Demonstrating Geologic Time

Lesson Plans and Activities

By Polly R. Sturgeon

Targeted Age:
Elementary to high school

Activity Structure:
Individual or partner activity

Indiana Standards and Objectives:
3.ESS.4, 4.ESS.3, 4.LS.2, 7.ESS.2, 8.LS.5, 8.LS.8, ES.5.4, ES.5.5, ES.5.6, Env.5.2

MATERIALS NEEDED

- Geologic event student cards
- Geologic event timeline cards
- Geological time scale
- Rope, receipt tape, or paper
- Measuring tape or meter stick
- Geologic Time Discovery Trunk (optional)

Introduction

In this lesson, students will organize geological events on a timeline. Students will analyze major evolutionary events and mass extinctions in order to construct a scaled model of Earth's 4.6 billion-year-old history.

Vocabulary

Chronology—the arrangement of events in order from oldest to most recent
Eon—the largest unit of geological time
Era—the second-largest unit of geological time; longer than a period but shorter than an eon
Extinction—the end of existence for a species, family, or larger group of organisms, typically over a period of 15 to 30 million years
Fossil record—a group of fossils which have been arranged in chronologic and taxonomic order
Geologic time—a chronological list of events in Earth's history using subdivided units of time; also known as "Deep Time"
Mass extinction—events in which at least 75 percent of all species go extinct within several thousands to millions of years
Period—the third-largest unit of geological time, longer than an epoch and shorter than an era

Background Information

The geological time scale is a reference system used to describe the distribution of rocks and fossils throughout time and space. Throughout the Earth's 4.6-billion-year history, volcanism, glaciation, asteroid impacts, and other major events have affected the living organisms that have inhabited the planet. Because the sheer expanse of time can be difficult to grasp, geologists divide Earth's history into smaller units of time. Most of the boundaries on the geological time scale correspond to major events in the fossil record, such as mass extinctions or the evolution of major organism groups. The ages associated with these boundaries are the result of hundreds of years of scientific study. Each date is determined by radiometric dating, which allows scientists to discover precise ages of mineral crystallization, and the comparison of millions of fossils in collections around the globe.

The geological time scale is organized into four units: eons, eras, periods, and epochs. The largest unit of geologic time is an eon. There are four eons in the history of the Earth. The three earliest and longest eons (Hadean, Archean, and Proterozoic) are informally referred to as the "Precambrian" or "Precambrian Time."

- The Hadean Eon (4,600–4,000 million years ago) is named for the Greek underworld Hades, and is characterized by global volcanism and asteroid impacts.
- The Archean Eon (4,000–2,500 million years ago) comes from the Greek word for "origin," and is characterized by a methane-rich atmosphere and the introduction of single-celled organisms.
- The Proterozoic Eon (2,500–542 million years ago) comes from the Greek word for "early life," and is characterized by the oxygenation of the atmosphere and evolution of soft-bodied multicellular organisms.
- The Phanerozoic Eon (542 million years ago–present) comes from the Greek word for "visible life, " and is characterized by the evolution of multicellular organisms into diverse forms. We are living in the Phanerozoic Eon.

Eons are subdivided into eras, which are the second-largest unit of geologic time. For the sake of simplicity, eras within the Precambrian are omitted from this lesson plan. The Phanerozoic Eon is organized into three eras.

- The Paleozoic Era (542–251 million years ago) comes from the Greek word for "old life," and is characterized by the introduction of invertebrates (such as trilobites and crinoids), land plants, and vertebrates (such as fish). All of Indiana's bedrock is Paleozoic in age.

- The Mesozoic Era (251–65.5 million years ago) comes from the Greek word for "middle life." It is known as the "Age of Dinosaurs," and is characterized by the first appearance of mammals and flowering plants.
- The Cenozoic Era (65.5 million years ago–present) comes from the Greek word for "new life," and is known as the "Age of Mammals." We are living in the Cenozoic Era.

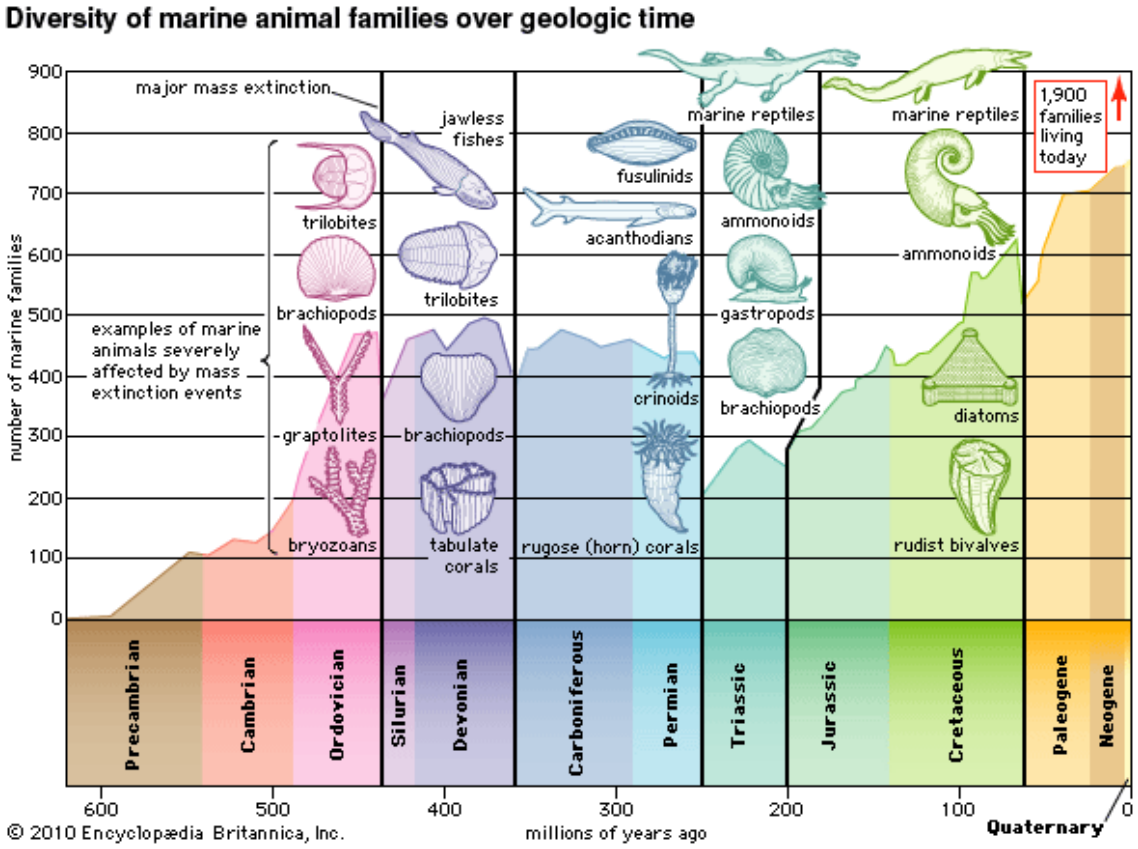
Eras are subdivided into periods, which are the third-largest unit of geologic time. Periods are characterized by geological events on a regional scale. For example, rocks from the Pennsylvanian Period in Indiana are exemplified by abundant plant fossils and coal seams. Periods can be subdivided into a smaller period of time known as an epoch, but those are omitted from this lesson.

- Cambrian Period (542–488.3 million years ago)
- Ordovician Period (488.3–443.7 million years ago)
- Silurian Period (443.7–416 million years ago)
- Devonian Period (416–359.2 million years ago)
- Mississippian Period (359.2–318.1 million years ago) *
- Pennsylvanian Period (318.1–299 million years ago) *
- Permian Period (299–251 million years ago)
- Triassic Period (251–199.6 million years ago)
- Jurassic Period (199.6–145.5 million years ago)
- Cretaceous Period (145.5–65.5 million years ago)
- Paleogene Period (65.5–23 million years ago)
- Neogene Period (23–2.6 million years ago)
- Quaternary Period (2.6 million years ago–present)

** Outside of North America, the Mississippian and Pennsylvanian periods are known as the Carboniferous Period.*

Five mass extinctions have occurred within Earth's 4.6-billion-year history. Mass extinctions are defined as events in which at least 75 percent of all species are lost within several thousands to millions of years. Each mass extinction event forms the end boundary of a geologic period (e.g, End Devonian extinction, End Permian extinction), and leads to an increase in diversity and territory for surviving species.

The diagram below illustrates the "Big Five" mass extinctions with vertical black lines. Notice the sudden decrease in organisms during the extinction event, followed by an increase in biodiversity after the event.



