Teacher's Introduction

This unit is designed to build on concepts learned in the previous unit, "What Are Fossils?", and take those concepts a step further to discover what we learn from fossils and how we learn it. Through the activities in this section, students will learn about the concepts of observation, deduction and logic. They will gain an appreciation for how scientists use observed facts to make decisions about possible theories. By applying those skills to modern day ecosystems students will gain an understanding of the past and how scientific models are used to learn about the past.

Fossils are pieces of the past. Just like a puzzle, we have to put those pieces together in a logical manner to come up with a valid picture of the past. By observing present day systems and interactions in environments, and applying logic and deduction, we can make inferences about the past. Observation is seeing and noting facts. Inference is a proposed reason or assumption based on observation. Paleontologists use these two principles to put together a picture of what the past was like. By making observations of fossils they can make inferences about the animals or plants they represent. Also, by making observations of modern day plants and animals that are similar to the fossils, they can make inferences about the past. Of course, we have no way of knowing exactly what the past was like, but if we are methodical in our observations, we can catch a glimpse of what life was probably like. This glimpse can tell us much more than what lived when. Scientists, and students, can examine similar life forms today, if they exist, and look at the environment they live in and the interactions that occur to draw conclusions about ancient environment that existed. In this way, fossils can be indicators of the past climates and ecosystems and of climate change.

For example, at Florissant Fossil Beds National Monument, in Colorado, there are found the petrified remains of giant Sequoia trees. Today these types of trees grow on the western coast of the U.S., in a very moist, moderate climate which is nothing like the present-day climate of Colorado. So, we can draw one of two conclusions about the past: either the climate of ancient Colorado was very different, or, ancient redwoods were able to survive in a much different climate than the one in which they thrive today. Also, carbonized fossils of many different plants, like palms and ferns that today only grow in warm moist parts of the country, are found in the same general layers of rock. This added evidence helps us in drawing the conclusion that the climate used to be warmer and wetter there, for it would seem unlikely that so many different species would change so much in their physiology and environmental needs. This brings us to one of the major concepts of the unit, uniformitarianism.

The meaning of the concept of uniformitarianism is much simpler than the word itself. Simply put, it means that the present is the key to the past. The theory was formulated by the Scottish geologist, James Hutton. In the Theory of the Earth with Proof and Illustrations, published in 1785, he stated his belief that the present is the key to the past and that processes now at work could account for all the geologic features of the earth, if sufficient time had passed. Hutton based his theory on the simple observation that weathering slowly disintegrates rocks. The debris that forms, gravel, sand, and silt, is transported by wind and water, and most of it ends up near or below sea level. Over time these layers are compacted and cemented and eventually turn into sedimentary rocks. In his theory, what remain uniform are the physical and chemical laws that govern geologic events.

A more modern term for the process is “actualism”. This term is used by some geologists because a uniform cause does not guarantee uniform results. For instance, the rate of sediment accumulation on the ocean floor today is not necessarily the same as the rate was a million years ago. Some scientists feel that the term actualism is more accurate because it doesn’t imply that the rates are uniform through time, only that the processes and physical laws have remained the same. Whichever term is used, the important concept is that the present is the key to the past.

While Hutton was applying the principle to geology, it can also be applied, to some extent, to environmental biology and ecology, for the same laws of biochemistry, energy flow and population dynamics that affect living systems today were in effect in ancient ecosystems. However, because organisms, as well as ecosystems, evolve and change they are not as constant through time as physical processes. But, by studying a present day ecosystem, one can make some inferences about the past.

A second major concept for this unit is evolution and natural selection. It is important to remember that the theory of evolution doesn’t provide all the answers. We do not know how important chance is in evolution or if life evolves by sudden or gradual changes or both. Nor does it answer the most compelling question of all; How did life begin? While discussing this theory of evolution, many strong feelings may emerge from the students. It is very important that no one be made to feel that their beliefs are “wrong” and the concept of theory will have to be emphasized. While some teachers shy away from such a controversial topic, discussing the theory can be an opportunity for talking about such important topics as the freedom of speech and belief.

Since humans first existed on the planet they have probably wondered about the origin of the earth. Stories explaining this concept date from nearly 5,000 years ago. The early Greek philosophers were the first to suggest that the world originated through and was controlled by natural processes and two Greek philosophers/scientists, Anaximander and Empedocles, suggested evolution about 500 B.C. The concept was not widely accepted, perhaps because two of the more popular philosophers, Plato and Aristotle, believed in a perfect world which stayed the same all through time. Throughout much of history most people believed that the world had been recently created by God. In the 16th Century the works of the Greeks were discovered and people began to question some of the religious beliefs. In the 18th Century Hutton’s principle of uniformitarianism suggested the age of the earth was much greater than generally believed. In the 19th century Lamarck put forth the theory of evolution but it was not widely accepted. He believed that things had evolved gradually, from the simple to the most complex and that in each generation organisms could change their characteristics to cope with the environment. They could pass these changes on to their offspring.

In 1859, Charles Darwin published his theory of natural selection. Alfred Russell Wallace came up with the same theory. Like Lamarck, they believed in evolution from simple to complex organisms but also believed change was caused by natural selection. Darwin's theory was based on four assumptions: that most species produce far more offspring than could possibly survive, that individuals vary and some variations may help those individuals have a better chance of survival, that an individual's chances of survival will be affected by the environment in which it lives and, those individuals best suited to their environment are more likely to survive and pass on their characteristics. Darwin saw two main sources of evidence for his theory. One was by looking at domesticated plants and animals. People have deliberately changed their characteristics by breeding together specifically chosen animals or plants for desirable traits. This artificial selection shows how traits can changed over many generations. Also, in his travels over the globe, Darwin noticed that plants and animals that live in similar environments look similar and have similar adaptations that help them to survive in their environment. He saw this as evidence of natural selection.

