Kansas 4-H Geology Leader Notebook

Chapter 5 — Fossils, Table of Contents

You Ol' Fossil

Fossils — Geology, Level I

What members will learn …

About the Project:

- What is a fossil?
- Steps a plant or animal go through to become a fossil.
- How long it takes to make a fossil.

About Themselves:

- How learning can be fun.
- The importance of learning and sharing historic stories.

Materials:

- 5 chicken bones
- 1 cup vinegar
- 1 cup salt water
- 2 cups dirt
- 2 cups clay
- 2 cups peat moss
- Activity Sheet 41, *How Fossils are Formed*
- Activity Sheet 42, *How Fossils are Formed, Word Blocks*
- Activity Sheet 43, *Fossil Enrichment*
- Activity Sheet 44, *Fossil Enrichment, Leader's Key*
- Baggies

Activity Time Needed: 30 minutes

Activity

Have you ever heard someone referred to as an "ol' fossil?" Today we are going to find out just what fossils are. Do you know what a fossil is? The definition of a fossil is: "Any naturally preserved, part, trace or all parts of an animal or plant that lived a very long time ago."

A fossil is evidence of prehistoric life, either plant or animal, which gives some indication of the shape, structure, or habit of the plant or animal. A fossil has been buried for a *long* time. Petrify is another term used sometimes when talking about fossils, *petrify* means turn to stone.

Leader's Notes:

Explain that it is a term for someone very old or their opinions are extremely antiquated.

Is it feasible for the members to collect millions of something? Explain that it might take more than their lifetime to collect such large numbers as a million.

How do we learn about the past through fossils? Millions of years ago there were no people to tell us about the plants and animals that lived, so we have to learn from the fossils. A million years is a short time in the span of the earth's history. Do you know of a building that has a million bricks in it?

Fossils tell us about when they lived (by the age of the rocks they are found in); where they lived (in water or on the land); what they ate (by the shape of their teeth or the absence of teeth); and their enemies or predators (marks left on shell or bones from other animals).

Most plants and animals did not become fossils when they died. The conditions were not right to be preserved as fossils. They simply rotted or crumbled, dried up and blew away, or were eaten by other animals. No trace was left of them. Countless plants or animals were never preserved as fossils so there are whole groups of plants and animals unknown to us. It is estimated that only 1 to 2 percent of all things that ever lived on earth have been preserved and found. Conditions have to be just right to make a fossil.

What are the steps a plant or animal goes through to become a fossil?

1. The animal dies.
2. It is buried immediately by sand or mud, tar, ash, etc.
3. It remains buried in one place for a long time.
4. Circulating water containing calcium carbonate or silica will react with its hard parts to make a fossil. (This is the replacement process.) It is the exchange process of mineral matter for animal parts or plant matter.

Hand out Activity Sheets 41, *How Fossils are Formed,* and 42, *Word Blocks*. Let members cut fossil pictures and word blocks apart and then try to match the picture to the word blocks in the correct order of how a fossil is formed before you give the answers of discussion. After you give them the answers, have them clear the table, mix up the answers and pictures, and see how fast they can match them again.

Answers: Sequence and Word Block Match — 5-F; 6-C; 1-E; 3-D; 4-A; 2-B.

A bone or imprint stands a better chance of being preserved in some environments than others. Try this experiment.

1. Place five chicken bones in five containers containing different materials such as vinegar, peat moss, salt water, clay, and dirt.
2. Check on the bones once a week and record any changes.
3. After four weeks, which bone showed the least amount of change? The greatest amount of change?
4. What are the reasons for any differences among the bones?

This experiment can be started one week and checked at the project meetings over a period of time. You may also want to assign this as a home project with members recording results and comparing at a project meeting. This experiment can also be done in different locations outdoors, or use other mediums. You may consider using covered containers. You may also need to add more liquids as time goes on, such as salt or vinegar, as it evaporates.

Why study and collect fossils?

1. They tell us what animals of the past were like.
2. They tell what the environment and conditions were like.
3. If we know what fossils are found in one rock formation we can identify it at other places.
4. We can compare the age of rocks in different parts of the continent.

The record of life on earth is preserved in the fossils in rocks. Most fossils represent only the hard parts of plants and animals. However under ideal conditions, soft tissue and soft-bodied organisms can be preserved. What animals have no remains on the rock? A few living things such as jellyfish, the slugs or shell-less snails, etc. have soft bodies, which at death dissolve and seldom leave fossils.

Dialogue for Critical Thinking:

Share:

1. How difficult was it to match the descriptions and arrange the order of fossil formations?
2. What major changes did you see in the chicken bones (After four weeks)? Why?

Process:

3. What is the most significant aspect of an animal that helps form fossils? Why?
4. What types of things can we learn from fossils?

Generalize:

5. What did you enjoy most from this lesson? Why?
6. How are fossils like remembering special events or activities?

Apply:

7. How do your parents record, remember, and share family history?
8. How do you think history will be recorded in the future?

Going Further:

Another experiment to show how a fossil could be preserved can be done at home.

1. Put about 2 inches of fine, clean sand in a container.
2. Arrange a fresh flower on the sand in its natural position.
3. Sprinkle sand carefully between the flower parts.
4. Cover with several inches of sand.
5. Allow about 3 weeks for the drying process.
6. Carefully remove the specimen, brush sand off with a soft brush. The flower should look like a fresh cut flower.

A few organisms are covered by wind blown sand on deserts or beaches or by falling ash from volcanic eruptions.

References:

Culver, Diann, *Dinosaurs*, 1993, Teacher Created Materials, Inc., Huntington Beach, CA 92647 (Thematic Unit)

Ramsey, Gabriel, McGuirk, Phillips, Watenpaugh, *Holt Earth Science Exercises and Investigations, Teacher's Edition*, Holt, Rinehart and Winston, Publishers, 1986.

Author: Sara Murphy, 4-H Geology Curriculum Team

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James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

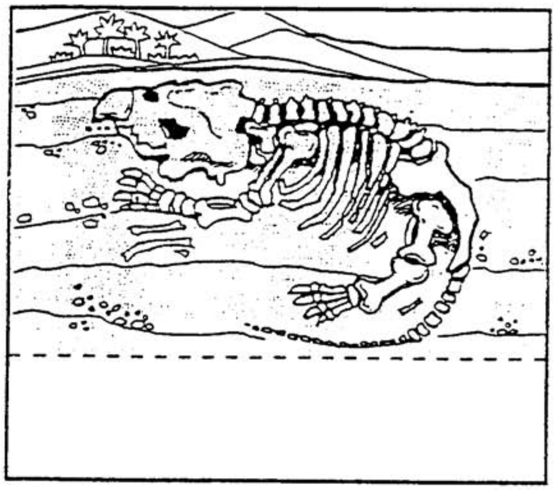
Hand out Activity Sheet 43, *Fossil Enrichment*. This activity may work better in your group as a discussion and answer activity.

You Ol’ Fossil

Activity Sheet 41, How Fossils Are Formed

Fossils — Geology, Level I

1



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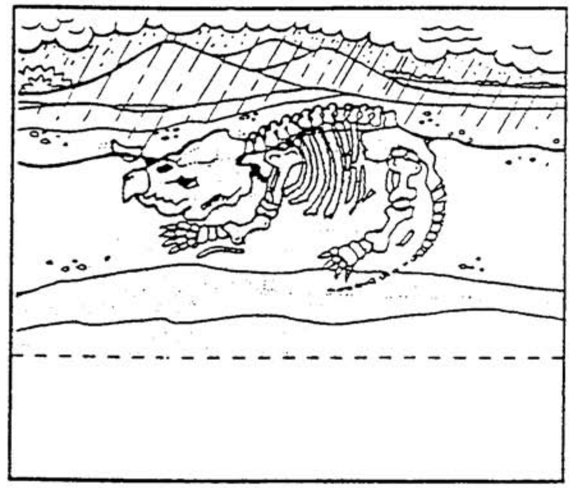

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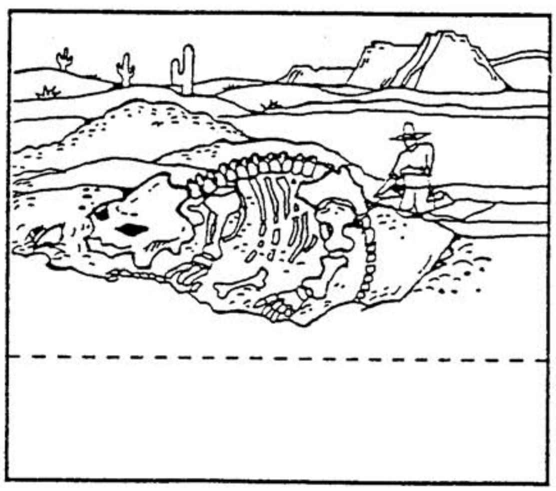

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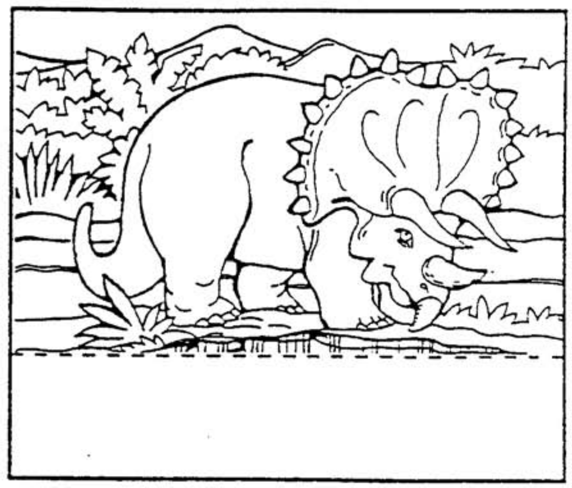

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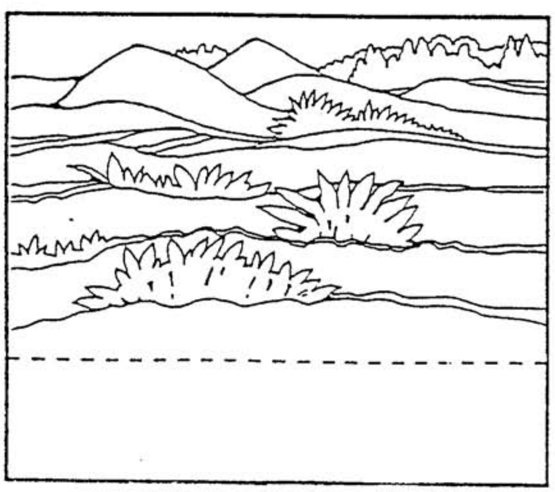

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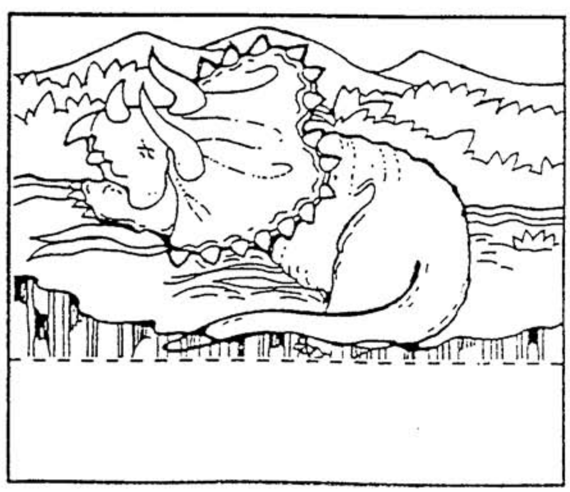


You Ol’ Fossil

Activity Sheet 42, How Fossils Are Formed, Word Blocks

Fossils — Geology, Level I

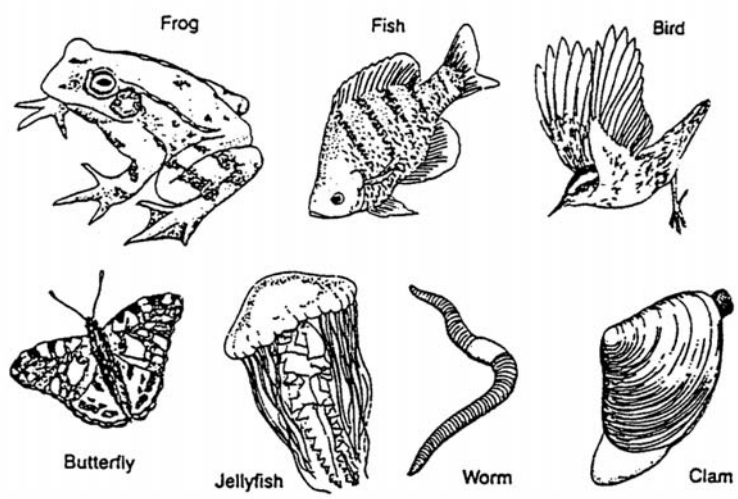
Cut out these blocks and tape or glue them to the matching drawing on Activity Sheet 41, *How Fossils Are Formed*.

