

Geological Time & Paleobiology

Fossil Mall Science Section



Also see:
 Tree of Life for Fossil Collectors
 Geologic Time Chart
 Geologic Time Chart Denoting Fossil Sites

**Chart of Geological Time:
 Denoting Significant Events in:
 Evolution, the Fossil Record, Paleontology and Paleobiology**
 "visit links for more information"

	ERA	Periods	EPOCH	Evolutionary Milstones
Phanerozoic EON (544 mya to present) <i>"The age of visible life"</i>		Quaternary (1.8 mya to today)	Holocene (11,000 years to today)	Last major ice age ends. Modern man migrates to the Americas.
			Pleistocene (1.8 mya to 11,000 yrs)	Neandertals appear and disappear; Homo erectus and Homo sapiens appear.
	Cenozoic Era (65 mya to today)	Tertiary (65 to 1.8 mya)	Pliocene (5 to 1.8 mya)	Ape-like ancestors of modern humans (Hominids); the Australopithecines appear and disappear. Homo habilis lives from 2.5 to 1.8 mya.
			Miocene (23 to 5 mya)	Grazing horses, antelopes appear
			Oligocene (38 to 23 mya)	Radiation of more modern animals; most modern bird forms have appeared; most modern mammals have appeared.
			Eocene (54 to 37 mya)	First grasses appear, a resource for herbivores; trees thrive. Some modern mammals appear: advanced primates; camels, cats, dogs, horses & rodents
			Paleocene (65 to 54 mya)	Flowering plants begin radiation extending through the Eocene. Small mammals radiate
			Mesozoic Era (245 to 65 mya)	Cretaceous (146 to 65 mya)
	Jurassic (208 to 146 mya)	Appearances include birds; crabs; frogs and salamanders Dinosaurs radiate to dominate the land		
	Triassic (245 to 208 mya)	Breakup of Pangaea begins Major extinction event: tabulate corals and conodonts disappear - ammonoids, reptiles and amphibians decimated Appearances include: dinosaurs; crocodiles; marine reptiles; turtles; Pterosauria and mammals Major groups of seed plants appear		
	Paleozoic	Permian (286 to 245 mya)		Major extinction of invertebrates (P-T). Trilobites fade away forever. All but articulate crinoids disappear

	Era (544 to 245 mya)	Carboniferous (360 to 286 mya)	Pennsylvanian (325 to 286 mya)	Divided as: Upper; Middle; Lower	Seedplants producing large trees
			Mississippian (360 to 325 mya)		Conifers & many winged insects appear
		Devonian (410 to 360 mya)			Reptiles appear. Trilobites become scarce
		Silurian (440 to 410 mya)			Mass extinction (F-F) Land colonized by plants and animals Appearances include: insects; sharks; amphibians (tetrapods); lung fishes and earliest seed plants. Extensive radiation of fishes.
		Ordovician (500 to 440 mya)			Jawed fish, cartilaginous fish and vascular plants appear. Primitive terrestrial predators: Arachnids.
		Cambrian (544 to 500 mya)			Mass extinction First land plants; bryozoans appear. Trilobites begin to specialize.
			Tommotian (530 to 527 mya)		Appearance of hard parts and vision - fossils become common. Appearances include: vertebrates; jawless fish; small shelly animals; conodonts; trilobites radiate repeatedly and reach their peak diversity.
Precambrian Time (4,500 to 544 mya) <i>"deep time on earth"</i>	Proterozoic Era (2500 to 544 mya)	Vendian (650 to 544 mya) or Ediacaran		No Epochs	Extinction at end of Vendian Macroscopic, soft-bodied organisms radiating. Oldest metazoans (multicellular animals) - Ediacaran Fauna.
		Neoproterozoic (900 to 544 mya) - Late			Macroscopic fossils of soft-bodied organisms. Chloroblasts arise from cyanobacteria through endosymbiosis. Stromatolite diminishing.
		Mesoproterozoic (1600 to 900 mya) - Middle			Sexual reproduction appears (about 1 billion years ago) First land fungi
		Paleoproterozoic (2500 to 1600 mya) - Early			More complex single-celled life with aerobic metabolism begin diversification Rusting of earth, depletion of oceanic Fe in banded iron formations Peak of stromatolite with cyanobacteria oxygenating the atmosphere
	Archaean (3800 to 2500 mya)				Primitive Eukarya appear Photosynthesis appears Oldest fossils - Apex Chert of Australia (3.55 BYA) - Prokaryotes dominate (Eubacteria and Archaea); simple cell forms form stromatolite First life appears - Heterotrophic, anaerobic, Asexual Oldest sedimentary rocks (3.8 BYA)
Hadean (4500 to 3800 mya)					Earth's environment extremely hostile to life as we know it