Darwin did not understand the reasons why variation occurred in populations but early in the 20th century biologists discovered genetics. In the 1920's a new theory was worked out which brought together genetics and an updated version of the theory of natural selection.

Unit Goals and Objectives

Goal: Students will realize the importance/value of studying fossils.
Objectives:
Students will identify 2 things we can learn from fossils.
(Climate change and changing adaptations.)

Goal: Students will understand how we formulate models of the past.
Objectives: Through activities and discussion students will apply the concepts of natural selection to present and past ecosystems.
Students will comprehend, through activities and discussions, how models work in forming theories.
Students will differentiate between observation and inference
Students will use clues presented to them to compare and contrast ancient animals to their modern day counterparts, noting adaptive changes.

Concepts

Observation: Seeing an occurrence or recognizing a fact.
Theory: A proposed explanation for a situation based on observation D facts.
Inference: A conclusion derived from observations.
Uniformitarianism: The concept that the present is the key to the past. The concept was formulated by the English geologist Lyle in the 18th century. The theory didn't receive much attention until it was promoted by the Scottish geologist, Hutton.
Natural Selection: Survival of the fittest
Evolution: The long term change in organisms caused by the survival the fittest. It often takes place over millions of years.

Vocabulary

Organism: A plant or animal.
Food Chain: A chain of organisms through which food energy is passed.
Herbivore: An animal that eats only plants.
Carnivore: Usually an animal, sometimes a plant, that eats other animals.
Omnivore: An animal that eats both plants and other animals.
Producer: An organism that can produce it's own food. Plants produce food when they turn sunlight into food through photosynthesis
Consumer: An organism that feeds on other organisms.
Prey/Predator: Prey is an animal that is killed and eaten by another animal, the predator.
Natural Selection: The survival of the fittest.
Adaptation: Characteristic that gives an organism a better chance of survival. Through evolution these characteristics are enhanced in a species.
Extinction: When all members of a species have died out.

Sources For Further Information

The Young Scientist Book of Evolution, The Young Scientist Book of Evolution, Barbara Cork and Lynn Bressler, Usborne Books, EDC Publishing, Tulsa Oklahoma. ISBN 0-86020-867-2

The Children's Picture Prehistorv: Prehistoric Mammals; Our world after the dinosaurs, Anne McCord, 1977, Usborne Books, EDC Publishing, Tulsa, Oklahoma. ISBN 0-86020- 128-7

My Life with Dinosaurs; How two dinosaur experts bring prehistoric monsters to life. Stephen and Sylvia Czerkas
Hands-on dinosaur reconstruction kits. Hard pieces are encased in a clay matrix. Students "excavate" the fossils (tools included) then reconstruct and paint (brush and paint provided). The reconstructed animal is 9" by 12". The kits are available from Acorn Naturalists, 17300 E. 17th St. #J-236 Tustin, CA, 92680.

Dimensional Dinosaurs; Build three different dinosaurs with die cut white foam board pieces. Children add details, texture and color using felt pens or watercolors. Lesson plans and work sheets included. Kits packaged for 24, 30, 36, or 100 students. The cost varies with quantity ordered. Order from A Child's Art Factory, 7371 Player Dr. San Diego, CA 92119.

Classroom Activities

Classroom Activity 1 Keys to the Past

Objectives: Students will learn what an inference is and differentiate between inference and observation. They will examine a scene and a series of statements about the scene and then determine which statements are observations and which are inferences.

Background: Modern science is based on observation and inference. Observation is seeing and noting facts. Inference is a proposed reason or assumption based on observation. Paleontologists use these two principles to form theories, or put together a picture of what the past was like. By making observations of fossils they can make inferences about the animals or plants they represent. Also, by making observations of modern day plants and animals that are similar to the fossils, they can make inferences about the past.

Materials:
Handouts (3) for each student or team: Dinosaur scene
List of statements
Petrified Bones and Tracks page

Procedure: Discuss the difference between observation and inference then pass out the handouts.
Have the students work individually or in teams. They will determine whether each statement is an observation or an inference. Later, go over their answers as a group, discussing the logic used in making their choices.

Answers:

Dinosaur Page

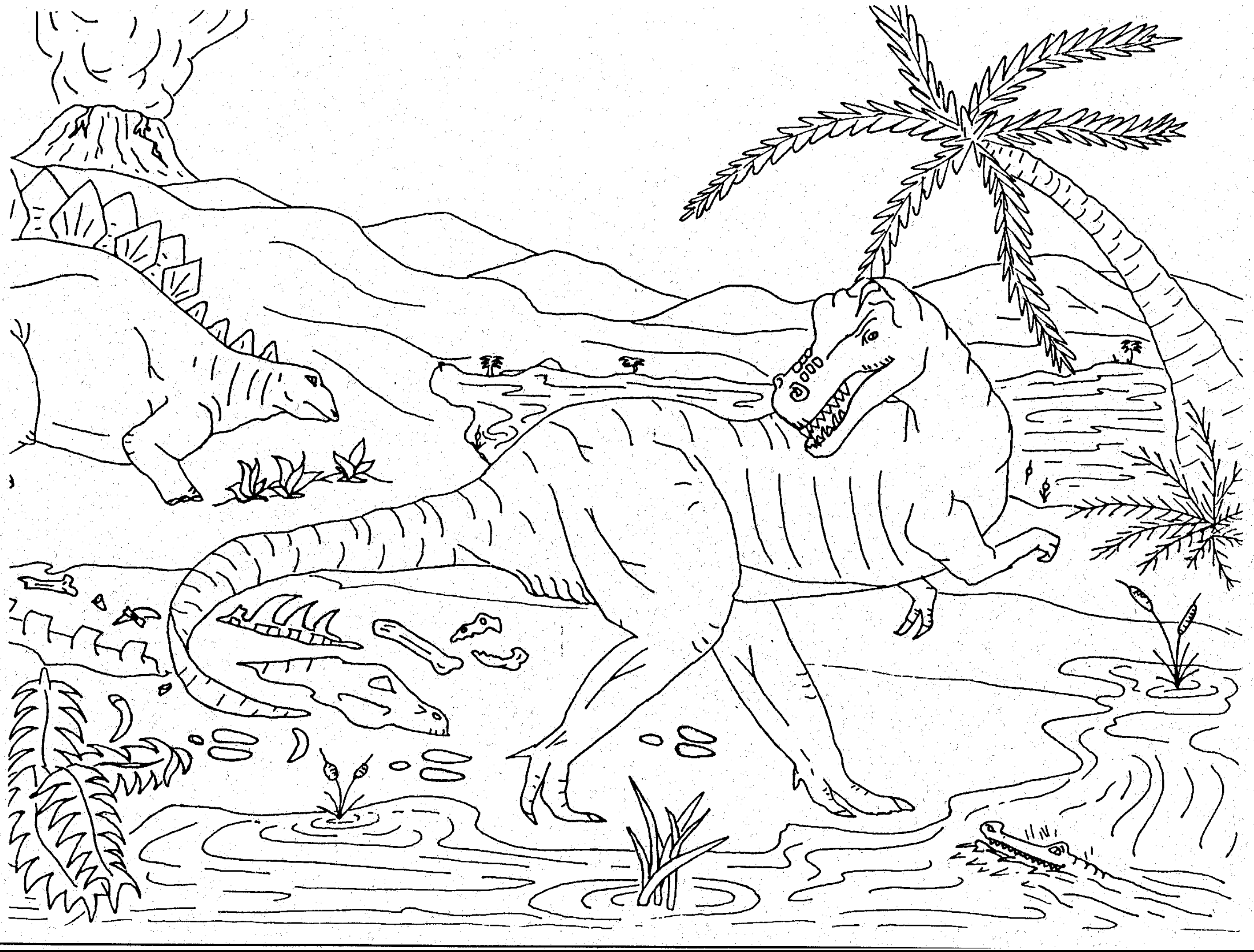
1. 0
2. 1
3. 1
4. 0
5. 1
6. 0
7. 1
8. 0
9. 0
10. 1
11. 0
12. 1
13. 0
14. 1
15. 0
16. 1
17. 0
18. 0

Tracks and Bones

1. 0
2. 1
3. 0
4. 1
5. 0
6. 0
7. 1

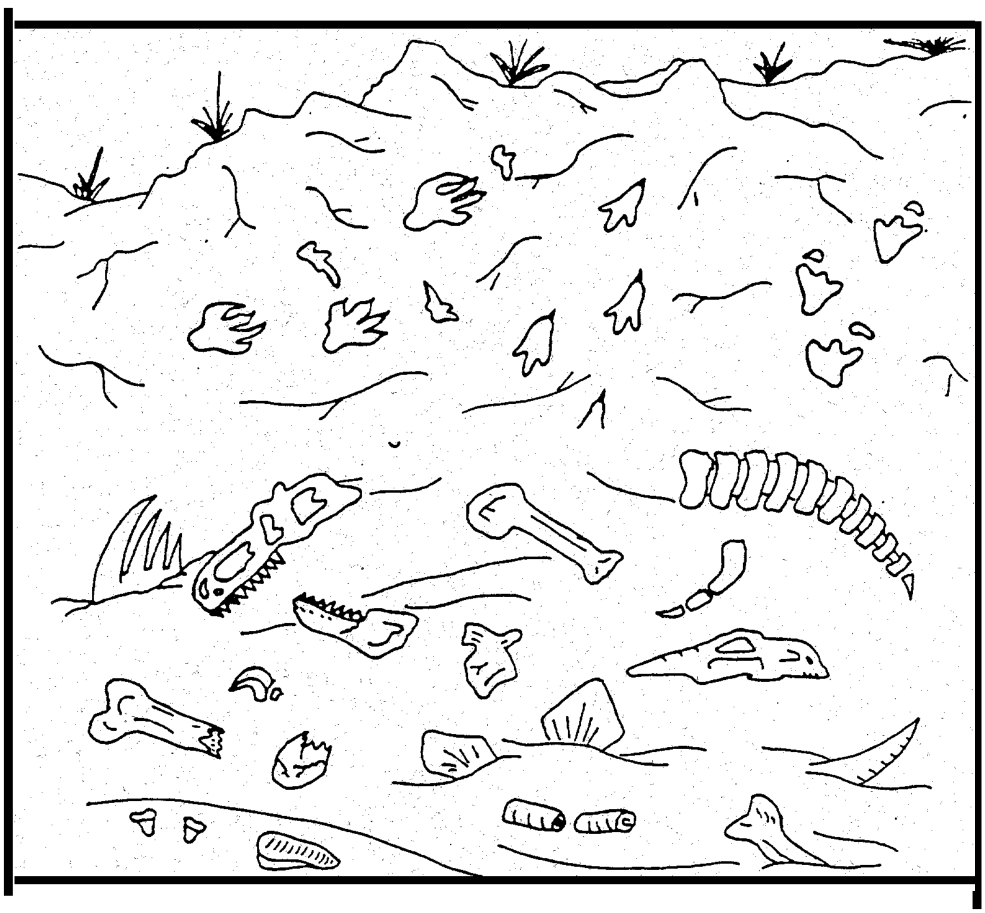
Dinosaur Scene: A time machine has been invented that travels into the past and takes pictures, sending them to the present. You are asked to look at one of the pictures and interpret what you see. Put an “O” before the statements that are observations and an “I” before the statements that are inferences.

