Earth

Lorenzo Ghiberti
Story of Noah, Gates of Paradise Florence, 1452

Many origin stories in the Middle East include a story about a great flood. In Genesis, God initially thought that his creation was good, but he quickly changed his mind and decided to drown everyone and start anew.

The upper part of the panel shows the ark – a huge pyramidal structure – at rest upon a mountain. (Some old interpretations suggested that the top of the ark was tied together as in a pyramid.) Noah and his family release the animals and survey the destruction and the drowned. In the upper right God gives instructions to Noah. His instructions form the basis of the natural law – rules to live by before the commandments were given to Moses. These are the Noahide laws

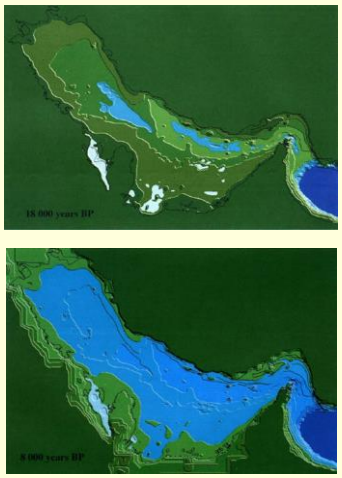
Do not deny God.
Do not blaspheme God.
Do not murder.
Do not engage in illicit sexual relations.
Do not steal.
Do not eat from a live animal.
Establish a legal system to ensure the laws are obeyed.

The lower portion of the panel shows on the right Noah's sacrifice in thanks to God, and on the left Noah's shameful drunkenness.

In the 17th Century some people tried to understand how the flood had occurred. Whence did the waters come? Whither did they recede? Thomas Burnet published a book entitled *The Sacred Theory of the Earth* (1690) suggesting that the earth was hollow and filled with water.

The Deluge

Many mythologies from the Middle East mention a great flood. With the rising seas levels after the last Ice Age, there may have been an incursion of the Indian Ocean into a low-lying region located in the present Persian Gulf.



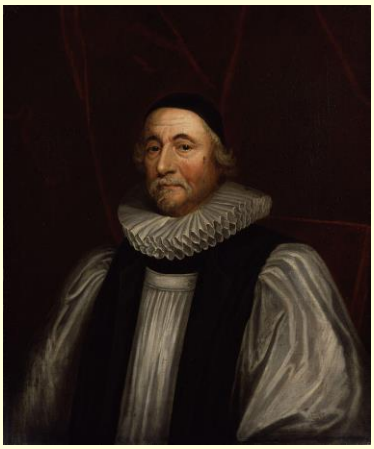
Lambeck, EPSL, 142:43-57, 1996

The prehistorical regions of the Persian Gulf would have been very fertile – there would have been lakes and marshland where the Tigris and Euphrates Rivers descended toward the Indian Ocean. Some have suggested that this area might have been the mythical garden of Eden. The sea levels rose slowly, but there may have been a cataclysmic flood associated with a tsunami.

EPSL - Earth and Planetary Science Letters.

James Ussher (1581-1656)

Ussher was a brilliant student of theology and went on to become an Archbishop in the Church of Ireland (part of the Anglican Communion). He wrote an important history of Christianity in Britain. In 1648 he published his chronology of the Bible: the Universe was created at around 6 pm on 22 October 4004 BCE; the Flood occurred in 2348 BCE; Solomon's Temple was built in 1004 BCE. Dating could be given as *Anno Mundi* (years since the creation).



