EXPLORE YELLOWSTONE
MARTIN CHILDREN’S DISCOVERY CENTER

GEOLOGY

EDUCATOR GUIDE

600 W. Kagy Blvd.
Bozeman, MT 59717
406-994-2251
museumoftherockies.org
visitmor@montana.edu

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Dear Educator,

Thank you for choosing to bring your students to the Explore Yellowstone Martin Children’s Discovery Center at the Museum of the Rockies (MOR), where our mission is to inspire visitors to explore the rich natural and cultural history of America’s Northern Rocky Mountains. A visit to the Discovery Center is a great way to help your students visualize concepts and spark their curiosity about a new topic.

Studies have shown that learning in museums is not limited to the time spent within their walls, but is heavily influenced by prior knowledge and experiences and continues long after the visit has ended. For these reasons, preparing your students for their museum visit and then extending their experience afterward will enhance the educational aspect of the field trip experience.

To aid you in linking this museum visit to your curriculum, the Museum of the Rockies’ Education Department has created this guide. Inside, you will find details on the Explore Yellowstone Martin Children’s Discovery Center, including a map of the exhibit and education goals. We have also assembled complementary classroom activities for various grade levels. We hope that these resources will help you prepare pre- and post-visit activities for your students that tie into your curriculum.

MOR is committed to providing the richest possible learning experience for your students and welcomes your questions and feedback. We look forward to seeing you at the Museum of the Rockies soon!

Sincerely,

Education Department
Museum of the Rockies
EXPLORE YELLOWSTONE GENERAL OVERVIEW

Exhibit’s Appropriate Age Levels: Birth through 8 years of age (or 2nd grade)
Curriculum is appropriate for preschool through 5th grade students.

Exhibit Overall Goal:
Introduce children to the wonders of Yellowstone National Park in a hands-on, immersive environment that empowers children to discover a lifelong passion for nature, science, and the Yellowstone experience.

Exhibit Description:
Explore Yellowstone is an immersive exhibit. From the moment kids enter through the Roosevelt Arch, they are surrounded by landscape scenes from Yellowstone. Murals surround them while overhead clouds float in the blue sky. In one area, children can “fish” with magnetic fishing poles for cutthroat and lake trout that have ball bearings sewn in their snouts and learn which fish to return to the “lake.” Mammoth terraces and bubbling mud pots help teach the concepts of thermal features and a “smell tube” lets them get a whiff of hydrogen sulfide. In the campground kids learn campground etiquette like bear-proofing food and removing litter or listen to stories and sing songs around the “campfire.”

A tot area, framed by murals of the Grand Canyon of the Yellowstone, gives infants a safe place to play while their parents watch from benches made of polished logs. Older kids can climb the fire tower and use binoculars to look for smoke, or play in a life-size eagle’s nest and learn about habitats.

In the lodge, children can dress up and pretend to be people working in Yellowstone. They can “cook” with an authentic wood stove that has a fake fire burning in the coal box or sit on child-size lodge pole furniture in front of the fireplace and read. A big clock over the fireplace helps them time the next eruption of “Old Faithful,” the largest of three cloth geysers. At the end of their visits, children can make post cards or drawings to take home before they exit through the Roosevelt Arch.
Exhibit Layout:
Eight discovery zones, each with a focus on different area of Yellowstone, provide just enough design, detail and props to suggest a time and place for children to become a part of Yellowstone.
BUILD THE EARTH
Students role-play the location and characteristics of Earth’s layers

PURPOSE:
This lesson will help students become familiar with the layers of the earth.

OBJECTIVES:
Students will:
1. Explain that the earth has layers
2. Describe some of the characteristics of each layer

VOCABULARY:
Inner Core
Outer Core
Lithosphere
Deep Mantle
Asthenosphere

ACTIVITY:
Begin activity by checking student’s prior knowledge on the layers of the earth by asking:
How are rocks formed and changed over time?
How can a rock experience heat and pressure?
How can a rock be melted back into magma?
Where does magma come from?

Discuss with students the internal structure of the earth and tell them that they are going make a model, which represents the layers of the earth.