A.	Heavy wind and rain wash away part of the sand and dirt. Then a part of the dinosaur can be seen.	The bones are hidden for millions of years. Water and minerals seep through sand and slowly turn the bones to stone.	D.
B.	A scientist finds the fossil of a dinosaur and carefully digs it out of the stone to take to a museum and study.	The bodies of some of the dinosaurs were covered by sand and dirt after they died.	E.
C.	All the dinosaurs died suddenly 65 million years ago.	Dinosaurs lived on Earth for 160 million years.	F.

You Ol’ Fossil

Activity Sheet 43, Fossil Enrichment

Fossils — Geology, Level I



Answer the following questions about the figures at left.

1. Which of the living things above would most likely leave a fossil? Why? ______________________________

____

2. Which of the living things would only leave fossils in the form of molds or casts? Why?__________________

____

3. Explain how each of these living things could form a fossil:

Butterfly: ____

____

Earthworm: ____

____

Fish: ____

____

Bird: ____

____

Clam: ____

____

Frog: ____

____

Jellyfish: ____

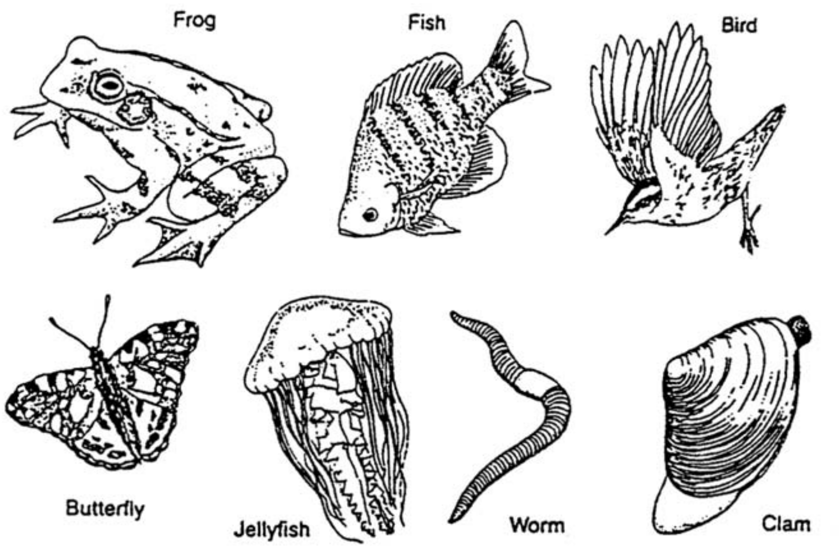
____

Holt Earth Science. Holt, Rinehart and Winston, Publisher

You Ol’ Fossil

Activity Sheet 44, Fossil Enrichment Leader’s Key

Fossils — Geology, Level I



Answer the following questions about the figures at left.

1. Which of the living things above would most likely leave a fossil? Why?

Fish, bird, clam, frog. These living things have hard body parts, which are easier to preserve than soft body parts.

2. Which of the living things would only leave fossils in the form of molds or casts? Why?

Earthworms and jellyfish. The earthworms and jellyfish only have soft body parts, which can only be preserved as a cast or mold.

3. Explain how each of living things could form a fossil.

Butterfly: **The butterfly could be preserved if it were trapped in tree sap or amber.**

Earthworm: **The earthworm could become buried in soft mud. After the earthworm decayed, it would leave an impression. If the impression became filled with mud or mineral material, a cast would be formed.**

Fish: **The fish could die and then sink to the bottom where it would be covered by mud.**

Bird: **The bird could become trapped in tar. The bones would be preserved.**

Clam: **The clam could become buried in soft mud and leave a mold as it decays.**

Frog: **The frog could die and sink to the bottom where it could become buried by mud.**

Jellyfish: **The jellyfish could become buried in soft mud and leave a mold as it decayed.**

Holt Earth Science. Holt, Rinehart and Winston, Publisher

The Great Divide

Fossils — Geology, Level I

What members will learn …

About the Project:

- Fossils are divided into groups (classified)
- Fossils were once a living organism
- Fossils can be identified by comparing to pictures

About Themselves:

- How to divide and match objects
- How to make decisions by comparing items.

Materials:

For each member

- Pencil and Paper
- Activity Sheet 45, *Fossil Game Board*
- Activity Sheet 46, *Fossil Game Board Pictures*

Activity Time Needed: 20 –30 minutes

Activity

Today we are going to learn about classifying fossils

Review what a fossil is. (*The remains or traces in rock of earlier plants and animals that lived many years ago, some even millions of years.*)

What is a living thing? (*A living thing can breathe, eat, grow, and move on its own.*)

What is a non-living thing? (*Something that has never been alive.*)

What is a once lived thing? (*Something that was once a part of a living thing but is not alive now.*)

Why is a green plant a living thing? (*It can breathe, eat, grow, and move on its own.*)

Why is a squirrel a living animal? (*It can breathe, eat, grow, and move on its own.*)

Why is a rock a non-living thing? (*It isn't able to breathe, eat, grow, and move on its own. Crystals grow and rocks move by sliding down hills but they can't breathe or eat.*)

What category would a fossil fit in? (*It once lived, it breathed, ate, grew, and moved on its own.*)

Leader's Notes:

A living plant must have water and soil to stay alive. We can demonstrate how it moves by placing it by a window and leaving it for several days-it moves toward the light-then if turned the other way will lean or move toward the light again.

For safety sake if there are no sidewalks in the neighborhood you may just sit outside or decide on another group of things to classify. Have each member keep track of one of the special features. Explain to them they are dividing into groups or classifying, as we would group together fossils.

We are going for a walk around the neighborhood. Observe all the vehicles you see in driveways or on the street. Let's divide them into groups. How will you classify (divide into groups) the vehicles? You may place all cars in one group, all vans in another, and all trucks in another. Then you may divide them into colors, number of doors, number of passengers, etc. What did you see the most of?

Why is it helpful to know how to group or classify like things together? (*Organizing information makes understanding and solving a problem such as classifying and identifying fossils easier.*) Probably primitive people made the first classification when they differentiated animals into those that were suitable to eat and those that were not. The ancient hunters divided animals into those found on land and those found in or around water.)

Hand out Activity Sheets 45, *Fossil Game Board*, and 46, *Game Board Pictures*. You may put it on card stock or have it laminated and reuse. Give members a few minutes to place pictures on the board in the correct column. Discuss answers. Gather your own items it you don't want to use game pieces.

The problem for us is to be able to put the proper name or identification with each fossil specimen. Once you know something is a fossil (once lived) how do you find out what kind of fossil it is? How is it identified? One way you can identify a fossil is by matching a fossil with a sketch of a once-living organism or picture of the fossil in a book. There are snails, corals, and organisms living today that are like ones that lived long ago. How do we know this? We find fossils that have the same characteristics and the same shape. These fossils tell us what the earth was like, and if they lived on land or water, at the water's edge or in deep water. We know this because we know where the modern organisms are found. Can you find pictures that show similarity between fossil life and things living today?

Another way to learn the proper identification of fossils is to learn the modern biological classification of organisms. This classification allows us to divide organisms into groups that have general characteristics. The first groups are very general and then are divided into more specific groups.

The two main fossil divisions of kingdoms are plants and animals. (Kingdom is the largest unit of division of organisms.)

Refer to vertebrate and invertebrate lessons.

Another major division under the group of animals is-does it have a backbone (vertebrate) or does it live without one (invertebrate)? As we continue to divide using more specific characteristics we can determine exactly what fossils we have found. There are more kingdoms (6), which you will learn as you advance in the lessons but these are the two most common ones.

Have pictures available and books if possible for the members to look at — you may have to check some out from the library.

The classification scale of division is:

Kingdom (Plant or animal)

Phylum (A group of closely related classes of plants or animals)

Class (A biologic unit — a subdivision of a phylum)

Order (Arrangement with respect to importance)

Family (A group of closely related genus)

Genus (A group descending from a common direct ancestor)

Discuss how things are recognized. Give example.

Would your grandmother recognize your teacher? (*Not unless you have showed her a picture or she had met her.*)

Would you recognize the President of the U.S.? (*You probably would because you have seen him on TV or in the newspaper.*)

How something is recognized depends upon how familiar you are with it and if you have seen something like it before. A visual match of a fossil with a sketch or picture is a simple quick way to make a primary identification using the classification key. You will learn more in later lessons about how to do this.

Dialogue for Critical Thinking

Share:

1. What was the most interesting thing about the Fossil Game Board? Why?
2. Which column on the Fossil Game Board was the most difficult to identify? Why?

Process:

3. Why is it important to know how to arrange things that look alike or have something in common?
4. What should you do if you can't find a picture or information about a fossil you have found?
5. How would the place where you found the fossils make a difference or help you identify them?

Generalize:

6. How does it help to match things that are alike?
7. Why does it help to compare and rank items based on certain facts or descriptions or use?

Apply:

8. How has the interest in dinosaurs helped draw attention to fossils?
9. Why should you be careful and take care of fossils you have found?
10. How can grouping like things help you in arranging your closet?

Going Further:

1. After your field trip divide fossils into groups that are alike. Are they all water animals or are there some plants or land animals in the collection? Try to find pictures in a fossil book that look like what you found. Is there an animal living today that looks like it?
2. Have members use their first name and add Asaurus (example: Johnasarus) to create an imaginary dinosaur or fossil name, then draw a picture of this dinosaur and its fossil.

References:

Featherby's Fables – Teachers Guide

Author: Sara Murphy, 4-H Geology Curriculum Team

Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey

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The Great Divide

Activity Sheet 45
Fossil Game Board

Fossils — Geology, Level I

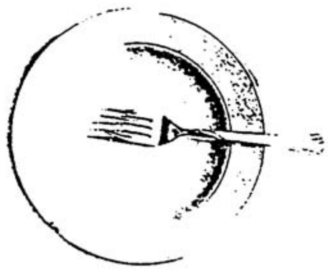
Living	Non-Living	Once Lived

The Great Divide

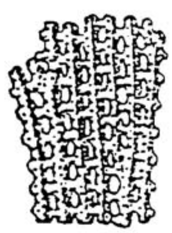
Activity Sheet 46, Fossil Game Board Pictures

Fossils — Geology, Level I










Vertebrate Fossils

Fossils — Geology, Level I

What members will learn …

About the Project:

- The definition of a vertebrate fossil.
- How vertebrate fossils are formed.
- The rarity of vertebrate fossils.