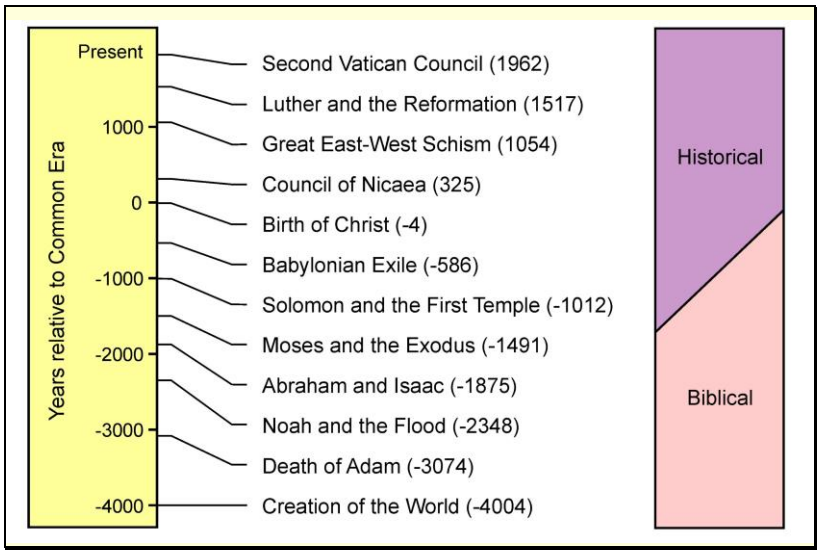
Portrait by Peter Lely, about 1655

Ussher's chronology was based on all the "begats" that occur in the bible.

And Adam lived an hundred and thirty years, and begat a son in his own likeness, and after his image; and called his name Seth …

And Seth lived an hundred and five years, and begat Enos … And Enos lived ninety years, and begat Cainan (*Genesis* 5 3-9)

Current geological studies suggest that there might have been a flood in the region of the Persian Gulf about 10000 years ago. This fits with the stories told in the Bible. But the dates do not compute. Ussher dated the origin of the world to 40004 BCE and the flood to 2348 BCE.



The left shows the dates of the world according to chronologies such as that of Bishop Ussher. There is historical evidence for the more recent of these events – from Solomon onward. Most people consider Biblical events earlier than Solomon as mythological.

The Fossil Record

The discovery of fossil remains of plants and animals in layers of sedimentary rock was initially attributed to the Deluge described in Genesis. However, it was not easy to explain why the fossils were at multiple levels if there had only been one flood. Furthermore, some of the fossils were from animals that no longer existed. This contravened the idea that Noah had preserved all God's species in the Ark.

Reconstruction of *Megalosauros*, bones of which were discovered in England in the 17th Century CE (about 9 m from nose to tail) .

Dinosaur bones were known since ancient times. They were thought to be the bones of giants, dragons, elephants. etc. The initial interpretation of the *Megalosaurus* bones were that they came from the giants mentioned in Genesis. The first full account of this dinosaur was published by William Buckland in 1824 and the name "dinosaur" (terrible lizard) was first used by Richard Owen in 1842.

Portrait by Henry Raeburn, 1776

James Hutton (1726-1797)

Born in Edinburgh and educated at the universities of Edinburgh, Paris and Leiden, Hutton decided to study the Earth using observation and inference rather than by reading scripture. In 1795 he published his *Theory of the Earth*, which proposed that the interior of Earth was hot, and that this heat was the engine which drove the creation of new rock through volcanic eruption. The rock was then eroded by air and water and deposited as layers in the sea; these layers then consolidated into stone. These sedimentary layers could then be uplifted by volcanic forces.

Hutton used a mode of explanation that combined scientific inferences with teleology. For example, see the following quotations from the preface to his *Theory of the Earth*

[on Erosion] A solid body of land could not have answered the purpose of a habitable world; for, a soil is necessary to the growth of plants; and a soil is nothing but the materials collected from the destruction of the solid land. Therefore, the surface of this land, inhabited by man, and covered with plants and animals, is made by nature to decay, in dissolving from that hard and, compact state in which it is found below the soil; and this soil is necessarily washed away, by the continual circulation of the water, running from the summits of the mountains towards the general receptacle of that fluid. The heights of our land are thus levelled with the shores; our fertile plains are formed from the ruins of the mountains; and those travelling materials are still pursued by the moving water, and propelled along the inclined surface of the earth. These moveable materials, delivered into the sea, cannot, for a long continuance, rest upon the shore; for, by the agitation of the winds, the tides and currents, every moveable thing is carried farther and farther along the shelving bottom of the sea, towards the unfathomable regions of the ocean.

[on the Earth as a Machine] We have now considered the globe of this earth as a machine, constructed upon chemical as well as mechanical principles, by which its different parts are all adapted, in form, in quality, and in quantity, to a certain end; an end attained with certainty or success; and an end from which we may perceive wisdom, in contemplating the means employed.

