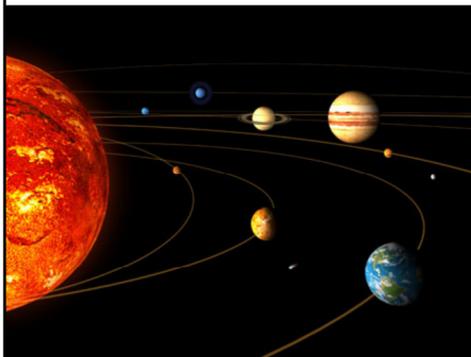


Geologic Time Line

History of the Earth and all
developments in life

Earth formation



- The universe began with is commonly called the “Big Bang”
 - ~15-16 Billion years ago
- The Milky Way galaxy began formation ~13.5 Billion years ago
- Earth and the Sol system are estimated to have begun forming ~6 billion years ago
 - On formation (from solar matter) – high temperatures, no atmosphere, no water
 - Over time, the surface cooled and oceans and an atmosphere developed

Earth, and the other planets are the result of stellar material that was ejected from the sun/star as it spun into its spherical shape and condensed – hence all the planets are roughly spherical and have both an axial rotation (like the sun) and orbit the sun in the same direction.

Current scientific hypothesis is that the Earth and other “inner planets” were formed from the collection of debris from the stellar formation process. The orb that we know as Earth was struck by an object, believed to be about the size of Mars, which cause materials to mix and a chunk to fully separate and enter an orbit around the planet. (We know the Moon is larger than any other planetary satellite and its mineral content is every similar to that of Earth)

Both orbs took millions of years to cool and may have been aided through comet (giant space slush ball) collisions, this is also hypothesized to be the source of the water found on Earth. Early atmospheric conditions would have been considered toxic due to the high amounts of gaseous methane, ammonia, and other chemical compounds.

Precambrian Era

- Hadean Eon (4600 – 4000 m.y.a.)
 - Planet formation and solidification of rock
- Archean Eon (4000 – 2500 m.y.a.)
 - Eoarchean Period (4000-3600)
 - Origins of Life (7 hypotheses)
 - Paleoarchean Period (3600-3200)
 - Oldest known form of life (bacteria)
 - Mesoarchean (3200-2800)
 - Stromatolites appear (microbe colonies)
 - Neoarchean (2800-2500)
 - Photosynthesis begins to create oxygen



*m.y.a. stands for “millions of years ago”

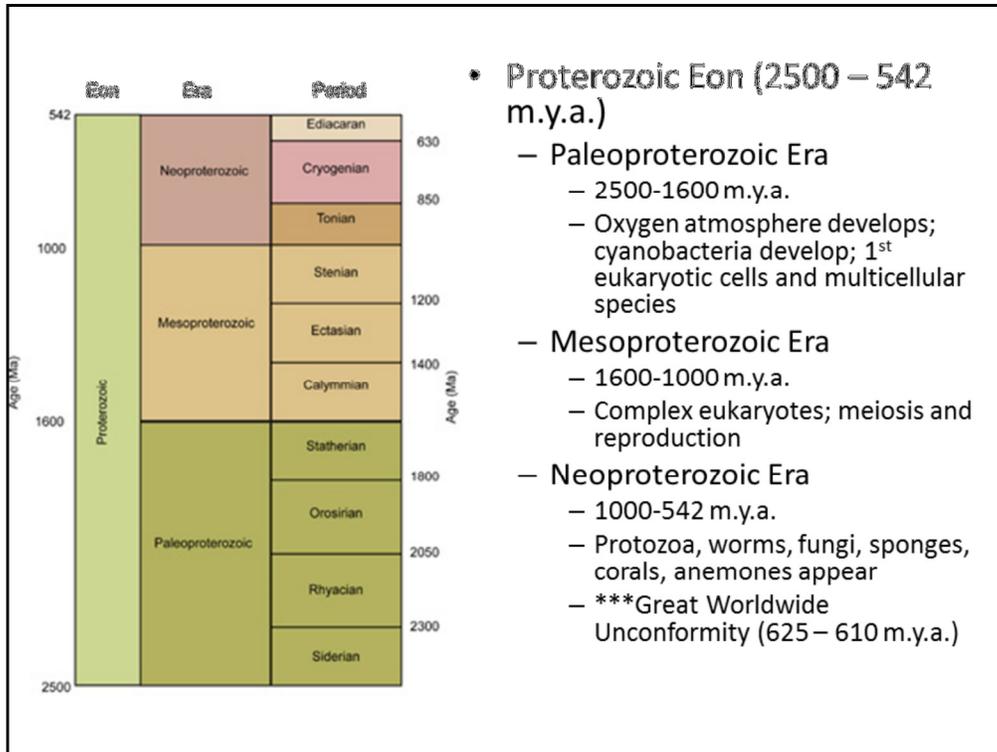
The origin of life is still relatively unknown with a number of hypotheses:

- 1 – lightning generated the first biological compounds from the atmosphere;
- 2 – mineral crystals in clay may have arranged organic molecules into patterns;
- 3 – deep-sea vents may have spewed and concentrated hydrogen rich molecules and the needed reactions;
- 4 – ice layers may have protected fragile organic compounds and extended their lives until they could react;
- 5 – RNA, a source of genetic information that can act like a protein may have provided the basis for the current DNA & protein system that organisms now use;
- 6 – simple, metabolism-based molecules may have developed, leading to more complex & efficient systems; or
- 7 – microbes may have been carried to Earth on meteorites, where favorable conditions allowed them to thrive

We DO KNOW:

About 3.8 billion years ago, we have evidence of the first single celled organisms (Prokaryotes)

Shortly afterwards, more complex cells developed, becoming the 1st bacteria and algae



The Proterozoic Eon is divided into three eras and shows the evolution of life into more complex structures.

It begins with the conversion of the atmosphere into a higher oxygen content one which may have led to the poisoning of many of the early cellular species and the evolution of “oxygen-users”

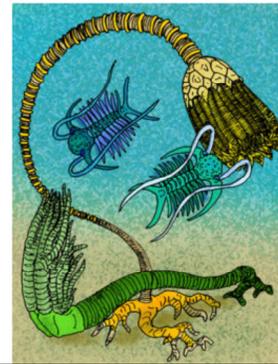
By the Neoproterozoic Era, eukaryotic structures had developed enough to form recognizable multi-cellular species like worms, fungi, corals and arthropods (exoskeleton, segmented body and legs with joints); many of these begin displaying a bilateral symmetry

Great Unconformity is a gap in the geologic time line. Observable evidence points to the exposure and subsequent erosion of the rock and mineral layers of this time period allowing for no fossil evidence during this time period. The same event may have also led to the evolutionary explosion in diversity that began shortly afterwards.

Phanerozoic Eon

Paleozoic Era

- Cambrian Period (542 – 488.3 m.y.a.)
 - Predominantly invertebrates, 1st vertebrates
- Ordovician Period (488.3 – 443.7 m.y.a.)
 - Early fish dominate the ocean
 - Sharks evolve, plants appear on land
- Silurian Period (443.7 – 416.0 m.y.a.)
 - Fish with teeth; animals on land
- Devonian Period (416.0 – 359.2 m.y.a.)
 - Ferns, mosses, insects and (recognizable) sharks appear
- Carboniferous Period
 - Mississippian sub-Period (359.2 – 318.1 m.y.a.)
 - True amphibians
 - Pennsylvanian sub-Period (318.1 – 299.0 m.y.a.)
 - Coniferous trees and reptiles
- Permian Period (299.0 – 251.0 m.y.a.)
 - Beetles, lizards and snakes first appear
 - Pangea has formed



Phanerozoic Eon began after a massive shift in the global climate during the Neoproterozoic Era, where the climate cooled to the point where ice sheets stretched from the poles to the equator at three separate events (“Snowball Earth”)

The Paleozoic was a time of dramatic change in geology, climate and evolution; beginning with the Cambrian explosion which resulted in the earliest ancestors of modern phyla.