About Themselves:

- The importance of their backbone.

Materials:

For each member

- One package of Lifesavers candy for each member.
- One large diameter pipe cleaner for each member.
- Blackboard, flipchart or poster board.

Activity Time Needed: 30 minutes

Activity

Vertebrates are animals with backbones. They include the familiar animals on earth — the fishes, frogs, lizards, snakes, birds and mammals, including, of course, humans. Vertebrates belong to the phylum Chordata.

A backbone is made up of vertebrae, which are bones that protect the spinal cord of an animal. The vertebrae are stacked around the spinal cord, allowing flexible movement.

Let's use these materials to help us visualize a backbone of an animal. Stack the candy on the pipe cleaner by pushing the pipe cleaner through the hole. Bend the ends of the pipe cleaner to keep the stack together.

Bend the "backbone." Does it break? Is it flexible? Twist the "backbone." How is this movement like your own back?

Vertebrate fossils are much more rare than those of the major invertebrate fossil group. This makes it more difficult to find and collect these fossils. Many vertebrates lived on land so their bones decayed before they could become fossilized. Since bone is porous, even those animals that died in water were not likely to fossilize since the bone could dissolve before the sediments would bury them. Most of the vertebrate fossils found are teeth, which are not very porous, are hard to begin with and fossilize easily.

One relatively common vertebrate fossil in Western Kansas is shark teeth. Sharks could produce many teeth in their lifetimes, since they replaced them as they were lost. As one fell out, another was already behind it pushing its way out.

Leader's Notes:

Use the blackboard, flipchart or poster board to highlight key words in this lesson and the members' ideas.

Provide a package of Lifesavers candy and a pipe cleaner to each member.

Point out that the bones allow flexibility while protecting the spinal chord.

Ask members if they have collected vertebrate fossils and what types.

Ask members to describe vertebrate fossils they have seen in museums.

Dialogue for Critical Thinking:

Share:

1. How are the lifesavers on the pipe cleaner like the bones in your back?
2. How are actual backbones different from your candy "backbone"?

Process:

3. What are vertebrae?
4. What are some animals with vertebrae?
5. Why are vertebrate fossils hard to find?
6. Were land or water animals more likely to become fossils? Why?
7. Why are sharks teeth easier to find than other fossils?

Generalize:

8. Why should you take care of your back?
9. What would happen if your back was broken?
10. Why do you think people have backbones?

Apply:

11. Can vertebrate fossils be found in the area where you live? If not, where could you go to look for some?

Going Further:

1. Visit a museum and observe the various types of vertebrate fossils and write a brief report on your findings.
2. Write a brief report on the types of vertebrate fossils that can be found in your state.

References:

Thompson, Ida, *The Audubon Society Field Guide To North American Fossils*, Alfred A. Knopf, Inc., New York, 1982.

Buchanan Rex, *Kansas Geology and Introduction to Landscapes, Rocks, Minerals, and Fossils*, University Press of Kansas, Lawrence, Kansas, 1984.

Authors:

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Invertebrates

Fossils — Geology, Level I

What members will learn …

About the Project:
- What are invertebrates.

About Themselves:
- The importance of soft body parts.

Materials:
- Large balloon with water in it
- A chair

Activity Time Needed: 15 minutes

Activity
Today we are going to talk about invertebrates. Does anyone know what this means? (*This means they lack a backbone or the cartilage that make up a backbone.*) Invertebrate is a name used for the largest lower section of the animal kingdom. Many in this group probably lived in or near the warm shallow water near the shore of an inland sea or ocean. Let's try an experiment to better understand what happens when animals lack a backbone or vertebrae.

Questions for Discussion:
Why do you think so many invertebrate animals live in water? (*Because of the support the water gives them.*) Examples: sponges, snails, and corals.

In the vertebrate (animals with backbones) group, what part is usually preserved by fossilization? (*The hard parts such as bones, teeth, and vertebraes.*)

Since there are no backbones in the invertebrates, what part would be fossilized? (*Their hard shells fossilize quite easily.*)

The majority of the fossils we collect are from invertebrates and are the most abundant.

Leader's Notes
Fill a balloon about $2/3$ full of water. Now put it over the back of a chair. There is no backbone to support it. What happens? It just flops around. Now lay it on a table. It stays straight because it has support. Put it in a pan of water — it will not flop around because the water holds it up.

You may want to talk about the different phylums.

Dialogue for Critical Thinking:

Share:

1. What happened when you put the balloon over the chair?
2. What did you think would happen?

Process:

3. How is the balloon like an invertebrate?
4. Do invertebrates have an advantage over vertebrates? Why? Why not?
5. How do invertebrates protect their bodies?

Generalize:

6. What non-bony parts of your body help protect you?

Apply:

7. What do you do to protect your skin, hair, etc.?
8. What type of invertebrate fossils can be found your area?

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Paleobotany

Fossils — Geology, Level I

What members will learn …

About the Project:

- Paleobotany is the study of ancient plants.
- How plants become fossilized.
- Who did some of the first collecting and studies of fossil plants in Kansas.

About Themselves:

- The concept of time.
- The importance of patience.

Materials:

- A geologic map of Kansas
- A geologic timetable
- A modern, small green leaf or fern
- Items needed to make homemade play-dough
- Example(s) of fossil fern, fossil leaf and petrified wood (if available)

Activity Time Needed: 2 to 2 ½ hours

Activity:

What is plaeobotany? (The word *paleo* is Latin meaning "ancient" and the word *botany* means "study of plants.")

Let's try an experiment with play-dough and modern leaves or fern. You can quickly duplicate the appearance of plant fossils. This process normally takes millions of years, but you can do it in about two hours.

Step 1) Make play-dough by using the following recipe.

1 cup flour

1 cup water

½ cup salt

2 teaspoons cream of tarter

1 tablespoon cooking oil

Mix the dry ingredients in a saucepan; add the oil and water to the dry ingredients. Cook three minutes or until the mixture pulls away from the sides of the pan. Store in an airtight container. It will keep for two weeks.

Step 2) Make a patty (¼" thick) large enough in diameter to press your modern leaf on.

Leader's Notes:

You will want to start this experiment first as it does take two hours to bake. You could have the play-dough made up ahead of time. Also, you may wish to perform this experiment ahead of time to show members completed example(s). This way the members do not need to be present for the entire two hours while they are baking.

Step 3) Gently press the leaf onto the surface of the play-dough being careful to make sure the leaf does not curl away from the play-dough and is completely flat.

Step 4) Place the patty with the leaf on a lightly oiled pie tin or cookie sheet and bake at 350 degrees for two hours.

Step 5) Remove the leaf from the oven and let it cool. After it cools, lightly spray the leaf and play-dough with a clear laquer to protect and preserve it.

Plants become fossilized in three ways.

Compression and Impression

You may wish to have a poster made up ahead of time with the definitions and examples of each if you have them.

This is the most common way of preservation. The fossilization process was started by leaves or small pieces of leaves falling into water, becoming waterlogged and sinking to the bottom of a swamp, river, lake or sea. As time passed, they were surrounded and then covered by fine soil particles, which pressed out the water and air until only the plant material remained. Deeper burial resulted in heat and pressure, which sometimes turned the plant material into a thin carbon film. While this was happening, the surrounding particles were being transformed into rock, usually shale or siltstone. In Kansas it is possible to have leaves fall into a sandy area and have the same thing happen.

Casts and Molds

These were formed when a plant part, usually some bulky part such as a trunk, branch or root was buried in the sand or mud. As time passed, the plant material rotted, and water carried the residue away. When, by chance, the walls of the cavity left by the plant parts were strong enough to resist crumbling, a hollow mold with the exact details of the outside of the plant part was created. When the cavity again filled with mineral matter, such as sand, a cast of the original specimen was formed. It is possible to find an empty mold and fill it with plaster-of-Paris and make your own cast of a specimen.

Petrification

This happened when plant material, usually a trunk or branch, fell into highly mineralized water. As the water slowly went away and the mineral formed, each cell of the original plant material was replaced leaving a hardened copy. Usually, the petrification is exact in every detail of the original cell structure. Calcite and quartz are examples of minerals that cause petrification.

Charles Sternberg Sr. in the late 1800s was one of the first persons that showed an interest in collecting fossil plants in Kansas. His discoveries in Ellsworth County, Kansas, started an interest by the best-known scientists in the country. These scientists in turn contacted him to collect other fossils in Kansas and later around the world. This is how the world famous Sternberg family of fossil collectors got their start.

Ask if any of your group have visited the Sternberg Museum in Hays, Kansas.

The age of a fossil plant can be closely estimated with the aid of a geologic map and geologic timetable. For example, a fossil fern is found in Douglas County, Kansas. The geologic map shows that Douglas County is in the Pennsylvania Period. By using the geologic timetable, you can see that the Pennsylvania Period was from 286 to 320 million years ago. Therefore, the fossil fern you have must be within that range.

Dialogue for Critical Thinking:

Share:

1. What happened when you made play-dough fossils?
2. How did your baked leaf compare to a real fossil?

Process:

3. How do plants become fossilized? (*Three methods*)
4. Why is the age of a plant fossil important?
5. How can you determine the age of a plant fossil?

Generalize:

6. If you spent two hours baking a leaf fossil, what did you learn about being patient?
7. Most fossils take millions of years, how can you explain how long a million might be? (**Note:** try to compare a million seconds, etc.)

Apply:

8. How can you better understand periods of time in relation to what you do? (*Consider fast food, computers, etc., to help them understand time.*)
9. How will this lesson help you be more patient in the future?

Going Further:

1. Visit a museum or rock shop and look at the plant fossils on display. Write a brief paragraph about the plant fossils you saw and share it with your group.
2. Make an educational display for your classrooms or county fair using your baked specimens and some plant fossils you have collected.

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How Did They Do That?

Fossils — Geology, Level II

What members will learn …

About the Project:

- How did bones and shell get in the rocks?
- Difference between molds, casts, imprints, and fossils.
- How fossils are preserved.

About Themselves:

- How to learn using comparisons.
- How to learn by experimenting.

Materials:

- Paper cup
- Paper plate
- Modeling clay
- Seashell
- Petroleum jelly
- Plaster-of-Paris
- Plastic spoon
- 2 dead insects or worms (flies, ants, etc)
- Varnish, sealer or laminating paper
- Small brush
- Activity Sheet 47, *Fossils: True and False*
- Activity Sheet 48, *Fossil Prints*
- Activity Sheet 41, *How Fossils are Formed* (from Level I Lesson: "You Ol' Fossil")

Activity Time Needed: 30 to 45 minutes

Activity

How is it possible for the imprint of a leaf or the footstep of a bird or beast or the bones and teeth of a fish to get shut up in the rocks?

They got in before the rocks became hard. The animals and bones got in when the rocks were still forming or in the making when they were just loose sediments. Those sediments on which they fell or were dropped in when they died were then the surface. Sand, mud, and usually water filled in and covered them rapidly. Sediments continued to make layers on top of each other and later the mud and sediments turned to stone sealing in the fossils (dead animals or plants).

Leader's Notes:

See lesson using the Peanut Butter Sandwich experiment to help them understand the process of fossils getting sealed up in the rocks. Use raisins or a leaf to show fossils.

Activity Sheet 41, *How Fossils are Formed*, from the Level I lesson "You Old Fossil" will help review this process.