[on Man] The globe of this earth is evidently made for man. He alone, of all the beings which have life upon this body, enjoys the whole and every part; he alone is capable of knowing the nature of this world, which he thus possesses in virtue of his proper right; and he alone can make the knowledge of this system a source of pleasure, and the means of happiness.

Hutton's Section in Holyrood Park, Edinburgh. Hutton described this rock formation in 1770. The section shows igneous rock at the bottom intruding itself in a long tube-like form through the surrounding sedimentary rock. At the interface between the two the sediments are broken and twisted. This must have come about by the eruption of molten rock (magma) through the softer sedimentary rocks.

This photograph shows Hutton's unconformity on the Isle of Arran. He described this in 1787. In the foreground the rock layers slope inland whereas in the distance the layers slope toward the sea. The inland sloping layers are the older rock and then the sea-sloping layers were formed by sedimentation over them.

Edward Burtynsky, Basque Coast #1, UNESCO Geopark, Zumaia, Spain 2015. From the exhibition *Anthropocene*.

Henry Cavendish (1731-1810)

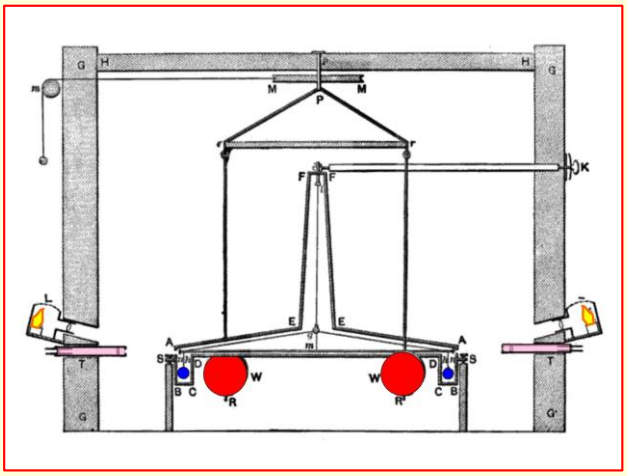
Cavendish derived his interest in science from his father, the Duke of Devonshire. He set up his own laboratory in London and conducted numerous experiments:

1. discovery of hydrogen (inflammable air0 from the action of acids on metal (1766)
2. determining that the air consists of 80% nitrogen and 20% oxygen (1785)
3. calculating the gravitational constant and thereby determining the mass of the Earth (1798)
4. clarified the laws of electricity – Ohm's Law, V=IR, and Coulomb's Law F∝(q1q2)/r2

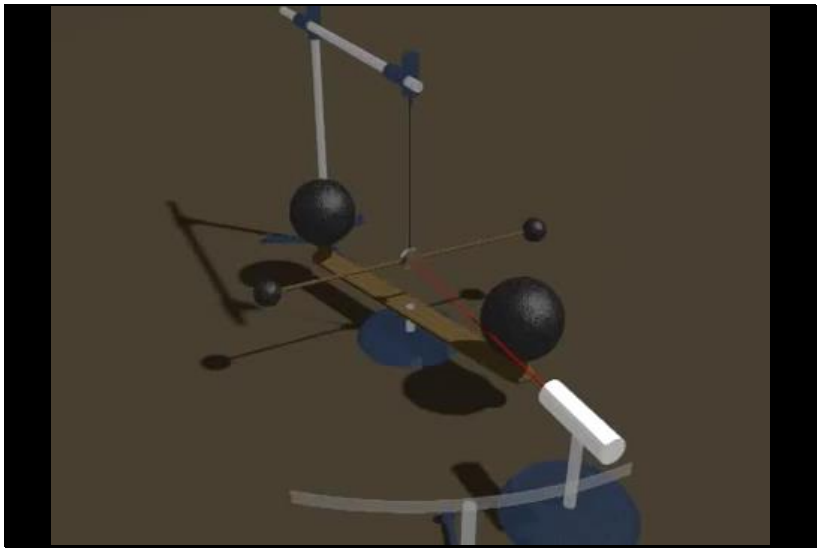
portrait is an aquatint by Christian Rosenberg from around 1805.