Have each student draw a card out of a hat that will have one of the layers of the earth written on it. (Numbers are for a class of 15, adjust accordingly for class size.)
Inner core (1)
Outer core (2)
Deep mantle (3)
Asthenosphere (4)
Lithosphere (5)

Have the students get into their earth layers groups.

Show the students a diagram of the layers of the earth, pointing out the layers to each group and briefly describing or asking students for brief descriptions of the layers.

Explain that the Earth has three main layers: crust, mantle, and core. Also explain that the mantle and core are divided into different “sub-layers.”

Next take the students to a large open area and explain that they are going to work together to “build” the Earth. Have the students join their layer groups and explain what each part does and why. (Descriptions below) You may ask the students why each layer does their specific movement. Let the students practice
any sound or movements for their parts. Now assemble the Earth from the inside out, with the students helping to remember which layers go where.

**Inner Core:** This student flexes his or her muscles (or pretend to lift weights) and stands in the center of the area. Tell the students that this represents that the inner core is very dense and is solid metal.

**Outer Core:** These students form a circle around the inner core. They should face in, toward the inner core. Then they will walk counterclockwise around the inner core while holding their arms out to the sides and waving them up and down. Tell the students that this represents the fact that the outer core is liquid and is moving.

**Deep Mantle:** These students join hands to form a circle around the outer core. The students will chant “hot rock, hot rock, hot rock.”

**Asthenosphere:** These students surround the deep mantle. They will sway their bodies back and forth to represent movement that occurs in this layer.

**Lithosphere:** These students form a circle around the entire rest of the Earth. They will face outward and slowly walk around the rest of the Earth. Have them chant “moving plates, moving plates”.

**TYING IT ALL TOGETHER:**
Discuss with the students that this model did show that there are multiple layers in the spherical Earth and showed what the layers are like. Ask the students if there are ways that the Earth model could have represented the Earth and its layers even more accurately? (Flat model- Earth is spherical, Lithosphere or plate movement- very slow, a couple centimeters a year, Size and depth of the layers, etc.). Have students label the internal structure of the Earth.
CALDERA COLLAPSE

Blowing up and popping a balloon under a layer of sand creates a realistic caldera

PURPOSE:
This lesson will help students know what a caldera is and understand caldera formation.

OBJECTIVES:
Students will:
1. Explain what a caldera is
2. Predict the effects of a caldera on landscapes
3. Describe Yellowstone’s caldera

VOCABULARY:
Caldera  Lava
Magma  Volcanic Eruption and Flow

ACTIVITY:
Prepare the demonstration by pouring a small quantity of flour into a balloon and attaching the balloon to tubing with a rubber band or tape. Lay the balloon under the soil mixture within the plastic tub. Then run the tube out of plastic tub and attach to the bicycle pump.

Facilitate a discussion about Yellowstone’s volcanic history. Encourage students to explain the importance of Yellowstone’s major caldera. Have students sit a few feet away from the demonstration. Begin to pump the balloon. Can the students explain what is happening? As you continue to pump, ask the students what will eventually happen. Using a pin, pop the balloon.

Encourage students to explain how the caldera collapsed and how lava continued to flow and refilled the crater after the eruption.

TYING IT ALL TOGETHER:
Outline the caldera on the relief map of Yellowstone. Based on what they know about Yellowstone’s geologic history, what do they think might happen in the future?

Adapted from Expedition Yellowstone! Curriculum sampler, National Park Service
GEOLOGIC FAIRY TALE
A play acting out the geologic history of the Yellowstone region

APPLICABLE AGES:
1st grade – 5th grade

LOCATION:
At the museum or in your classroom

RESOURCES AND MATERIALS:
- Name cards
- Blue tarp (Sea)
- Blue/green streamers (River)
- Red blanket, sheet, or hat (Volcano)
- Tape

PURPOSE:
This lesson will help students understand a general geologic history of southwestern Montana.