A great majority of fossils are found in sediments that were deposited under water. The marine sedimentary rocks were deposited under conditions that were favorable for organisms during life and which helped preservation after death.

Mount St. Helen erupted in 1980 with ash covering 150 square miles north of it. A good magazine to check out of the library would be *Earth,* April 1995 issue.

A few organisms are covered by wind blown sand on deserts or beaches or by falling ash from volcanic eruptions. Can you think of a volcano that erupted in the United States and ash covered trees, animals and everything around it for miles? Why don't volcanoes leave many good fossils? (*Usually the ash and lava is too hot to preserve the dead organisms.*)

A fossil is any natural preserved part, trace, or entire remains of an animal or plant that lived in the past.

Let's think about the different ways a fossil can be formed and the difference between these groups.

You may want to hand out the Activity Sheet 47, *Fossils: True & False* to do as you talk about this lesson, or you may want to wait until the end to do it.

There are five ways a fossil can be made:

1. Preservation without change.
2. Replacement by a mineral.
3. Hollow space in a shell or bone is filled in by a mineral.
4. Imprint is formed or filled.
5. Thin carbon film is formed.

Organisms or parts of organisms are commonly preserved (fossilized) in four general conditions:

1. With the hard parts unaltered or slightly altered
2. With the hard parts completely remineralized
3. As a mold
4. As casts and steinkerns

Mold

Hand out the Activity Sheet 48, *Fossil Prints*. This experiment will help members understand molds and casts.

A mold is when a shell, plant, or animal would be buried in soft mud. The mud would harden into rock, then the shell or animal would rot or dissolve away and leave an impression of the shell in the rock. The handprint you made to give your parents or grandparents at Christmas is an example of a mold.

Cast

Sometimes material fills a mold and then hardens. The hardened material is the same size and shape of the plant or animal that left the mold. A cast does not contain any part of the original animal. It was formed inside the mold fossil. It is shaped like the living thing. (Soft bodied plants and animals leave fossils in the form of molds and casts.)

The definition of a steinkern is the consolidated mud or sediment that filled the hollow interior of a fossil shell or other organic structure (such as a bivalve shell).

Petrification and Permineralization

The replacement by minerals is when a plant or animal remains are covered over and decay is taking place. When the water that passes through the soil carries dissolved minerals, the minerals can enter the remains of the dead plants or animals and replace some or all of the original plant or animal. It is petrified and has a mineral replacement. The minerals are deposited in the empty space where the organic substances have decayed away. This process may happen very slowly and the mineral matter duplicates the structures or it may be so fast that no trace of the original structure remains. Calcium carbonate, silica and iron sulfide are common replacement compounds.

Burial

When a plant or animal is covered by sand or soil the decay the process is slower than when it is exposed to the air. Teeth, shells, bones and other hard parts do not decay as fast as soft parts.

Find two dead insects (flies, ants, etc.) and place each on a board. Leave one as it is but the other one you are going to preserve by keeping the air from it. Cover it with several coats of varnish or sealer or seal it with self-applying laminating film. Which do you think will last longer?

Bring examples or do at the meeting.

Tar, Amber, Ice

Discuss other ways prehistoric life was preserved. For example, skeletons of saber-toothed tigers have been found in the tar pits of California, and mammoth elephants have been frozen in the glaciers of Siberia. Flesh and other soft parts, sometimes whole plants or animals, have been preserved under these unusual conditions, but this is not common. Another unusual preservation process is displayed when you find insects in amber.

Amber is the fossil resin from coniferous trees. It is usually yellow or brown and transparent. Insects would become stuck in it and die. The library may have pictures that show amber and fossils in ice or from the tar pits. Amber is very popular for jewelry.

Distillation — Carbon Imprints

Many plant fossils have been preserved when the nitrogen, oxygen and hydrogen have been removed, leaving only a black carbon film preserved in the rock.

Prints — Trace Fossils

Animals walking over soft mud have left footprints. Some animals laid down in mud and left body prints that were preserved. These prints are outlines that were made on soft mud that later hardened. Footprints can tell us how an animal walked and how big it was. Body prints tell us the shape of the body and, sometimes, how skin looked. Look for footprints, animal tracks or writing on concrete driveways or sidewalks. You may also see footprints of birds or animals in a dry riverbed or shoreline. These simulate very well how fossil impressions are made. If you put a footprint in cement it would remain, but if it were put in snow it would soon disappear. Other examples of trace fossils are: teeth marks, excrement, stomach stones and trails.

Burrows are often found in Kansas. They were likely formed by shellfish, etc. burrowing in mud. Trails and burrows are the most common trace fossils in Kansas.

The following are commonly mistaken for fossils, but are not:

Pseudofossils are inorganic objects that bear a superficial resemblance to things of organic origin, but have never been alive.

Dendrites are dark branching patterns that occur on the surface of different rocks. They resemble ferns and plant fossils. They are mineral deposits of some manganese oxide or iron oxide. They are usually much smaller then true ferns.

As you go through these descriptions continue to remind the members what a fossil is. Emphasize these are not fossils.

Bring samples to show when possible.

Note: Glacial Striations can only be found in the Northeast corner of Kansas.

Glacial Striations and Slickensides are grooves produced by glaciers moving over a rock. Striations are produced when two rock units move past each other along a fault. Slickensides is a polished rock surface caused by one rock sliding over another.

Concretions and Weathering Products often resemble fossils. They are the results of inorganic forces rather than the remains of animals. Septarian concretions and core-in-core are the two things most commonly mistaken for fossils in Kansas.

Vertical Tubes look like burrows made by worms usually in sedimentary rocks. Some of these may be from the escape of gas bubbles through the sediment while it was changing into sedimentary rock.

Raindrop Prints, Ripple-marks, and Mud Cracks are formed through natural, inorganic phenomena. The use of the word fossil for these is inaccurate.

Dialogue for Critical Thinking:

Share:

1. What happened when you made your cast and mold prints?
2. What types of fossils do you like to collect? Why?

Process:

3. What are some of the ways fossils are made?
4. What is the difference between a mold and a cast? (*In a mold the area where the fossil was is empty. A cast is filled in part of a mold. Mold is outside, cast is inside.*)
5. What happens in petrification? (*Mineral replaces original material.*)

Generalize:

6. What did you learn about yourself as you compared different fossilization processes?
7. How do comparisons and experimentation help you learn about other things?

Apply:

8. How can you use comparisons, processes, and experimentation to learn in the future?

Going Further:

1. Find some specimens that look like fossils but aren't.
2. Find examples of the various fossil look-alikes discussed above.
3. See how many different mineral replacements you can find in your fossils.

References:

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Culver, Diann, *Dinosaurs, Thematic Unit*, Teacher Created Materials, Inc., Huntington Beach, CA 1993.

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Author: Sara Murphy, 4-H Geology Curriculum Team

Reviewed by: Rex Buchanan, Geologist, Kansas Geological Survey

James P. Adams, Associate Professor, 4-H Youth Development, Kansas State University

Activity Sheet 47, *Fossils: True and False*,

True/False Answers:

1. F
2. T
3. F
4. F
5. T
6. F
7. F
8. T
9. T
10. F

Word Scramble Answers:

1. Fossil
2. Mold
3. Cast
4. Print
5. Sediment

Matching Answers:

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

How Did They Do That?

Activity Sheet 47, Fossils: True and False

Fossils — Geology, Level II

True/False

True — Write T on the line next to the number of the sentence that is true.

False — Write F if the sentence is false.

1. ____ Every organism becomes a fossil.
2. ____ There are more teeth fossils than skin fossils.
3. ____ Most fossils were found in igneous rock.
4. ____ All fossils were laid down in water.
5. ____ Most fossils were laid down in water.
6. ____ Dinosaurs left footprints wherever they walked.
7. ____Molds and casts are actual remains.
8. ____ Molds were made before casts.
9. ____ Molds and casts show the actual size of organisms.
10. ____ There are some fossils of every organism that ever lived.

Word Scramble

Unscramble each of the following to form a word or term that you have just learned.

1. SLOSFI ______________________________________
2. LOMD ______________________________________
3. TACS ______________________________________
4. TRIPN ______________________________________
5. TEDMINSE ______________________________________

Matching

Match the two lists. Write the correct letter on the line next to each number.

1. ____ fossil	a) always laid down on land
2. ____ fossil prints	b) least likely to become fossils
3. ____fossil molds	c) most likely to become fossils
4. ____organisms with no hard parts	d) any clue to past life
5. ____organisms with hard parts	e) most are formed in water

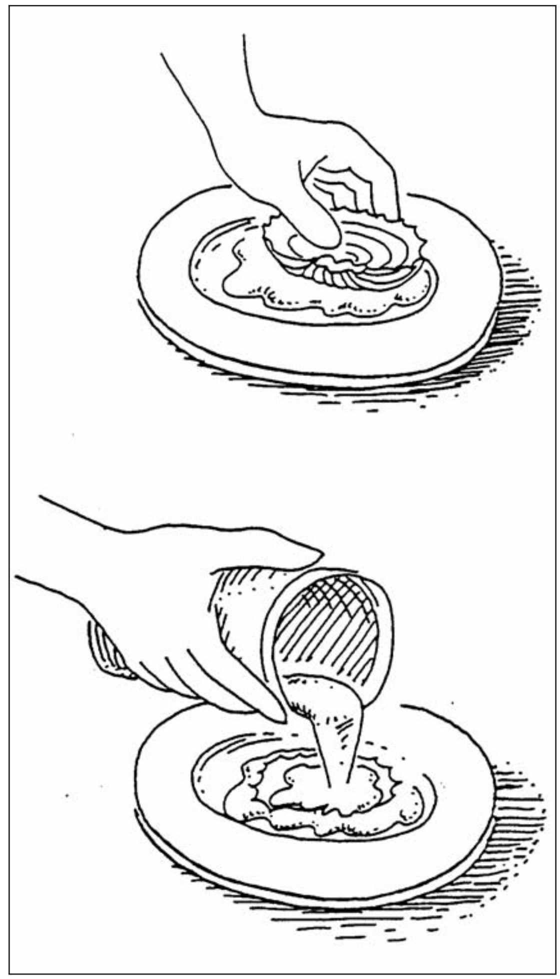
How Did They Do That?

Activity Sheet 48, Fossil Prints

Fossils — Geology, Level II

Purpose:

To determine how fossils were preserved.



Materials Needed:

- paper cup
- paper plate
- modeling clay
- seashell
- petroleum jelly
- plaster of Paris
- plastic spoon

Procedure:

- Place a piece of clay about the size of a lemon on the paper plate.
- Rub the outside of the seashell with petroleum jelly
- Press the seashell into clay.
- Carefully remove the seashell so that a clear imprint of the shell remains in the clay.
- Mix 4 spoons of plaster of Paris with 2 spoons of water in the paper cup.
- Pour the plaster mixture into the imprint in the clay. Throw the paper cup and spoon away.
- Allow the plaster to harden, about 15-20 minutes.
- Separate the clay from the plaster mold.

Results:

The clay has an imprint of the outside of the shell, and the plaster looks like the outside of the shell.

Why?

The layer of clay and the plaster are both examples of fossils. The clay represents the soft mud of ancient times. Organisms made imprints in the mud. If nothing collected in the prints, the mud dried, forming what is now called a mold fossil. When sediments filled the imprint, a sedimentary rock formed with the print of the organism on the outside. This type of a fossil is called a cast fossil.

Fossil Detective: Fossil Classification

Fossils — Geology, Level II

What members will learn …

About the Project:

- How to identify fossils.
- To develop an understanding of the basis of classification of fossils.
- How symmetry helps identify fossils.
- How to tell the difference between vertebrates and invertebrates.