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Geologic Time Chart with Mass Extinctions:

Era	Period	Information
Cenozoic	Quaternary - 2 my	Humans dominate near the very end (last 100,000 years), and in the last 200 years there is another mass extinction. Rate of species loss is now estimated at 4000 species/year.
	Tertiary - 65 my	Mammals become dominant large animals, insects and flowers co-evolve.
		K/T mass extinction - possibly due in part to a large meteor impacting the earth near the Yucatan peninsula
Mesozoic	Cretaceous - 130 my	Diatoms, dinoflagellates and other one-celled organisms become abundant among marine life. The first flowers (angiosperms) and first primates appear during this period.
	Jurassic - 180 my	Dinosaurs dominate on land. Birds first appear.
		Triassic mass extinction - 35 % of all animal families go extinct,
	Triassic - 230 my	Reptiles dominate the land, mollusks such as cephalopods dominate the oceans. Dinosaurs and marine reptiles appear in late Triassic. Atlantic and Indian oceans appear. First mammals appear during this period, but remain rare.
		Permian mass extinction - many forams, corals, bryozoa, brachiopods, arthropods and crinoids go extinct.
Paleozoic	Permian - 270 my	Reptiles dominate the land. Seas contract in mid-Permian leading to a decline in marine life.
	Carboniferous (sometimes divided into Pennsylvanian and Mississippian) - 350 my	The eastern US was covered by coal swamps with scale trees (lycopods) and seed ferns. Reptiles arose and diversified during this period. Warm shallow seas led to diversification of marine life. Much of the US submerged.
		Devonian mass extinction
	Devonian - 400 my	Widespread invasion of land by mollusks, arthropods and amphibians. Fish diversified and dominated the oceans.
	Silurian - 430 my	Invertebrates dominated during this period. In the late Silurian plants and possibly some animals invaded the land.
	Ordovician - 500 my	First vertebrates appear (jawless fish) and bryozoans and crinoids appear. Invertebrates dominated the period however.
	Cambrian - 600 my	Called the 'Cambrian Explosion' because here is where most phyla appear. Sponges, archaeocyathids, brachiopods, trilobites, primitive mollusks, and echinoderms first appear.
Precambrian	Precambrian - 4.5 billion years	The earth forms, cools, in the latter half of this era there is evidence of bacteria, cyanobacteria and stromatolites.

Mnemonic to remember periods (Cambrian to Quaternary):

THE GEOLOGIC TIME SCALE

Table 1. The development of life through time.