1. The volcano is erupting.
2. The camptosaurus is going to eat the stegosaurus.
3. The stegosaurus will run into the water to escape.
4. The camptosaurus is leaving tracks in the ground.
5. The ground where the camptosaurus is walking is wet.
6. There are plants growing in the water.
7. The camptosaurus is going into the water to eat the plants.
8. There is a tree growing next to the river.
9. The tree looks like a palm tree.
10. The climate is warm.
11. The stegosaurus is eating the plant.
12. The stegosaurus is an herbivore.
13. There are bones from a dead animal by the shore.
14. The camptosaurus killed the animal.
15. Some more bones are in the water.
16. The camptosaurus can't swim and will drown.
17. Lava is coming down the sides of the volcano.
18. The camptosaurus has sharp teeth for eating meat.



Tracks and Bones: You are a paleontologist and you have just discovered a layer of rock with many fossils in it, both petrified bones and tracks. Decide whether the following statements are observations or inferences.

1. There are tracks from three different animals in the rock.
2. One animal was chasing another animal.
3. Two different animals died in this spot.
4. When the animals walked here the ground was wet.
5. One of the animals that died here had bony plates.
6. One of the animals that died here had sharp teeth.
7. The animal that had sharp teeth ate meat.



Classroom Activity 2
Distant Relatives

Objective: Students will match clues about ancient mammals to the corresponding mammals. They will then use that information to match the ancient mammals to their modern counterparts.

Background: Mammals have existed since the reign of the dinosaurs. At that time mammals were small, mostly nocturnal creatures. When the dinosaurs became extinct, mammals' characteristics (fur, live-bearing, nursing their young,) allowed them to survive. They adapted and radiated to fill the niches which were abandoned by the dinosaurs. The fossil record allows us to compare and contrast these early mammals with modern ones. Some ancient mammals gave rise to the modern species while others became extinct with no living counterparts. Paleontologists use comparative anatomy, using the skeletons of modern animals to gain information about the possible traits of the fossils they are studying. Also, by learning about the natural history of the living counterparts, scientists can sometimes draw conclusions about the natural history of the ancients and how they may have fit into their ecosystem.

Materials:
copies for each student of:
clues about ancient mammals (follows)
ancient mammals (follows)
modern mammals (follows)
Reference books with natural history information

Procedure:
Part one:
Discuss information from the background section with the students. Pass out the clues and illustrations of the animals. Students read the clues about the ancient mammals and match those clues to the corresponding animal.

Part two:
Using common knowledge about the modern animals and further research if desired, students match the ancient mammals to their modern counterparts.

Modern Mammal or Family	Fossil Mammal	Matches Clues
Perissodactyla Hoofed feet with 1 or 3 toes	Miohippus Moropus	#4 #2
Artiodactyla Hoofed feet with 2 or 4 toes Camel, antelope, llamas	Stenomylus	#6
Carnivora Special teeth for tearing meat Cat and Dog family, and others	Western Sabertooth cat	#3
Rodentia Chisel-like front teeth for gnawing Praire Dog, mice, beavers etc.	Castorides	#5
Proboscidea Huge size, long trunk Elephant	Zygophodon	#1

Go over the answers (provided) discussing the similarities and differences. In the answer sheet, first listing for each modern mammal is the order. Orders are classifications of animals, based on physical and physiological similarities.

Follow up:

Talk about the clues given for the fossil mammals, Which one of the clues are observations that could be made from studying fossilized animals and which clues are inferences?

Discuss what environmental factors could have influenced changes seen over time (evolution). For example, today camels live in areas with shifting sands and have soft pads on their feet, *Stenomylus* had hooves and lived in savannah-like grasslands. How wood these different types of feet help in each environment? Modern horses have only one toe, a hoof, while *Miohippus* had three toes. One toe means less surface area touching the ground and is an advantage in speed. *Castroides* was considerably larger than modern beavers, and would have needed much more food to survive.

