Fossils and the Geologic Time Scale

Activity using a scaled model of Earth time

North Carolina Geological Survey

Background:

Earth formed nearly 4.6 BILLION years ago. That's a huge number for us Earthlings to wrap our heads around. As a way to understand time, humans have divided it into manageable units – minutes, hours, days, weeks, months, years, etc. We use clocks and calendars as tools to understand time.

Geoscientists use a tool for time called the Geologic Time Scale (**GTS**). The GTS is used to interpret the timing and events of Earth events. Rather than minutes, days, weeks, etc., the GTS is divided into Eons, Eras, Periods, and Epochs. Each of these time divisions is based on significant events in Earth history – appearance (or disappearance) of certain life forms, formation or breakup of continents, and mass extinctions.

Students will build a scaled model of geologic time in this activity by placing Earth events or fossils on a tape measure timescale. A scaled model of geologic time will shrink Earth history but will use ratios to replicate the proportions of Earth events. It's easy to do and there are specific instructions provided!

Targeted Grade Level(s):

8th grade

2023 Science Standard(s):

ESS.8.1 Understand the history of Earth and its life forms based on evidence of change recorded in fossil records and landforms.

ESS.8.1.1 Analyze and interpret data to conclude the relative age of Earth and relative age of rocks and fossils from index fossils and ordering of rock layers.

Objectives:

To provide students with an awareness of how old Earth is, to demonstrate the large expanses of time between Earth events, and to show how life has evolved and changed over geologic time using a **scaled model of geologic time**. This activity can incorporate math skills and even the arts.

Materials:

1. A long hallway or open space such as a gymnasium floor
2. Tape measure
3. Calculator
4. List of important Earth dates (included), fossil pictures (optional)
5. Tape, sticky note pads, optional: crayons, colored pencils

Estimated Time:

1 class periods, possible homework assignments

Teacher Info:

- There are several options when creating a scaled model of Earth time or Earth events. You could have students focus on important events in Earth history, on fossils and evolution in Earth history, on important geologic events in North Carolina, or even just mass extinctions throughout Earth history. There are so many possibilities!
- Students can be creative by drawing pictures of fossils or Earth events or you can print images if you're low on time.
- For any version of this activity, you/students will need to know the date/time of the Earth event in order to calculate its position on the scaled model.
- This activity does require pre-planning and prep. For specific instructions, please see the next pages.

PRE-ACTIVITY INSTRUCTIONS

1. Determine what Earth events, fossils, and/or life forms you would like to place on your timescale. Many of these (including dates) have been provided in this packet, but feel free to use whatever you feel is appropriate or interesting for your students. You can print out pictures or even have your students be creative by drawing the events, fossils, and/or life forms. If time is short, this can be as simple as writing the event/fossil/life form on a small piece of paper.

2. **Determine the Length of Your Timescale:**

   You can use any timescale length that you'd like or have available, but a timescale less than 25 feet will not be able to show the vastness of geologic time as easily as a longer scale. ***All the calculations in this packet are based on a 50-foot timescale length*** but instructions are written so you can use any length you have available. You need to know the length of your timescale in order to complete the pre-activity calculations.

3. **Main Timescale Calculation:** the calculation below is based on a 50-foot timescale length. To modify the calculation, just swap out '50 feet' in the equations below for the length of **your** timescale.

   To make this a scaled model of geologic time, you will need to determine how much geologic time is represented by ***each foot*** on your timescale. Here is the equation to do this:

   Age of Earth (years) / Length of timescale (feet) = Years per foot on timescale

   4,600,000,000 years / **50** feet = 92,000,000 years per foot on timescale

   In other words: Each foot on this 50-foot timescale represents 92 million years. This number never changes for the entire activity. *If your timescale is a different length than 50 feet, just substitute that number in the equation instead of 50 to figure out your time/distance ratio.*

4. **Event/Fossil Calculations:** It's time to determine where the Earth events, fossils, or life forms that you chose will be placed on your timescale. You can do these calculations yourself before class, or have students complete these as homework assignments before the activity. Here are two examples:

   The oldest shark fossils are 409,000,000 years old. Where do you place the oldest shark fossil on your timescale?