About Themselves:

- How each fossil belongs to a family like people do.
- How dividing a large group into smaller subgroups by similarities and differences helps to understand classification.
- How fossils record life like your diary.

Materials:

- A collection of fossils that members have collected
- Newspapers
- A magnifying glass
- A fossiliferous limestone slab
- Member Handout 27, *Vertebrate and Invertebrate Animals*
- Member Handout 28, *Symmetry*
- Member Handout 29, *Mollusks*
- Activity Sheet 49, *Vertebrate and Invertebrate Animals Chart*
- Activity Sheet 50, *Vertebrate and Invertebrate Animals Chart, Leader's Key*

Activity Time Needed: 30-45 minutes

Activity

Plants and animals are unique, just as humans are. Everything, every group, needs a name. What is your family name? Who gave it to you? Were you named after someone else? Do you have a special nickname?

Today we are going to talk more about names and how to identify fossils by grouping them together. Fossil hunters are like a detective solving a crime. They must gather clues, assemble them, and finally determine what they mean. In this lesson, you will have a chance to be a "fossil detective." You will become familiar with various types of evidence found in the rock record and you can use information to learn about past environments, history, and types of plants and animals that lived, which will help us to learn to classify and identify our fossils.

Leader's Note

Be especially sensitive to the children, i.e. some may come from families with several names and members may not live with their parents, etc.

You may want to give each member a magnifying glass and use some props, such as a cap, to pretend to be detectives.

Most fossils are found in sedimentary rocks. Sedimentary rocks are layers of settled sediments. Igneous and metamorphic rocks do not have favorable conditions for preserving fossils because of the way these rocks were formed, the heat and pressure.

Imagine you are examining a rock outcrop. There are several types of rocks here. What type would you most likely find fossils in? Why? The most common feature of sedimentary rock is layering. Each layer or bed of rocks gives clues to the conditions under which it was originally deposited as sediment. As the different layers were deposited, plants and animals died and were trapped in them. They left clues or traces behind to help us solve the mystery.

Fossils are unique storehouses of information. The level or rock in which fossils are found provide clues as to when and where the animal lived. Teeth are clues to what kind of food it ate. The dimensions of the internal cavities in the skull may reveal the size and shape of the brain, which helps us determine how intelligent the creature may have been. Footprints hint at how their maker walked and at what speed, whether it traveled in herds or alone, and if it moved on two feet or four. We can tell if the corals lived in shallow or deep water and the temperatures and reef conditions.

The distance between the footprints is a stride. A large animal takes long strides, while a small animal takes very small strides.

Common names change from place to place, but scientific names are universal. Latin names were used because they could be understood around the world. This system is used around the world. Latin names (scientific) may seem hard to pronounce because we don't commonly use them, but scientists use this system to communicate their finds and understand each other clearly.

Perhaps you can give some examples of Latin names, or you may want to talk to a Latin student or teacher to understand this better. Perhaps an older member is taking a Latin course at school and would like to share some terms and names, as well as pronounce the fossil names.

Have you had much luck at identifying fossils up to this point of the project, or did you have someone help you or do it for you?

One way to become familiar with a large group of things, is to divide the larger group into smaller groups, based on similarities and differences. Grouping, or classifying, makes it easier to remember how the members of the small group are alike and how they are different from other groups.

The Linnaean System of Classification is based on structures that indicate relationships among groups of living things. This system is used both for living and fossil forms of organisms.

Now, focus on the fossils that you have brought to the meeting. First, group all specimens that are alike together. Determine the Kingdom. There are six Kingdoms:

Spread newspaper on the tables because most fossils will not be clean. You may wish to bring some extra fossils for someone who doesn't have very many, or for those who have forgotten theirs.

Kingdom:	Organism:
Archaebacteria	Primitive bacteria
Eubacteria	Cyano bacteria
Fungi	Mushrooms and relatives
Protists	Single cells
Plantae	Plants
Animalia	Animals

Determine which of the six Kingdoms the fossil belongs to. The two main kingdoms are the plant and animal kingdoms, so this should be pretty easy. The majority of the fossils collected will be from these Kingdoms.

Provide Member Handout 27, *Vertebrate and Invertebrate Animals*, and Activity Sheet 49, *Vertebrate and Invertebrate Animals Chart*.

Next, decide whether it is a vertebrate or invertebrate organism. An animal with an internal skeleton of cartilage or bone is said to have vertebrae (backbone) or a spinal cord. Invertebrate animals don't have a backbone — mollusks, arthopods, brachiopods, cnidarias, and the bryozoas. Invertebrate animals are the most abundant fossils and are the most useful to geologists in studying sedimentary rocks. Fossils are like a picture book. The story of life and clues are there for us to see and study in the fossil bearing rocks.

Refer to the lesson on Vertebrates and Invertebrates that explains the difference between them.

Next, divide your groups into smaller groups, taking out the brachiopods and mollusks. You may do this by looking at the symmetry. Each valve of the pelecypods is nearly a mirror-image of the other, so that the plane of symmetry lies along the line at which the valves join. This is true of most clams. Brachiopods are quite different. Their valves are seldom similar, the plane of symmetry that divides the animal into mirror-image halves passes vertically down the midline of cuts between the valves of a clam (mollusks) and across the valves of a brachiopod.

Use Member Handout 28, *Symmetry* to help members understand this. Symmetry is the orderly arrangement for the parts of an object with reference to lines, parts, or points. A valve is the device that is used to open or close the shell. Show the diagram of brachiopod and mollusks.

Brachiopods are further divided into the articula and then inarticulates. The articulates have two valves that have a well-developed hinge and muscle system. The inarticulateshave a hing that is poorly developed and the pedicle emerges from between the valves instead of from an opening in one valve. (Can you see a hole in the articulates? Can you see the difference?) The valves are commonly held together by muscles and have no hinge-teeth or dental sockets.

Use Member Handout 29, *Mollusks* to show the differences.

The three main classes of Mollusks are:

Gastropods or snails: have a single valve shell that is typically coiled.

Bivalves (Pelecypods): clams, oysters and fresh water mussels have shells composed of two halves, usually, but not always of equal size.

Cephalopods: squids, nautilus and the ammonoids have a shell of one valve, usually coiled and partitioned by septa.

Septa is wall separating two cavities or masses of softer tissue in an organism.

Now group all specimens of each phylum and class into smaller categories so the fossils in each category are essentially the same. You will now be identifying to the genus level. Pay special notice to the size and individual characteristics. Sometimes you will not be able to classify down to the genus.

You will now need a magnifying glass to examine specimens.

Some good books you might use are:

Ancient Life Found in Kansas Rocks (from the Kansas Geological Survey)

Invertebrate Fossils (Moore, Lalicker, Fischer)

Fossils (A Golden Guide)

Record in Rock (University of Nebraska)

Dialogue for Critical Thinking

Share:

1. What portion of the activity was the hardest? Why?
2. What type of fossil is easiest to identify? Why?

Process:

3. Why is fossil history important?
4. Why are most fossils found in rocks laid down by water?
5. How do you tell the difference between vertebrate and invertebrate fossils?

Generalize:

7. How does dividing items into groups help you learn?
8. What is the importance of symmetry in things other than fossils?

Apply:

9. Why is family history important?
10. How does you family keep track of their ancestors' history?

Going Further:

1. Talk to your grandparents or some older member of the family. Have they kept a diary from long ago? Perhaps someone has researched their family tree. Have them share something interesting about this.
2. Encourage members to learn about their family history when they are with their relatives, just as we are learning the history left by fossils, it's as if the fossils kept a diary for us. Each family has its history.
3. Observe a fossiliferous rock. Try to see how many different kinds of specimens you can find. It is suggested that younger members learn the Kingdom and Phylum of the fossils. As the members get older and their knowledge increases, they should learn the class and genus of fossils.
4. Explore why there are now six kingdoms instead of four.

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Fossil Detective: Fossil Classification

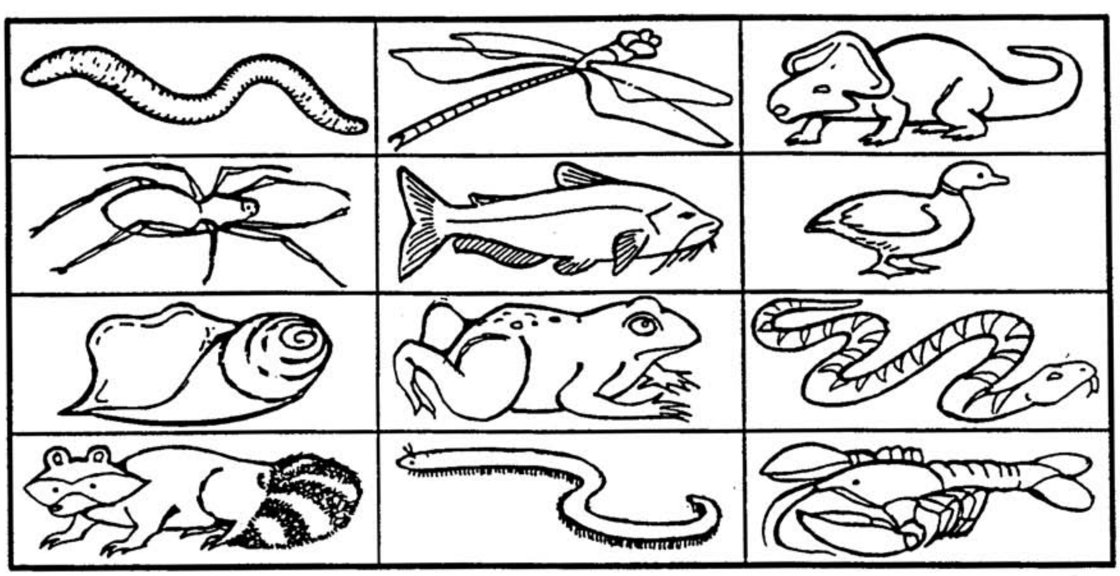
Member Handout 27, Vertebrate and Invertebrate Animals

Fossils — Geology, Level II

All animals are classified into two major groups: vertebrate and invertebrate. Vertebrate animals include all animals that have a backbone or spine. Invertebrate animals include all animals without a backbone or spine. Classify the animals below (on the activity sheet, next page) into vertebrate/invertebrate groups, then into a subgroup, then by the name of the animal, and finally by the picture of the animal. (Cut out the picture and glue it to the chart.) Use the words from the word box th help identify the animals.