Cambrian – fish, arthropods, sea stars (and their cousins), molluscs and possibly the ancestral cephalopods (squids and their relatives) begin populating the ocean areas

Ordovician – fish are predominantly jawless; plants and arthropods begin to colonize areas of land; sharks begin to evolve

Silurian – first ray-finned fish, land scorpions appear in the ocean; first creature to develop a lung structure and breathe air

Devonian – first insects, crabs, ferns develop; sharks are recognizable as ancestors of today's species; ancestral species of many modern groups including tetrapods (four-limbed species) appear

Carboniferous – evolution of true amphibians, reptiles and coniferous (pine) trees

Permian – all the continents have fused into Pangea (the 3rd/4th “supercontinent” to have formed); beetles begin to evolve; seed plants and conifers begin to diversify; therapsida (mammals and other closely related groups) evolve



Artistic rendition of *C. megalodon* chasing and preparing to eat a pair of blue whales



Phanerozoic Eon Mesozoic Era

- Triassic Period (251.0 – 199.6 m.y.a.)
 - Rise/birth of the Dinosaurs (class Dinosauria)
 - First mammals (about the size of mice and rodents)
- Jurassic Period (205 – 145.5 m.y.a.)
 - Flowering plants and trees (Angiosperms)
 - First Aves (reptile offshoot with wings and feathers)
- Cretaceous Period (144 – 65.5 m.y.a.)
 - “decline/death of the dinosaurs”
 - Mass extinction wipes out most dinosaurs/reptiles (KT Event)



Begins after the Permian-Triassic (P-Tr) extinction event or “Great Dying” where 96% of all marine species, 70% of all terrestrial vertebrate species becoming extinct (also the only known mass extinction of insects – 57% of families & 83% of all genera) – was so severe that it may have taken up to 10 million years for Earth’s biodiversity to recover.

Triassic – rise of the dinosaurs; also 1st appearance of crocodylians, flies turtles and recognizable mammals

Jurassic – the largest of the dinosaurs evolve during this period, including allosaurus, diplodocus, brachiosaurus and stegosaurus; Pangea begins to split; salamanders, newts, stingrays and birds begin to evolve and appear

Cretaceous – (all the dinosaurs in “Jurassic Park” are from this time period!) Atlantic Ocean begins to form; first flowering plants appear (bees follow within 30 million years); India becomes an island; snakes, ticks and ants evolve

- T. rex evolves about 68 million years ago and joins the dinosaurs in the KT event extinction about 65 million years ago

Phanerozoic Eon Cenozoic Era

- Paleogene Period (65 – 23.03 m.y.a.)
 - Mammals begin to diversify
- Neogene Period (23 – 2.588 m.y.a.)
 - Expanding open vegetation (i.e. plains)
 - India joins Asia; Americas join; Antarctica freeze mountains uplift
- Quaternary / Anthropogene Period
 - Pleistocene (2.588 m.y.a. – 11,700 years ago)
 - The last great “ice age” – large mammals, early Homo sapiens
 - Holocene (11700 – present)



Paleogene – first primates evolve; flightless birds diversify; Mediterranean forms; mammalian species evolve and diversify to include rodents, armadillos, whale ancestors, bats, tapirs, rhinos, camels, canines, cats, sloths, marsupials, pigs, elephants and deer

Neogene – whales have evolved; giraffes appear; the estimated time of the ape/monkey split; insects begin to diversify; megafauna diversifies

Quaternary – end of the last Great Ice Age; genus *Homo* evolves, begins to develop and use tools (including fire); last reversal of the Earth’s magnetic field occurs about 0.7 million years ago