OBJECTIVES:
Students will:
1. Learn geologic vocabulary
2. Act out a general sequence of geologic events that illustrate geologic principles and history.
3. Learn the names of several common plant and animal fossils

VOCABULARY:
Sedimentary  Igneous
Volcano  Crinoid
Metamorphic  Magma
Brachiopod

ACTIVITY:
Parts to Assign:
Basement Rock
Sea (2 people)
Crinoids
Brachiopod
River
Mud and Sand → Sedimentary Rock (2 people)
Weather (2 people)
Bumper/Forces (2 people)
Volcano (2 people)

The Script:
Once upon a time, when the earth was young, there was a very hard very strong rock making up the land. The rock, which was named Basement Rock, was classified as metamorphic because it had been subjected to heat and pressure over time and looked twisted and folded and tortured because of this. Basement Rock had been through a lot and was very strong and tough and was not afraid of anything!

But Basement Rock was very short, and when the great Sea came into the land it covered Basement Rock. In this Sea lived many happy creatures such as Crinoid. Crinoid was an animal that had a stem attached to the sea floor. Her arms reached up to gather food. Another creature living in the Sea was Brachiopod. Brachiopod was great-great grandfather to what we today call clam. Brachiopod lived on the bottom of the sea floor along with Crinoid. She had two sides. Over many millions of years, Sea appeared and disappeared, appeared and disappeared, sometimes forcing Brachiopod and Crinoid to search for a new home, or worse, die.

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River when she had water in her, brought Sand and Mud down to Sea and laid the mud on the floor of Sea. Both Brachiopod and Crinoid because they lived on the bottom of the sea, would sometimes get covered over with new sand and mud that came into Sea from river. Sometimes Brachiopod and Crinoid would climb to the top through the mud and live longer, but sometimes they would get buried and die. So much Sand and Mud was brought in that it became very thick. The weight of the new Sand and Mud on top of the old packed the old down, squeezed it and pushed harder and harder. Water left the spaces between the mud grains and hard cement took its place. With time Sand and Mud became hard Sedimentary Rock that contained the fossilized hard parts of Brachiopod and Crinoid.

( Remember hard strong Basement Rock is lying patiently under all this new Sedimentary Rock)

Then a big piece of rock, Bumper, from way out west, bumped into Basement Rock! It pushed on Basement Rock and Sedimentary Rock. It pushed and pushed until Basement Rock began to grow taller and taller and Sedimentary Rock began to bend over the top of tall Basement Rock until together they made a mountain!

But it was not to last forever. Remember, Sedimentary Rock was the top of the mountain, and Sedimentary Rock was not as strong and tough as Basement Rock. Sedimentary Rock was just made out of sand and mud and sea shells. Well, the clouds came and the powerful Weather brought wind, rain and snow down on Sedimentary Rock. Weather is causing Sedimentary Rock to break apart into boulders, gravel, sand and mud. Rivers are forming and washing away parts of Sedimentary Rock.

The top of the mountain was completely washed away in places. And guess who is peeking out now? Basement Rock! He is strong and tough, not made of mud and sand! He can’t be washed away so easily.

But, uh oh! What is happening now? Oh no! Basement Rock feels something hot, hot, hot at its feet. Oh, it’s pushing through an itty bitty crack. It’s making the itty bitty crack much bigger now! Oh here it comes...it’s...it’s...VOLCANO!!!! Hot magma! It’s exploding; it’s spreading out over the top and covering Basement Rock and Sedimentary Rocks in some places. Oh! It’s hardening now and making a dark blanket of Igneous rock on top of all the other rocks.

But, Weather won’t be stopped. Here he comes to do his work, turning Igneous, Sedimentary Rock and Basement Rock into small pieces and washing them away towards the sea.

TYING IT ALL TOGETHER:
After the play ends, bring all the students together to discuss what they just performed. Ask about how much time they think it takes to have the Earth go through all those changes. Try to get across the sense of the immensity of geologic time. Ask whether the changes have stopped, or does the Earth keep changing?
MY PET ROCK

Students examine their rock, using all the senses except taste, then discover it while blindfolded

PURPOSE:
Students will gain an understanding of the variety of characteristics that rocks may have along with identification of common attributes

OBJECTIVES:
Students will:
1. Observe and note the variations in the select group of rocks
2. Use their sense to identify their own rock

ACTIVITY:
Have students sit in two smaller circles on the floor. Pass out one rock/mineral to each student. Tell the students that they will be using their observation skills, specifically their senses. Ask the students which senses they will be using to observe their rocks- sight, smell, touch, hear (sorry, no taste).

