LESSON #3: Age of Earth:
Creating a Time Line Scaled to the Outline of a Human Body

Focus questions

1. How old is the Earth?
2. When did life evolve?
3. How can we create a time line to show the age of the Earth in a way we can relate to?

What students do in this activity

Students will work with a partner to draw an outline of their bodies on a large sheet of paper. They will then measure their body length and use ratios to create a scale indicating how many inches equals how many years. Next they will write in specific dates on their body outlines to create a time line showing the age of the Earth and significant events that occurred during Earth's history.

Estimated teaching time

Two class periods (one to introduce the topic and start work and the second to finish the time scale and discuss what they discovered)

(Students may have to move desks out of the way in order to have room to roll out paper and trace themselves.)

General supplies to complete this lesson plan

- Roll of butcher paper long enough for each student to draw his/her outline
- Scissors to cut paper

Each student will need the following or access to it

- **Handout of Geologic Time Scale and Important Events in Earth's History**
- Pencil, paper
- Butcher Paper to trace outline of body on
- Colored Markers
- Ruler
- Calculator

Learning goals

Students will:
1. Learn the age of the Earth
2. Learn when major events occurred during Earth's history
3. Learn that animals did not appear for the first 90 percent of Earth's history
4. Learn that one way to relate to the great amounts of time in geology is to create a time line using something they know well
5. Develop an appreciation for great spans of time

Advance preparation

1. Copy **Geologic Time Scale** onto overhead.
2. Copy **Geologic Time Scale** and **Major Events in Earth's History** back to back. (one per student)
3. Cut roll of paper into usable lengths for students.
4. Find a space where students can lay on the ground and trace their bodies on paper.

Introducing the activity

1. Ask the students "How old is the Earth?"
2. Show students the geologic time scale overhead and discuss how the Earth is divided into different time eras, periods, epochs and ages.
3. Ask the students "How could you create a time line that would show the age of the Earth in way you could understand it?"
4. Explain that they are going to create a time line showing the age of the Earth in a format they can relate to.

Facilitating the activity

1. Hand out **Geologic Time Scale** and list of **Major Events in Earth's History**.

2. Ask them to write down how tall they are in inches. If they do not know, have students partner up and measure each other.

3. Have students create a time scale relating inches to millions of years.

   They can use the following mathematical formula to figure out how many years an inch equals. (See Teacher's Background for more information.)

   4,500,000,000 (age of Earth) = HX
   H = Height in inches
   X = Millions of years

   For example if a student is 48 inches tall the formula would be:

   4,500,000,000 = 48x
   x = 4,500,000,000/48
   x = 9,375,000 years
   Therefore each inch equals 9.4 million years.

4. Ask students to figure out what 1/2", 1/4" and 1/8" equal in millions of years.

5. Hand out sheet of butcher paper for tracing bodies.

6. Have students pick a partner, who will help them trace their body outline.

7. Have students roll out paper, tape it to floor, and trace their partner's body.

8. Ask them to plot time periods and major events on their body outline.

Summarizing and reflecting

Ask students to consider the following questions. This can be done as a group activity or as a writing assignment.

- What does this time line show you about life on Earth?
- What does the time line show you about how long the dinosaurs were on Earth?
- Put the following modes of travel in chronological order: flight, swim, walk.
- What can you say about humans specifically, how long they have been on the planet, and their impact on the planet?

Optional activity:

As a group activity, the students could create a time line that ran around the inside of the classroom or down the length of a hallway. Students could be assigned an individual time period, such as the Jurassic or Tertiary, and then would have to research significant events that occurred during that period and draw the event, find drawings/photos of it, or write a paragraph about it. This might encourage more artistic perspectives to come out.

Another optional activity is for students to create other time lines based on other well-known scales, such as a single year, single day, 12-hour clock, or football field.

TEACHER BACKGROUND: The Age of the Earth

Geologists did not always have a way to measure time in numbers of years. Originally they only knew that some events occurred before other events. This is what is known as relative time; event A occurred some time before event B. In practical terms for geologists, this means that when they look at a wall of rock, such as the Grand Canyon, they know that the rocks at the bottom are older than the rocks at the top. This is known as the Law of Superposition: younger rocks sit atop older rocks.

Geologists have been able to supplement this information by using fossils. In the late 18th and early 19th centuries, paleontologists discovered that rocks of the same age may contain the same fossils, even when the rocks are separated by long distances. This gave geologists a way to give a relative date to widely separated rocks.

As geologists developed the relative age of various rocks, they began to create a time scale to show how rocks and fossils related to each other. They divided the Earth's history into eons, which are subdivided into eras, which are subdivided into periods, which are subdivided into epochs. The names of these subdivisions, such as Paleozoic or Cenozoic, refer to the evolution of life. For example, ***zoic*** refers to animal life, and ***paleo*** means ancient, ***meso*** means middle, and ***ceno*** means recent.