The equation for Cavendish's production of hydrogen is
$Zn + 2HCl \rightarrow ZnCl + H_2$

Density of the Earth



To measure the density of the Earth, Cavendish used an apparatus built by an English clergyman, John Mitchell, who died before he could perform his experiments. The experiment was set up in an enclosed room 10 ft high to prevent any air currents from affecting the measurements. The apparatus measured the tiny force exerted by two large lead balls (red), each weighting 158 kg, on two small lead balls (blue), each weighing 0.73 kg. The force was determined by observing the tiny movement of the small balls toward the large balls when the large balls were brought close. This movement was read off a scale lit by focused candle light (orange-yellow) using a telescope (pink). All the movements were in the horizontal plane and therefore were not affected by the downward force of the Earth's gravitational pull.



https://www.youtube.com/watch?v=vWlCm0X0QC0
Video from Animations for Physics and Astronomy

This animation greatly exaggerates the size of the effect in order to illustrate the mechanisms in the experiment. In principle, this experiment would work with any masses, but large masses are needed to get a measurable result. This modern replication uses a mirror system to measure the angle moved by the small balls. From recording the movement of the balls, Cavendish could determine the force exerted on the small balls by the large balls. Knowing the distance between the centers of the balls then allowed him to calculate the gravitational constant:

Newton's law of gravitational attraction:

$F \propto m_1 m_2/d^2$

or

$F = Gm_1m_2/d^2$ where G is the gravitational constant.

Cavendish's calculation of G was within 2% of that obtained with modern measurements

$6.674 \text{ X } 10^{-11} \text{ Nm}^2/\text{kg}^2$

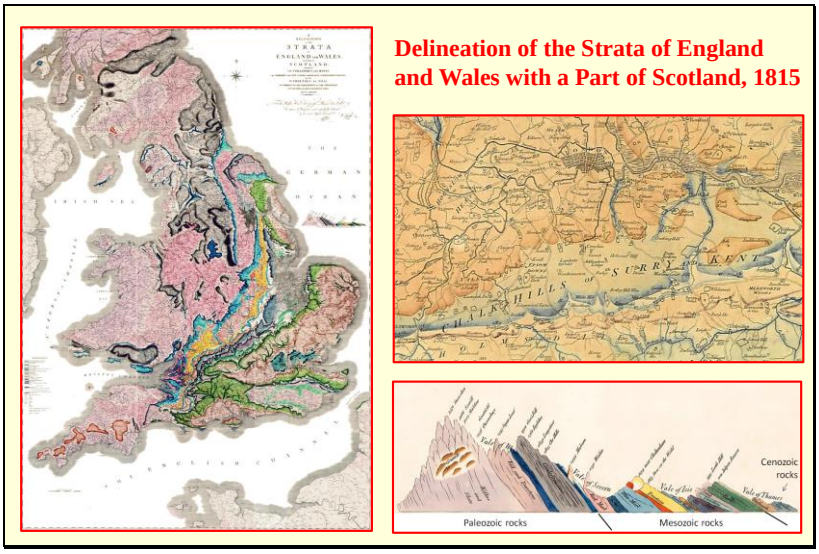
Knowing the diameter of the Earth (Eratosthenes) one can then calculate its mass. Cavendish actually reported its density.The diameter of the Earth is 12,742 km and its weight is 5.972×10^{24} kg

William Smith (1769-1839)

The son of a blacksmith (hence the name), Smith worked as a surveyor and became fascinated by the layers of earth and rock that he observed when surveying for mines and canals. He classified each stratum in terms of the type of earth and the fossils that it contained. He found that the strata were consistent in different regions. In 1815 he published his geological map of England. Smith was largely ignored by the Geological Society of London. After an unsuccessful business venture in a Somerset quarry, Smith wound up in debtors' prison.