Now tell the students that they will be putting their senses to the test- that you will be removing their sense of sight temporarily. Tell them that they will be wearing a blindfold, and will have to use their sense of touch, hearing, and smell to find their rock. Also tell them that they will be passing the rocks around the circle in order to find their own rock. If they think they have their own rock, they should put it on their lap and continue to pass other rocks that come to them around the circle. Instruct the students to get one last touch, smell, and hear of their rock and put their rock in the white bin in the center of the circle. Have the classroom teacher assist you in putting on blindfolds. Remind the students that even if they can see through the blindfold, that they should close their eyes and put their other senses to the test. Once all the students think they have their rock, have them take off their blindfolds to check.

Given time, have the students share one thing about their rock that makes it different from all the other rocks. Identify common minerals with the students and a way to remember which is which. Return Pet Rocks.

EXTENSION:
Tell the students that you will be giving them 3 minutes to observe their rocks and think of three things they notice about their rock/three words to describe their rock. When the students are ready, have them share their observations. As the students are sharing their observations, record them on the board. As you are recording, try to group together the observations by physical properties, without attaching a label, yet. Once every student has shared, discuss their observations and have the students generate labels for each group of observations on the board. For instance, “Some people described their rocks as black or white or gray or pink. What are all of those things? Others could be shininess (luster), shape, texture, etc.
ROCK CYCLE ROLL

Students act out the rock cycle by moving through stations that represent the life cycle of a rock

PURPOSE:
This lesson will help students know the stages that rocks can move through and forces that can change rocks over time.

OBJECTIVES:
Students will:
1. Explain the rock cycle
2. Describe the rock cycle processes

ACTIVITY:
Before lesson, have rock cycle roll activity set up with 7 rock cycle stations and dice: earth’s interior, soil, river, clouds, ocean, mountains, and volcano. Begin activity with asking students: do rocks always remain the same rock forever? Can rocks change over time? How? (Students should give examples of erosion, plate movement, eruptions, weathering, etc.)

Tell students that in this activity, they are going to become part of the rock cycle and experience what a rock can go through in millions of years or just a couple seconds. Show the students each station and tell them that they will be rolling the die to see where they go in the rock cycle. Remind the students of appropriate behavior with the dice. Tell the students that they also have to record their rock cycle journey in their journals.

TYING IT ALL TOGETHER:
Ask your students:
Where did you go on your journey?
Where did you begin and end?
Did you get stuck anywhere for a while?
Why do you think this did or did not happen?

EXTENSION:
Write a short story about your journey as a rock in the rock cycle roll below.
**Stations:**

**Earth's Interior**
Components on dice:
- Tectonic Plates move: go to volcano
- Magma is forced up: go to volcano
- Pressure occurs, More layers: remain here
- Pressure occurs: remain here
- Pressure occurs: remain here
- Tectonic plates push upward: go to mountains

**Soil**
Components on dice:
- Pressure occurs: go to Earth’s interior
- Pressure occurs: go to Earth’s interior
- Rock breaks down: remain here
- Pressure occurs: go to Earth’s interior
- Rock breaks down: remain here
- Sediment being formed: remain here

**River**
Components on dice:
- Flood water causes redeposit of silt to flood plain: go to soil
- Sediments form: go to soil
- Water washed away layers: go to mountains
- Silt washed into ocean: go to ocean
- Sediments under pressure: go to Earth’s interior
- Ice melts carrying rocks: go to river

**Ocean**
Components on dice:
- Sand washes up onto shore: go to soil
- Ocean floor being subducted: go to Earth’s interior
- Sand washes up onto shore: go to soil
- Ocean floor being subducted: go to Earth’s interior
- Dust evaporates with water: go to clouds
- Sand washes up onto shore: go to soil

**Clouds**
Components on dice:
- Rain: go to ocean
- Snow: go to mountains
- Rain: go to soil
- Snow: go to mountains
- Rain: go to soil
- Rain: go to ocean

**Mountains**
Components on dice:
- Wind erosion occurs: go to soil
- Wind erosion occurs: go to soil
- Ice melts carrying rocks: go to river
- Glacier or avalanche occurs: go to ocean
- Ice melts carrying rocks: go to river
- Wind erosion occurs: go to soil

**Volcano**
Components on dice:
- Volcano erupts spewing forth lava: go to mountain
- Tectonic plates push upwards: go to mountains
- Magma crystallizes: remain here
- Volcanic ash and dust are pushed into atmosphere: go to clouds
- Crystallized magma pushes up to surface: go to soil
- Magma flows into the ocean: go to ocean
Station Pictures:

Earth’s Interior
Soil
River
Ocean
Clouds
Mountains
Volcano
The Rock Cycle Roll....