The names of periods generally refer to the place where they were named. For example, *Cambrian* is named for the ancient name of Wales, Cambria and the *Jurassic* refers to the Jura Mountains on the border between France and Switzerland, where rocks of this age were first studied.

In the early 20th century, scientists made a great breakthrough that changed their understanding of the age of rocks. They discovered that atoms decay over time. These unstable particles decay at a set rate, regardless of time, temperature, pressure or chemical changes. Scientists define this decay in terms of its half-life, the time in years it takes for half the atoms to decay. Decay of the atoms creates what is known as an isotope, atoms whose nuclei have the same atomic number, but different atomic weight. By knowing this decay rate and by measuring the number of isotopes remaining, geologists can determine the absolute age of a rock.

This technique has been refined over the years and allowed geologists to create the geologic time line now used by all geologists.

History of Life on Earth

In the past few decades, geologists have put together a thorough record of life on Earth. "With all the various discoveries and better understanding of evolutionary processes, we now have very few natural gaps in the fossil record. Gone are most of the so-called 'missing links,'" says Dr. Liz Nesbitt, Curator of Paleontology at the Burke Museum of Natural History and Culture. "We can see the evolution from fish to amphibians, mammal-like reptiles to mammals, or dinosaurs to birds. The Burgess Shale is one more layer in this story."

The story begins 4.55 billion years ago when Earth coalesced out of the remains of the Big Bang. A billion years later, life appeared. These microbes, known as *cyanobacteria,* looked like beads and lived in shallow seaways dotted with islands surrounded by lagoons and mudflats. The cyanobacteria could photosynthesize and breathe in oxygen, advanced life processes that imply that life must have evolved earlier but left no evidence.

Life remained simple for another two billion plus years until the development of sexual reproduction at about 1.2 billion years. Microscopic red algae (Bangiomorpha pubescens) are the first complex multicelled organisms, in which cells could perform a specialized task. They are part of the large group of species known as eukaryotes, or organisms that have the cell DNA enclosed in a nucleus in a cell, as opposed to prokaryotes, which lack a nucleus and where the DNA floats freely through the cell. Animals, plants and fungi are eukaryotic. Bacteria, such as cyanobacteria, are prokaryotic.

Despite what some call the "big bang of eukaryotic evolution," another 600 million years passed until animals appeared. The evidence comes from sponge and cnidaria (jelly fish and coral) embryos from China, dated at 590 to 570 million years ago (mya). Paleontologists consider these two groups to be the most primitive of modern animals. Shortly after, a wide-spread group of animals, known as the Ediacaran or Vendian fossils, appeared. First discovered in the Ediacara Hills of South Australia, they have been found world-wide. All are soft-bodied and most are circular impressions.

Then came the "small shelly fauna," as paleontologists dub the first animals with hard parts. Found on most continents, and also known as the Tommotian fauna (after a locale in Russia), they are minute caps, cups and blades. The Tommotian is the first evidence of the great expansion of life forms exemplified by the Burgess Shale and called the Cambrian radiation or explosion.

Paleontologists date the Cambrian explosion at around 545 to 535 million years ago. The key development was the skeleton, in particular shells and exoskeletons. Most often made of calcium carbonate, skeletons offer protection from predators and from the environment, a development that led to what has been termed an "arms race," as prey evolved to defend itself and predators evolved to defeat the new armor. This battle can be seen in the Burgess Shale with trilobites that have bites taken out them and priapulid worms with cone-shaped animals in their guts. Animals also developed eyes, grew larger, and started to move more quickly. In this remarkably short period, animals evolved the basic shapes that would last for at least the next half billion years.

In addition to animals becoming more complex ecological community complexity diversified. Skeletons allowed animals to move further and eat in new ways. Grazers prospered, forcing algae to adapt. Animals began to burrow, to avoid predation. Others started filter feeding and some moved off the bottom and became swimmers and floaters. After nearly 90 percent of its history, the stage was set for the evolution of such beasts as millipeds, monkeys and mosasaurs.

After the Cambrian explosion animals in the oceans continued to diversify. Significantly, the oldest known fish, armored but jawless, evolved in the Ordovician Period (490-443 mya), followed by rapid diversification over the next 30 million years with the development of jaws and colonization of fresh water. Not to be overshadowed, about 420 million years ago a half-inch long milliped began to live on land: the first beast to do so. Amateur fossil collector and bus driver Mike Newman found the fossil in Scotland. To recognize his role in the significant find, the new species — Pneumodesmus newmani — has been named after him.