Clues:

1
*ate plants
*had huge tusks that stood out
*may have used the tusks for fighting rival males
*lived in western North America
*very large size

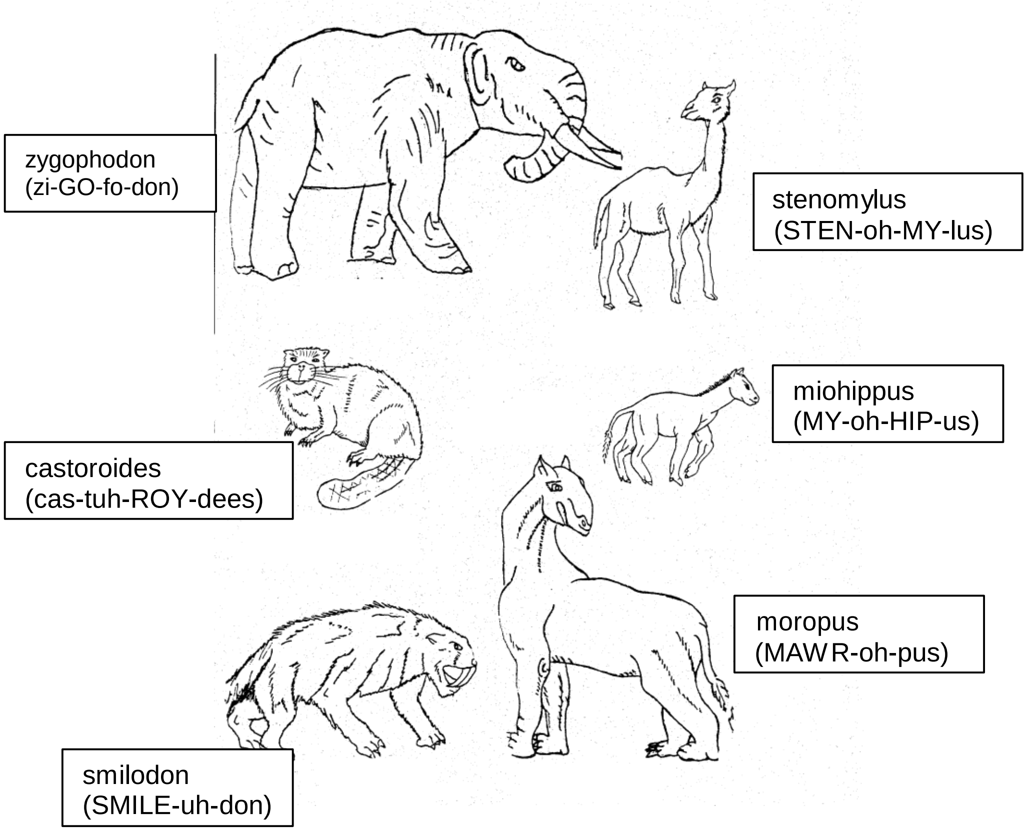
2
*ate leaves, grass and roots
*claws on its front feet for
*head like a large horse
*sloping back

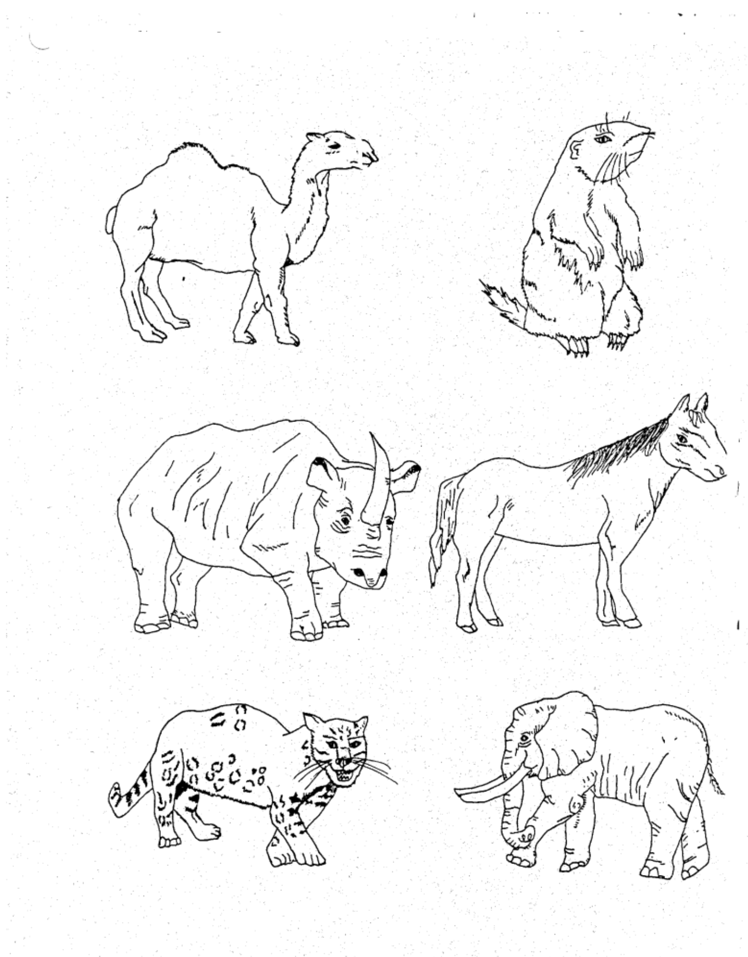
3
*ate meat
*had two long, pointed front teeth that hung down from its upper jaw
*heavily built with large, powerful front legs
*claws on feet

4
*ate leaves and grass
*was about the size of a sheep
*had 3 toes on each foot
*had long legs

5
*ate water plants
*lived in lakes and ponds
*was almost 8 feet long and weighed as much as a black bear

6
*ate plants
*looked camel-like
*had hard hooves


zygophodon
(zi-GO-fo-don)
stenomylus
(STEN-oh-MY-lus)
miohippus
(MY-oh-HIP-us)
castoroides
(cas-tuh-ROY-dees)
moropus
(MAWR-oh-pus)
smilodon
(SMILE-uh-don)



Classroom Activity 3
Make a Diorama

Objectives: In this project students will combine research skills and art activities to produce a diorama showing an ancient scene. Through research they will reconstruct an ancient ecosystem, showing the crucial elements of that ecosystem. They will apply the concept of uniformitarianism when reconstructing the past.