Record your journey in the rock cycle below:

1. Starting Point: ___________________________________________________
2. _______________________________________________________________
3._______________________________________________________________
4._______________________________________________________________
5._______________________________________________________________
6._______________________________________________________________
7._______________________________________________________________
8._______________________________________________________________
9._______________________________________________________________
10 Ending Point:___________________________________________________
ROCK CYCLE TAG
A lively game of freeze tag that acts out a simple rock cycle

PURPOSE:
This lesson will help students become familiar with some of the changes rocks can go through, while identifying several change mechanisms.

OBJECTIVES:
Students will:
1. Name three processes that create or affect rocks
2. Describe how the three processes affect rock

ACTIVITY:
Take the students outside and play “freeze” tag. Three people are chosen to be "Heat & Pressure", and three people are chosen to be "Hot Magma." All the other students are loose sediments. If “Heat & Pressure” tag the magma, the loose sediments must “freeze” and turn into a rock. “Hot Magma” must come along and re-melt the rock.

TYING IT ALL TOGETHER:
After the game ends, review with everyone what the processes were that the game represents. Go over the names of each of the rock kingdoms and how they are formed.
**ROCK TO ROCK: A FANTASY JOURNEY**

A story that leads students on a guided visualization of their journey as a rock through the rock cycle

**PURPOSE:**
This lesson will help students learn the sequence of events that might occur to an individual rock through time, and gain a sense of the forces that act upon rocks.

**OBJECTIVES:**
Students will:
1. Name the three rock families
2. Describe the processes that change rocks over time
3. Explain the rock cycle

**VOCABULARY:**
- Metamorphic
- Sedimentary
- Igneous
- Erosion
- Decomposition
- Deposition
- Magma
- Lava
- Sediment

**ACTIVITY:**
Read the following story while the children sit with their eyes closed. Students can be spread throughout the classroom or an area outside. Have the students stay in their area and encourage them to imagine and act out the story as you read it.

*Imagine that you are a rock as big as a baseball. Your home is on a sunny hillside and you can see down into a deep valley with a river roaring far below. You like your home. Sometimes you can feel the sunlight warming you.*

*During winter, the crack on top of you gets bigger because the ice pushes hard on the sides of the crack. One spring the rain pours in little streams rushing down the hillside. You feel the water flowing over you and into the soft mud below. Suddenly you feel a rumbling and the Earth begins to shake. You look uphill and a large wall of mud rushes down and sweeps you up. You are rolling down, down, down into the valley. Ow! You hit another rock and you split along the crack. Now you are two halves rolling down the hill.*

*Splash! You land in the river. For days and days you are pushed by the swift, strong waters. Rolling and bumping along you are breaking into smaller and smaller pieces, you are slowly turning into sand and gravel. Finally the river enters the ocean and your many pieces settle onto a large, flat area along with millions of pieces of sand, gravel and silt. More pieces settle on top of you and you are getting squished. More and more weight presses down. Your small pieces get pushed and stuck together with other pieces. You are now hardening and becoming a sedimentary rock.*

*The pressure grows as you are being pushed deeper into the Earth. You begin to get warmer and warmer. You change color and form into many hard crystals. You have been changed into a metamorphic rock. You keep getting pushed farther down. It is HOT. It is boiling hot! Everything begins to melt and you are part of a hot mass of melted rock called magma deep underground. A long time goes by. Then...*
You are being pushed up and the Earth is shaking and rumbling again. You can feel yourself rising higher and higher. Fire, ash, dust and steam surround you and, with a loud explosion, you burst up out of the top of a volcano. Red-hot lava is all around. You are a scalding, steamy piece of lava shooting through the air and you land on the ground. Away from the heat of the volcano you slowly cool and harden and turn from lava into a cold, grey igneous rock. Soon the dark ashes blow away, the sun comes out and you feel the sunlight warming you high up in the mountains – your new home.