Millions of years before present	Event	Relative to a calendar year*
Precambrian		
4600	Beginning of Earth	1/1/00 12:00 AM
3900	Inferred origin of life (first cells)	2/25/00 1:02 PM
3800	Oldest age-dated rocks on Earth	3/5/00 11:28 AM
3600	Fossil blue-green algae and stromatolites (prokaryotes)	3/21/00 8:20 AM
3250	First fossil evidence of bacteria	4/18/00 2:52 AM
2100	First fossil evidence of single-celled life with a cell nucleus (eukaryotes)	7/18/00 8:52 AM
1500	First multicelled organisms (seaweed and algae)	9/3/00 11:28 PM
670	Oldest marine worms and jellyfish	11/8/00 8:05 PM
600	Vendian period begins: Ediacarian fossils	11/14/00 9:23 AM
Paleozoic Era		
544	Cambrian system begins	11/16/00 6:31 PM
515	Burgess Shale organisms (Canada); first animals with a notochord	11/21/00 3:15 AM
505	Ordovician system begins	11/21/00 10:18 PM
505	First fish	11/21/00 10:18 PM
470	First fossil evidence of land plants	11/24/00 4:57 PM
438	Silurian system begins	11/27/00 5:53 AM
430	First vascular land plants	11/27/00 9:07 PM
414	Oldest lung fish fossils	11/29/00 3:36 AM
408	Devonian system begins	11/29/00 3:01 PM
408	Oldest fossil evidence of mosses	11/29/00 3:01 PM
385	First insects (beetles), scorpions, and centipedes	12/1/00 10:49 AM
380	First lobe-finned fish	12/1/00 8:20 AM
375	First land animals (amphibians)	12/2/00 5:52 AM
370	First sharks	12/2/00 3:23 PM
365	First seed plants (ferns)	12/3/00 12:54 AM
360	Mississippian system begins	12/3/00 10:26 AM
330	First possible reptiles	12/5/00 7:33 PM
320	Pennsylvanian system begins, Kentucky coal formed	12/6/00 2:36 PM
286	Permian	12/9/00 7:21 AM
260	Sail-backed reptiles (<i>Dimetrodon</i>)	12/11/00 8:52 AM
245	End of Paleozoic: 96% of all life on Earth perishes	12/12/00 1:26 PM
Mesozoic Era, the "Age of Reptiles"		
245	Triassic system begins	12/12/00 1:26 PM
240	First crocodiles	12/12/00 10:57 PM
228	First dinosaurs (about the size of a cat), such as <i>Eoraptor</i> and <i>Saitoposuchus</i>	12/13/00 9:48 PM
221	First mammals (shrew-like)	12/14/00 11:08 AM
210	First turtles	12/15/00 8:05 AM
208	Jurassic system begins	12/15/00 11:53 AM
195	<i>Dilophosaurus</i> , an Early Jurassic dinosaur	12/16/00 12:39 PM
155	First bird, <i>Archaeopteryx</i>	12/19/00 4:49 PM
152	<i>Apatosaurus</i> and <i>Brachiosaurus</i> , Late Jurassic long-necked dinosaurs	12/19/00 10:32 PM
150	<i>Tyrannosaurus</i> , a Late Jurassic meat-eating dinosaur	12/20/00 2:20 AM
148	<i>Stegosaurus</i> , a Late Jurassic plate-backed dinosaur	12/20/00 6:09 AM
144	Cretaceous system begins	12/20/00 1:46 PM
115	First flowering plants	12/22/00 9:00 PM
82	Duck-billed dinosaurs (<i>Maiasaurus</i>)	12/25/00 11:50 AM
80	<i>Protoceratops</i> (first dinosaur eggs ever discovered)	12/25/00 3:39 PM
75	<i>Triceratops</i>	12/26/00 1:10 AM
70	<i>Tyrannosaurus rex</i> and <i>Velociraptor</i>	12/26/00 10:41 AM
65	End of Mesozoic Era, probably meteor or comet impact	12/26/00 8:13 PM
Cenozoic Era, the "Age of Mammals"		
65	Tertiary system begins	12/26/00 8:13 PM
64	First ancestors of dogs and cats	12/26/00 10:07 PM
60	Grasses become widespread	12/27/00 5:44 AM
57	First ancestors of pigs and deer	12/27/00 11:27 AM
55	First horses (<i>Eohippus</i>)	12/27/00 3:15 PM
45	First ancestors of rabbits	12/28/00 10:18 AM
39	First monkeys	12/28/00 9:43 PM
4	Oldest human-like ancestors (hominids)	12/31/00 5:20 PM
2	Quaternary system begins	12/31/00 8:57 PM
1	First of four ice ages	12/31/00 10:05 PM
1	Oldest direct human-ancestor fossil, <i>Homo habilis</i>	12/31/00 11:02 PM
0.1	First modern man, <i>Homo sapiens</i>	12/31/00 11:48 PM
0.05	Approximate age of fossil mammoth and mastodon bones from Big Bone Lick, Ky.	12/31/00 11:54 PM
221 years	Revolutionary War	12/31/00 11:59 PM
58 years	World War II	1/1/01 12:00 AM

*Calculated on the basis of a 365-day year even though 2000 is a leap year.

The scale of geologic time is vast, currently estimated at nearly 4.6 billion years. During that time, life evolved into the familiar forms we see today. These materials are provided to assist in understanding time relationships and how life on Earth changed through time.

The dates shown were compiled from several available sources. Table 1 shows some important events in Earth history, presented in the order in which they occurred. The data are also shown on the scale of a calendar year. When geologic time is compressed to the scale of a calendar year, 1 second equals about 146 years. At this scale, World War II began about 0.4 second before midnight on December 31; because of rounding, this is shown as midnight of the new year.

On the back of this sheet is a chart showing the geologic eras, systems, and series; the oldest is at the bottom. On the chart, each dot, number, or letter represents 1 million years. The dots get "older" as you read down the chart, or to the right along a row. Thus, they represent millions of years before present ("mybp") and show the ages of the oldest known fossils of selected animals or the time of an event. Not all of the items shown in Table 1 are shown on the chart because of space limitations.

For more information on the geologic time scale, see:

- www.uky.edu/KGS/education/activities.html
- Dinosaurs: Fact and Fiction (pubs.usgs.gov/gip/dinosaurs/)
- Fossils, Rocks, and Time (pubs.usgs.gov/gip/fossils/)
- Geologic Time (pubs.usgs.gov/gip/geotime/)
- Teaching About Evolution and the Nature of Science (www.nap.edu/readingroom/books/evolution98/)
- Learning from the Fossil Record (www.ucmp.berkeley.edu/fosrec/fosrec.html)

The dot scale of geologic time is adapted from an idea by Charly Zuppann of the Indiana Geological Survey, Bloomington, Indiana.