Word Box

Animal Subgroups		Animal Names	
Mammal	Insect	dragonfly	conch
Bird	Snail	earthworm	snake
Reptile	Spider	thousand leg	raccoon
Dinosauria	Crustacean	brown spider	catfish
Fish	Worm	protoceratops	lobster
Amphibian	Centipede/Millipede	duck	frog



Fossil Detective: Fossil Classification

Activity Sheet 49, Vertebrate and Invertebrate Animals Chart

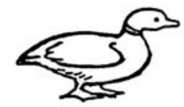
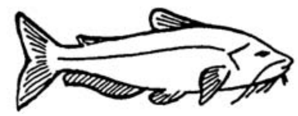
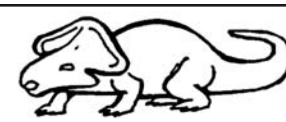
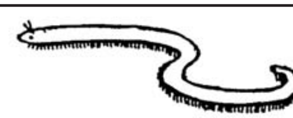
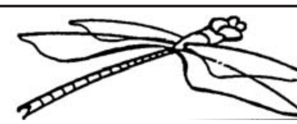
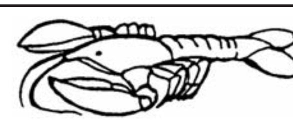
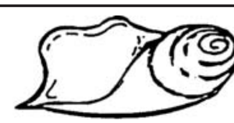
Fossils — Geology, Level II

Major Group	Subgroups	Name	Picture

Fossil Detective: Fossil Classification

Activity Sheet 50, Vertebrate and Invertebrate Animals Chart, Leader's Key

Fossils — Geology, Level II

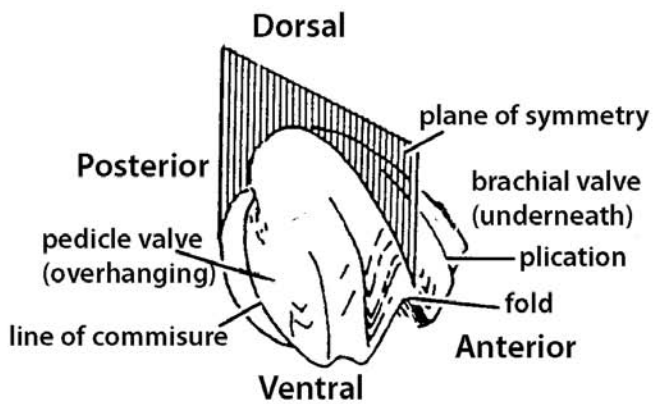
Major Group	Subgroups	Name	Picture
vertebrate	Reptile	snake	
vertebrate	Bird	duck	
vertebrate	Fish	catfish	
vertebrate	Amphibian	frog	
vertebrate	Mammal	raccoon	
vertebrate	Dinosauria	protoceratops	
invertebrate	Worm	earthworm	
invertebrate	Centipede/Millipede	thousand leg	
invertebrate	Insect	dragonfly	
invertebrate	Crustacean	lobster	
invertebrate	Snail	conch	
invertebrate	Spider	brown spider	

Fossil Detective: Fossil Classification

Member Handout 28, Symmetry

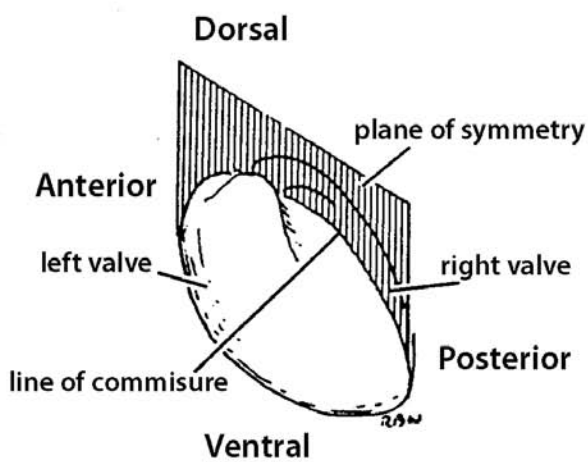
Fossils — Geology, Level II

Equilateral Symmetry (Brachiopod)



Right and left are the same; valve halves are different.

Bilateral Symmetry (Clam)



The two valve halves are the same.

Fossil Detective: Fossil Classification

Member Handout 29, Mollusks

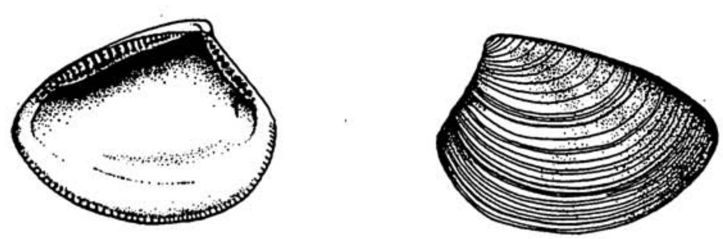
Fossils — Geology, Level II

Note: When you see an X beside a fossil picture, such as X1 or X2, it means the picture has been enlarged that much from the actual size of the fossil.

1. Gastropods

Turritella
x1

Bivalvia
2. Pelecypods

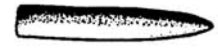


Nucula
x2

3. Cephalopods

Acanthoceras
x 1/2

Baculites
x 1/2



Belemnite
x 1/2

Paleobotany

Fossils — Geology, Level II

What members will learn …

About the Project:

• Terminology for identifying plant fossils.

About Themselves:

• Observation techniques.

Materials:

• Member Handout 30, *Plant Fossil Terminology*
• Member Handout 31, *The Classification of Kansas Plant Fossils*
• Activity Sheet 51, *Plant Fossil Identification*
• Activity Sheet 52, *Plant Fossil Identification, Leader's Key*

Activity Time Needed: 45 minutes

Activity

To identify plant fossils it is necessary to understand the terminology associated with fossil and modern plants. Understanding the plant fossil classification handout will make it easier to identify the fossils. We will go over the terms before we do the activity sheet.

Member Handout 31, *The Classification of Kansas Plant Fossils*, can also be used to help you identify specimens. **Plant classifications often use the term "division" instead of the term "phylum" used in the animal classification. Plant classification is not as consistent as animal classification so you may find different arrangements in different books.**

Dialogue for Critical Thinking

Share:

1. What fossil terms did you know?
2. What fossil terms were difficult to learn? Why?

Process:

3. What are angiosperms?
4. What are gymnosperms?
5. What are monocots?
6. What are dicots?

Leader's Notes

Review the Member Handout 30, *Plant Fossil Terminology*.

Provide Activity Sheet 51, *Plant Fossil Identification*.

Use Member Handout 31, *The Classification of Kansas Plant Fossils* to aid with this lesson.

Generalize:

7. How do you prefer to learn identifying characteristics of plant fossils? Why?
8. What observation techniques do you use to identify fossils?

Apply:

9. What reference do you use most to help identify plant fossils? Why?
10. What plant types are found in your area?
11. What other areas do you use the observation skills learned in geology?

Going Further:

Take a field trip to a local museum or university to see their collections of fossil plants and with their help, try to determine into which of the terminologies they fall. Look for modern or fossil examples of as many terms as you can find.

References:

Andrews, Henry, *Studies in Paleobotany*, John Wiley and Sons, New York, 1961.

Arnold, Chester, *An Introduction to Paleobotany*, McGraw-Hill, New York, 1947.

Bates, Robert and Jackson, Julia, *Dictionary of Geological Terms*, Doubleday, New York, 1984.

Case, Gerard, *A Pictorial Guide to Fossils,* Van Nostrand Reinhold, New York, 1989.

Gillespie, William, Clendening, John, and Pfefferkorn, Hermann, *Plant Fossils of West Virginia,* West Virginia Geological and Economic Survey, Morgantown, 1978.

Lapidus, Dorothy, *Dictionary of Geology and Geophysics*, Facts on File Publications, New York, 1987.

Authors:

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Paleobotany

**Member Handout 30
Plant Fossil
Terminology**

Fossils — Geology, Level II

Algae: Algae is a widely diverse group of photosynthetic plants, almost exclusively aquatic, that includes seaweeds and fresh water forms. They range in size from one cell to the giant kelps which can be 30 feet long. Although they are considered primitive because they lack true leaves, roots, stems and vascular systems, they have varied and complex life cycles.

Moss: Mosses are various small, green, non-flowering plants that often form a dense matlike growth.

Club Moss: Club Mosses are small plants that creep on the ground, send up stalks and branches, and reproduce by means of spores borne in cone-like organs.

Horsetail: Horsetails are also called Scouring Rushes. Horsetails have long, slender and straight stems that are jointed. The genus Calamites is the most common Pennsylvanian period Horsetail. Some of the species of Calamites grew to a height of 40 feet and stems 3 inches in diameter are common. Their stems were upright and grew from roots. The roots of Calamites are like the roots of modern corn plants. Clusters of slender leaves also grew from the joints, especially on young branches. Generally found in shales.

Seed Fern: Seed Ferns resembled tree ferns in shape, while some others grew close to the ground or formed vines. Fronds were normally arranged spirally on the stems and/or trunks. Seeds or seed-like structures were situated on the foliage and were not borne in cones, thus they are different from the conifers.

True Fern: True Ferns had a great variety of growth forms, ranging from small to some that formed trees. True Ferns look similar to Seed Ferns, but there are differences. True Ferns reproduce by spores, not seeds. Also, the fronds were at the end of the stem or at the top of the trunk.

Cycad: A Cycad is a palm-like tree. They have stout trunks. They were both small plants and large trees. Seeds and pollen-bearing organs are situated on cone-like structures called STROBILI and on cones. Pollen is borne on one plant, while seed cones are borne on another.

Cycadeoids: Cycadeoids are another group of palm-like trees. They originated and became extinct during the Mesozoic Era.

Ginkgoes: Ginkgoes (Ginko) are another form of palm-like trees. They originated and became almost extinct during the Mesozoic Era. Only one living species remains, Ginkgo biloba (maidenhair tree).

Cordaites: Cordaites were Gymnospermous trees that existed from the upper Mississippian Period into the Triassic Period. There are no living representatives. They have strap shaped, parallel veined leaves.

Voltziales: Voltziales are conifers. It is believed that the Voltziales may have been the transitional plants between Cordaites and conifers. Voltziales leaves are needle-like and have the appearance of pine trees. A good example of a Voltziales is Walchia.

Conifer: Conifers are Gymnospermous trees having needle-like foliage and seeds borne in cones.

Monocotyledon: Monocotyledons are flowering plants with one embryonic leaf and parallel-veined leaves. In other words, a monocot has only one fertile leaf.

Dicotyleon: Dicotyleons are flowering plants with two embryonic and branching leaves. In other words a dicot has two fertile leaves.

Paleobotany

Activity Sheet 51, Plant Fossil Identification

Fossils — Geology, Level II

Draw a line to match the name with the picture.