Background: The meaning of the concept of uniformitarianism is much simpler than the word itself. Simply put, it means that the present is the key to the past. The theory was formulated by the Scottish geologist, James Hutton. In 1785 he stated his belief that the present is the key to the past and that processes now at work could account for all the geologic features of the earth, if sufficient time had passed. In his theory, what remains uniform are the physical and chemical laws, like gravity and weathering that govern geologic events.

A more modern term for the process is “actualism”. This term is used by some geologists because a uniform cause does not guarantee uniform results. For instance, the rate of sediment accumulation on the ocean floor today is not necessarily the same as the rate was a million years ago. Some scientists feel that the term actualism is-more accurate because it doesn’t imply that the rates are uniform through time, only that the processes and physical laws have remained the same. Whichever term is used, the important concept is that the present is the key to the past.

While Hutton was applying the principle to geology, it can also be applied, to some extent, to environmental biology and ecology, for the same laws of biochemistry, energy flow and population dynamics that affect living systems today were in effect in ancient ecosystems. However, because organisms, as well as ecosystems, evolve and change they are not as constant through time as physical processes. But, by studying a present day ecosystem, one can make some inferences about the past.

Materials:

cardboard boxes	glue
construction paper	scissors
modeling clay	yarn
etc.	

For research materials, use encyclopedias, sources from the list of further information, magazine articles, or contact a National Park to obtain information (list provided) about that park.

Directions:
Research a period and place in geologic history. With the information you obtain, make a diorama showing the ancient ecosystem. Some things to consider are; What animals do you wish to portray? What did those animals eat? What adaptations did they have that would help them to survive? What dangers did they have to be on the lookout for? What was the climate like? What was the landscape like? Look at your sources of information and decide what clues were used to come up with this information. Are there any modern day animals that are similar and that live in a similar environment? Use the present as a key to the past by

researching those animals to gain insights into their lives.

Follow-up: After the students have completed their dioramas, ask them to give an oral presentation about what they learned, and how they applied the concept of uniformitarianism to their project.

Agate Fossil Beds National Monument P.O. Box 427 Gering, NE 69341 (308) 436-4340	Fossil Butte National Monument P.O. Box 592 Kemmerer, WY 83101 (303) 877-4455
Badlands National Park P.O. Box 6 Interior, SD 57750 (605) 433-5361	Hagerman Fossil Beds National Monument P.O. Box 570 Hagerman, ID 83332 (208) 733-8398
Dinosaur National Monument P.O. Box 210 Dinosaur, CO 81610 (303) 374-3000	John Day Fossil Beds National Monument 420 W. Main St. John Day, OR 97845 (503) 575-0721
Florissant Fossil Beds National Monument P.O. Box 185 Florissant, CO 80816 (719) 748-3253	Petrified National Forest Park Petrified Forest, AZ 86028 (602) 524-6228

Classroom Activity 4 Pollen Analysis

Objectives: Students will be introduced to the value of pollen analysis in reconstructing the past.

Background: Pollen has three characteristics that make it very valuable for studying the past and reconstructing ancient ecosystems. The most important is that pollen can be fossilized if it is buried under the right circumstances. The exine of pollen is very durable and almost indestructible and the pollen is extracted from the surrounding rock by dissolving the rock in acids.

Another attribute is its distinctive shape. Each kind of plant has its own unique shape of pollen, different from every other kind of plant. Like a person's fingerprint, this unique shape can be used to identify a particular plant.

Another important characteristic of pollen is its size. These microscopic "fingerprints" can be carried by the wind for great distances before they fall to the ground to become, potentially, fossils. "So, fossilized pollen can give clues about the regional environment instead of just telling about what grew in a particular area. Go over These important characteristics of pollen with the class before starting the activity. As an example of the broader look at the past that we can obtain from studying pollen we will look at an example from Florissant Fossil Beds National Monument in Colorado. There we find a tremendous variety of very intricate fossils of leaves and insects from a period of time nearly 35 million years ago, during the late Eocene epoch. Due to volcanic activity, a stream was dammed to form a lake and many, many layers of leaves and insects that fell into the lake were buried under layers of volcanic ash and preserved as detailed fossils. These fossils give us much information about what grew right next to the lake and fell into it.

But, if you extract the pollen from the shales by dissolving the shales in acid a wealth of further information is revealed. Many species of plants that are NOT represented as leaf fossils are discovered by looking at the fossil pollen. This pollen was carried by the wind to land in the lake and we can gain an idea of what the whole region was like by identifying it.

However, it is important to remember that plants that are insect pollinated do not produce as much pollen as plants that are wind pollinated. This means that insect pollinated plants would not be as well represented in the fossil record and the fossil record would not reflect relative abundance.

Directions: Pass out the handout. Ask the students to look at the list of plants that are found as "macro" fossils (leaves). Using encyclopedias or plant guide books, have them research some of the plants to find out what kind of climate they live in and associations with other plants. What conclusions can they draw about the ancient climate at Florissant? Now have them look at the plants that show up in the fossil pollen record. Are there any further insights that can be drawn? (The pollen analysis gives a more regional picture and some of the plants reflect a drier, more upland ecosystem).