- End Ordovician extinction– Glaciation within the supercontinent Gondwana produced two pulses of extinction over a period of several million years. The onset of glaciation caused sea levels to drop and water temperature to cool, which affected shallow-water communities. When the glaciers receded, sea levels rose and ocean oxygen levels declined, causing another pulse of extinction. About 85 percent of all species were lost, including many trilobites, brachiopods, and corals. Deep-water organisms largely survived and would go on to diversify in the Silurian Period.

- End Devonian extinction– A series of global cooling events occurred over a 20-million-year period, possibly due to the depletion of carbon dioxide by land plants and/or large-scale volcanism. About 75 percent of species went extinct, including all armored fish (placoderms) and many species of coral, reef-building sponges (stromatoporoids), and trilobites. Small vertebrates, such as tetrapods, survived and would go on to evolve into reptiles, amphibians, and birds.

- End Permian extinction– Widespread fires, ash clouds, and ocean acidification caused by massive volcanism in Siberia resulted in the "Great Dying," in which 96

percent of all species went extinct over a span of about 50,000 years. All species of trilobites, blastoids, and sea scorpions (eurypterids) were lost, and nearly all species of brachiopods, crinoids, gastropods, and corals went extinct. On land, about two-thirds of amphibians and many plant species died. The loss of major predators cleared a path for the rise of dinosaurs.

- End Triassic extinction– Massive volcanic eruptions within the supercontinent Pangea caused climate change and ocean acidification. About 80 percent of species went extinct, including all conodonts and many species of reptiles. Dinosaurs largely survived.
- End Cretaceous extinction– A large asteroid impacted the Yucatan Peninsula, causing ash to block sunlight around the world and oxygen levels to drop. About 76 percent of all species were lost, including all non-bird dinosaurs, large marine reptiles, pterosaurs, and ammonites. Mammals quickly adapted and filled new ecological niches.

The phenomena that led to these mass extinctions remain relevant to our planet today. Many scientists believe that the Earth is currently experiencing a sixth mass extinction, named the "Holocene extinction" for its onset during the Holocene Epoch (11,650 years ago–present). Since the loss of Ice Age megafauna 10,000 years ago, humans have domesticated plants and animals, extracted fossil fuels, and expanded to every continent on Earth. These actions have helped our species to thrive, but have also contributed to the depletion of natural resources, ocean acidification, and rapid increase of greenhouse gases.

The combination of human activity and fluctuations in global climate have pushed many species to extinction. From passenger pigeons and dodo birds to golden frogs and northern white rhinoceros, species are going extinct at an increasing rate. The fossil record is critical in helping scientists understand today's changes in order to inform our future.

Time (millions of years ago)	Scale	Distance to Add	Major Event	Era
4600 (4.6 billion)	460 cm (4 m 60 cm)	0	Planet Earth forms	Precambrian Time
4300 (4.3 billion)	430 cm (4 m 30 cm)	30 cm	Continents form	
3800 (3.8 billion)	380 cm (3 m 80 cm)	50 cm	Oceans form	
3500 (3.5 billion)	350 cm (3 m 50 cm)	30 cm	First prokaryotes	
2400 (2.4 billion)	240 cm (2 m 40 cm)	110 cm	Breathable atmosphere	
2100 (2.1 billion)	210 cm (2 m 10 cm)	30 cm	First eukaryotes	
600	60 cm	150 cm	First jellyfish	
542	54.2 cm	5.8 cm	Cambrian Explosion	Paleozoic Era
530	53 cm	1.2 cm	First fish	
470	47 cm	6 cm	First land plants	
444	44.4 cm	2.6 cm	First mass extinction	
400	40 cm	4.4 cm	First insect	
375	37.5 cm	2.5 cm	First amphibian	
365	36.5 cm	1 cm	Second mass extinction	
340	34.5 cm	2 cm	Indiana limestone deposited	
300	30 cm	4.5 cm	Indiana coal deposited	
252	25.2 cm	4.8 cm	Third mass extinction	Mesozoic Era
240	24 cm	1.2 cm	Age of Dinosaurs begins	
220	22 cm	2 cm	First mammal	
200	20 cm	2 cm	Fourth mass extinction	
150	15 cm	5 cm	First bird	
130	13 cm	2 cm	First flowering plant	
70	7 cm	6 cm	First grass	
65	6.5 cm	0.5 cm	Fifth mass extinction	
55	5.5 cm	1 cm	First horse	Cenozoic Era
6	0.6 cm (6 mm)	4.9 cm	First hominids	
2.6	0.26 cm (2.6 mm)	0.34 cm	Ice Age begins	
0.3 (300,000 yrs ago)	0.002 cm (.02 mm)	0.0005 cm	First humans	
0.015 (15,000 yrs ago)	0.001 5 cm (.015 mm)	0.0005 cm	Glaciers retreat from Indiana	
0.01 (10,000 yrs ago)	0.001 cm (.01 mm)	0.0005 cm	Megafauna extinction	

Procedure

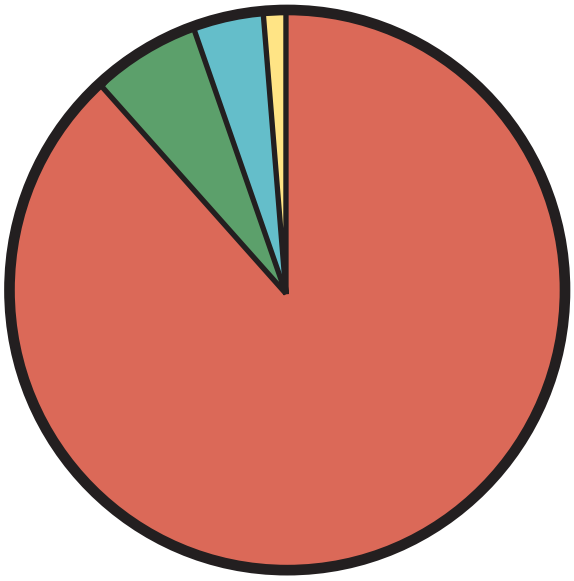
1. Assess students' knowledge of geologic time by asking the following guiding questions. Discuss ways in which living things have changed over time.

   How old is the Earth?
   When did life first appear?
   What kinds of living things first formed on Earth?
   Do those organisms still exist?
   When did reptiles first appear?
   When did humans first appear?
   Did dinosaurs and humans live on Earth at the same time?
   What is different about the Earth now than it was in the geologic past?

2. Explain that a geologic time scale is used to organize Earth's 4.6 billion-year-old history. Introduce the geologic time scale and explain that the units of geologic time (such as "era" and "period") are not equal in length because they are based on major changes in the fossil record.

3. OPTIONAL: Evaluate the distributions of geologic eras in Earth's history with a pie chart. Note that the Hadean, Archean, and Proterozoic Eons are referred to as "Precambrian Time" in the example below. Subtract the beginning and end of each era to get the total number of years in the era, then convert that number to a percentage and graph the results. Does the pie chart reflect the notion that eras are based on major changes in the fossil record? Ask students to hypothesize which era had the most changes based on its percentage of time.

Geologic Era	Begin (mya)	End (mya)	# Years (mya)	Percentage (# Years ÷ 4600) x 100
Precambrian Time	4600	542	4058	88.3
Paleozoic Era	542	251	291	6.3
Mesozoic Era	251	65.5	185.5	4
Cenozoic Era	65.5	0	65.5	1.4



4. Explain that 4,600,000,000 (4.6 billion) is too large of a number for people to easily grasp. To assist understanding, geologists represent Earth's history on a timeline where a certain length is equal to a certain number of years. The timeline in this activity is 4 meters and 60 centimeters (or 15.09 feet) in length, and uses the following scale:

   1 meter = 1 billion years
   1 centimeter = 10 million years
   1 millimeter = 1 million years

   ADAPTATION: If space is available, create a longer timeline using the scale of 1 meter per 100 million years. This will create a 46-meter-long (or 150.9-foot) timeline.

5. OPTIONAL: Reinforce the concept of a timeline by graphing a student's life on sheet of notebook paper (typically 11 inches or 27.9 centimeters long). Determine a scale (such as 2.5 centimeters = 1 year) and ask students to come up with 10 major life events. Place each life event on the timeline. Group the events into periods, such as "Preschool," "Elementary School," and "Middle School." Make comparisons to the geologic time scale.

6. Distribute a set of Geologic Event student cards to each student or student pair. Instruct students to put the events in order from oldest to most recent. Undoubtedly there will be errors, and most students will be surprised that jellyfish are so much older than humans! Allow for class discussion as events are placed into the correct order.