Scotland can also lay claim for another dramatic point in evolution: the first insect, which also appears to be the first animal that flew. Found near the same formation as the milliped, and basically just a set of jaws 1/250" across, the insect had sat in a drawer in the Natural History Museum in London, little noticed since 1926. When researchers looked more closely, they were startled by what they found. They reported their findings in February 2004.

Animals living on land imply that plants had already made the same move. The earliest plants were primitive and did not resemble modern plants for millions of years. By 360 million years ago though, ferns, mosses, horsetails and conifers had evolved. Swamps were widespread and some even contained beasts with four legs, including the first to live on land, an amphibian in the genus Acanthostega, that crawled out 370 million years ago during the Devonian.

Yet another long-known fossil, it was restudied by paleontologist Jenny Clack in the 1980s and '90s. Her analysis and interpretation led to fundamental rethinking of early tetrapod (four limbs) evolution. Prior to Clack's work, prevailing wisdom held that land colonization drove evolution of legs and feet, but Acanthostega couldn't stand on its own legs. Clack describes it as basically a "fish with fingers." It

The Dawn of Diversity

LIFE IN THE BURGESS SHALE

appears that legs came first and then colonization.

The following geologic period, the Carboniferous, marks another key development, the amniote egg, in which the embryo is protected by a hard shell. This allowed animals to lay eggs on dry land, thus facilitating the complete colonization of land by animals. The first to appear were the reptiles.

The dawning of the Permian at 290 mya saw the rise of the mammal-like reptiles, the precursors of the mammals. The Permian also marks the formation of the supercontinent of Pangaea, when all the landmasses coalesced into one. Reptiles continued to diversify, with mammal-like reptiles the dominant animals. And then life on Earth nearly disappeared. In the sea, over 90 percent of species went extinct. On land, at least 70 percent of all vertebrates disappeared.

Life came roaring back in the Triassic with the evolution of dinosaurs and mammals. Mammals, although diverse, remained in the background for the next 160 million years. Reptiles took to the air (pterosaurs) and sea (mosasaurs and plesiosaurs) in the Triassic, but it wasn't until the Jurassic that dinosaurs began to truly diversify. Birds (archaeopteryx) and flowering plants also appear in the Jurassic at 150 mya and 145 mya, respectively. Dinosaurs reigned until 65 mya, when they and 50 percent of all species perished.

With the elimination of the dinosaurs, mammals took over, diversifying rapidly during the Tertiary. They evolved from small animals to the largest beasts ever known, blue whales. And yet, arthropods, such as insects, which first appeared during the Cambrian explosion, are still the most numerous group on the planet.

"In looking back over the fossil record, two aspects should stand out. The first is that evolution and extinction are facts of life. The second is that people keep making new discoveries all of the time." summarizes Dr. Nesbitt. "The Burke Museum is extremely fortunate to be able to display the Burgess Shale because it displays these aspects as well as any fossils ever found."

