Lesson 3 It's a Matter of Time

Objectives

- Comprehend geologic time;
- Differentiate between different divisions of geologic time; and
- Understand the environment during the Late Triassic Period where Petrified Forest National Park is located today.

Main Idea

To develop an understanding of geologic time and the Late Triassic Period as represented by the geologic and fossil records at Petrified Forest National Park.

Essential Skills

- writing
- cooperating
- decision making
- identifying
- analyzing
- classifying
- generalizing

Mathematical Skills

- measuring
- calculating time
- recording
- organizing data
- basic mathematical skills
- graphing
- scale

Materials

- student journals
- large sheet of paper
- markers or crayons

Pages to Photocopy

- *Creating Timelines* Student Activity Sheet pages 31-32
- Geologic Timeline cards pages 33-36

The following table aligns this lesson with the Arizona Science Standards (5-24-04). Most curriculum connections shown are implicit within the lesson. Others are achieved through teacher interaction with the class, including discussion of the background information provided. Teachers are encouraged to expand on the lesson to increase its potential as an educational tool and a fun learning experience.

Curriculum Connections: Paleontology Lesson 3 It's a Matter of Time

Arizona Science Standards (5-24-04)

	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8
Strand 1: Inquiry Process	C2-PO4 C2-PO5 C4-PO2	C2-PO4* C2-PO5* C4-PO2*	C4-PO1	C4-PO1*	C4-PO2*
Strand 2: History & Nature of Science		C2-PO1 C2-PO3	C2-PO1 C2-PO2 C2-PO3	C2-PO3*	C2-PO1*
Strand 3: Science in Personal & Social Perspectives		C1-PO1			
Strand 6: Earth & Space Science				C1-PO3 C1-PO4	

* repetition of a performance objective from an earlier grade level

Introduction

Geologic time can be a difficult concept to understand. Our own lives are so brief when compared to the age of the Earth and its geological activities and features that the hundreds of millions of years of geologic time are almost incomprehensible. But to understand Earth activities today - the source, the overall effects, the consequences - we must have at least a rudimentary grasp of geologic time. How can we understand earthquakes and better predict their location and magnitude without understanding plate tectonics? How can we truly appreciate the power of water and its erosion of rock without understanding how Grand Canyon and other erosional features formed? How can we predict the affect of human activities on the global climate without understanding ancient climate changes and periods of mass extinction? By studying the past, we can better understand the present and more accurately predict future changes.

Lesson Framework

1. Terminology
A list of defined terms for teachers.

2. Geologic Time
Background information for teachers about geologic time, including a geologic timeline of the Earth.

3. Geologic Time at Petrified Forest
Background information for teachers that is specific to Petrified Forest National Park, including a description of the Late Triassic environment based on the stratigraphy of the rock layers in the Chinle Formation.

4. Activity: *Creating Timelines*
An in-class student activity led by the teacher that helps students understand linear timelines through the creation of a personal timeline on paper and a geologic timeline with the entire class.

Terminology

absolute dating - an estimate of the true age of a mineral or rock based on the rate of decay of radioactive materials
Chinle Formation - rock formation within Petrified Forest National Park and the larger area of the Painted Desert, containing several distinct rock layers, dating to over 200 million years ago; represents the Late Triassic Period
chronology - an arrangement or sequence of events over time
Era - largest division of geologic time based on the overall characteristics of fossils within its timespan
geologic time - chronology of Earth's formation, changes, development, and existence
Pangaea - a supercontinent in existence during the Mesozoic and Paleozoic Eras that contained all seven continents present on Earth's surface today in a single land mass
Period - division of geologic time smaller than an era, based on rock layers and the fossils they contain
relative dating - dating of events or substances in comparison with one another, in chronological order; comparing types of fossils is often a relative dating technique
stratigraphy - the layers, or strata, of rocks on the earth's surface
Triassic Period - the first geologic timespan within the Mesozoic Era, dating from 248-206 million years ago; the Late Triassic Period is well represented at Petrified Forest National Park

Geologic Time

How many years must pass before something can be measured using a geological time scale? “This day will never end.” “My grandparents were once my age?!” Are these measured as geologic time?