7. Position a 4-meter-and-60 centimeter-long timeline made of rope, toilet paper, or receipt tape in the classroom where it is visible to all students. Instruct the class to place the Geologic Event timeline cards on the timeline. Earlier events will be separated by long periods of time in the beginning of the timeline, while the most recent events will be very condensed at the end of the timeline. Ask students to identify any patterns that they see.

   ADAPTATION: For younger students, place a pre-measured mark on the timeline for each event card. For advanced students, ask them to convert geologic time to centimeters using the scale, then measure the distance between each event with a meter stick or measuring tape.

8. Revisit the concept that geological eras are based upon major changes in the fossil record. Discuss how life has grown in complexity over time and how extinctions often allow surviving species to thrive. Ask students to make observations and provide examples from the timeline.

   OPTIONAL: Use the Geologic Time Discovery Trunk or other fossil specimens to explore the organisms involved in major evolutionary events.

9. Discuss the placement of humans along the timeline. Where would each student's personal timeline fit into the geologic timeline? Human existence is a tiny fraction of Earth's long history, yet our species is causing rapid changes to global climate and biodiversity. Discuss the possibility of a sixth major extinction.

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Name:

_____

Class Period:

_____

MATERIALS NEEDED

- Geologic event student cards
- Geologic event timeline cards
- Geological time scale
- Rope, receipt tape, or paper
- Measuring tape or meter stick
- Geologic Time Discovery Trunk (optional)

1. Place the Geologic Event cards in chronological order, from oldest to most recent.

2. Order the following major events from oldest (6) to most recent (1).

First mammal	First insects	First jellyfish	First fish	First humans	First grass
____	____	____	____	____	____

3. Did the timing of any major events in geologic time surprise you? List at least one example below.

4. For what percentage of Earth's history has life existed on Earth? How long have humans existed on Earth? Use your geologic time scale to answer this question.

   (Age of first life _____ ÷ Age of Earth _____) x 100 = _____%

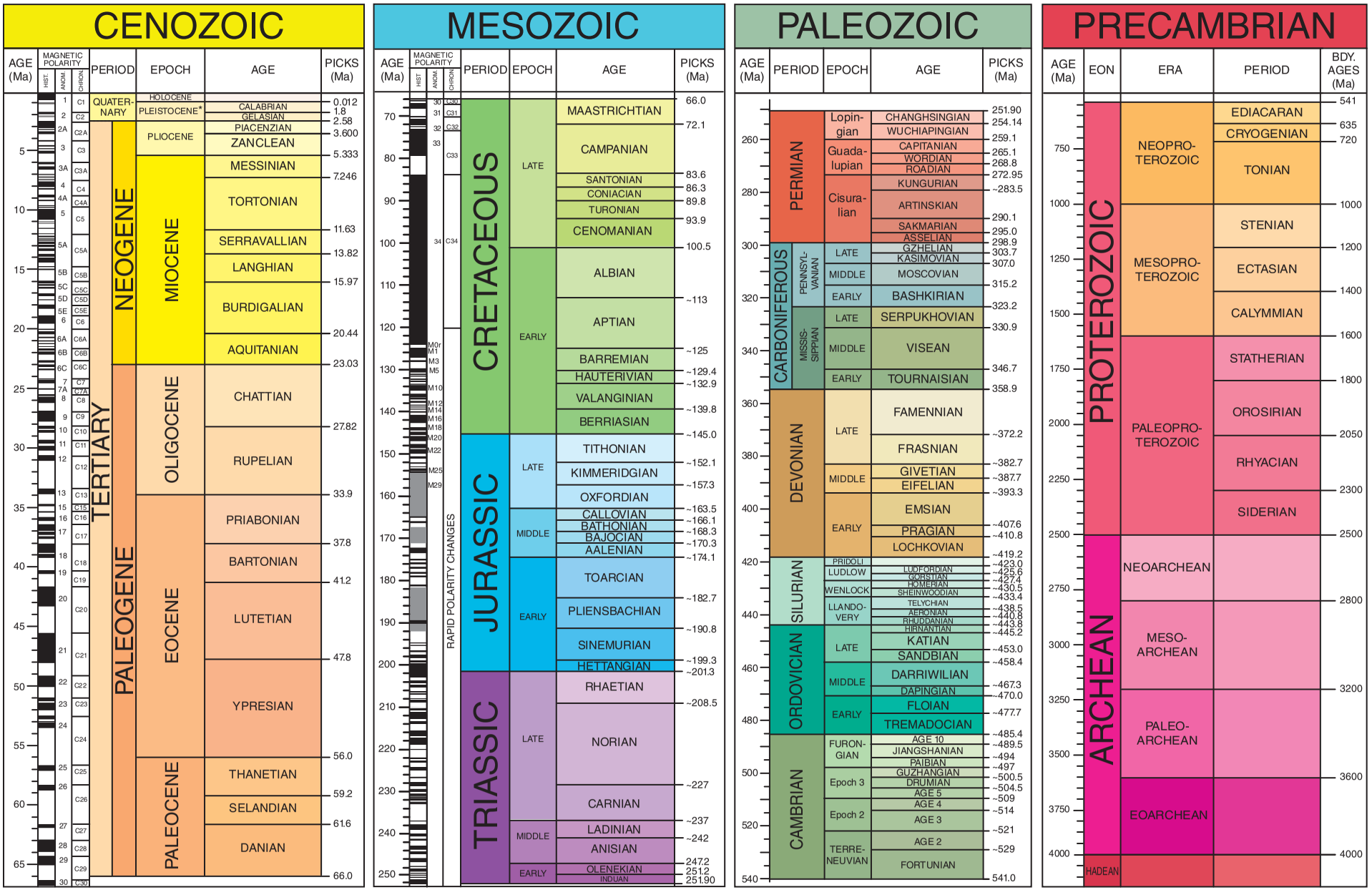
   (Age of first human _____ ÷ Age of Earth _____) x 100 = _____%

5. How do scientists determine when a geologic era begins or ends? Give an example.

6. Many scientists believe that the Earth is currently experiencing a sixth mass extinction, named the "Holocene extinction" for its onset during the Holocene Epoch. Since the loss of Ice Age megafauna 10,000 years ago, humans have domesticated plants and animals, extracted fossil fuels, and expanded to every continent on Earth. These actions have helped our species to thrive, but also have contributed to the depletion of natural resources, ocean acidification, and rapid increase of greenhouse gases.

   Do you think the Earth is experiencing a sixth mass extinction? Why or why not?

GSA GEOLOGIC TIME SCALE v. 5.0



Walker, J.D., Geissman, J.W., Bowring, S.A., and Babcock, L.E., compilers, 2018, Geologic Time Scale v. 5.0: Geological Society of America, https://doi.org/10.1130/2018.CTS005R3C. ©2018 The Geological Society of America

*The Pleistocene is divided into four ages, but only two are shown here. What is shown as Calabrian is actually three ages—Calabrian from 1.80 to 0.781 Ma, Middle from 0.781 to 0.126 Ma, and Late from 0.126 to 0.0117 Ma.

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 over 1.6 Ma.

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REFERENCES CITED

Cohen, K.M., Finney, S., and Gibbard, P.L., 2012, International Chronostratigraphic Chart: International Commission on Stratigraphy, www.stratigraphy.org (accessed May 2012). (Chart reproduced for the 34th International Geological Congress, Brisbane, Australia, 5–10 August 2012.)

Cohen, K.M., Finney, S.C., Gibbard, P.L., and Fan, J.-X., 2013, The ICS International Chronostratigraphic Chart: Episodes v. 36, no. 3, p. 199–204 (updated 2017, v. 2, http://www.stratigraphy.org/index.php/ics-chart-timescale; accessed May 2018).

Gradstein, F.M, Ogg, J.G., Schmitz, M.D., et al., 2012, The Geologic Time Scale 2012: Boston, USA, Elsevier, https://doi.org/10.1016/B978-0-444-59425-9.00004-4.

Previous versions of the time scale and previously published papers about the time scale and its evolution are posted to http://www.geosociety.org/timescale.

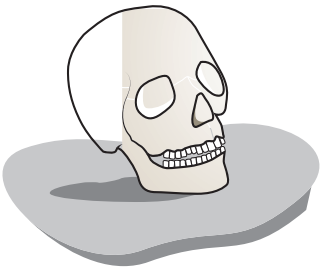
Planet Earth forms

Earth forms from a cloud of dust and rocks. The Moon forms soon after.