Portrait by Hugues Fourau, 1837

The Geological Society of London was composed of rich amateurs. They met to discuss geological ideas but did little in the way of field research. Its president George Ballas Greenough came from a family that had made its fortune on selling patent medicine. He produced a map for the Geological Society in 1819 that was largely a plagiarism of Smith's work. The story is told in Simon Winchester's 2001 book *The Map that Changed the World.*



The map produced by William Smith was made up of 15 separate sheets. When arranged as a full map the size was 8 ft 9 in (2.67 m) high and 6 ft 2 in (1.88 m) wide. About 400 copies of the map were printed. Each of the printed maps was hand-colored and the colors of the surviving maps vary. Some are bright and some have faded. The map included a strata section from Mt. Snowdon to Kent. This served as a legend for the map. It also showed the relative ages of the strata.

There is a high resolution digital copy of the map at
https://upload.wikimedia.org/wikipedia/commons/e/ef/%27Strata_of_England_and_Wales%27_The_William_Smith_Geological_Map_-_High_Resolution_YORYM_2004_25.jpg
This file is huge (70 Mb) and will take a while to download.

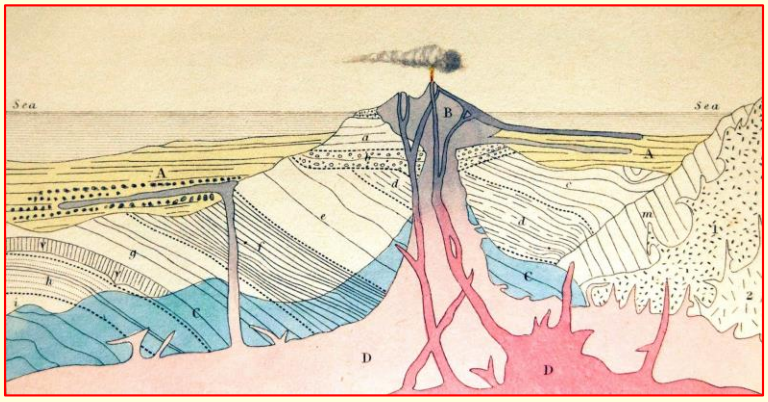
Charles Lyell (1797-1875)

Born in Scotland just south of the Grampian Mountains, Lyell was educated at Oxford. Of independent means, he took to geology as a hobby. He championed the uniformitarianism of James Hutton – the idea of the earth undergoing continual and long-lasting changes according to constant causal principles (as opposed to catastrophism). His *Principles of Geology* was first published in 1833 and went through 12 editions over the subsequent 42 years. His particular contributions concerned the way in which volcanoes rise and the effects of glaciation.

portrait by Lowes Cato Dickinson, 1870

Charles Darwin was much taken with Lyell's book. It supported the idea that the world was very old – sufficiently old to allow for the gradual evolution of the species.

Elements of Geology by Charles Lyell, 1838



Lyell described three main kinds of rocks:

- igneous rocks formed by the crystallization of molten rock (magma)
- sedimentary rock formed by the erosion of other rocks (either igneous or earlier sedimentary) and the deposition of the resultant material in layers at the bottom of the sea
- metamorphic rock formed by compression of igneous and sedimentary rock deep within the earth.

Some questions remained unanswered. There was no clear explanation for how some sedimentary rocks became oriented so close to the vertical. Volcanoes could distort the adjacent rocks but this was not sufficient.Another question was exactly how old were the different rocks. Geologists could place the different rocks in time by the level at which they occurred. Geological periods could be identified and named for the characteristic rocks – Cambrian and Devonian, for example. But how long were the periods and how old was the Earth?