Thousands and millions of years are used on a geological time scale. Geologic time is the chronology of the Earth’s formation, changes, development, and existence. Grand Canyon began forming 5 million years ago. The Chinle Formation in the Painted Desert began forming over 200 million years ago. The Earth is 4.6 billion years old. These events are measured on a geological time scale.

Scientists do not measure geologic time on a clock or calendar. They use a linear timeline based on the age of rocks and their corresponding fossils, as well as the change in life that occurred over millions of years. The Geologic Timeline on the next page shows an accepted timeline for the Earth based on current science. The timeline is subject to change as new discoveries are made.

Precambrian Time marks the origin of the Earth at about 4,500 million (4.5 billion) through 543 million years ago. The oldest rocks and fossils found on Earth to date are within Precambrian Time. You can see some of the oldest rocks on Earth at the bottom of Grand Canyon. The metamorphic Vishnu Schist that creates the inner gorge of the canyon is 2,000 million (2 billion) years old. The fossil record of the Proterozoic Era shows that life was very primitive, consisting of photosynthetic bacteria, primitive marine plants, and single-celled animals.

The **Phanerozoic Eon** consists of the Paleozoic, Mesozoic, and Cenozoic Eras. The **Paleozoic Era** marks the formation and movement of a supercontinent geologists call Pangaea, from 543 million through 248 million years ago. All continents presently on the surface of the Earth had their origins within this single land mass. During the six periods of the Paleozoic, life developed rapidly from marine plants and invertebrates, to fish and spore-bearing plants, to amphibians. At the beginning of the Paleozoic, Pangaea was located closer to the South Pole and covered by glaciers, but by the end of the era, it had migrated to the equator, where its glaciers melted, resulting in global climate change. The end of the Paleozoic was a time of mass extinction amongst Earth’s life forms.

The **Mesozoic Era** marks the development of life forms of increasing complexity, including reptiles, dinosaurs, small mammals, birds, conifers, cycads, and flowering plants, from 248 million through 65 million years ago. During the first period of the Mesozoic, the Triassic Period, the rocks now within Petrified Forest National Park and the greater Painted Desert region were deposited. During the Jurassic and Cretaceous Periods, dinosaurs developed into giants, dominating the animal world. The end of the Mesozoic Era is marked by a mass extinction of the dinosaurs, leaving only their fossilized remains to tell their story.

We are currently in the **Cenozoic Era**, dating from 65 million years ago through today. This era includes the development of large mammals and of human beings. It also includes several periods of continental glaciations, or ice ages, that played a role in the formation of geological features visible on Earth today.

Geologic Timeline

Information in this table was taken from www.ucmp.berkeley.edu/help/timeform.html on 3/24/04	Era	Period	Major Physical Events	Life Forms
Phanerozoic Eon 543 million years ago to today	**Cenozoic** 65 million years ago to today	Quaternary 1.8 million years ago to today Tertiary 65 to 1.8 million years ago	Continental glaciations	humans large mammals
	Mesozoic 248 to 65 million years ago	Cretaceous 144 to 65 million years ago Jurassic 206 to 144 million years ago Triassic 248 to 206 million years ago	Pangaea completely broken apart by beginning of Jurassic	extinction of dinosaurs flowering plants birds dinosaurs small mammals reptiles conifers cycad plants
	Paleozoic 543 to 248 million years ago	Permian 290 to 248 million years ago Carboniferous 354 to 290 million years ago Devonian 417 to 354 million years ago Silurian 443 to 417 million years ago Ordovician 490 to 443 million years ago Cambrian 543 to 490 million years ago	Pangaea moves towards equator and begins to break apart Pangaea located near South Pole	mass extinction of 90% of all marine animal species amphibians fish spore-bearing land plants marine plants invertebrates
Precambrian Time 4500 to 543 million years ago	**Proterozoic** 2500 to 543 million years ago	Neoproterozoic 900 to 543 million years ago Mesoproterozoic 1600 to 900 million years ago Paleoproterozoic 2500 to 1600 million years ago		primitive marine plants single-celled organisms
	Archaean 3800 to 2500 million years ago		oldest dated rocks on Earth	photosynthestic bacteria form stromatolites
	Hadean 4500 to 3800 million years ago		origin of the Earth Solar System forms	no life