TYING IT ALL TOGETHER:
Analyzes the processes taking place in the story a bit. Ask students to name the forces acting on them as a rock. Ask them to correlate the force with the result – their changed rock status. Drawing up a chart showing the force – result correlation is a good visual aid.
Ask students to list all the rock types they became in the story. Did they visit all the rock kingdoms? Ask the students to speculate on where they might end up next is the story continued, and what rock kingdom might they visit next.

EXTENSIONS:
Have the students draw pictures of their experiences as a rock as imagined during the fantasy journey. Then look at samples of the three rock types and use a rock cycle diagram to further explain.
ROCKETTY ROCK ROCK ROCK ROCK

A fast moving game that teaches the names of the three rock kingdoms and how each rock type is formed

PURPOSE:
This lesson will help students become familiar with the names and formation of the three rock kingdoms

OBJECTIVES:
Students will:
1. Name the three rock kingdoms
2. Describe rock cycle processes

VOCABULARY:
Igneous Magma
Metamorphic Volcano
Sedimentary Heat and Pressure
Lava

ACTIVITY:
Have students stand in a circle with you in the middle. Tell them that this is a game about the three rock kingdoms. Have the students remind you of the names of the three kingdoms. Tell the students that you will spin around in the center, point at someone in the circle and say sedimentary, igneous, or metamorphic. The role of the person being pointed at and the two people on either side is to act out the formation process of that particular rock kingdom.

This is a timed event! The three people acting out the rock kingdom need to complete the action before the person in the center says Rocketty Rock Rock Rock.

Depending on the age of the group, the instructor can give the movements, aid in having the students create the movements, or have the students solely come up with the movements. It’s important that the whole group does the same three movements for the three rock kingdoms.

Movement Options:
Sedimentary- the three people stack their hands together like pancakes. Ask the students- why would this be sedimentary? There are layers in the rocks from sedimentation.

Igneous- two people on either side form the sides of a volcano and the person in the middle is the lava shooting out the top.

Metamorphic- two people on either side, gently, with one hand, push down on the middle persons head to represent pressure; person in the middle fans his/her face to represent heat. Or the two people on either side lean gently into the middle person

Penalties: If one of the three people either don’t do anything or do the wrong rock, they switch with the person in the center of the circle. If the person in the center of the circle says “Rocketty, Rock, Rock, Rock” before the people pointed at complete their rock formation, the middle person switches with the person in the center of the circle. Practice rounds are always helpful for the students.
TYING IT ALL TOGETHER:
Sit everyone down in a circle. Review the rock kingdoms and how they are generally formed. As you talk about each rock kingdom, send examples of various rock types from that kingdom around the circle, pointing out typical rock characteristics about each kingdom.
YELLOWSTONE GEOLOGIC TIMELINE

Students draw a mural and lay out a timeline rope marking major geologic events in the Yellowstone area.

PURPOSE:
Students will gain an understanding of the geologic history of the Yellowstone region.

OBJECTIVES:
Students will:
1. Demonstrate their understanding of events in geologic history in the Yellowstone Ecosystem
2. Calculate the distance between dates along the timeline using the timeline scale
3. Explain how the Yellowstone Area has changed over time

ACTIVITY:
Dream Cave and Mural:
Read the “Dream Cave” to all the students. Divide the descriptions of the dream cave (found on pages 6-15) into sections based on geologic events and number sections consecutively. Divide the students into groups and give each group one of the sections and a large sheet of paper. Ask each group of students to draw the descriptions they find in their sections to recreate what Joseph Grimes saw in the cave. When the students are finished, assemble all of the sections consecutively to create one large mural of the cave wall and, thus, the chronological record of Yellowstone’s geologic history. Ask each student group to describe the geologic history portrayed in their section.

