

How Earth's Changes Change Life

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9th grade Biology

Introduction:

This lesson is designed for a 9th grade Biology class during as an introduction to evolution. In this lesson students will learn about how Earth has changed throughout its history and how living things have changed with it. Students will examine how the changes in Earth can cause the extinction of organisms and at the same time can create new niches in which organisms can evolve to take advantage of new niches or niches that become available from extinctions. Students will also examine how organisms have changed the Earth to make it possible for different organisms to evolve and flourish. Students often do not have difficulty in understanding that organisms have changed over time but they fail to master the understanding of the driving forces of evolution. This lesson will give students a better understanding of evolution driving forces and how Earth's resources can change creating a driving force for the evolution of new organisms.

Standards:

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Materials

Paper/Pencil
Calculator Tape
Internet
Handouts

Lesson**Introduction: 15-minutes**

Students will make a short time line of their own life. The students are to think of five personal events that have happened in their life. These events can be good or bad. Some examples may be a birth of sibling, the meeting of a new friend, a friend moving away, a parent divorce or remarried. After they are complete ask the students to think and reflect about how their life had changed after each event. This could be made into a writing activity if the teacher wishes.

Earth's Time Line: 60-minutes

Students will work in a groups. Each group will measure out a 4.5 meter length of calculator tape, with each meter representing a billion years and each millimeter equaling million years. Students will then place the beginning and end of each of Earth's Periods on the time line. Along with other major events (the events are numerous and it is teacher's choice on what ones to use).

Period Research and Presentations: Two class periods

Student groups will be asked to research a specific Period. Each group will create a presentation on their assigned Period and present to class.

What plants and animals (maybe only bacteria) species were dominant during your Period? (Include pictures)

What types of resources did they use?

Do they resemble any type of animals you know today? If so what? Are they believed to be ancestor to any plants or animals on Earth today?

How long did they thrive on Earth?

Why did go extinct? If unable to find reasons give your thoughts why.

Evaluation: 30-minutes

Students will do a write up of their understanding of the activity. In our district we use Collins Writing. Student will do a Type three writing with the following “Focus Correction Areas”.

1. Describe how Earth has changed since its beginng.
2. Describe how Life has changed though out Earth's history
3. Explain Earth properties effect the life on Earth and how life on Earth effect Earth's properties.

Extension: Have students research Earth's current changes it is going through, global warming, and determine how that could effect the current life on Earth.

Earth Time Line

Background: Scientists have developed a time scale for earth history called the Geologic Time Scale. This scale outlines the major events in Earth's history. Scientists use the principle of superposition, radiometric dating, and the fossil record to create the scale.

Goal:

Construct an Earth time line that shows major time divisions and major earth events using the following materials:

- Paper tape
- Scissors
- Metric ruler
- Table of Major Earth Events (provided on back)

Use the following scale for your model: 1 millimeter = 1 **million** years before present. (1mm = 1mybp).

Step 1: Use the above scale for your model and the age of Earth (4,600 mybp) to determine how long your paper tape needs to be.

Length of paper tape in millimeters = _____

Length of paper tape in centimeters = _____

Length of paper tape in meters = _____

Step 2: Measure and cut the paper tape. Decide which end of the paper tape is today (0 mybp) and which end is the beginning of Earth (4,600 mybp).

Step 3: Use the information in the table below to show the four major time eras on your time line. Always measure from the "today" end of the tape. Color and label each era.

Era	Time Range in mybp	Color
Cenozoic	0-66	yellow
Mesozoic	66-251	green
Paleozoic	251-542	blue
Precambrian	542-4,600	red

Step 4: Add the key events information given on the Geologic Time Scale to your time line in the correct location. You may need to write very small and/or use arrows to label some key events.