Geologic Time at Petrified Forest

To understand the geology and paleontology of Petrified Forest National Park we must look more closely within the Triassic Period of the Mesozoic Era, going back 250 million to 210 million years ago. The supercontinent of Pangaea was breaking apart. What is now North America was near the equator. The Painted Desert region was not dry and arid as it is today, but was a subtropical environment filled with lush plant life, large amphibians and reptiles, and fish that swam in the many rivers, streams, and small lakes found in the region. This area was the drainage basin for large mountains that once loomed on the southern horizon, their volcanic cones erupting and releasing ash into the air and waterways.

Geologists study the stratigraphy, or rock layers, of the Chinle Formation found within the park to create an image of the Late Triassic environment. The Stratigraphy of Petrified Forest National Park diagram on the next page shows an accepted stratigraphy of rock layers in the park based on current science. The names given in the diagram are subject to change as new discoveries are made.

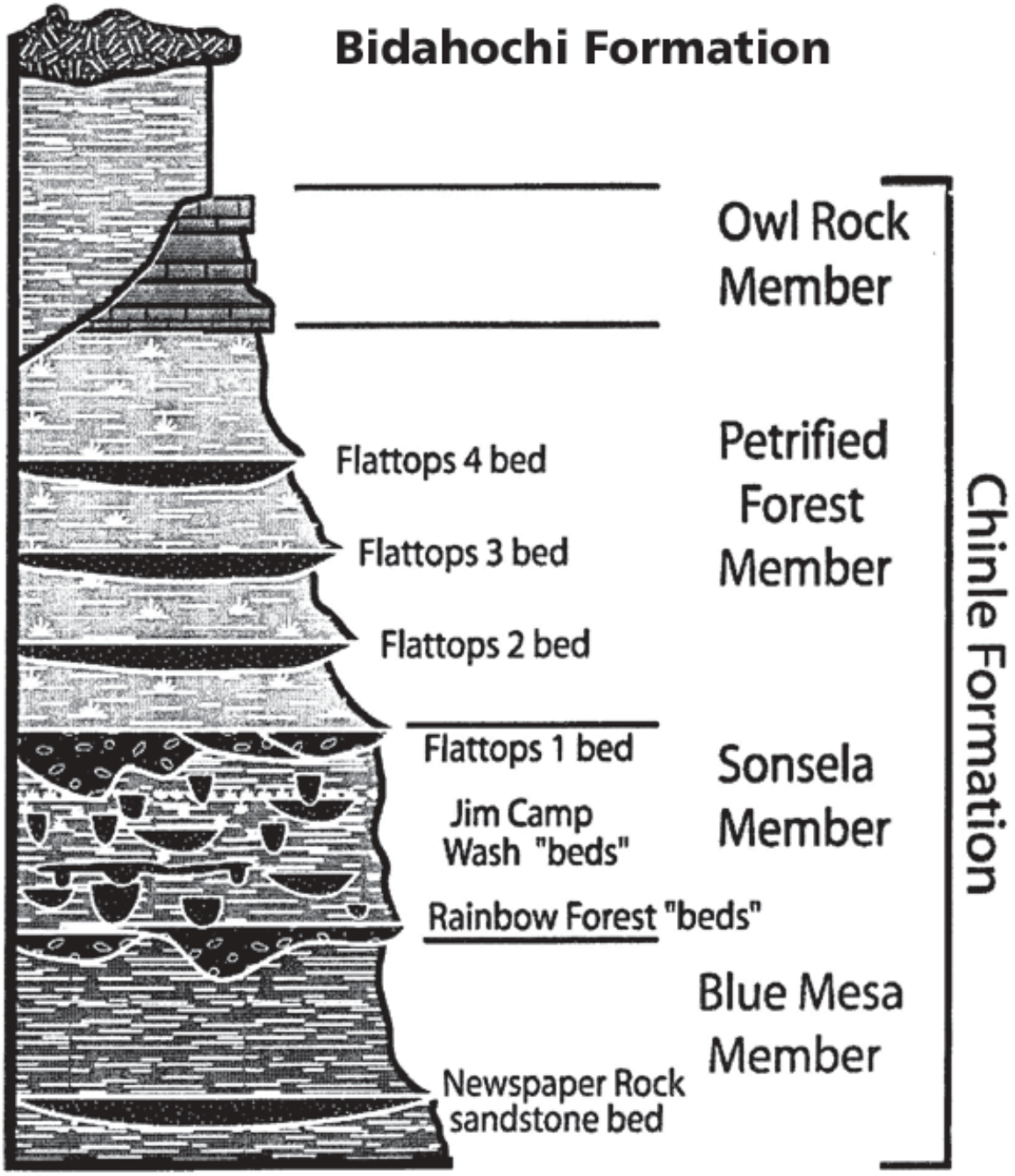
The Bidahochi Formation consists of igneous rock formed in recent times, 4-8 million years ago, during the Tertiary Period of the Cenozoic Era. A large lake basin covered most of northeastern Arizona. Inside and outside the lake basin volcanoes formed and erupted, spreading ash and lava over land and into the lake. Exposed in the park are volcanic landforms that began forming underwater, such as Pilot Rock. Where the Bidahochi Formation meets the Chinle Formation is an unconformity, a break in the rock record. Due to erosion occuring before the Bidahochi formed, 200 million years of time represented by rock layers is missing! The hardness of the basaltic rock of the Bidahochi protects the softer rock of the Chinle Formation from erosion.