Continents form

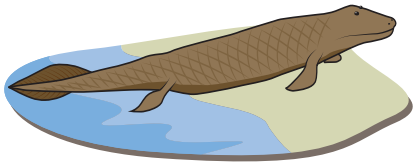
Volcanoes produce early land masses that are melted and reformed by plate tectonics.

First humans



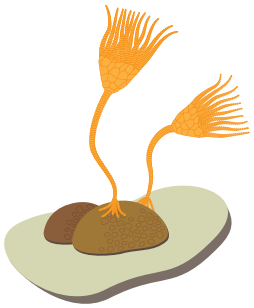
Modern humans (*Homo sapiens*) develop delicate skeletons and large brains. They evolve from hominids in Africa and migrate worldwide.

First amphibians



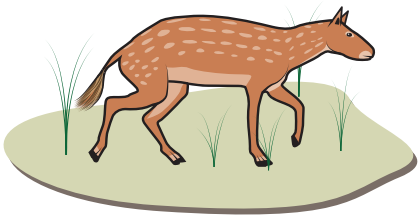
Amphibians evolve from fish and move onto land. They are the first animals with backbones (vertebrates) to live on land.

Indiana limestone deposited



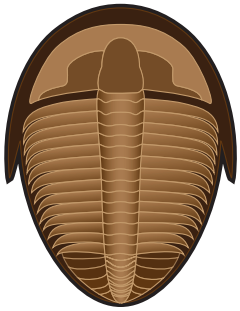
Crinoids thrive in a shallow sea that covers Indiana. Their remains form the famous Indiana limestone.

First horse



Horses (*Eohippus*) evolve in North America. The earliest horses had three toes and were significantly smaller than those alive today.

Cambrian Explosion

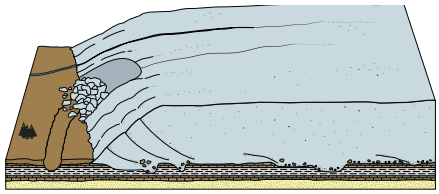


Increased oxygen levels allow animals to develop shells and quickly diversify.

Oceans form

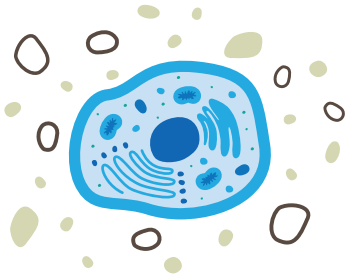
Water vapor in the Earth's atmosphere condenses to form the first oceans.

Ice Age begins



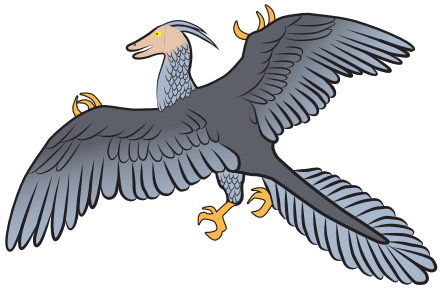
Large sheets of ice flow south from Canada and cover much of North America. Average global temperatures were 9°F to 18°F cooler than today.

First eukaryotes



Multicellular organisms evolve from prokaryotes and develop complex organelles.

First bird

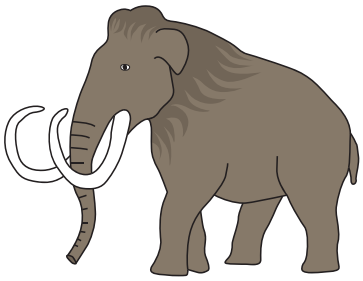


Birds evolve from theropod dinosaurs. The earliest accepted bird fossil is the *Archaeopteryx*.

Indiana coal deposited

Warm swamp forests provide carbon material that becomes Indiana's coal deposits.

Megafauna extinction

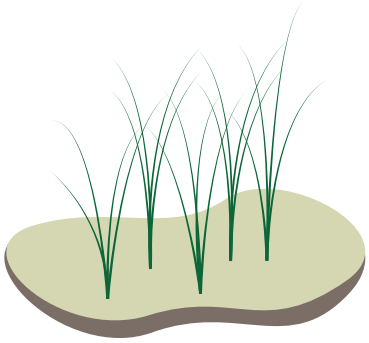


Mastodons, mammoths, and other large Ice Age mammals go extinct from climate change and human predation.

First flowering plant

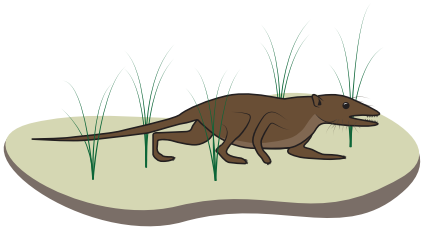
Seed-producing angiosperms develop. They become the most diverse group of land plants.

First grass



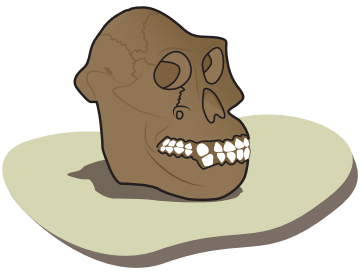
Grasses evolve and rapidly diversify.

First mammal



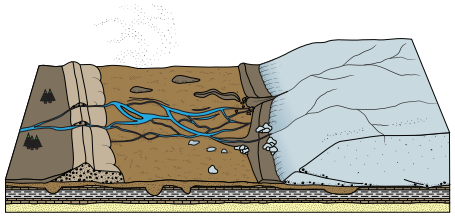
Mammals evolve from egg-laying reptiles. The earliest mammals were small and covered in fur.

First hominids



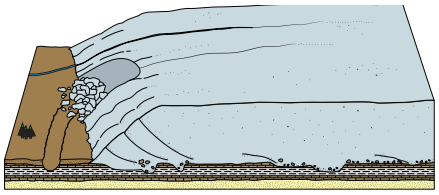
Human-like apes evolve and begin to walk on two legs.

Glaciers retreat



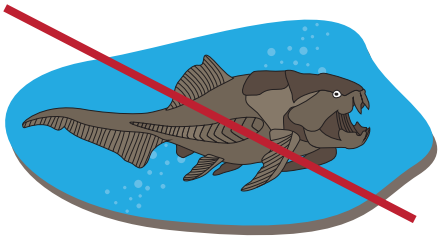
Glaciers extend across central Indiana before retreating to the north. The melting ice forms streams that carve valleys into the bedrock.

First mass extinction



Glaciers cause 85 percent of all marine species to go extinct. Trilobites, brachiopods, and coral are dramatically reduced.

Second mass extinction



Global cooling causes 75 percent of all species to go extinct, including all armored fish and many species of trilobites and coral.

Third mass extinction

Massive volcanoes cause 96 percent of all marine species and 70 percent of all land animals to go extinct.

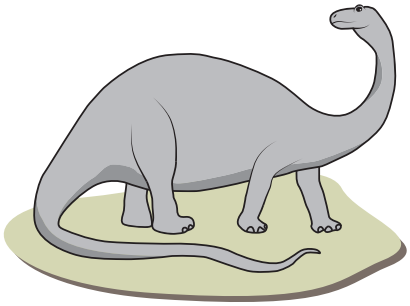
Fourth mass extinction

Massive volcanoes cause 80 percent of all species to go extinct. Dinosaurs largely survive.

Fifth mass extinction

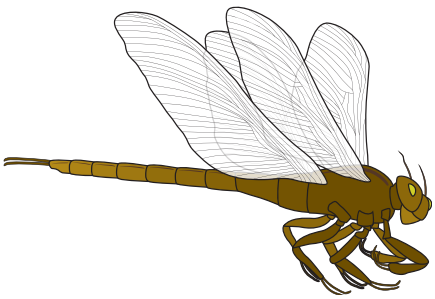
An asteroid impact causes ash to block sunlight around the world. 76 percent of all species go extinct, including all non-bird dinosaurs.

Age of Dinosaurs begins



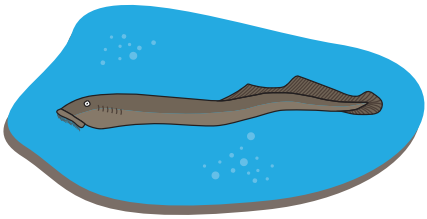
Dinosaurs and other reptiles evolve from amphibians and dominate the land and sea.