Eon	Era	Period	Epoch	Key events
Phanerozoic	Cenozoic	Quaternary 2.6 my	Holocene	
			Pleistocene	<i>Homo sapiens</i> appears ~200,000 yrs
		Neogene 23 my	Pliocene	First species of <i>Homo</i> appear ~2.5 mybp
			Miocene	Beginning of Ice Ages ~2.6 mybp
		Paleogene	Oligocene	First species of hominids appear ~6 mybp
			Eocene	
	Paleocene			
	Mesozoic	Cretaceous 145.5 my		Late Cretaceous Mass Extinction
				Chicxulub crater forms ~65.5 mybp
		Jurassic 200 my		Flowering plants appear ~142 mybp
				Birds appear ~150 mybp
		Triassic 251 my		Late Triassic Mass Extinction
	Paleozoic	Permian 299 my		Mammals appear ~210 mybp
				Dinosaurs appear ~225 mybp
		Pennsylvanian 318 my		Late Permian Mass Extinction
				Reptiles appear ~305 mybp
		Mississippian 359 my		
		Devonian 416 my		Late Devonian Mass Extinction
				Amphibians appear ~365 mybp
Silurian 444 my		Land plants appear ~425 mybp		
		Late Ordovician Mass Extinction		
Proterozoic	"Precambrian"	Ordovician 488 my		Insects appear ~450 mybp
				Bony fish appear ~485 mybp
		Cambrian 542 my		Beginning of Cambrian explosion ~530 mybp
	First Multicellular Organisms ~630 mybp			
Archean	"Precambrian"	2.5 billion		Oxygen begins to accumulate in atmosphere ~2,000 mybp
				First one-celled organisms ~3,500 mybp
				Earliest evidence of oceans ~3,800 mybp
				Oldest known rocks ~4,000 mybp
		4.6 billion		Moon forms ~4,500 mybp
				Formation of Earth ~4,600 mybp

Highlights of the history of the Earth. Time is not drawn to scale.

Earth Time Line Analysis

Refer to the Earth Time Line you constructed to answer the following questions.

1. Arrange the four eras in order from longest to shortest duration.
2. During which era did the first life forms exist and what were they like?
3. How many millions of years went by after Earth formed before the first life forms appeared?
4. Were mammals and dinosaurs ever on Earth at the same time? If so, when?
5. What is a “mass extinction”?
6. How many mass extinctions have there been and what caused them?
7. What relationship do you see between mass extinction and the start of the Mesozoic and Cenozoic eras?
8. Did the mass extinction 66 mybp kill off **all** of the bacteria, fish, amphibians, birds, mammals, and flowering plants? How do you know?
9. The Pleistocene Ice Age ended about 10,000 years ago. Are humans able to survive an ice age? How do you know?
10. How long have humans been on Earth relative to all of Earth time?

(mya = million years ago)

The times are approximate and may vary by a few million years.

**Precambrian Time
(4567 to 542 mya)**

Hadean Eon (4567 to 3800 mya)

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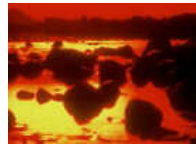
- 4650 mya: Formation of [chondrules](#) in the Solar Nebula
- 4567 mya: Formation of the Solar System
Sun was only 70% as bright as today.
- 4500 mya: Formation of the Earth.
- 4450 mya: The Moon accretes from fragments of a collision between the Earth and a planetoid;
Moon's orbit is beyond 64,000 km from the Earth.[33]
Earth day is 7 hours long[34]
- Earth's original hydrogen and helium atmosphere escapes Earth's gravity.
- 4455 mya: Tidal locking causes one side of the Moon to face the Earth permanently.[30]
- 3900 mya: Cataclysmic meteorite bombardment.
The Moon is 282,000 km from Earth.[34]
Earth day is 14.4 hours long[34]
- Earth's atmosphere becomes mostly carbon dioxide, water vapor, methane, and ammonia.
- Formation of carbonate minerals starts reducing atmospheric carbon dioxide.
- There is no geologic record for the Hadean Eon.



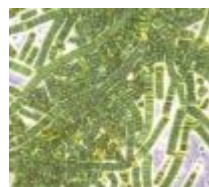
Hadean Eon
(4567 to 3800 mya)

Archean Eon (3800 to 2500 mya)

- 3800 mya: Surface of the Earth changed from molten to solid rock.
- Water started condensing in liquid form.
- Earth day is 15 hours long
- 3500 mya: Monocellular life started (Prokaryotes).
First known oxygen-producing bacteria: cyanobacteria (blue-green algae) form



Archean Eon
(3800 to 2500 mya)





stromatolites

- 3000 mya: Atmosphere has 75% nitrogen, 15% carbon dioxide.
- Sun brightens to 80% of current level.
- Oldest record of Earth's magnetic field.

Proterozoic Eon (2500 to 542 mya)

Paleoproterozoic Era (2500 to 1600 mya)

Siderian Period (2500 to 2300 mya)

- Stable continents first appeared.
- 2500 mya: First free oxygen is found in the oceans and atmosphere.
- 2400 mya: Great Oxidation Event, also called the Oxygen Catastrophe. Oxidation precipitates dissolved iron creating banded iron formations.[14]
- Anaerobic organisms are poisoned by oxygen.