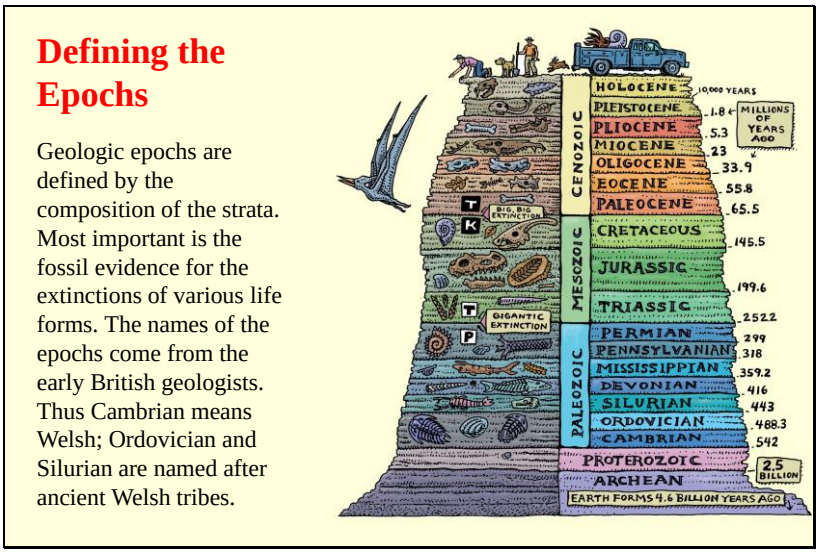
Dating the Past

Before the scientific revolution, the only way one could date the past was by means of the historical record. Geological findings soon showed that the Earth had existed long before human history. Stratigraphy (e.g. at the Grand Canyon) could give relative dating but not absolute.

In the 19th Century scientists tried to estimate the age of the Earth using such ideas as how long it would take for a molten mass of rock to cool to its present temperature, or how long it would take for the salt in the oceans to reach its present concentration.

It was only in the 20th Century that radio-isotope dating allowed precise measurements of the age of wood and the age of rocks.

The photograph show the strata in the Grand Canyon. The Colorado river has cut through the earth to reveal the different rock layers. The river has eroded its way over the last 6 million years but the rocks date from 200 million to 1800 million years ago.
https://www.nps.gov/articles/age-of-rocks-in-grand-canyon.htm

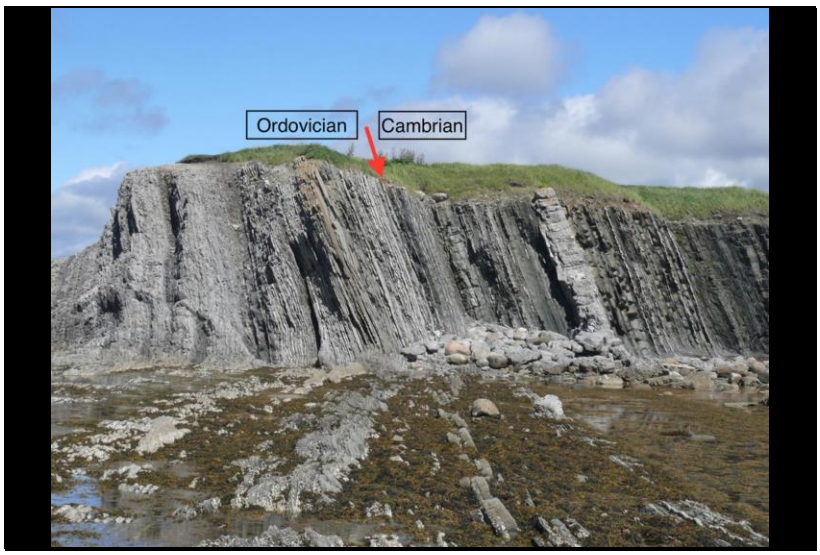


Some epoch names come from the places where the strata were first observed. Devonian comes from Devon; Permian comes from Perm, a city in Russia near the Urals; Jurassic comes from the Jura mountains in France. Other names come from the type of matter in the strata: carboniferous indicates coal and cretaceous chalk. Triassic comes from triad – because of the three layers.

There are 5 recognized mass extinctions. The most recent is between the Cretaceous and Paleocene epochs. That was when all dinosaurs other than avian dinosaurs became extinct.