Formulas for Figuring Out Inches and Millions of Years

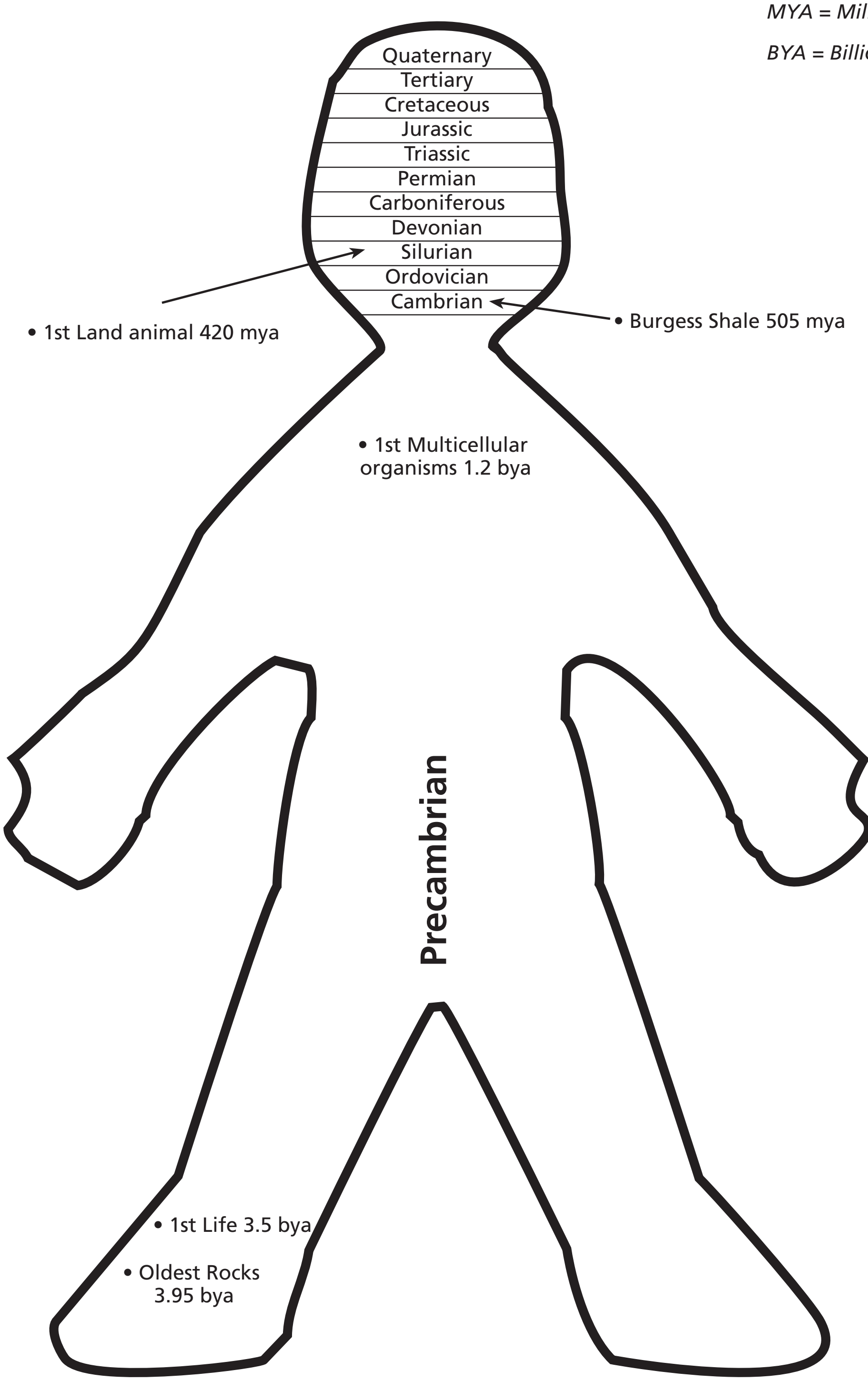
Example Heights	Formula	Million years per inch
48	4,500,000,000 = 48x	9.37
54	4,500,000,000 = 54x	8.33
60	4,500,000,000 = 60x	7.5
66	4,500,000,000 = 66x	6.81
72	4,500,000,000 = 72x	6.25

For each inch between these numbers, subtract .18 million years, therefore for a 49-inch-tall person a million years is equal to 9.19 million years.

Sample of time scale on body outline

MYA = Million Years Ago

BYA = Billion Years Ago



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STUDENT HANDOUT

Major events in Earth's history

History of life:
(MY = million years before present)

- First evidence of life — 3500 MY
- First multicellular organisms — 1200 MY
- First animals — 590 MY
- Burgess Shale fossils — 505 MY
- Early land plants — 438 MY
- First animal on land — 420 MY
- First insect and first flight — 400 MY
- First amphibians — 370 MY
- First reptiles — 310 MY
- Dinosaurs appear — 240 MY
- First mammals — 225 MY
- First birds — 150 MY
- Flowering plants appear — 140 MY
- Extinction of dinosaurs — 66 MY
- Early horses and other familiar animals — 37 MY
- Earliest hominids — 2 MY

Physical geology:
(MY = million years before present)

- Formation of Earth — 4600 MY
- Oldest rocks yet discovered — 3950 MY
- Start of formation of Appalachian Mts. — 450 MY
- Start of supercontinent Pangaea (all continents pushed together) — 360 MY
- Break-up of Pangaea begins — 225 MY
- Formation of Rocky Mts. — 60 MY
- Major deformation of Alps and Himalayas — 50 MY
- Beginning of formation of Cascades — 40 MY
- Beginning of Ice Ages — 1.6 MY
- Eruption of Mount St. Helens — 0 MY (May 1980)
- Nisqually earthquake — 0 MY (2001)

Newspapers In Education
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STUDENT HANDOUT

Geologic time scale

Eon	Era	Period	Sub-period	Epoch	MYA
	Cenozoic	Quaternary		Holocene	0.01
				Pleistocene	1.8
		Tertiary	Neogene	Pliocene	5.3
				Miocene	23.8
			Paleogene	Oligocene	33.7
				Eocene	54.8
				Paleocene	65
	Mesozoic	Cretaceous			144
		Jurassic			206
		Triassic			248
		Permian			290
		Carboniferous	Pennsylvanian		323
			Mississippian		354
		Devonian			417
		Silurian			443
		Ordovician			490
		Cambrian			543
Proterozoic	Late				900
	Middle				1600
	Early				2500
Archean	Late				3000
	Middle				3400
	Early				3800?