Follow up: Florissant Fossil Beds is located on the western flanks of the Pikes Peak region. It is in the Montane life zone, one of five life zones encountered as you travel upward in elevation in the Pike's Peak region. The great plains to the east of the mountain are one life zone. As you move upward you pass through the Foothills, then into the Montane ecosystem (where Florissant is located) on up into the sub-alpine life zone and finally near the top of the peak, the alpine, or tundra, life zone. Just as today, life zones and plant communities are influenced by altitude, and so it must have been in the past, with the Florissant Valley being very lush and wet because of the stream and lake and the surrounding uplands being colder and dryer.

Microclimates are pockets of vegetation where the climate is different from the surrounding area. Some of the factors influencing a microclimate are shown below. Have the students locate a microclimate in their neighborhood or nearby park. How is it different from the surrounding area? What factors are influencing the microclimate? If this microclimate were to become a fossil deposit, would it be misleading about the general climate? How would you gain a better picture of the overall climate? (By studying the fossil pollen).

NORTH-FACING SLOPES

1. Shady (receive indirect rays of sun)
2. Snows melt slowly
3. Rainwater evaporates slowly
4. More soil moisture available for plants
5. Larger and more abundant plants

SOUTH-FACING SLOPES

1. Sunny (receive direct rays of sun]
2. Snows melt rapidly
3. Rainwater evaporates quickly
4. Less soil moisture available for plants
5. Smaller and fewer plants

Pollen Analysis Handout

There are three things about pollen that make it very valuable for studying the past. One is that pollen can be fossilized if it is buried under the right circumstances. Another characteristic is its distinctive shape. Each kind of plant has its own special shape of pollen, different from every other kind of plant. Like a person's fingerprint, this shape can be used to identify a particular plant. Another characteristic of pollen is its size. Because it is so small pollen can be carried by the wind for great distances before it falls to the ground. So, fossilized pollen can give clues about what the climate of a whole region was like, instead of just telling about what grew in a particular spot. However, it is important to remember that plants that are insect pollinated do not produce as much pollen as plants that are wind pollinated. How do you think that would affect the fossil record when we look at fossil pollen?

As an example of the bigger picture of the past that we can see when we study pollen we will look at Florissant Fossil Beds National Monument in Colorado. At Florissant we find many different fossil leaves and insects that are about 35 million years old. Because of mud flows from a huge volcano that was active back then, a lake was dammed and many, many layers of leaves and insects hat fell into the lake were buried under layers of volcanic ash and preserved as detailed fossils. These fossils give us a great deal of information about what grew right next to the lake.

But, pull out a microscope to look at the fossil pollen and the picture of the past becomes much bigger. Many species of plants that are NOT represented as leaf fossils are discovered by looking at the fossil pollen. This pollen was carried by the wind to land in the lake and we can get an idea of what the whole region was like by identifying it.

Directions: Look at the list of plants that are found as “macro” fossils (as leaves). Using encyclopedias and plant guide books, research some of the plants to find out what kind of climate they live in and associations that they have with other plants. What conclusions can you draw about the ancient climate at Florissant? Now, look at the plants that show up in the fossil pollen record. Research those plants and find out what kind of climate they are found in and what associations they have with other plants. Does looking at the fossil pollen record give you any further insights into the ancient climate?

Leaf and Pollen Comparison List

When researching these plants, remember that they were growing nearly 35 million years ago. Some of them are now extinct. However, they were very similar to modern day plants and have been included into modern day plant families (names of families end with the suffix “aceae”). So, if you can’t find a particular kind of plant, look up the family. The plants listed would have had very similar growth habits and needs as other members of the Family.

Fossilized plants from
Florissant Seauoia, Family
Taxodiaceae Poculus, Family
Salicaeae Athavana, Family
Sapindaceae Saoindus, Family
Sapindaceae Cercocarous,
Family Rosaceae

Fossilized pollen from
Florissant Junlans, Family
Juglandaceae Celtis, Family
Ulmaceae Pseudotsuga, Family
Pinaceae Family
Chenopodiaceae
Family Amaranthaceae

Follow-up: What did you discover? Did the plants that had fossilized pollen seem to grow in a different type of life zone or environment than the plants with fossil leaves? Life zones, in general, are influenced by altitude and latitude. For example, the entire North American continent is divided into three major life zones: The Boreal, or northern zone also includes areas above 8,000 feet in elevation, the Austral, or southern zone includes areas between 3,500 feet and
8,000 feet in elevation and the Tropical zone which can include areas below
3,500 feet. The U.S. can be divided into regions with each region having its own climate and life zones. In Colorado today there are five different life zones that are determined by the altitude.

There were also different life zones in the ancient Florissant region. The valley itself was very lush and wet, but the highlands around it were drier and cooler. The kinds of plants that grow in a life zone are also influenced by “microclimates”. Some of the factors that influence a microclimate are listed below. What kind of life zone do you live in? Can you find any microclimates in your neighborhood?

NORTH-FACING SLOPES

1. Shady (receive indirect rays of sun)
2. Snows melt slowly
3. Rainwater evaporates slowly
4. More soil moisture available for plants
5. Larger and more abundant plants

SOUTH-FACING SLOPES

1. Sunny (receive direct rays of sun)
2. Snows melt rapidly
3. Rainwater evaporates quickly
4. Less soil moisture available for plants
5. Smaller and fewer plants

Outdoor Activities

Outdoor Activity 1

Food Chain Game

Objectives: After playing this game the students will apply the concept of natural selection to present and past ecosystems. They will understand how models work in forming theories and how the present can be a key to the past (uniformitarianism).