First insect



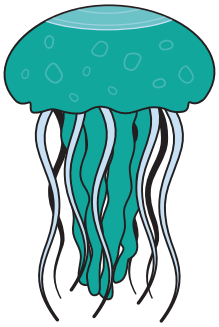
Insects begin to occupy the land. They develop wings and become the first animals to fly.

First fish



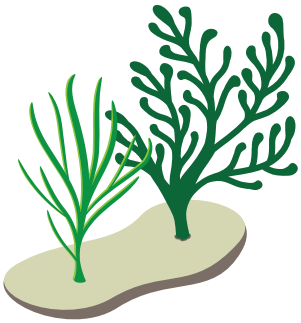
Jawless fish develop backbones and evolve in shallow oceans.

First jellyfish



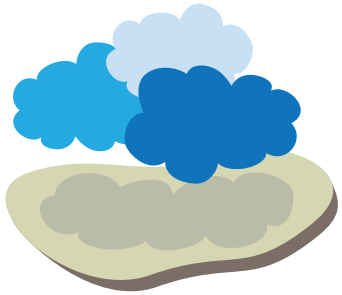
Jellyfish evolve to become one of the first free-swimming predators.

First land plants



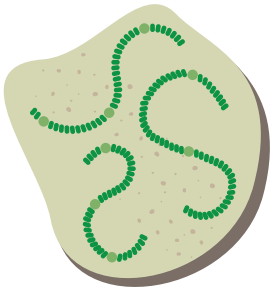
Plants like green algae move onto land and begin to diversify.

Breathable atmosphere



Iron oxide runs out and oxygen begins to accumulate in the atmosphere.

First prokaryotes



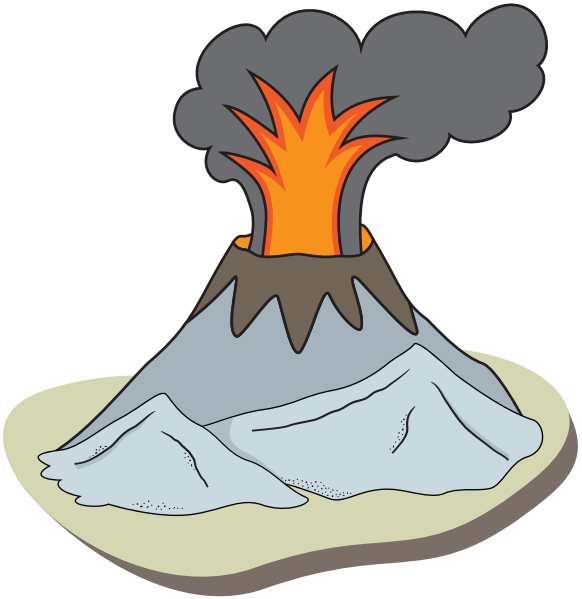
Single-celled cyanobacteria begin to release oxygen into the atmosphere through photosynthesis.

4,600 million years ago

Planet Earth forms

Earth forms from a cloud of dust and rocks. The Moon forms soon after.

4,300 million years ago



Continents form

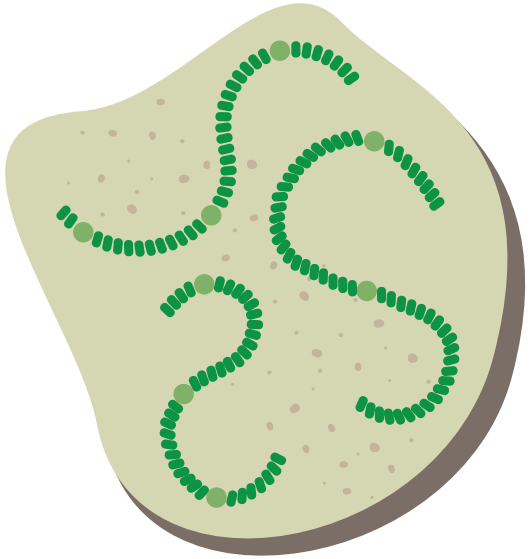
Volcanoes produce early land masses that are melted and reformed by plate tectonics.

3,800 million years ago

Oceans form

Water vapor in the Earth's atmosphere condenses to form the first oceans.

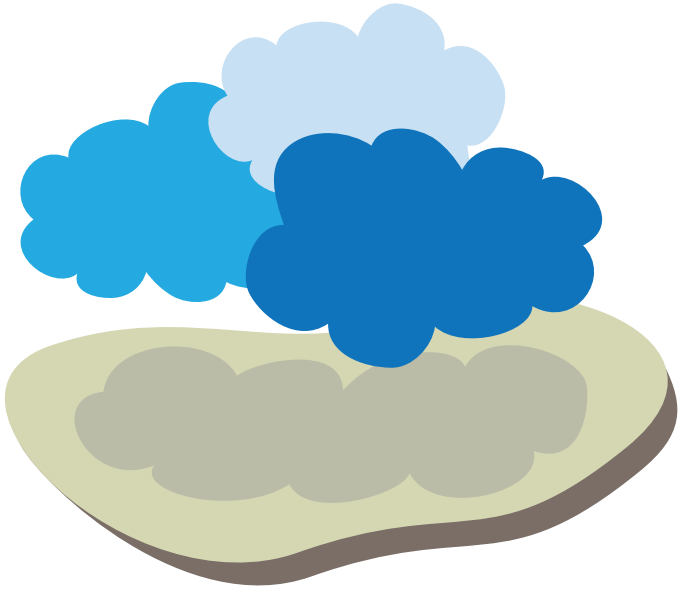
3,500 million years ago



First prokaryotes

Single-celled cyanobacteria begin to release oxygen into the atmosphere through photosynthesis.

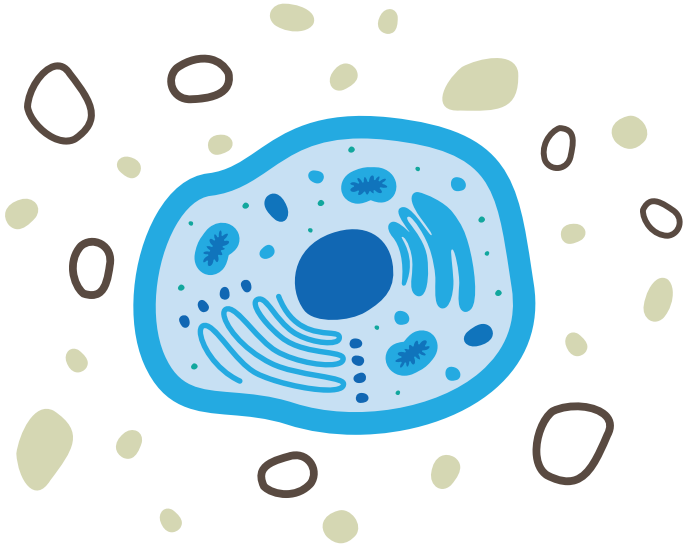
2,400 million years ago



Breathable atmosphere

Iron oxide runs out and oxygen begins to accumulate in the atmosphere.

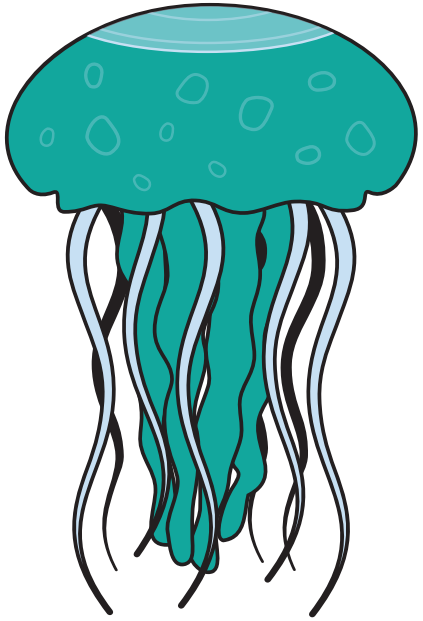
2,100 million years ago



First eukaryotes

Multicellular organisms evolve from prokaryotes and develop complex organelles.

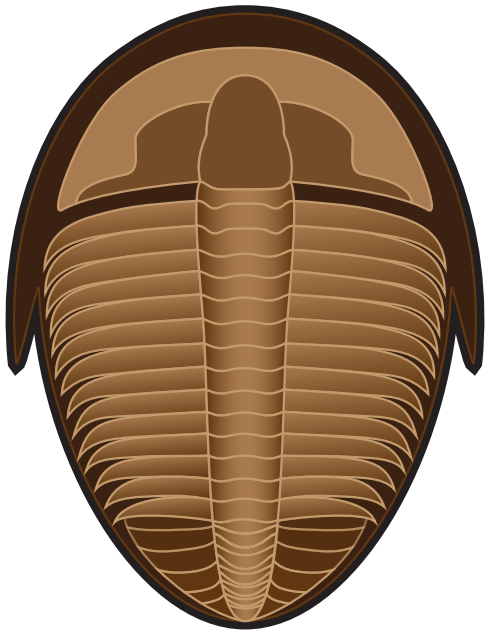
600 million years ago



First jellyfish

Jellyfish evolve to become one of the first free-swimming predators.