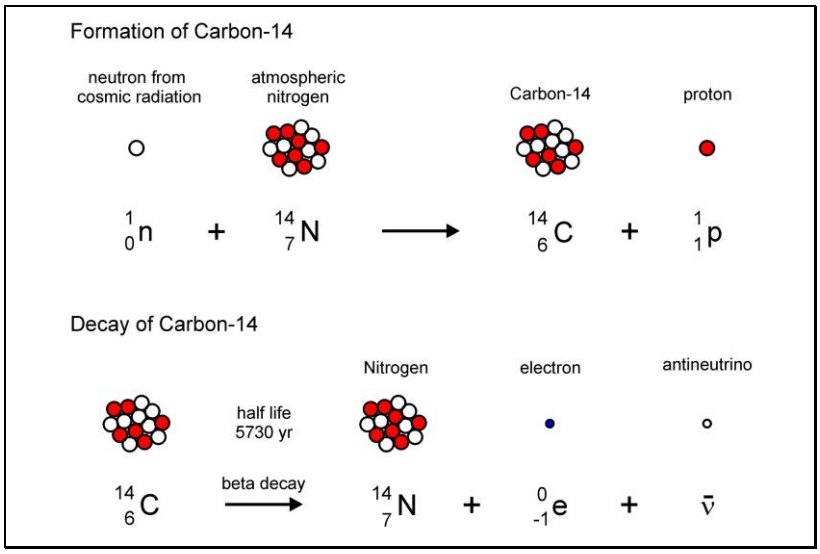
Elizabeth Kolbert's 2014 book *The Sixth Extinction: An Unnatural History* argues that current extinction of animal and plant species due to human manipulation of the world represents a sixth extinction.

The illustration suggests that the latest epoch is the Anthropocene. We shall return to this later in the presentation.



This is the location of the Global Boundary Stratotype Section and Point (GSSP) at Green Point on the West Coast of Newfoundland. A GSSP (often referred to as a "golden spike") is an internationally designated reference point on a stratigraphic section which defines the lower boundary of a geologic stage. This particular GSSP defines the border between the Ordovician (485–443 million years ago*)* and Cambrian (541-485 mya) periods.

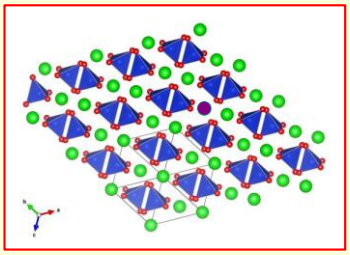
Once they were sequenced, the strata then needed to be dated.
Two important radio-isotope dating methods involve the decay of Carbon-14 first reported by Willard Libby in 1946, and the decay of Uranium to Lead as reported Arthur Holmes in 1913.



The illustration shows the principles underlying the Carbon-14 technique. The method can be used to date when organic material stopped living, e.g. when wood was obtained from a tree.

Carbon-14 is continually formed in the earth's atmosphere by cosmic radiation: nitrogen-14 absorbs a neutron, emits a proton and becomes carbon-14. Carbon is taken up into plants from the atmosphere's carbon dioxide during photosynthesis. This plant carbon then becomes part of the animals that feed on the plants (or on other animals that feed on plants). In living organisms, carbon is continually ingested and the ratio of carbon-14 to carbon-12 is therefore the same as the ratio in the atmosphere. When a living organism dies, however, no more carbon is taken in from the atmosphere. In nonliving material, the carbon-14 decays and the ratio of carbon-14 to carbon-12 decreases.

Radiocarbon dating is not applicable to ages of greater than about 50,000 years because the amounts of the remaining carbon-14 become too small to measure accurately. For earlier dates, radioactive isotopes with longer half-lives are used.

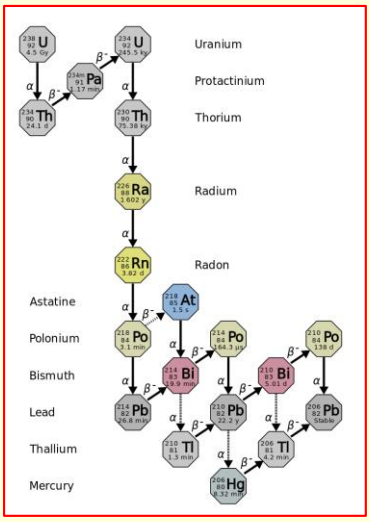


Zircon Crystals

Occasional zircon crystals are contained in rocks of all kinds. The composition is mainly zirconium silicate: $ZiSiO_4$. In the crystal diagram the zirconium is green the silicon blue and the oxygen red. The crystals are very resistant to heat and pressure. Atoms of other elements such as uranium (purple) may be included in the crystal lattice instead of the zirconium atom. All the isotopes of uranium are unstable with half lives that vary between 159,200 years and 4.5 billion years.