Huronian ice age

Rhyacian Period (2300 to 2050 mya)

- 2200 mya: Organisms with mitochondria capable of aerobic respiration appear.
- 2100 mya: End of Huronian ice age

Orosirian Period (2050 to 1800 mya)

- Intensive orogeny (mountain development)
- 2023 mya: ☀ Meteor impact, 300 km crater Vredefort, South Africa [9]
- 2000 mya: Solar luminosity is 85% of current level.
- Oxygen starts accumulating in the atmosphere
- 1850 mya: ☀ Meteor impact, 250 km crater Sudbury, Ontario, Canada [9]

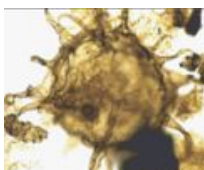
Statherian Period (1800 to 1600 mya)

- Complex single-celled life appeared.
- Abundant bacteria and archaeans.

Mesoproterozoic Era (1600 to 1000 mya)

Calymmian Period (1600 to 1400 mya)

- Photosynthetic organisms proliferate.
- Oxygen builds up in the atmosphere above 10%.



Proterozoic Eon
(2500 to 542 mya)

- Formation of ozone layer starts blocking ultraviolet radiation from the sun.
- 1500 mya: Eukaryotic (nucleated) cells appear.
- Ectasian Period** (1400 to 1200 mya)
- Green (Chlorobionta) and red (Rhodophyta) algae abound.
- Stenian Period** (1200 to 1000 mya)
- 1200 mya: Spore/gamete formation indicates origin of sexual reproduction.[36]
- 1100 mya: Formation of the supercontinent Rodinia



Neoproterozoic Era (1000 to 542 mya)

Tonian Period (1000 to 850 mya)

- 1000 mya: Multicellular organisms appear.
- 950 mya: Start of Stuartian-Varangian ice age
- 900 mya: Earth day is 18 hours long.
- The Moon is 350,000 km from Earth.[31]

Cryogenian Period (850 to 630 mya)



- 750 mya: Breakup of Rodinia and formation of the supercontinent Pannotia
- 750 mya: End of last magnetic reversal
- 650 mya: * Mass extinction of 70% of dominant sea plants due to global glaciation ("Snowball Earth" hypothesis).
- The Moon is 357,000 km from Earth.[31]

Ediacaran (Vendian) Period (630 to 542 mya)

- 600 mya: Earth day is 20.7 hours long.[35]
- 590 mya: ☀ Meteor impact, 90 km crater Acraman, South Australia
- 580 mya: Soft-bodied organisms developed:





- Jellyfish, Tribrachidium, and Dickinsonia
- 570 mya: End of Stuartian-Varangian ice age
- Shelled invertebrates appeared
- 550 mya: Pannotia fragmented into Laurasia and Gondwana

appe

Phanerozoic Eon (542 mya to present)

Paleozoic Era (542 to 251 mya)

Cambrian Period (542 to 488.3 mya)

- Abundance of multicellular life.
- Most of the major groups of animals first appear
- Tommotian Stage (534 to 530 mya)**
- 510 mya: Vertebrates appeared in the ocean.
- Solar brightness was 6% less than today.

Ordovician Period (488.3 to 443.7 mya)

- diverse marine invertebrates, such as trilobites, became common
- First green plants and fungi on land.
- Fall in atmospheric carbon dioxide.
- 450 mya: Start of Andean-Saharan ice age.
- 443 mya: Glaciation of Gondwana.
- * Mass extinction of many marine invertebrates.
- Second largest mass extinction event.
- 49% of genera of fauna disappeared.

Silurian Period (443.7 to 416 mya)

- 420 mya: End of Andean-Saharan ice age.
- Stabilization of the earth's climate
- Land plants and coral reefs appeared
- First fish with jaws - sharks
- Insects (spiders, centipedes), and plants appear on land

Devonian Period (416 to 359.2 mya)

- Ferns and seed-bearing plants (gymnosperms) appeared

Paleozoic Era
(542 to 251 mya)



- Formation of the first forests
- Earth day is ~21.8 hours long.
- 400 mya: Land animals appeared, wingless insects