Horsetail

Seed Fern

True Fern

Cordaites

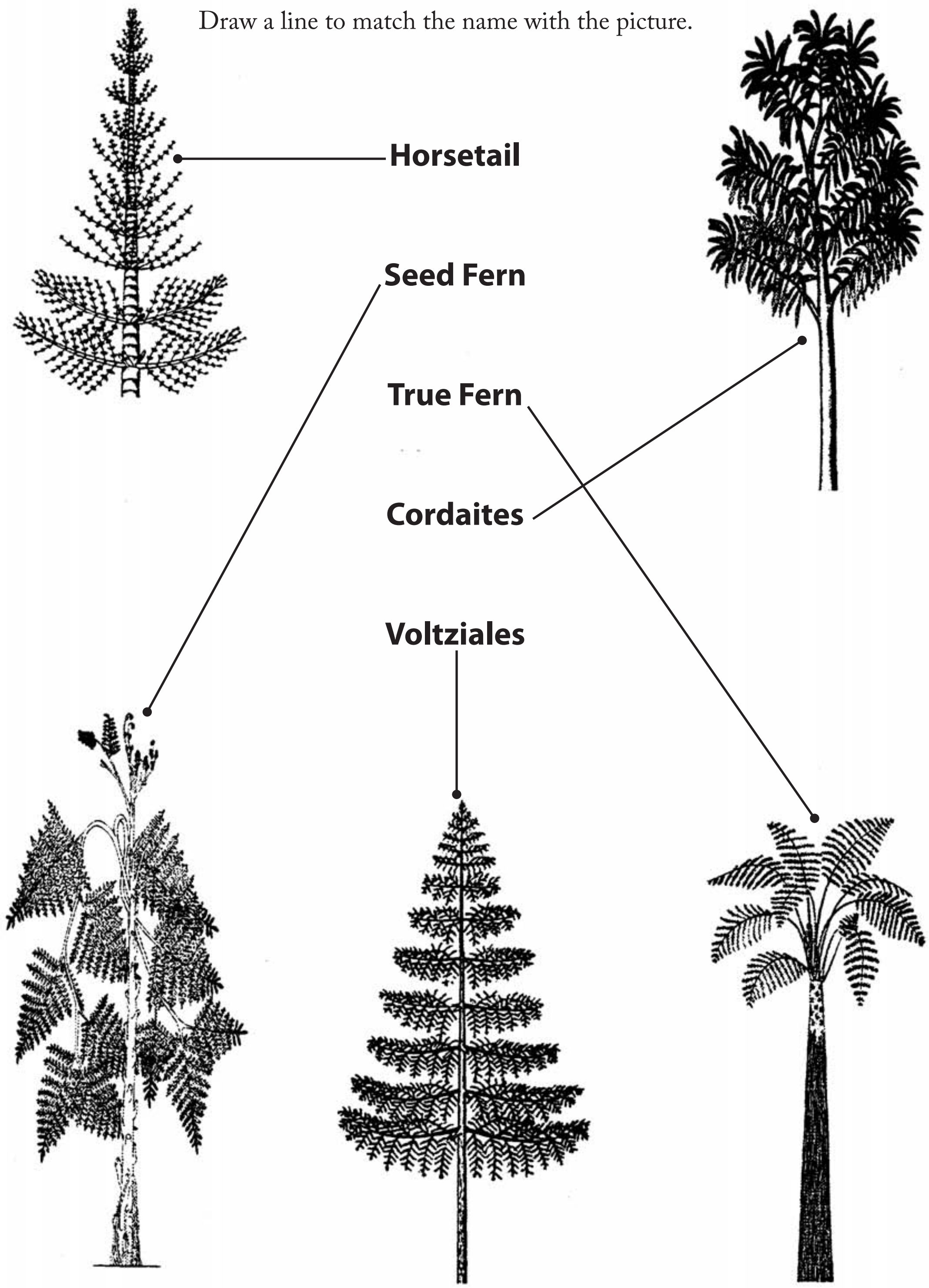
Voltziales

Paleobotany

**Activity Sheet 52,
Plant Fossil
Identification
Leader's Key**

Fossils — Geology, Level II

Draw a line to match the name with the picture.



Paleobotany

Member Handout 31, The Classification of Kansas Plant Fossils

Fossils — Geology, Level II

Kingdom: Monera
- **Phylum:** Cyanobacteria (blue-green bacteria or blue-green algae)

Kingdom: Plantae
- **Phylum:** Rhodophyta (red algae)
- **Phylum:** Chlorophyta (grass – green algae)
- **Phylum:** Bryophyta (Mosses – Pennsylvania to recent)
- **Phylum:** Tracheophyta (vascular plants)
  - **Class:** Lycopsida (Club Mosses)
  - **Class:** Sphenopsida (Horsetails)
  - **Class:** Filicopsida (True Ferns – Devonian to recent)
  - **Class:** Gymnospermospida (Spore producing)
    - **Order:** Pteridospermales (Seed Ferns – Devonian to Jurassic)
    - **Order:** Cycadales (Cycads – Permian to Recent)
    - **Order:** Cycadeoidales (Cycadeoids – Triassic to Cretaceous)
    - **Order:** Caytoniales (Caytoniales – Triassic to Cretaceous)
    - **Order:** Glossopteridales (Glossopterids – Pennsylvanian to Jurassic)
    - **Order:** Ginkoales (Ginkoes – Triassic to recent)
    - **Order:** Cordaitales (Cordiates – Pennsylvanian to Permian)
    - **Order:** Voltziales (Voltziales – Pennsylvania to Triassic)
    - **Order:** Coniferales (Conifers – Triassic to recent)
  - **Class:** Angiospermopsida (Flowering plants)
    - **Subclass:** Monocotyledonae (Monocots, Grass – Cretaceous to recent)
    - **Subclass:** Dicotyledonae (dicots, higher flowering plants, Cretaceous to recent)

Note: Terms "Phylum" and "Division" are often used for the same level of classification in different references.

Vascular and Nonvascular Plants

Fossils — Geology, Level III

What members will learn …

About the Project:

- Plant fossil terminology
- Two types of plant reproductive systems (Gymnosperms and Angiosperms)

About Themselves:

- How their circulation system compares to plants.
- How plants and animals obtain vital nutrients.

Materials:

- A fresh stalk of celery
- Red food coloring
- A small glass
- 1 cup of water
- A modern leaf showing the veins
- A fossil leaf or pinna showing the veins (if available)
- A geologic map of Kansas
- A geologic timetable
- A magnifying glass
- Pencils
- Member Handout 32, *Vascular Structures*
- Activity Sheet 53, *Vascular and Nonvascular Plants*
- Activity Sheet 54, *Vascular and Nonvascular Plants, Leader's Key*
- Member Handout 33, *Plant Fossils from Pennsylvanian and Permian Periods*

Activity Time Needed: 1 hour

Activity

1) We are going to try this experiment

Step 1) Add the cup of water to a small glass or jar

Step 2) Add a few drops of red food coloring to the water

Step 3) Cut a fresh stalk of celery at both ends and stand one end in the glass or jar.

Notice, after a while, that the red color will work its way to the end of the celery that is not in the water.

Leader's Notes

Have your group work in pairs to perform this experiment. As the celery sits in the colored water, discuss the terms on Member Handout 32, *Vascular Structures*. Then check the experiment.

This is how nutrients travel through the veins and feed the plants.

Pass around a modern leaf and point out the veins.

2) Discuss the terms Vascular and Nonvascular

a) **Vascular:** A vascular plant is a plant that has a fully developed circulatory system that can carry nutrients through the roots, trunk, branches, leaves, seeds, fruit or flowers. The nutrients are carried throughout the plant by way of veins, which can easily be seen on a leaf. A good example of a Vascular plant would be a tree.

Use Member Handout 33, *Plant Fossils from the Pennsylvanian and Permian Periods*.

b) **Nonvascular:** A Nonvascular plant is a plant that does not have a fully developed circulatory system, in other words it would not have roots, a trunk, branches or leaves. A good example of a Nonvascular plant would be algae.

3) Discuss the terms Angiosperm and Gymnosperm

a) **Angiosperm:** An Angiosperm is a plant that reproduces via flowers and fruits. The Angiosperm originated during the Cretaceous Period. A good example of an Angiosperm would be an apple tree.

b) **Gymnosperm:** A Gymnosperm is a plant that reproduces by way of seeds and spores which are held in cones, but does not flower or bear fruit of any kind. A good example would be a pine tree.

Use the diagram on Member Handout 32, *Vascular Structures* to explain terms. Distribute Activity Sheet 53, *Vascular and Nonvascular Plants* to each member. Discuss answers.

4) Discuss the terms Leaf, Pinna, Pinnule, Frond, and Lobe.

a) **Leaf:** A Leaf is a flattened plant structure attached to a stem. It is the principle organ of photosynthesis.

b) **Pinna:** Pinna are the leaves that make up a Frond.

c) **Pinnule:** Pinnules are the small leaflets that make up a Pinna.

d) **Frond:** A Frond is made of several pinna.

e) **Lobe:** A Lobe is a pointed or rounded portion of a leaf that protrudes outward.

Dialogue for Critical Thinking

Share:

1. What happened to the celery stick in the experiment? Why?
2. What type of plant circulatory system is in the celery?

Process:

3. What is the difference between vascular and nonvascular?
4. What is the difference between an angiosperm and a gymnosperm?

Generalize:

5. How is a plant circulatory system similar and different from an animal circulatory system?
6. How do plants and animals obtain vital nutrients?

Apply:

7. Why do we not find fossils of many of the plants we see everyday?
8. What kinds of plants do we still have today that are also found as

fossils? Why?

Going Further:

1. Take a field trip and collect a few modern or fossil plants and try to determine whether they are Angiosperms or Gymnosperms. Also, try to determine whether they have Pinnules, Pinna, Fronds or Leaves with single or multiple Lobes.

References:

Andrews, Henry, *Studies in Paleobotany,* John Wiley and Sons, New York, 1961.

Arnold, Chester, *An Introduction to Paleobotany*, McGraw-Hill, New York, 1947.

Bates, Robert, and Jackson, Julia, *Dictionary of Geological Terms*, Doubleday, New York, 1984.

Gillespie, William, Clendening, John, and Pfefferkorn, Hermann, *Plant Fossils of West Virginia,* West Virginia Geological and Economic Survey, Morgantown, 1978.

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Lesquereux, Leo, *The Flora of the Dakota Group*, Government Printing Office, Washington D.C., 1891.

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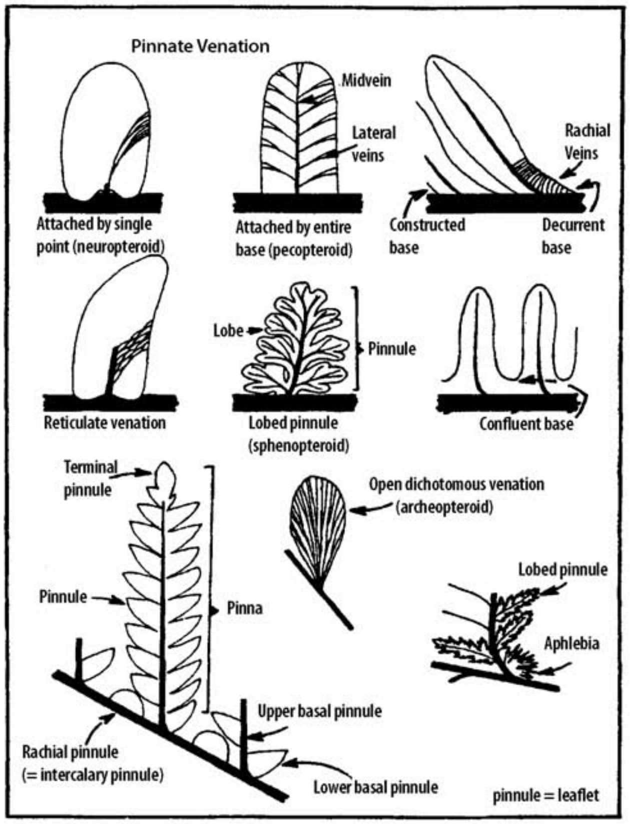
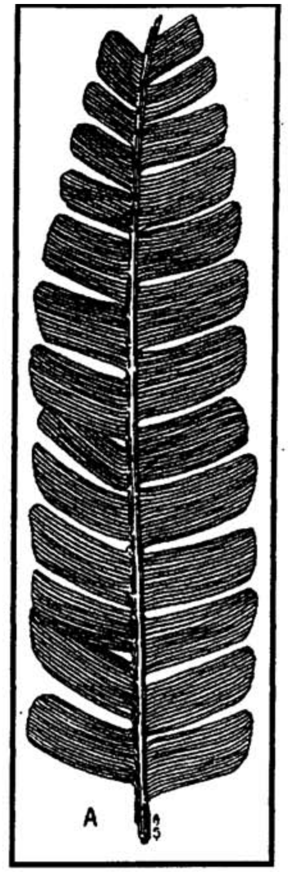
Vascular and Nonvascular Plants

Member Handout 32, Vascular Structures

Fossils — Geology, Level III



Examples of Fern Pinnules



Example of a Pinna from a fern

A leaf showing three lobes; there are three main veins

An example of a fern frond

Vascular and Nonvascular Plants

Activity Sheet 53, Vascular and Nonvascular Plants

Fossils — Geology, Level III

Vascular, Nonvascular, Angiosperm, Gymnosperm, Leaf, Pinna, Pinnule, Frond, Lobe

Instructions: Below each example pictured, write the term or terms (listed above) that best describes it.