   409,000,000 years / 92,000,000 years per foot = **4 feet**

   The oceans formed around 3,800,000,000 years ago. Where do you place this event on your timescale?

   3,800,000,000 years / 92,000,000 years per foot = **41 feet**

   You or your students can continue to do these calculations for as many events, fossils, or life forms that you wish. We'll explain in the next step how to lay out the timescale and how these calculations will dictate event placement.

DAY OF ACTIVITY INSTRUCTIONS

Laying out the Timescale:

1. Place a tape measure on the floor that equals your predetermined length. For our examples, remember that we're using a 50-foot timescale. Use whatever means you have to make sure the tape measure remains in place on the floor throughout the activity.
2. On a piece of paper or a sticky note, write "EARTH FORMS" and on another piece of paper or sticky note, write "TODAY".
3. Place the "EARTH FORMS" paper at the end of your tape measure (at the 50 feet end) and tape it to the floor.
4. Place the "TODAY" paper at the beginning of your tape measure (at the zero inches end) and tape it to the floor.

Creating the Timescale:

Begin placing your Earth events/fossils/life forms on the timescale, based on the calculations you completed. Using our two examples from earlier in these instructions:

a. Place a picture of a shark/fossil or a piece of paper with "oldest shark" written on it on the timescale at the **4-foot** mark. ***Start at the "TODAY" end of the timescale and count to 4 feet.*** Tape the picture/paper to the timescale or the floor at the 4-foot mark.
b. Place a picture of an ocean or a piece of paper with "oceans form" written on it on the timescale at the **41-foot** mark. **Start at the "TODAY" end of the timescale and count to 41 feet.** Tape the picture/paper to the timescale or the floor at the 41-foot mark.
c. Continue this process with all the events/fossils/life forms that you chose and calculated until your timescale is complete.

There you have it – a scaled model of geologic time! We hope you enjoyed your journey.

See the following pages for:

a. Important events/fossils/life forms and their associated dates
b. Post-activity discussion questions
c. Interesting facts about geologic time

Important Dates in Geologic Time

Geologic Time	Event/Fossil/Life Form	Age (years)
Precambrian		
Hadean Eon	Earth forms	4,600,000,000
	Moon forms	4,500,000,000
Archean Eon	Oldest rocks form	4,200,000,000
	Oceans form	3,800,000,000
	First land masses form	3,600,000,000
	Oldest fossil of cyanobacteria – oxygen!	3,500,000,000
Proterozoic Eon	Oldest fossils of single-cell life (eukaryotes)	1,750,000,000
	Oldest fossils of multi-celled life (algae)	1,500,000,000
	First supercontinent (Rodinia) forms	1,100,000,000
	Oldest fossils of jellyfish & marine worms	670,000,000
Phanerozoic		
Cambrian Period	Explosion of life – trilobites & brachiopods	542,000,000
	Oldest fossils of vertebrate fish (*Myllokunmingia*)	530,000,000
	Oxygen present in atmosphere at today's levels	500,000,000
Ordovician Period	Oldest fossils of land plants (moss, liverwort, lichen)	470,000,000
	End of Ordovician Mass Extinction	440,000,000
Silurian Period	Oldest fossils of vascular land plants	428,000,000
Devonian Period	Oldest insect fossils (*Rhyniognatha hirsti*)	412,000,000
	Oldest shark fossils (*Doliodus problematicus*)	409,000,000
	Oldest amphibian fossils (*Acanthostega*)	375,000,000
	End of Devonian Mass Extinction	360,000,000
Carboniferous Period	Oldest reptile fossils (*Hylonomus*)	320,000,000
	Supercontinent Pangea forms	300,000,000
Permian Period	First mammal-like reptiles (synapsids, *Lystrosaurus*)	299,000,000
	End of Permian Mass Extinction (96% of all species lost)	252,000,000
Triassic Period	Oldest dinosaur fossils (*Eoraptor*)	228,000,000
	Oldest mammal fossils (*Morganucodon*)	221,000,000
	Pangea begins rifting, Atlantic Ocean starts forming	201,000,000
	End of Triassic Mass Extinction	199,000,000
Jurassic Period	Oldest bird fossils (*Archaeopteryx*)	155,000,000
Cretaceous Period	Oldest flowering plants fossils (*Archaefructus*)	142,000,000
	Oldest *T. rex* and *Giganotosaurus* fossils	75,000,000
	End Cretaceous Mass Extinction	66,000,000
Tertiary Period/Paleogene	Oldest primate fossils (*Teilhardina*)	55,000,000
	Oldest whale fossils (Pakicetus)	52,000,000
	Oldest canine (dog) fossils (Hesperocyon)	37,000,000
	Oldest feline (cat) fossils (Proailurus)	25,000,000
Tertiary Period/Neogene	Oldest megalodon shark fossils (*C. megalodon*)	15,000,000
	Oldest human-like ancestors from Africa (Australopithecus)	4,000,000
	Oldest human fossils outside of Africa (Homo erectus)	1,200,000
	Oldest modern human fossils (Homo sapiens)	200,000
	Beginning of last North American glacial period	100,000
	Beginning of the Neolithic Age ("Stone Age")	10,000