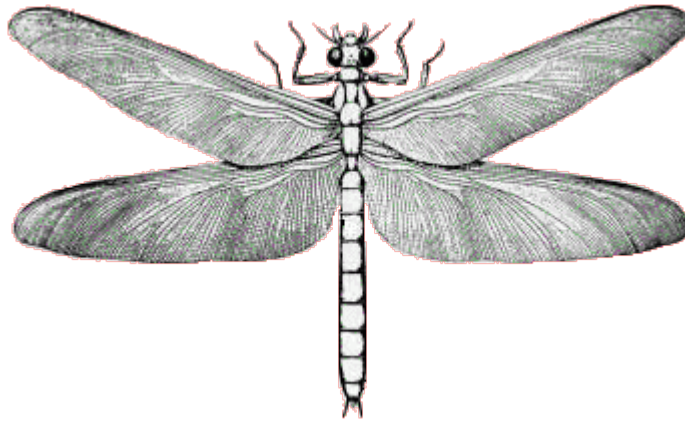


- 375 mya: Vertebrates with legs, such as Tiktaalik
- Atmospheric oxygen level is about 16%
- First amphibians appear
- 374 mya: * Mass extinction of 70% of marine species.

This was a prolonged series of extinctions occurring over 20 million years. Evidence of anoxia in oceanic bottom waters, and global cooling. Surface temperatures dropped from about 93°F (34°C) to about 78°F (26°C)

- 370 mya: First trees appeared
- 359 mya: ☀ Meteor impact, 40 km crater Woodleigh, Australia

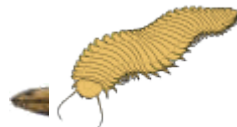
Carboniferous Period (359.2 to 299 mya)
Mississippian Epoch (359.2 to 318.1 mya)
 (Lower Carboniferous)



- 350 mya: Beginning of Karoo ice age

- Large primitive trees develop
- Forests consist of ferns, club mosses, horsetails, and gymnosperms.
- Oxygen levels increase
- Vertebrates appear on land
- First winged insects.
- Seas covered parts of the continents
- Animals laying amniote eggs appear (318 mya)

Pennsylvanian Epoch (318.1 to 299 mya)





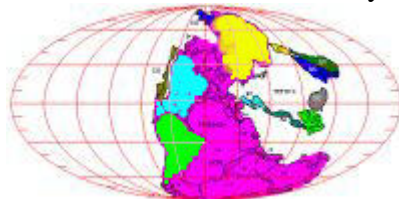
(Upper Carboniferous)

- 300 mya: First reptiles
- Atmospheric oxygen levels reach over 30%
- Earth day is ~22.4 hours long.
The Moon is 375,000 km from Earth.[31]
- Giant arthropods populate the land
- Transgression and regression of the seas caused by glaciation
- Deposits of coal form in Europe, Asia, and North America

Permian Period (299 to 251 mya)



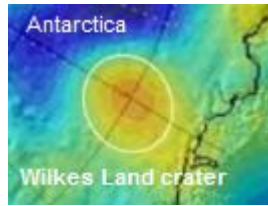
- 275 mya: Formation of the supercontinent Pangea



- Conifers and cycads first appear
- Earth is cold and dry
- Sail-backed synapsids like *Edaphosaurus* and *Dimetrodon* appeared
- 260 mya: End of Karoo ice age.
- 251 mya: * Mass extinction (Permian-Triassic)
- Possible 480km-wide meteor crater in the Wilkes Land region of Antarctica [26]
- Period of great volcanism in Siberia releases large volume of gases (CO₂, CH₄, and H₂S) [8]
- Oxygen (O₂) levels dropped from 30% to 12%
Carbon dioxide (CO₂) level was about 2000 ppm
Temperatures reach 50-60°C on land, and 40°C at the sea-surface.[37]



Earth's worst mass extinction eliminated 90% of ocean dwellers, and 70% of land plants and animals.



Mesozoic Era (251 to 65.5 mya)

Triassic Period (251 to 199.6 mya)

- Break-up of Pangaea starts
- Survivors of P-T extinction spread and recolonize
- Reptiles populate the land.
- 240 mya: Sea urchins (*Arkarua*) appear
- 235 mya: Evolutionary split between dinosaurs and lizards
- Giant marine *ichthyosaurs* and *plesiosaurs* populate the seas
- First small dinosaurs such as *coelophys* appear on land
- *Adelobasileus* proto-mammal emerged (225 mya)
- 214 mya: Meteor impact, 100 km crater Manicouagan, Quebec, Canada [9]
- 205 mya: First evidence of mammals: *Morganucodon*
- 201 mya: Volcanism in Central Atlantic Magmatic Province[38]
- * Mass extinction killed 20% of all marine families



