal naturally or normally lives and grows.

Herbivore – An animal that only eats plants.

Index Fossils – An indicator of a particular time in the Earth's history.

Inference – Assumption based on an observation.

In situ – In it's original position or place.

Lepidodendron – A Pennsylvanian fossil club moss. It was tall (100-feet high), branching, with slender leaves and had distinctive diamond shaped leaf scars along the trunk.

Limestone – A sedimentary rock made of layers of carbonated sediments (sea life) that thrived in a warm shallow sea. Fossils are often found in this type of rock.

Lycopods – Scale trees. Vascular plants found from the Devonian to Recent periods. The had simple leaves in spirals. The stem was not jointed. Fossils are common in coal-bearing strata.

Mammoth – An extinct elephant having a sloping back and plated teeth that resembled a washboard. Mammoths were grazers and fed on grasses, sedges, and shrubs.

Mastodon – An extinct elephant having a straight back. They were slightly smaller than the Mammoth. Their teeth exhibit a pattern of cone-shaped cusps ideal for browsing. They ate leaves and branches gathered with their trunk from their forest habitat.

Megafauna – Animals weighing more than 100 pounds when alive. The Mammoth, Mastodon, Giant sloth, and Short-faced cave bear would have been megafauna.

Mesozoic – This geologic era represents the time of "Middle" life. The Mesozoic Era lasted from 245 to 66 million years ago.

Microfauna - Animals weighing less than 100 pounds.

Midden – A refuse heap.

Migrate – To move from one region, climate or environment to another.

Mineral – A substance found in the earth that always has the same properties. These properties include color, hardness, shininess, and the way the mineral breaks or splits.

Mississippian Period – 345 to 310 million years ago when Kentucky was covered by a warm, shallow sea in which corals, brachiopods, crinoids, blastoids, bryozoans, and foraminifera (a protozoan) flourished. The sedimentary rocks and most fossil remains of the Mammoth Cave region are from this time period.

Mold – A cavity in which a substance is shaped. A fossil used to create a replica, or cast.

Natural Selection – Survival of the fittest.

Observation – Seeing and recording a fact.

Omnivore – An organism that eats both plants and animals.

Orienteering – Using a map and compass to navigate your way between checkpoints along an unfamiliar course.

Overthrust – Caused when pressure pushes rock strata up until one side folds over onto the second side. This will cause younger rock layers to be located under older layers.

Paleoenvironment – An ancient environment reconstructed by studying fossils and the rocks in which they were preserved.

Paleontologist – A scientist who studies fossil remains to learn about life of the ancient past.

Paleontology – The scientific study of prehistoric plants and animals in their geologic context.

Paleozoic – A geologic era that is marked by the culmination of all classes of invertebrates except insects and the appearance of seed-bearing plants, amphibians and reptiles. The Paleozoic era is divided into seven periods designated by inundations of seas. The Mississippian and Pennsylvanian periods of Kentucky occurred during the Paleozoic era.

Pangaea – A hypothetical "super" continent. It is believed that Pangaea broke apart about 200 million years ago, during the Mesozoic Era, to form the present day continents.

Pelecypods – Also called Bivalves. A common fossil in marine rock. Pelecypods have shells with two valves that are the same size and shape. The shells often show growth lines, and radiating ridges and grooves, useful for identification. Oysters, mussels, and clams are living types.

Pennsylvanian Period – 310 to 280 million years ago. This was the development of deltas, lowlands, and great swamps. Great trees that formed the coal forests were prominent. Most common were the scale trees (lycopods), seed ferns, horsetails, and cordaites. The coal regions of eastern and western Kentucky developed during this period.

Period – A division of geologic time longer than an epoch and included in an era. A period is usually set off by a significant or striking quality, change or series of events.

Petrification – A process that replaces living materials (wood or bone) with mineral matter. Organic matter is thus turned to stone.

Petrify – To convert into stone or a stony substance.

Precambrian Era – The oldest and longest of the eras. It began when Earth was first formed 4.6 billion years ago. Few fossils of this era have been found.