Important Dates in North Carolina Geologic History

Geologic Time	Event/Fossil/Life Form	Age (years)
Precambrian (Hadeon Eon, Archean Eon, Proterozoic Eon)		
	Oldest dated rocks in NC (near Roan Mountain)	1,800,000,000
	A volcanic island arc called "**Old Carolinia**" starts to form off the coast of an ancient continent called Gondwana (parts of ancient South America, Africa, and Antarctica)	630,000,000
	Oldest known fossil from NC (fern, *Pteridium*)	620,000,000
	Volcanoes of Old Carolinia went extinct. New volcanoes formed on top of the extinct volcanoes (called **"New Carolinia"**). These volcanoes were also along the edge of Gondwana. The volcanoes of New Carolinia also eventually went extinct.	550,000,000
Phanerozoic		
Cambrian Period	Rocks of "New Carolinia " (extinct volcanoes) began to rift away from Gondwana at a divergent plate boundary. This created a new ocean – Rheic Ocean. As New Carolinia rifted, it sank and became buried by thousands of feet of ocean sediment	520,000,000
Ordovician Period	A separate volcanic arc (Milton Arc) began to form in another ocean called the Iapetus Ocean. The rocks of New Carolinia were on a collision course with the Milton Arc volcanoes as rifting and diverging plate continues.	475,000,000 – 460,000,000
	The Milton Arc volcanoes began a collision with ancient North America at a convergent plate boundary. Soon after, New Carolinia began to collide with the Milton Arc and ancient North America. By 440,000,000 ago, the Iapetus Ocean had completely closed and the convergence of the Milton Arc and New Carolinia was complete	450,000,000 – 440,000,000
Carboniferous Period	Gondwana begins to move towards ancient N. America (which now includes the rocks of the Milton Arc and New Carolina) at a convergent plate boundary. Its collision with N. America was so powerful that slabs of massive rocks were pushed over 100 miles northwestward into the interior of N. America. Friction from rocks grinding past each other caused enormous heat, which caused rocks to melt, creating magma. Once cooled, this magma became the granite rocks of NC	330,000,000 – 300,000,000
Permian Period	Formation of the supercontinent Pangea and the 1000 mile long Appalachian Mountains	300,000,000 – 250,000,000
Triassic Period	Pangea begins to rift apart at a divergent plate boundary, creating the Atlantic Ocean. Rifting caused continental basins to form (Triassic basins near Durham and Sanford) and fill with sediment and clay. Coal and other resources formed in these basins. Fossils of reptiles (*Phytosaurus*) and plants (cycads) are found in these Triassic basins	201,000,000
Cretaceous Period	Sea levels rose dramatically, causing the deposition of fluvial and marine sediments in eastern NC. Fossils of dinosaur bones and teeth (*Hadrosaurus*), shark teeth, shells, and trees have been found from this time	75,000,000
Tertiary Period/Paleogene	Sils and clays of NC's Coastal Plain began to form. Marine fossils (brachiopods, sea urchin, whales) have been found from this time	50,000,000 – 25,000,000
Tertiary Period/Neogene	Uplift and erosion of the Piedmont created thick sediment deposits in the Coastal Plain. Fossils of *C. megalodon* sharks can be found. Carolina Bays and modern floodplains formed.	5,000,000 - present