Mesozoic Era
(251 to 65.5 mya)

Jurassic Period (199.6 to 145.5 mya)

- Earth is warm. There is no polar ice
- Cycads, conifers and ginkgoes are the dominant plants
- Age of the dinosaurs
- Giant herbivores and vicious carnivores dominate the land
- Flying reptiles (Pterosaurs) appeared.
- 180 mya: North America separates from Africa
- 167 mya: Meteor impact, 80 km crater Puchezh-Katunki, Russia [9]
- 166 mya: Evolutionary split of monotremes from primitive mammals
- 150 mya: First birds like *Archaeopteryx* appear
- 148 mya: Evolutionary split between marsupial and eutherian mammals
- 145 mya: Meteor impact, 70 km crater Morokweng, South Africa [9]



Cretaceous Period (145.5 to 65.5 mya)

- Period of Active Crust Plate Movements
- 133 mya: Meteor impact, 55 km crater



Tookoonooka, Australia [9]

- 125 mya: Africa and India separate from Antarctica
- Global warming event starts (120 mya)
Carbon dioxide levels were 550 to 590 ppm [27]
- Flowering plants (angiosperms) appeared
- 110 mya: Crocodiles appeared
- South America breaks away from Africa (105 mya)



Caution:

Do not poke

T. rex with

your pointer

- Formation of the Atlantic Ocean
- Earth has no polar ice
- Birds and oldest group of living placental mammals developed
- 100 mya: Earth's magnetic field is
3 times stronger than today.
- 90 mya: Global warming event ends
- Western Interior Seaway separates North America
into Laramidia (west) and Appalachia (east)
- 70 mya: . Meteor impact, 65 km crater
Kara, Russia [9]
- 68 mya: *Tyrannosaurus rex* thrived
- 67 mya: Deccan Traps volcanic eruptions start in India
and produce great volume of lava and gases.
- 65.5 mya: . Meteor impact, 170 km crater
Chicxulub, Yucatan, Mexico [9]
- * Mass extinction of 80-90% of marine species
and 85% of land species, including the dinosaurs.



Cenozoic Era (65.5 mya to today)

Paleogene Period (65.5 to 23.03 mya)

Tertiary Period (65.5 to 2.58 mya)

Paleocene Epoch (65.5 to 55.8 mya)

- 63 mya: End of Deccan Traps volcanic eruptions in India
- Flowering plants become widespread.
- Social insects achieve ecological dominance.
- Appearance of placental mammals (marsupials, insectivores, lemuroids, creodonts)
- 60 mya: Earliest known ungulate (hoofed mammal)
- Formation of the Rocky Mountains
- 55.8 mya: Major global warming episode (PETM)[39] North Pole temperature averaged 23°C (73.4°F), CO₂ concentration was 2000 ppm.



Eocene Epoch (55.8 to 33.9 mya)

- 50 mya: India meets Asia forming the Himalayas
 - 45 mya: Australia separates from Antarctica Earth day is 24 hours long. The Moon is 378,000 km from Earth.[32]
 - Modern mammals appear rhinoceros, camels, early horses appear
 - 35.6 mya: Meteor impacts, 90 and 100 km craters Chesapeake Bay, Virginia, USA, and Popigai, Russia [9,10]
 - 34 mya: Global cooling creates permanent Antarctic ice sheet [21]
 - 34 mya: Global cooling creates permanent Antarctic ice sheet [21]
- ##### Oligocene Epoch (33.9 to 23.03 mya)
- Appearance of many grasses
 - First elephants with trunks
 - 27.8 mya: La Garita, Colorado supervolcanic eruption

Neogene Period (23.03 mya to today)

Miocene Epoch (23.03 to 5.3 mya)

- African-Arabian plate joined to Asia
- 14 mya: Antarctica separates from Australia and South America circum-polar ocean circulation builds up Antarctic ice cap.
- Warmer global climates
- First raccoons appear.
- Drying of continental interiors
- Forests give way to grasslands
- 6 mya: Upright walking (bipedal) hominins appear



Pliocene Epoch (5.3 to 2.58 mya)

- 4.4 mya: Appearance of *Ardipithecus*, an early hominin genus.