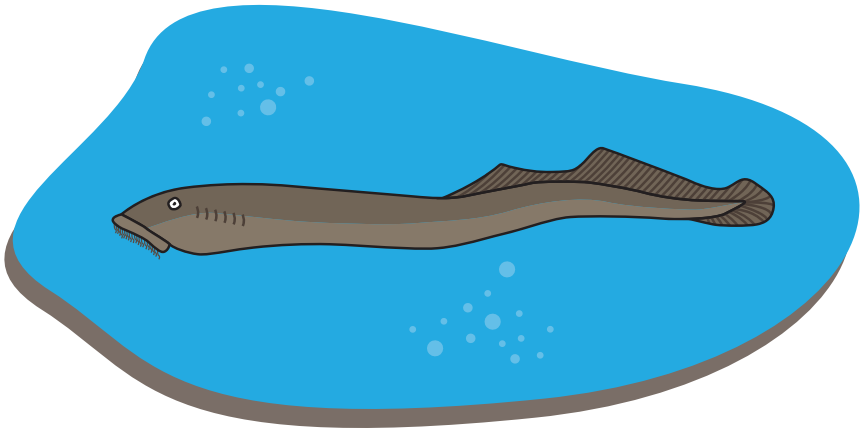
542 million years ago



Cambrian Explosion

Increased oxygen levels allow animals to develop shells and quickly diversify.

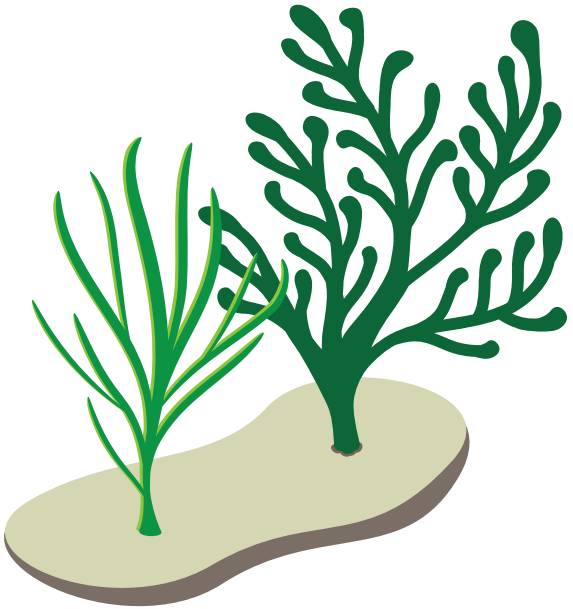
530 million years ago



First fish

Jawless fish develop backbones and evolve in shallow oceans.

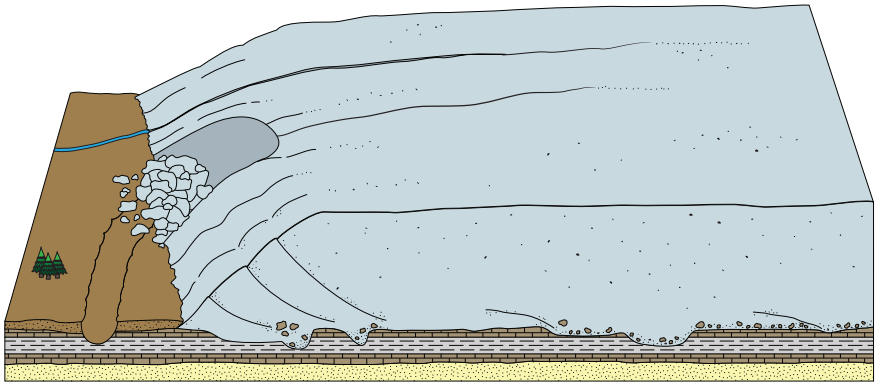
470 million years ago



First land plants

Plants like green algae move onto land and begin to diversify.

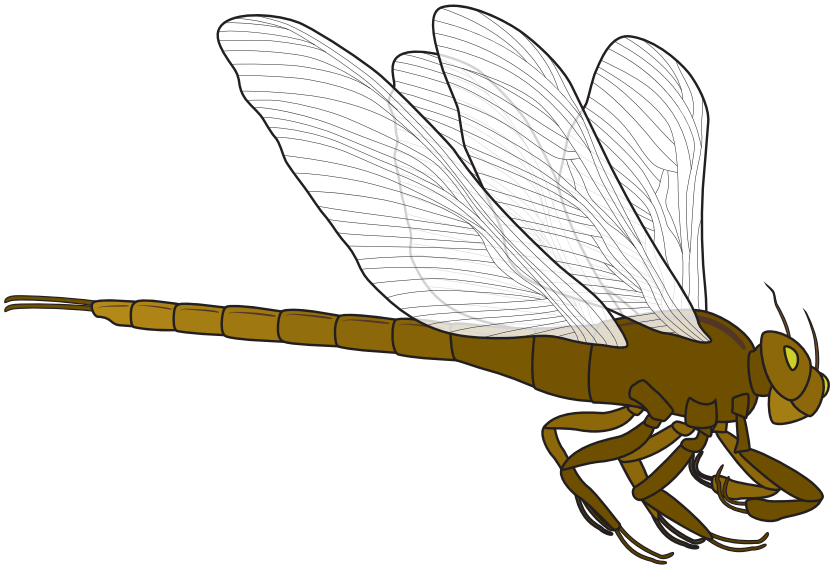
444 million years ago



First mass extinction

Glaciers cause 85 percent of all marine species to go extinct. Trilobites, brachiopods, and coral are dramatically reduced.

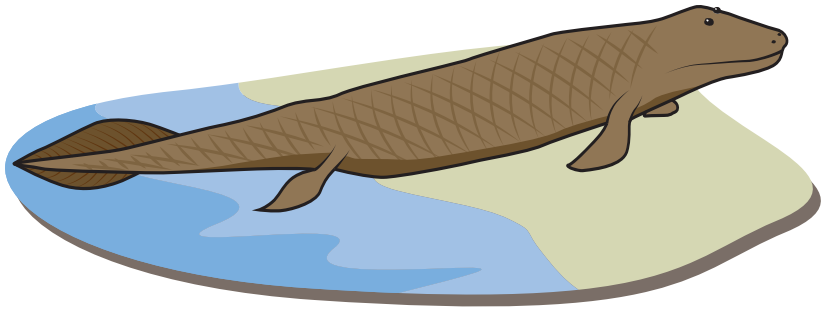
400 million years ago



First insect

Insects begin to occupy the land. They develop wings and become the first animals to fly.

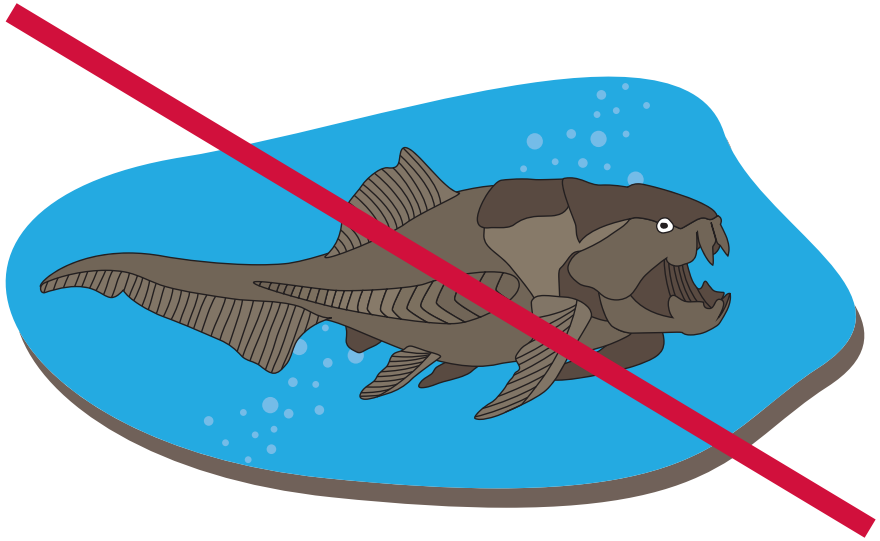
375 million years ago



First amphibians

Amphibians evolve from fish and move onto land. They are the first animals with backbones (vertebrates) to live on land.