Background: No materials are needed for this game. However, the game should be played in an open area with no obstructions that the students can run into or trip over. Tag, rather than tackle, may have to be emphasized to certain individuals in the group. This game can be adapted to any environment or period in time. Choose two food chains: one that could exist in your environment today and one that existed in an ancient environment. Present day examples are: grass, prairie dog, badger; aspen, elk, mountain lion. Examples from the past are cycads, *Apatosaurus* (herbivore), tyrannosaur (carnivore); fern, oreodont (herbivore), sabertooth cat (carnivore).

Procedure: Divide the students into three equal groups. Using the present day food chain, those in group 1 are the plant species of your chosen food chain, members of group 2 are the herbivorous species of your food chain and group 3 members are the carnivorous species.
Group 1 members scatter out in the playing field, rooted in place. Group 2 members stand spread out on one side of the leader, Group 3 members on the other side of the leader.

At signal, herbivores will try to reach a plant and carnivores will try to tag a herbivore. If an herbivore reaches a plant it is safe; it has procured food and will live to play another round. If a carnivore tags an herbivore it has caught its meal and will survive to play another round.

Any species that is “eaten” becomes the species that ate it, as it is incorporated into that animal’s body. Plants tagged by a herbivore will become herbivores for the next round, herbivores that are eaten will be carnivores for the next round. Any animal that is not successful at obtaining food in a round dies. Its body decomposes and adds nutrients to the soil, helping plants to grow. Thus, any unsuccessful animals will become plants for the next round.
Play several rounds (enough for the populations to go through considerable fluctuations) with the present-day food chain then play some rounds with the ancient- day food chain.

Follow up: When the time period is up, assemble the students and discuss these concepts: What happened during rounds where food was plentiful for one of the species? How did that affect the next round? Did anyone remain the same species for the entire game? What advantage (adaptation) did that person have? Are they particularly fast or agile? Or, did they apply any strategies?

What adaptations do plants have that can lessen their chances of being eaten? Perhaps they don’t taste good, grow in inaccessible places, have thorns or spines, or have short reproductive cycles so they are able to produce seed and ensure survival of the species even if they are eaten.

What adaptations do animals have that could help chances of survival? Speed, good vision, and behavior can all be factors.

Classroom Follow-up: Research the species that were involved in your food chains, past and present. What adaptations do the members of the present-day ecosystem have that can help them to survive? How do these adaptations affect future generations? Discuss survival of the fittest and how that affects the characteristics of offspring. Evolution is the sum of many generations being affected by survival of the fittest and chance.

What happened when you played the game using the members of an ancient food chain? Did the same principles apply? Do we know for sure that the same principles applied or are we making an assumption? What are we basing our assumption on? Is it a valid assumption?

When you played the game with the ancient food chain, the students had to imagine that they were in the ancient environment. How has the climate changed? Would those plants and animals survive today? Research the members of the ancient food chain. What clues do we find in the fossils of the ancient ecosystem? How do these clues help us form theories about the actual plants or animals?

Have the teacher or a classmate keep track of the numbers of the different animals and plants from each round and graph the fluctuations. What patterns, if any, do you see?

Outdoor Activity 2
Adaptation Game

Objectives: This game gives students an opportunity to consider why and how life forms adapt.

Background: Adaptations are physical or mental characteristics that help an organism to survive. Over time, natural selection and evolution enhance adaptations. When change occurs in the environment, different characteristics may help or hinder the individual animals in a population. If those animals are helped, they survive the changing situation and pass on the genes which give those characteristics to their offspring. If the animals are hindered, then the species may go extinct.

It is important that the students remember that none of the changes or adaptations happen quickly in nature. Some of the environmental changes take place within one lifetime while others may take thousands or millions of years. Some adaptations, like insects' immunity to a pesticide, occur over a few generations, while most others take millions of years to develop.

Procedure:

1. Photocopy pages of “Possible Adaptations” and cut out each adaptation so it is separate.
2. Divide students into two teams and have each group number off so that each student has a number.
3. Have the teams line up about 40 feet apart facing the other team.
4. Place the adaptation cards in the center between the two teams.
5. Have a copy of the “Changing Situations” list in hand.

Now you are ready to play the game. Call out a “Changing Situation” and a number. The students whose numbers have been called run to the center and pick up one or more cards until they have adaptations that will help their team cope with the change. They return to their team with the cards they picked up.

When the players return to their teams with the cards have them read out loud the solutions they chose and explain why they are helpful. All cards that offer a reasonable solution to the problem count as a point for that team. Return all cards to the center after the adaptations have been discussed. The team with the most points wins.

Changing Situations

Your Predators become camouflaged	Disease and insects kill almost all of the trees you depend on
Your prey becomes camouflaged	The climate becomes very cold
The plants you eat become extinct	The animals you eat develop armor
Your predators begin to run faster	Other animals find and eat your eggs
The area you live in turns to desert	The ocean you live in dries up
The plants you eat develop spines	Your food supply becomes seasonal
Humans use pesticides to kill you	The animals you eat start to only come out at night
The animals you eat begin living underground	The plants you eat develop a bad taste

Adaptations

Become camouflaged	Develop better night vision
Hibernate	Learn to store food
Build an underground home	Develop muscles and claws for digging
Shed more fur to keep cooler	Become warm-blooded
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 smell
Develop a better sense of hearing	Develop a way to store water in your body
Become immune to pesticide	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	