With the exception of the Bidahochi Formation, rock layers in the park are sedimentary and included within the Chinle Formation, formed over 200 million years ago. The type of sedimentary rock and its distribution paints a picture of the ancient Triassic environment. Sandstones and conglomerates (layers with lots of gravel) indicate rapidly moving water because the sediment particles are large and heavy. Claystones and mudstones indicate slow, almost stagnant water because the sediment particles are small and lightweight.

The high concentrations of petrified logs, what we call petrified forests, found in certain rock layers of the Chinle Formation, indicate a series of ancient log jams. Tree trunks over 100 feet long were carried down huge rivers, washed into slow eddies on the inside of large river bends, or dumped into the large flood plain. Over time they were buried by the sediment also carried in the river waters, slowing down the process of decay and decomposition. Over many years of undisturbed rest, the preserved tree trunks were slowly petrified by the minerals seeping through the sediments in groundwater, leaving colorful rock replicas to tell their story.

Paleontologists study the petrified wood, other plant fossils, and animal fossils to add the living component to the environment described by geologists. By studying the ancient physical environment and the evidence of all the life found, paleontologists can study the ecosystem of the Late Triassic Period determining the interactions between the animals, the plants, and their surroundings.

Stratigraphy of Petrified Forest National Park



Daniel Woody, 2003

CREATING TIMELINES

TEACHER INSTRUCTIONS

OBJECTIVE

To develop student understanding of linear time through the creation of a personal timeline and a geologic timeline.

MAIN IDEA

This activity has two parts. First, students create individual personal timelines on paper, by placing events in their life onto a straight line. Then they will create a geologic timeline as a class activity.

MATERIALS

copies of Student Activity Sheet - one per person or per cooperative group
large sheets of paper
pencils, crayons, or markers
long rope (12 feet or longer)
permanent marker, flagging, or colored tape (optional)
copies of geologic timeline notecards, pages 33-36

PROCEDURE

PERSONAL TIMELINE

1. Follow the instructions on the Student Activity Sheet

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GEOLOGIC TIMELINE

1. Choose a large enough area in or out of the classroom where the rope could either be laid out on the floor or stretched to its full length betweeen two students holding either end.
OPTIONAL: Pre-divide the rope into equal increments, for example every 6 or 12 inches, to create the *scale*, or ruler of time. A permanent marker, flagging, or colored tape works well. For advanced students, ask the *students* to create the scale.