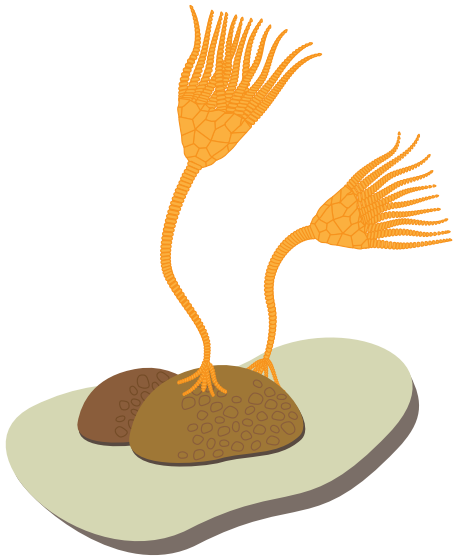
365 million years ago



Second mass extinction

Global cooling causes 75 percent of all species to go extinct, including all armored fish and many species of trilobites and coral.

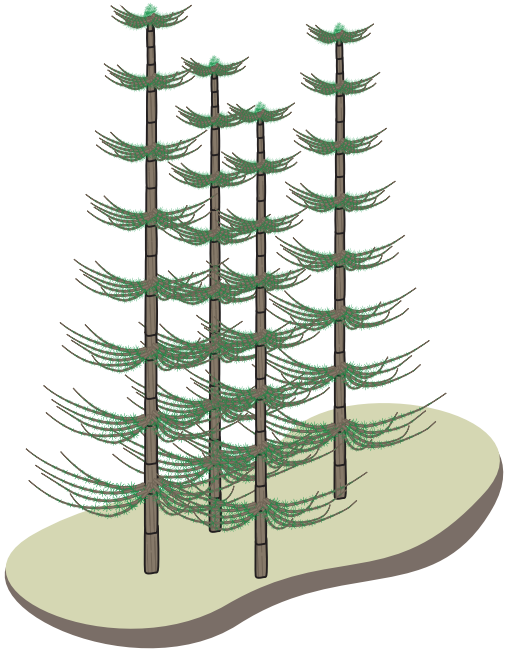
340 million years ago



Indiana limestone deposited

Crinoids thrive in a shallow sea that covers Indiana. Their remains form the famous Indiana limestone.

300 million years ago



Indiana coal deposited

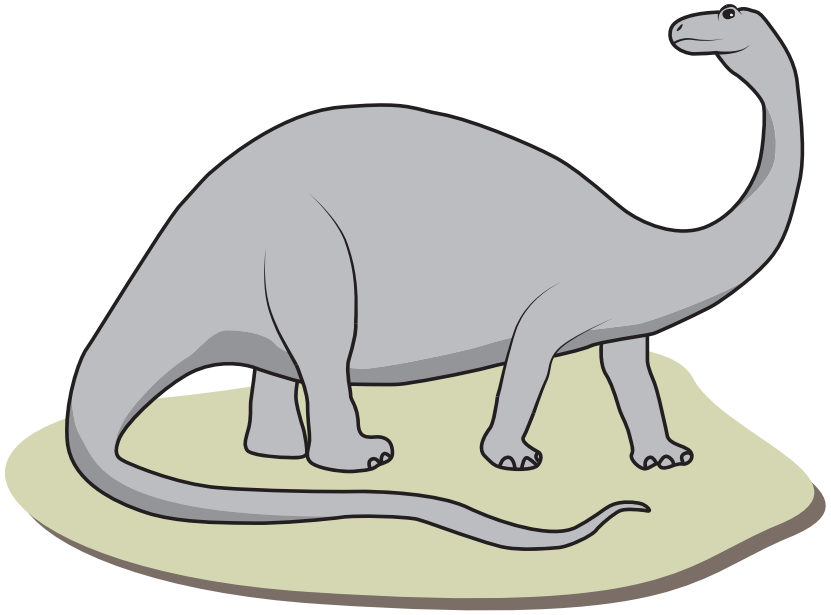
Warm swamp forests provide carbon material that becomes Indiana's coal deposits.

252 million years ago

Third mass extinction

Massive volcanoes cause 96 percent of all marine species and 70 percent of all land animals to go extinct.

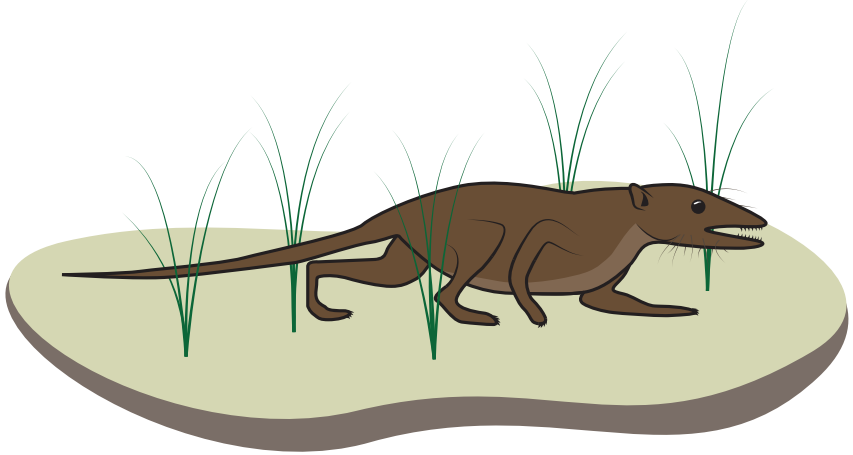
240 million years ago



Age of Dinosaurs begins

Dinosaurs and other reptiles evolve from amphibians and dominate the land and sea.

220 million years ago



First mammal

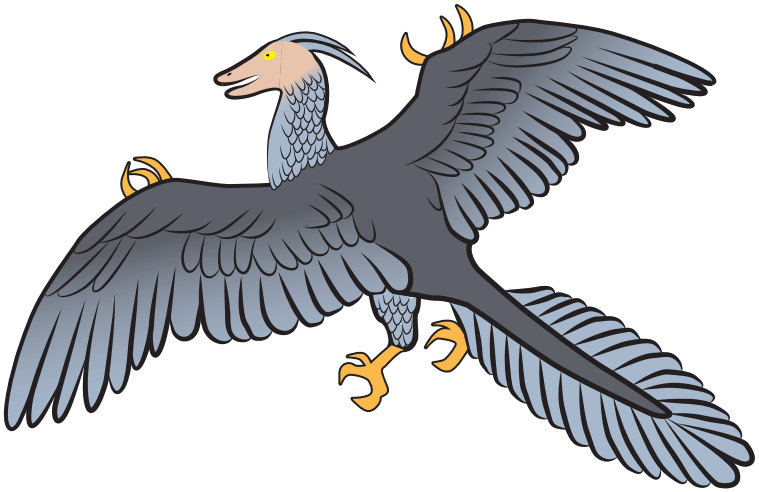
Mammals evolve from egg-laying reptiles. The earliest mammals were small and covered in fur.

200 million years ago

Fourth mass extinction

Massive volcanoes cause 80 percent of all species to go extinct. Dinosaurs largely survive.

150 million years ago



First bird

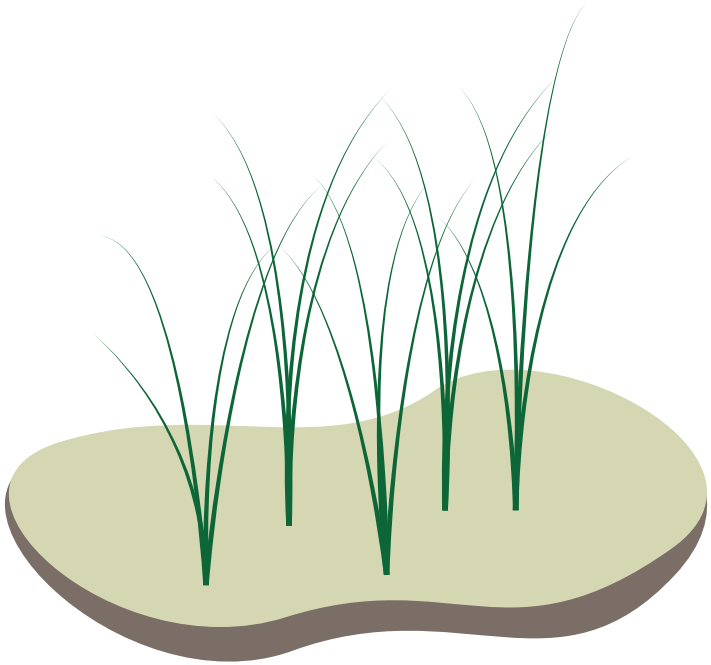
Birds evolve from theropod dinosaurs. The earliest accepted bird fossil is the *Archaeopteryx*.