Timeline:
Explain to the students that they will make a time line to review the major events in Yellowstone’s geological history and to visually demonstrate the time between these events. Allow students to assist in marking the rope with a piece of colored tape to represent the eleven events described on the Event Cards. Explain the math—one inch equals ten million years. (Events toward the end are relatively close together. Colored string may be used to mark those events.) Divide students into eleven groups and give each an Event Card. Instruct them to study the event on their card. Have a volunteer from each group stand along the rope matching his or her event with the correct mark on the rope. After volunteers are at the proper locations, have a second student from each group read the event card aloud beginning with the earliest event.

EXTENSION:
Pose the problem—if you were to walk back in time at the rate of one century per step, the first step would return you to the early 1900s. But to return to the oldest event in Yellowstone’s geologic history (2.7 billion years ago) you would walk about halfway around the world. Calculate how many miles you would have to walk back to arrive at 2.7 billion years ago, given that each step you took measured 3 feet. (Solution: X feet divided by 2,700,000,000 years equals 3 feet divided by 100 years. Then, X feet equals 3 feet multiplied by 2,700,000,000 years divided by 100 years would equal 81,000,000 feet. Then X miles divided by 81,000,000 feet equals 1 mile divided by 5,280 feet. X miles would then equal 81,000,000 feet divided by 5,280 feet. The answer is 15,341 miles.)
# RESOURCES:

## Yellowstone Ecosystem Geologic Time Line

<table>
<thead>
<tr>
<th># of Years Ago</th>
<th>Event</th>
<th>Distances marked on rope:</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6 billion</td>
<td>Earth formed.</td>
<td>0’ 0”</td>
</tr>
<tr>
<td>2.7 billion</td>
<td>Oldest rocks found in Yellowstone. Only lifeforms capable of survival were primitive plants. Atmosphere was mostly carbon dioxide. Observed rocks are igneous and metamorphic—no fossils.</td>
<td>12’ 3”</td>
</tr>
<tr>
<td>570 million</td>
<td>First Paleozoic seas reached Yellowstone. Little change in next 500 million years. Examples: Cambrian (Buffalo Plateau trilobites, sponges, and worms); Cretaceous (Mt. Everts—leaves, ferns, clams, shark teeth)</td>
<td>33’ 6”</td>
</tr>
<tr>
<td>100 million</td>
<td>Mesozoic marine reptiles—pleiosaurs and ichthyosaurs—appeared. (Later Paleozoic seas)</td>
<td>37’6”</td>
</tr>
<tr>
<td>75 million</td>
<td>Laramide Orogeny (mountain building) began and lasted for 20 million years</td>
<td>37’8”</td>
</tr>
<tr>
<td>55 million</td>
<td>Absaroka volcanic began. Buried forests. Quietness and explosive volcanic eruptions occurred over the next 15 million years.</td>
<td>37’10”</td>
</tr>
<tr>
<td>40-10 million</td>
<td>Relatively quiet, hot, dry climate characterizes this period of thirty million years. It was populated by primitive camels, elephants and horses.</td>
<td>38’</td>
</tr>
<tr>
<td>10-2 million</td>
<td>Regional uplift took place, and the Yellowstone Plateau gained much of its elevation. The Teton Rang and Gallatin Mountains uplifted across this period.</td>
<td>38’ 3”</td>
</tr>
<tr>
<td>2 million</td>
<td>Caldera period began.</td>
<td>38’ 3-13/16”</td>
</tr>
<tr>
<td>640,000</td>
<td>Youngest Yellowstone caldera was formed.</td>
<td>38’ 3-15/16”</td>
</tr>
<tr>
<td>640,000-70,000</td>
<td>Post-caldera lava flows.</td>
<td>38’ 3-15/16”</td>
</tr>
<tr>
<td>70,000-14,000</td>
<td>Last major glaciations (Pinedale); glacial erratic deposited; thermal activity happens.</td>
<td>38’ 3-15/16”</td>
</tr>
<tr>
<td>Present Day</td>
<td>Yellowstone as it is today.</td>
<td>38’ 4”</td>
</tr>
</tbody>
</table>

*Adapted from Expedition Yellowstone! Curriculum sampler, National Park Service*
Please contact the Education Department with any questions, comments or suggestions regarding this curriculum.