2. Use the timeline notecards provided, OR you can create your own.

3. Distribute the notecards to students and briefly discuss geologic time and the age of the Earth. Explain that the rope represents a geologic timeline. If applicable, explain the scale on the rope - how many years does each increment represent?

4. Ask the students with TODAY and EARTH'S BIRTHDAY to go to either end of the rope - either standing at the end or holding the end up, stretching the rope taut between them.

5. Have the other students with cards go to the rope and spread themselves out along it in the order that the events occurred. Students who do not have cards can help with the line up and spacing.

6. Students will initially spread themselves out evenly along the rope, but to accurately show a geologic timeline, which includes all the time *in between* the events, help students place themselves along the rope appropriately. This will mean clumping a lot of them together at the TODAY end and leaving a lot of open area at the other end and in the middle.

7. Discuss why the timeline looks as it does. Where are humans along the timeline? Where would each student's personal timeline fit into the geologic timeline? Looking at all of human existence on a geologic timeline shows that it is only a brief moment in the history of the Earth. If your armspan represented the Earth's geologic timeline from fingertip to fingertip, one swipe of a nail file on the fingernail marking today and all of human existence would be gone!

CREATING TIMELINES

STUDENT ACTIVITY SHEET

You are going to create two different timelines: a PERSONAL TIMELINE on paper and a GEOLOGIC TIMELINE with the whole class.

PERSONAL TIMELINE

WHAT YOU WILL NEED....

large sheets of paper
pencil, marker, or crayon

WHAT YOU WILL DO....

1. Choose a partner to help you make your timeline diagram. You will be using your armspan from fingertip to fingertip, so make sure your paper is large enough. Lie down with your arms stretched out to both sides on your paper. Have your partner carefully trace the outline of your hands, arms, and if there is enough room, your head, too! This will be the diagram on which you will plot your personal timeline.

2. Choose the longest fingertip of one hand on the diagram and label it your BIRTHDAY. Label the longest fingertip on the other hand TODAY.

3. Turn your timeline into a ruler by dividing it into equal pieces, like a ruler is divided equally into inches. Subtract the year you were born from the year of today. Here's an example.

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  2004
- 1994
    10
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This gives you the total number of years on your timeline, also called the *scale*. Using this example, the timeline would have 10 equal pieces.

How many years did you get when you subtracted the year you were born from the year of today? Divide your timeline into that many equal pieces.

4. Now number each of the lines on your timeline using years. Using the example above, the timeline would start at 1994 at the fingertip labeled BIRTHDAY. The next line would be 1995, then 1996, then 1997, and so on until 2004 at TODAY. This "ruler" of time would look like this:

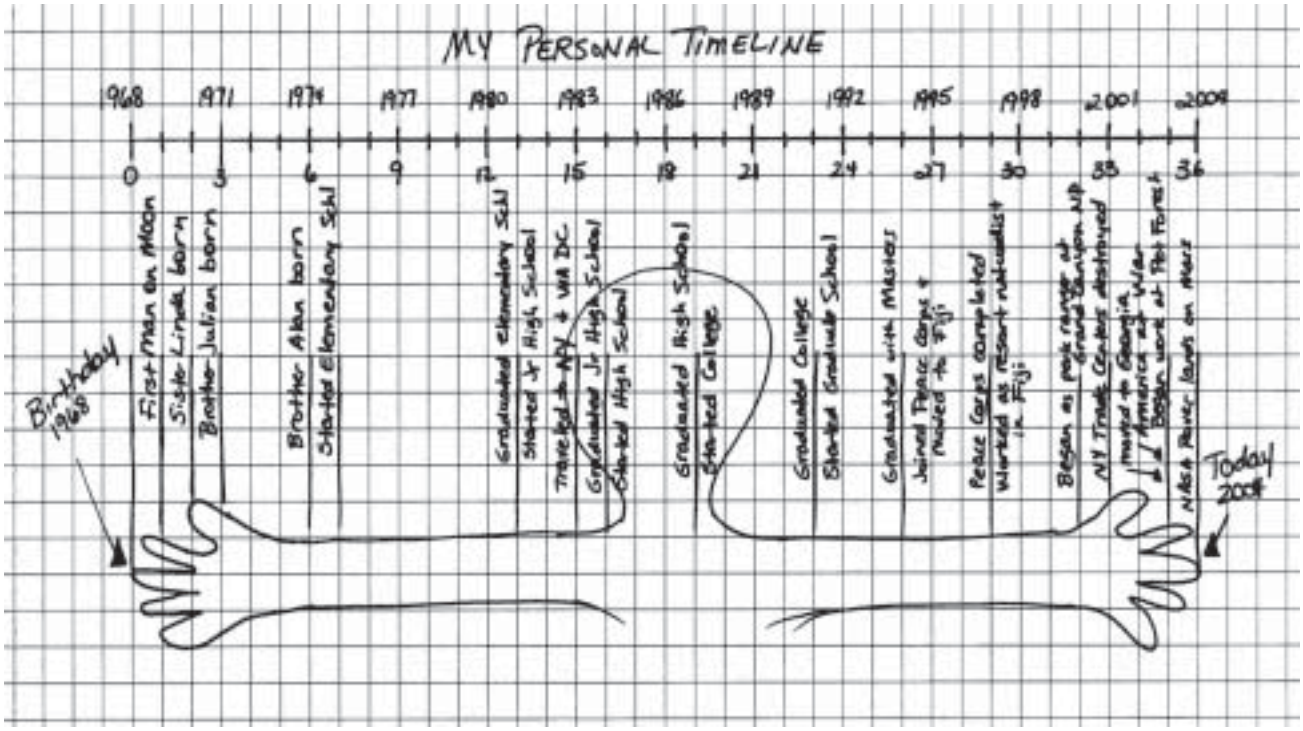
5. Go back as far as you can remember in your life. Make a list of important events that have occurred in your lifetime. Here are some examples:

→ First learned to walk
→ First year at school
→ Baby brother was born

You might also want to include important world events like:

→ PlayStation first released in Japan, 1994
→ New York World Trade Centers were destroyed, 2002
→ NASA Space Rover lands on Mars, 2004

Below is an example of a personal timeline. This timeline represents the years between 1968 and 2004 and has 36 years. Look at how much time in that 36 years was spent in school! Wow!



GEOLOGIC TIMELINE

Now you will make a GEOLOGIC TIMELINE as a class activity. Your teacher will help you.

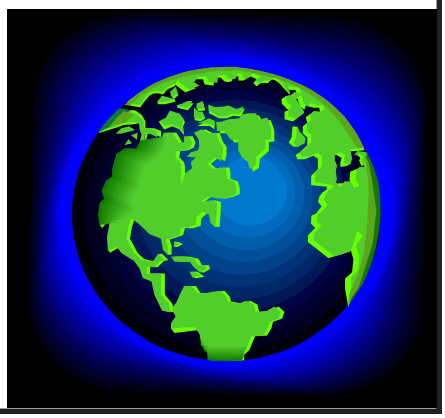
CONCLUSION

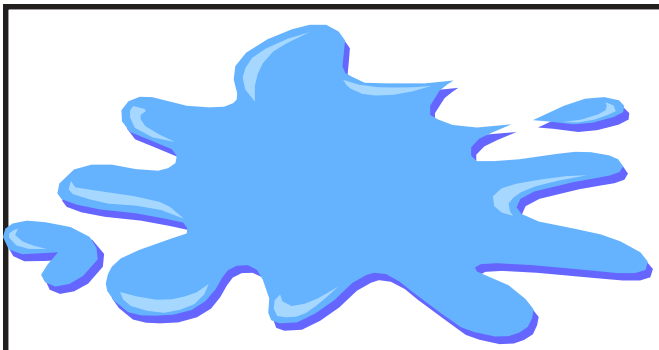
How does your geologic timeline look? Do you have large empty spaces at the beginning and everything pushed together at the end? Then you've made the timeline correctly! Geologic time covers so much time that the existence of human beings could easily be overlooked. It may seem like a long time ago that dinosaurs ruled the earth, but it was very recent in geologic time. Aren't you glad school days are not measured in geologic time?!