Cenozoic Era
(65.5 mya to today)

- 4 mya: North and South America join at the Isthmus of Panama.
Animals and plants cross the new land bridge.
Ocean currents change in the newly isolated Atlantic Ocean.
- 3.9 mya: Appearance of *Australopithecus*, genus of hominids.
- 3.7 mya: *Australopithecus* hominids inhabit Eastern and Northern Africa.
- 3 mya: Formation of Arctic ice cap.
- Accumulation of ice at the poles
- Climate became cooler and drier.
- Spread of grasslands and savannas
- Rise of long-legged grazing animals

Quaternary Period (2.58 mya to today)

Pleistocene Epoch (2.58 mya to 11,400 yrs ago)

- Several major episodes of global cooling, or glaciations
- 2.4 mya: *Homo habilis* appeared
- 2.1 mya: Yellowstone supervolcanic eruption
- 2 mya: Tool-making humanoids emerge.
Beginning of the Stone Age.
- 1.7 mya: *Homo erectus* first moves out of Africa
- 1.3 mya: Yellowstone supervolcanic eruption
- 1.3 mya to 820,000 yrs ago: Sherwin Glaciation
- Presence of large land mammals and birds
- 700,000 yrs ago: Human and Neanderthal lineages start to diverge genetically.
- 680,000 to 620,000 yrs ago: Günz/Nebraskan glacial period
- 640,000 yrs ago: Yellowstone supervolcanic eruption
- 530,000 yrs ago: [Development of speech in Homo Heidelbergensis](#)[15]
- 455,000 to 300,000 yrs ago: Mindel/Kansan glacial period
- 400,000 yrs ago: Hominids hunt with wooden spears
and use stone cutting tools.
- 370,000 yrs ago: Human ancestors and Neanderthals
are fully separate populations.
- 300,000 yrs ago: Hominids use controlled fires
- 230,000 yrs ago: Neanderthal man spreads through Europe
- 200,000 to 130,000 yrs ago: Riss/Illinoian glacial period
- 160,000 yrs ago: *Homo sapiens* appeared.
Origin of human female lineage (Mitochondrial Eve)
- 125,000 yrs ago: Eemian stage or Riss/Würm interglacial period.
Hardwood forests grew above the Arctic Circle.
Melting ice sheets increased sea level by 6 meters (20 feet)
- 110,000 yrs ago: Start of Würm/Wisconsin glacial period
- 105,000 yrs ago: Stone age humans forage for grass seeds such as sorghum.
- 80,000 yrs ago: Non-African humans interbreed with Neanderthals[28]
- 74,000 yrs ago: Toba volcanic eruption
releases large volume of sulfur dioxide
- *Homo sapiens* reduced to about 10,000 individuals.
- 70,000 yrs ago: Tahoe glacial maximum
glaciers cover Canada and northern US.



- 60,000 yrs ago: Oldest male ancestor of modern humans[3]
 - 46,000 yrs ago: Australia becomes arid, bush fires destroy habitat, and megafauna die off.
 - 40,000 yrs ago: *Cro-Magnon* man appeared in Europe.
 - 28,000 yrs ago: Neanderthals disappear from fossil record.[29]
 - 26,500 yrs ago: Taupo supervolcanic eruption in New Zealand
 - 22,000 yrs ago: *Tioga* glacial maximum sea level was 130 meters lower than today
 - 20,000 yrs ago: Invention of fired ceramic pottery.
 - 19,000 yrs ago: Antarctic sea ice starts melting.[22]
 - 15,000 yrs ago: Bering land bridge between Alaska and Siberia allows human migration to America
 - 12,900 yrs ago: . [Explosion of comet over Canada](#) [23, 24, 25] causes extinction of American megafauna such as the mammoth and sabretooth cat (*Smilodon*), as well as the end of Clovis culture
 - 11,400 yrs ago: End of Würm/Wisconsin glacial period. Sea level rises by 91 meters (300 ft)
- Holocene Epoch** (11,400 years ago to today)
- Development of agriculture
 - Domestication of animals.
 - 9,000 yrs ago: Metal smelting started
 - 5,500 yrs ago: Invention of the wheel

- 5,300 yrs ago: The Bronze Age
 - 5,000 yrs ago: Development of writing
 - 4,500 yrs ago: Pyramids of Giza
 - 3,300 yrs ago: The Iron Age
 - 2,230 yrs ago: Archimedes advances mathematics
 - 250 yrs ago: Start of the Industrial Revolution
 - 50 yrs ago: Space travel
- Artificial satellite orbits the earth (1957).
Humans walk on the surface of the moon (1969).