Neuropteris

Neuropteris

Cone

Pecopteris

Sassafras

Blue-green algae or Cyanobacteria

Vascular and Nonvascular Plants

Activity Sheet 54, Vascular and Nonvascular Plants, Leader's Key

Fossils — Geology, Level III

Vascular, Nonvascular, Angiosperm, Gymnosperm, Leaf, Pinna, Pinnule, Frond, Lobe

Instructions: Below each example pictured, write the term or terms (listed above) that best describes it.

Neuropteris

Pinnule
Vascular

Neuropteris

Pinna
Vascular

Cone

Gymnosperm

Pecopteris

Frond
Vascular

Sassafras

Leaf
Vascular
Angiosperm
Lobe

Blue-green algae or Cyanobacteria

Nonvascular

Vascular and Nonvascular Plants

Member Handout 33, Plant Fossils from the Pennsylvanian and Permian Periods

Fossils — Geology, Level III

Bark

1. Diagonal (lipidodendron) and/or vertical rows (sigillaria) of leaf cushions, each row separated by a furrow or ridge.
2. Leaf scars near center of cushions.

Calamites

1. Branch or leaf scars at horizontal joints.
2. Vertical patterns of ribs or grooves on sections.

Annularia

1. A whorl of linear leaves.
2. Leaves attached and encircling the joint of the stem.
3. Each leaf has a midvein.
4. Whorls are generally laid out flat.

Sphenophyllum

1. Leaves are wedge shaped.
2. Leaves are narrowest and not touching at the base.

Equisetites

1. Leaves are touching for some distance above the base.
2. Leaves are long and parallel to the stem.

Asterophyllites

1. A whorl of linear leaves.
2. Leaves narrower and more sharply pointed than annularia.
3. Leaves are seen side-view and not laid out flat like annularia.

Pecopteris

1. Pinnule directly and broadly attached to rachis.
2. Sides of pinnule nearly parallel and the apex is generally rounded.
3. Midvein sharply defined and straight.
4. Midvein forks near apex.
5. Veins fork one or more times.

Alethopteris

1. Pinnules directly and broadly attached to rachis, especially on the lower side.
2. Pinnules generally robust.
3. Midvein sharply defined and straight.
4. Veins are generally close and deep.
5. Some veins enter the base of the pinnule directly from the rachis independent of the midvein on one or both sides.

Vascular and Nonvascular Plants

Member Handout 33, Plant Fossils from the Pennsylvanian and Permian Periods, continued

Fossils — Geology, Level III

Neuropteris

1. Pinnule is generally tongue-shaped, but some triangular or oval.
2. Pinnule is attached to the rachis by a short stalk.
3. Midvein terminates just below apex.
4. Venation becomes fan-shaped near the apex.
5. One or more veins enter the pinnule from rachis.

Cyclopteris

1. Oval or round pinnule.
2. Venation is generally radiating.
3. Venation varies from thin to thick and from close to distant.

Odontopteris

1. Pinnule is generally attached to the rachis by the entire width.
2. Veins enter pinnule directly from the rachis.
3. No distinct midvein.
4. Venation is thin and varies from close to distant.

Eusphenopteris

1. Pinnules are rounded.
2. Pinnules are generally attached to the rachis by the entire width.
3. Pinnules never have toothed margins.
4. The pinnules closest to the pinna vein are generally larger and more developed than the others.
5. Venation is generally radiating from the midvein.

Sphenopteris

1. Pinnule narrowly attached to rachis.
2. Pinnule margin is irregular, lobed and/or tooth-like.
3. Midvein branches off into each pinnule segment.
4. Venation is thin and fan-like.

Aphlebia

1. Very irregular shaped, lettuce-like appearance.

Cordaites

1. Long strap-like leaves, rarely found complete.
2. Leaf has a narrow and clasping base with a tapering, rounded apex.
3. Parallel veins with no midvein.

Walchia

1. Short needle-like leaves.

Paleobotany

Fossils — Geology, Level IV

What members will learn …

About the Project:

- Paleobotany can aid in the understanding of ancient, local landscapes and climates.

About Themselves:

- The value of their historical data.

Materials:

- Geologic Map of Kansas (Kansas Geological Survey)
- Geologic Timetable (Kansas Geological Survey)
- Member Handout 34, *Ancient Landscapes and Climates*
- Activity Sheet 55, *Ancient Landscapes and Climates*
- A colored Geologic Map of Kansas would be helpful and is available from the Geologic Survey
- Leader Key, Activity Sheet 56, *Ancient Landscapes and Climates*

Activity Time Needed: 45 minutes

Activity

Let's review and discuss the ancient landscapes and climates member handout. It will aid you in understanding how certain plants grew or were developed in certain environments. It will help you understand why plants became extinct or flourished.

The Activity Sheet will further help you understand these concepts.

Dialogue for Critical Thinking:

Share:

1. What unique characteristics did you learn about various landscapes and climates of the past?
2. How did you utilize the Geologic Map and Timetable of Kansas?

Process:

3. What is the significance of the Geologic Period?
4. How does climate affect plant life and the potential for good plant fossils?

Leader's Notes

Make sure your members have a basic understanding of how to interpret a geologic map and geologic timetable. Also, be sure they understand Member Handout 34, *Ancient Landscapes and Climates*.

Generalize:

5. How does paleobotany help explain history of the earth?
6. What other methods are used to record historical happenings?
7. What is the value of your personal history? (Think about genetics and medical history.)

Apply:

8. How can you use these concepts to predict where coal might be found 200 million years from now?
9. What other energy sources do you think will be significant in the near future (20-50 years)? Why?

Going Further:

If you find an area to collect fossil plants, identify them and make an educational exhibit detailing the different genera, landscape and climate.

References:

Andrews, Henry, *Studies in Paleobotany*, John Wiley and Sons, New York, 1961.

Arnold, Chester, *An Introduction to Paleobotany*, McGraw-Hill, New York, 1947.

Bates, Robert and Jackson, Julia, *Dictionary of Geological Terms*, Doubleday, New York, 1984.

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Lapidus, Dorothy, *Dictionary of Geology and Geophysics*, Facts on File Publications, New York, 1987.

Lesquereux, Leo, *The Flora of the Dakota Group*, Government Printing Office, Washington D.C., 1891.

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Paleobotany

Member Handout 34, Ancient Landscapes and Climates

Fossils — Geology, Level IV

To fully understand ancient plant life, it is necessary to give some attention to the environment, the PALEOCLOGY, under which the plants grew. The reverse is true as well. To understand the PALEOCOLOGY, it is important to understand ancient plant life.

Many inferences bearing on probable environments can be drawn from the distribution and structural changes of ancient plants. Plants are sometimes referred to as the thermometers of the past. When living species are also found as a fossil, we can assume that they grew under conditions similar to those required by the species present.

Geological history is punctuated with climatic fluctuations of major proportions. At times, much of the earth's surface was covered with ice, and other times, the luxuriant vegetation thrived almost to the North and South poles. The most intensive glaciation occurred during the Pre-Cambrian, the Permian and the Pleistocene periods. We know little about the effect of the Pre-Cambrian glaciation upon the vegetation because no land plants have been found in the rocks of this period. However, the Permian ice sheet changed the aspect of the flora over the entire earth through the eradication of the majority of the Paleozoic coal swamp plants and they were replaced by larger more hardy types, such as Sassafras, Ficus and Magnolia. The Pleistocene glaciation caused wide spread changes in the distribution and composition of modern floras.

Various climatic conditions existed in the long intervals between the periods of major glaciation. By the late Devonian Period, certain plants adapted to the different climates, and plants that earlier would only grow in wet, humid and warm climates began to grow in much drier and colder climates.

Climates during the Pennsylvanian Period were very favorable for Gymnosperm plant growth. The climate was moist and rainy and probably warm most of the time, which ferns and conifers from this period required. During the Pennsylvanian period, most of the peat, which transformed into coal through heat and pressure, was deposited. It took ten feet of peat to make a foot of coal.

Plants from the Permian are not nearly as common as those from the Pennsylvanian Period and thus those climatic conditions will not be discussed in this lesson.

Climatic conditions during the Cretaceous Period were favorable for plant growth, although there is evidence of inadequate moisture during the early part of the period. During the Cretaceous Period, plants evolved into floras closely resembling the floras of today. There were able to adapt to less moisture and colder temperatures, even mild winters. The flora of the Cretaceous were living close to streams, rivers and of course close to the Cretaceous Sea which went from the present Gulf of Mexico to the Arctic in the North. During the Cretaceous, the Angiosperms evolved.

Tertiary Period floras are very similar to today's plants. We can assume that the enviroment during that period would be similar to today's environment.

To review, it is possible, once a fossil has been found and correctly identified as to location found, geologic time period and Genus, to visualize the environment while that plant was living.

Paleobotany

Activity Sheet 55, Ancient Landscapes and Climates

Fossils — Geology, Level IV

Circle the Correct Answer for Each Period, Age, Climate:

1) A **Pecopteris** is found in Douglas county.

Geologic Period:	Pennsylvanian	Cretaceous	Pleistocene
Age in Years:	50 million	75 million	300 million
Climate:	Hot and Dry	Warm and Moist	Cold and Dry

2) A **Sassafras** is found in Ellsworth County.

Geologic Period:	Pennsylvanian	Cretaceous	Pleistocene
Age in Years:	50 million	100 million	300 million
Climate:	Hot and Dry	Cold and Dry	Seasonal

3) An **Angiosperm** is found in Barton County.

Geologic Period:	Pennsylvanian	Cretaceous	Pleistocene
Age in Years:	50 million	100 million	300 million
Climate:	Hot and Dry	Cold and Dry	Seasonal

Briefly Answer the Following (explain your answers):

1) Is it possible to find Angiosperm from the Pennsylvanian Period?

2) How is coal formed?

3) From which period is there very little fossil plant record?

4) If you collect a fossil plant that has a living relative today, what will this tell you about the environment of the era where the fossil plant grew?

Paleobotany

Activity Sheet 56, Ancient Landscapes and Climates Leader's Key

Fossils — Geology, Level IV

Circle the Correct Answer for Each Period, Age, Climate:

1) A **Pecopteris** is found in Douglas county.

Geologic Period:	**Pennsylvanian**	Cretaceous	Pleistocene
Age in Years:	50 million	75 million	**300 million**
Climate:	Hot and Dry	**Warm and Moist**	Cold and Dry

2) A **Sassafras** is found in Ellsworth County.

Geologic Period:	Pennsylvanian	**Cretaceous**	Pleistocene
Age in Years:	50 million	**100 million**	300 million
Climate:	Hot and Dry	Cold and Dry	**Seasonal**

3) An **Angiosperm** is found in Barton County.

Geologic Period:	Pennsylvanian	**Cretaceous**	Pleistocene
Age in Years:	50 million	**100 million**	300 million
Climate:	Hot and Dry	Cold and Dry	**Seasonal**

Briefly Answer the Following (explain your answers):

1) Is it possible to find Angiosperm from the Pennsylvanian Period?
No. Angiosperms evolved during the Cretaceous Period.

2) How is coal formed?
Peat is transformed into coal by heat and pressure.

3) From which period is there very little fossil plant record?
Pre-Cambrian

4) If you collect a fossil plant that has a living relative today, what will this tell you about the environment of the era where the fossil plant grew?
It was much like today's environment. The temperature, soil and rainfall would be very similar.