The Kentucky Geological Survey is a research and public-service institute within the Research and Graduate Studies division of the University of Kentucky. Contact the Survey:

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CHAPTER 10: Introduction to the Lithosphere

(b). Geologic Time

Geologists and geomorphologists describe the Earth's geologic history through a temporal system known as the **geologic time scale** (Table 10b-1). On this scale, time is measured using the following four units of time: **eons**, **eras**, **periods** and **epochs**. All of these temporal subdivisions are established on the occurrence of some important geologic event. For example, *Hadean Eon* represents the time on Earth when life did not exist. During the *Archean Eon* life started and was dominated by one-celled **prokaryotic** life forms. **Eukaryotic** one-celled organisms became dominant in the *Proterozoic Eon*. Multicellular organisms ruled the planet during the **eon** known as the **Phanerozoic**.

Table 10b-1 describes some of the important geologic events that have occurred since the Earth's formation some 4.6 billion years ago.

Table 10b-1: Geologic time scale.

Eon	Era	Period	Epoch	Major Geologic Milestones
	Cenozoic	Quaternary (0-1.6 million yrs BP)	Holocene (Present-10,000 yrs BP)	Modern humans develop. Pleistocene Ice Age Interglacial.
			Pleistocene (10,000 -1,600,000 yrs BP)	Pleistocene Ice Age. Extinction of many species of large mammals and birds.
			Pliocene (1.6-5.3 million yrs BP)	Development of hominid bipedalism. Cascade Mountains began forming. Climate cooling.
			Miocene (5.3-24 million yrs BP)	Chimpanzee and hominid lines evolve. Extensive glaciation in Southern Hemisphere. Climate cooling.

Phanerozoic	Tertiary	Oligocene (24-37 million yrs BP)	many types of modern plants evolve. Creation of the Alps and Himalaya mountain chains. Volcanoes form in Rocky Mountains.
		Eocene (37-58 million yrs BP)	Primitive monkeys evolve and Himalayas began forming. Australian plate separates from Antarctica. Indian plate collides with Asia.
		Paleocene (58-65 million yrs BP)	Rats, mice, and squirrels evolve. Shallow continental seas become less widespread.
	Mesozoic	Cretaceous (65-144 million yrs BP)	First flowering plants, greatest dinosaur diversity, Cretaceous Mass Extinction (65 m BP), and Andes Mountains form. Africa and South America begin to separate. Climate cooling because of mountain building. Shallow seas have extensive distribution.
		Jurassic (144-208 million yrs BP)	First birds and mammals appear. Nevadian Mountains form. Large areas of the continents covered by shallow seas. Climate generally warm and stable with little seasonal or latitudinal variation. Shallow seas expanding.
		Triassic (208-245 million yrs BP)	First dinosaurs. Extensive deserts exist in continental interiors. Climate warm. Shallow seas limited in distribution.
		Permian (245-286 million yrs BP)	Permian Mass Extinction. Reptiles become more diverse. Climate cold at beginning of the Permian then warms. Average elevation of landmasses at their highest shallow seas

	Paleozoic	Pennsylvanian (286-320 million yrs BP)	less extensive. First reptiles appear. Winged insects evolve. Occasional glaciation in Southern Hemisphere.
		Mississippian (320-360 million yrs BP)	Primitive ferns and insects evolve. Forests appear and become dominant. Mountain building producing arid habitats in the interior of some continents.
		Devonian (360-408 million yrs BP)	First amphibians and trees appear. Appalachian Mountains form. Extinction of primitive vascular plants. Landmasses generally increasing in altitude. Climate cooling.
		Silurian (408-438 million yrs BP)	Major extinction event occurs. First land plants and insects. Continents are generally flat. Tectonic uplift begins.
		Ordovician (438-505 million yrs BP)	First fish and fungi. Greatest extent of shallow seas. Climate becoming warmer.
		Cambrian (505-551 million yrs BP)	Invertebrates become common. Fossilization of the Burgess Shale. Large areas of shallow seas near the equator. Climate was warm.
Proterozoic (551-2500 million yrs BP)	Also known as Precambrian		Eukaryotic cell organisms develop. First multicellular organisms. Changes in the lithosphere created major land masses and extensive shallow seas.
Archean (2500-3800 million yrs BP)			Slow development of the lithosphere, hydrosphere, and atmosphere. First single-celled prokaryotic organisms.
Hadean (3800-4600 million yrs BP)			Earth's oldest rocks come from the end of this Eon.