Predation – The behavior of capturing and feeding on another organism.

Predator – An organism that captures and feeds on other organisms.

Prehistoric – The time before recorded history.

Prey – An organism that is hunted and eaten by another organism.

Principle of Horizontality – States that sediments are placed in horizontal layers.

Principle of Superposition – Principle which describes the layering of rocks. It states the oldest rock is on the bottom and the youngest is on the top.

Quadruped – An animal with four feet.

Radioactive Dating – A dating method that measures the amount of radioactive decay that has taken place in the rocks being studied.

Relative Dating – A method of dating rock layers by their relationships or proximity to each other. Both archaeologists and paleontologists use relative dating.

Relative Time Scale – Placing rocks and events in the chronological order in which they occurred.

Replica – A duplicate, close copy or reproduction.

Sandstone – A sedimentary rock made of layers of compressed and cemented sand grains.

Sediment – The material that settles to the bottom of a liquid. It is transported and deposited by water, wind or glaciers.

Sedimentary Rocks – A type of rock formed of mechanical, chemical, or organic sediments transported from their source and deposited as sediment in layers on lake or river bottoms, river sandbars, beaches, and oceans. The sediments can be formed of fragments, formed by precipitation or solution, or formed from inorganic remains (shells or skeletons) of organisms.

Seed Ferns – An extinct plant that developed seeds on its leaves and grew to a height of nine feet. Flowering plants may have evolved from seed ferns. Most fern-like fossils are not true ferns, but seed ferns.

Shale – A sedimentary rock made of layers of clay, mud or silt.

Short-Faced Bear – A flesh-eater that lived 1,000,000 to 10,000 years ago. The most powerful land predator of its day, it combined size, strength, and speed with stout fangs and vise-like jaws to hunt large prey such as bison and giant ground sloths.

Sinkhole – A surface depression created by underground collapse.

Solution – A substance dissolved in another substance. Sugar dissolved in water is "in solution".

Species – The division of animal classification below Genus. A group of animals having common attributes, designated by a common name, that has the same structure, and that can breed together.

Strata – Layers of material. Often one of a number of parallel layers one upon another.

Stratigraphy – The study of layered rocks, their distribution, origin, fossil content, and relative age.

Stratification – The arrangement of rocks in distinct layers or strata, resulting from the action of water or wind. Common in sedimentary rocks.

String Grid – A square meter (approximately three square feet) frame divided into small ten-centimeter squares (less than four inches).

Succession – The things that follow each other in sequence. For an ecosystem, it is the unidirectional change created as competing organisms and (especially) the plants respond to and modify the environment. For example, an open field would have a development from weeds to grass to forest community, in that order.

Symbiosis – When two very different organisms live together and each receives what it needs to survive from the other. For example, Lichen is an algae and fungus together.

Tapir – A browser related to rhinoceroses and appearing at the same time. Abundant in North America during the Pleistocene epoch and still found in South America and Asia.

Topography – Description of the physical characteristics of an area that shows relative positions and elevation.

Trace – Fossil signs left behind such as footprints, nests, and burrows.

Trilobites – A large group of arthropods abundant in the Paleozoic seas. They had segmented exoskeletons divided into three lobes.

Uplifting – Caused when pressure pushes rock strata upwards until it breaks, leaving the rock layers exposed on their end. The rock strata are now laying vertically instead of horizontally.

Vertebrates – Animals with backbones such as fish, reptiles, and mammals.

Weathering – The disintegration and breakdown of rocks at or near the earth's surface.

Mechanical weathering – occurs when rocks are broken into smaller and smaller pieces. This can occur by the activity of plant roots breaking rocks apart; by freezing and thawing that produces wedges in rocks; by physical banging of hard materials; or by rubbing against the rock by sediments found in water or the air.

Chemical weathering – occurs as water carrying other chemical elements alters the rocks. An example is carbonic acid. Water combines with carbon dioxide to produce a weak acid (carbonic acid). The carbonic acid is carried to the point of contact by the water. When the carbonic acid comes in contact with limestone rock a chemical reaction is produced which dissolves the rock.

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