Discussion / Critical Thinking Questions

1. What observations do you have about the scaled timeline you've created?

2. Using other science knowledge that you have, can you guess the process that cyanobacteria used to produce oxygen? How long did it take from the first known cyanobacteria for oxygen to be present in the atmosphere at today's levels?

3. It took about 800,000,000 years for the first oceans to form on Earth. Do you have any ideas or speculation on where the water came from to produce the oceans?

4. Do you have any observations about geologic time periods and mass extinctions?

5. Many scientists agree that we're in the midst of a 6th mass extinction event. What is different about this mass extinction than the five others that occurred in the past?

Interesting Facts about Geologic Time

1. According to the National Park Service:
   One million seconds is equivalent to about 11 days and 14 hours
   One billion seconds is equivalent to about 32 years, and
   4,600,000,000 seconds (Earth's age) is equivalent to 147 years!
2. The time between the first dinosaurs (228,000,000 yrs) and the dinosaur extinction (66,000,000 yrs) means that dinosaurs ruled Earth for about 162,000,000 years. Modern humans have only existed for 200,000 years.
3. *T. rex* existed closer to the time of humans than it did to the first dinosaurs (*Eoraptors*).
4. Bacteria were the only life on Earth for almost 3,000,000 years – that is about 68% of Earth's history.
5. Earth's atmosphere has not always contained oxygen. For billions of years, the atmosphere consisted of toxic gases like ammonia, sulfur dioxide, and methane.
6. The moon formed between 50,000,000 to 100,000,000 years after Earth formed and is thought to have formed from a collision of a Mars-sized planet with the newly-forming Earth.
7. The largest mass extinction in Earth's history occurred at the end of the Permian Period, about 252,000,000 years ago. Nearly 96% of all life on Earth went extinct at this time. Scientists believe that Earth went through a period of global glaciation followed by a period of global warming. Aquatic life that had adapted to cold were not able to evolve quickly enough to adapt to a hotter Earth.