130 million years ago

First flowering plant

Seed-producing angiosperms develop. They become the most diverse group of land plants.

70 million years ago



First grass

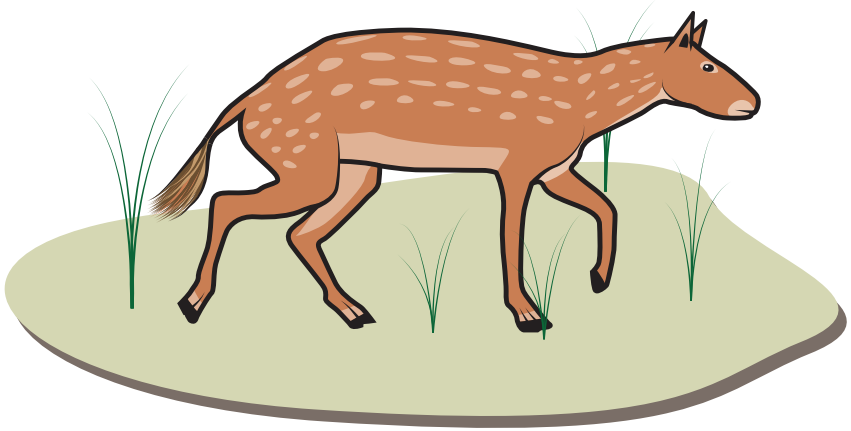
Grasses evolve and rapidly diversify.

65 million years ago

Fifth mass extinction

An asteroid impact causes ash to block sunlight around the world. 76 percent of all species go extinct, including all non-bird dinosaurs.

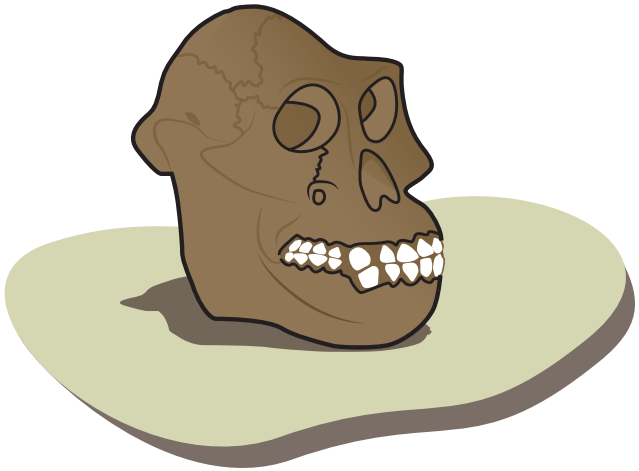
55 million years ago



First horse

Horses (*Eohippus*) evolve in North America. The earliest horses had three toes and were significantly smaller than those alive today.

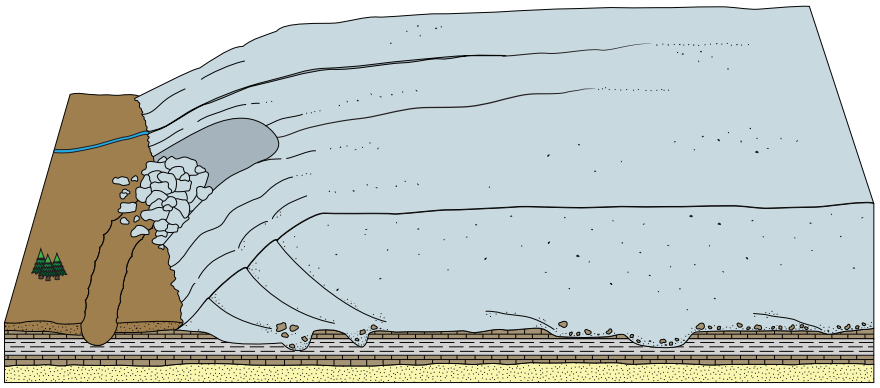
6 million years ago



First hominids

Human-like apes evolve and begin to walk on two legs.

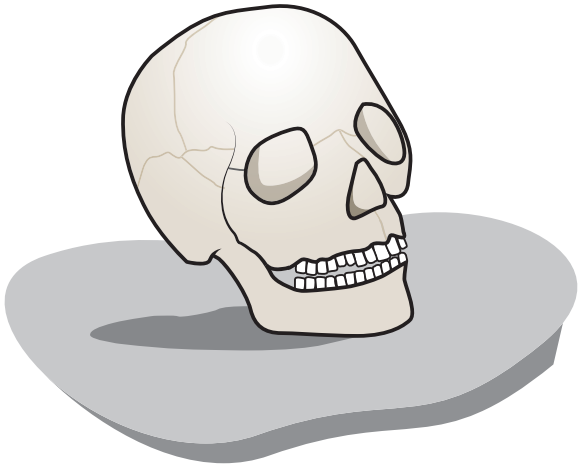
2.6 million years ago



Ice Age begins

Large sheets of ice flow south from Canada and cover much of North America. Average global temperatures were 9°F to 18°F cooler than today.

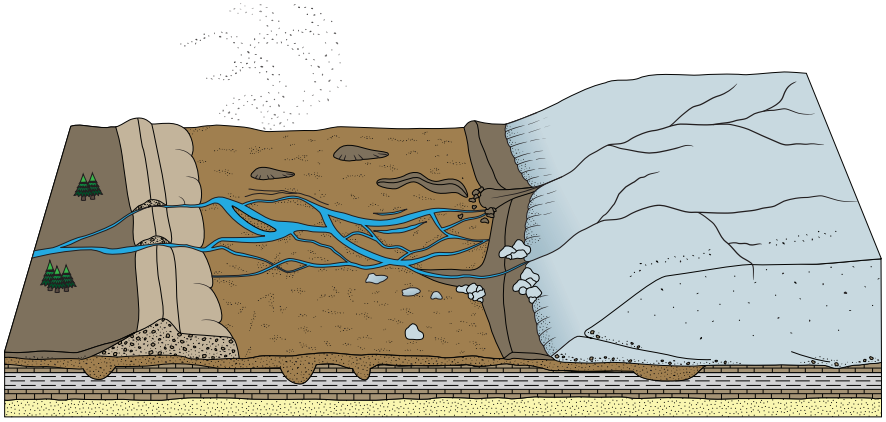
300,000 years ago



First humans

Modern humans (*Homo sapiens*) develop delicate skeletons and large brains. They evolve from hominids in Africa and migrate worldwide.

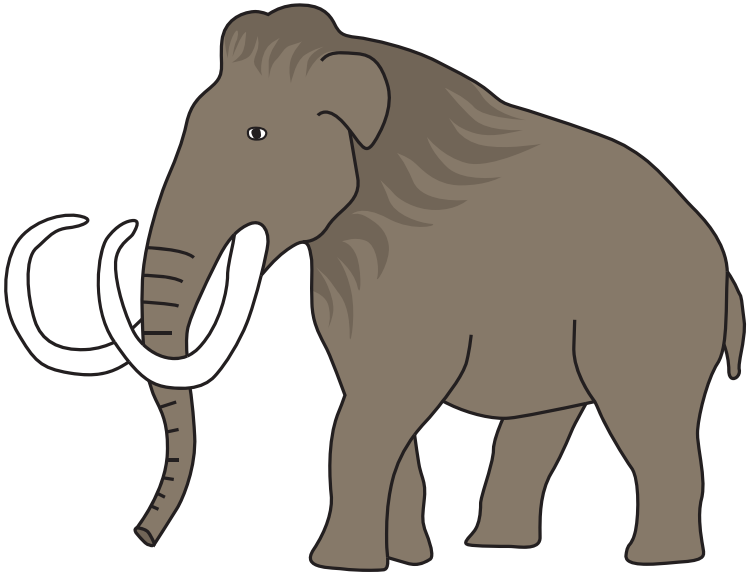
15,000 years ago



Glaciers retreat from Indiana

Glaciers extend across central Indiana before retreating to the north. The melting ice forms streams that carve valleys into the bedrock.

10,000 years ago



Megafauna extinction

Mastodons, mammoths, and other large Ice Age mammals go extinct from climate change and human predation.