TODAY

EARTH'S BIRTHDAY

4,500 MILLION YEARS AGO



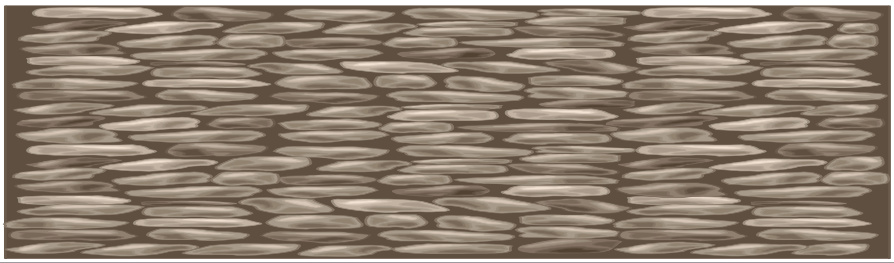


PROTEROZOIC ERA BEGAN

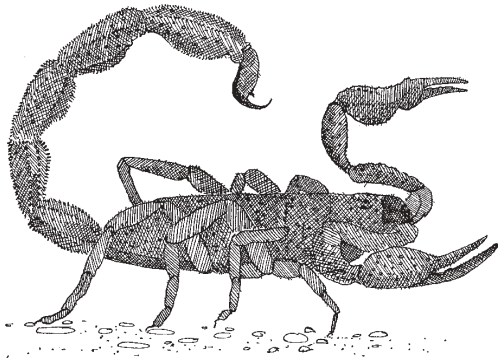
2,500 MILLION YEARS AGO

OLDEST ROCKS IN ARIZONA

2,000 MILLION YEARS OLD



PALEOZOIC ERA BEGAN



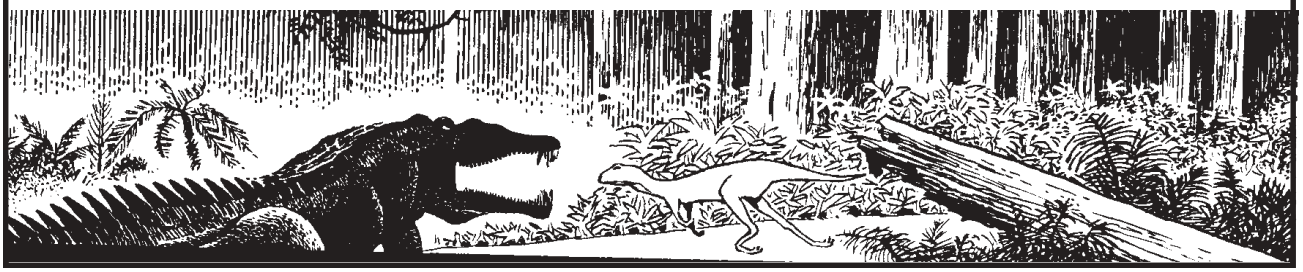
543 MILLION YEARS AGO

MESOZOIC ERA BEGAN

248 MILLION YEARS AGO

TRIASSIC PERIOD ENDED

206 MILLION YEARS OLD



DINOSAURS

EXTINCT

65 MILLION YEARS AGO

CENOZOIC ERA BEGAN

65 MILLION

YEARS AGO

COLORADO PLATEAU BEGAN TO FORM 60 MILLION YEARS AGO

OLDEST HUMAN ANCESTORS 8 MILLION YEARS AGO

GRAND CANYON BEGAN TO FORM 5 MILLION YEARS AGO