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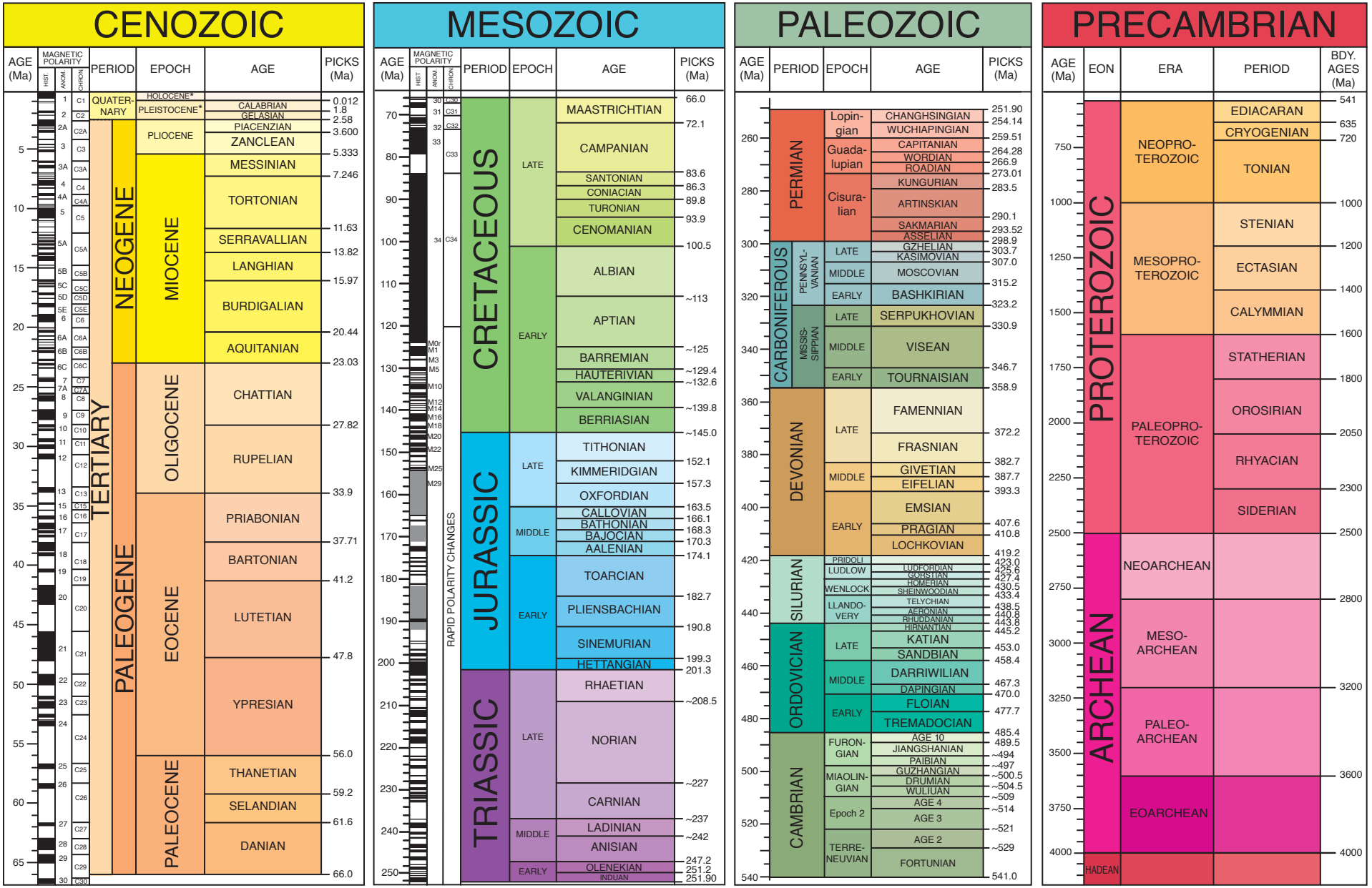
GEOLOGIC TIME SCALE v. 6.0



*The Pleistocene is divided into four ages, but only two are shown here. What is shown as Calabrian is actually three ages: Calabrian from 1.8 to 0.774 Ma, Chibanian from 0.774 to 0.129 Ma, and Late from 0.129 to 0.0117 Ma. The Holocene is divided into three ages: Greenlandian from 0.0117 to 0.0082 Ma, Northgrippian from 0.0082 to 0.0042 Ma, and Meghalayan from 0.0042 to present. The geologic community broadly recognizes the Anthropocene as a proposed new time interval of Earth history, partly coincident with the Holocene. Currently, the Anthropocene has an informal designation, with a proposed age span extending from the present to a beginning point between ca. 15,000 yr B.P. and as recent as 1960 CE.

The Cenozoic, Mesozoic, and Paleozoic are the Eras of the Phanerozoic Eon. Names of units and age boundaries usually follow the Gradstein et al. (2012), Cohen et al. (2012), and Cohen et al. (2013, updated) compilations. Numerical age estimates and picks of boundaries usually follow the Cohen et al. (2013, updated) compilation. The numbered epochs and ages of the Cambrian are provisional. A "~" before a numerical age estimate typically indicates an associated error of ± 0.4 to more than 1.6 Ma.

Walker, J.D., and Geissman, J.W., compilers, 2022, Geologic Time Scale v. 6.0: Geological Society of America, https://doi.org/10.1130/2022.CTS006C. (Walker—University of Kansas; Geissman—University of Texas–Dallas, University of New Mexico.)

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