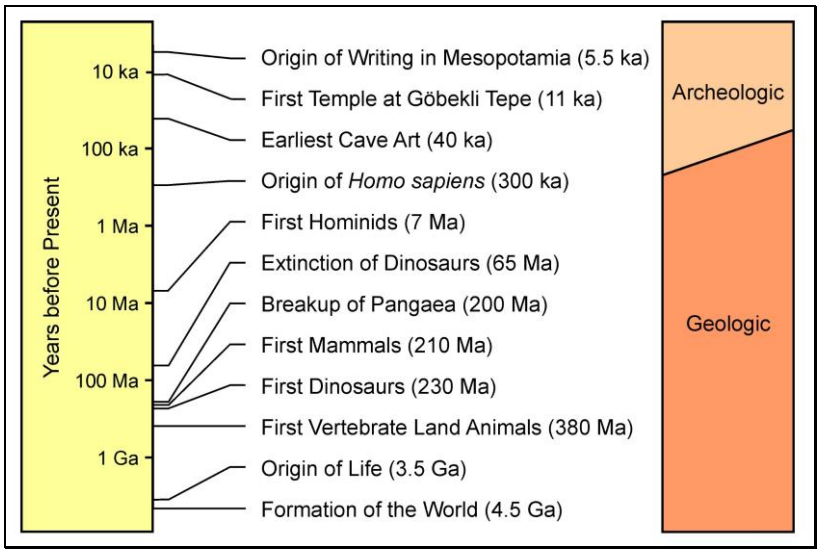
Uranium Decay

Uranium decays by emitting an alpha particle (2 protons and 2 neutrons) to become thorium. Most uranium atoms have an atomic weight of 238. A very small amount is uranium-235 which is used in the atomic bomb. Both decay through a series of intermediary radioactive atoms to form stable isotopes of lead. Thus the number of lead atoms relative to the number of remaining uranium ions in a zircon crystal can give us the age at which the crystal was formed.



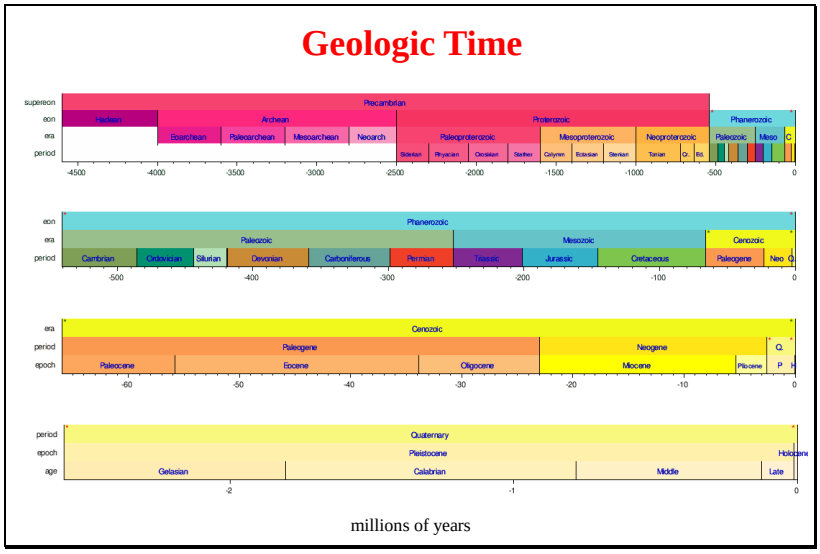
U^{238} decays to Pb^{206} with a half life of 4.5 billion years.
U^{235} decays to Pb^{207} with a half-life of 710 million years.

Two main techniques are used for uranium dating. One involves the ratio of Pb^{206} to U^{238}. The other involves calculating the ratio between the two different lead isotopes.



Radiometric dating of the earliest rocks in the Earth and of the meteors (which come from the protoplanetary dust of the asteroid belt) give the age of the world as 4.5 Billion years. Note that the timescale is logarithmic for this diagram.

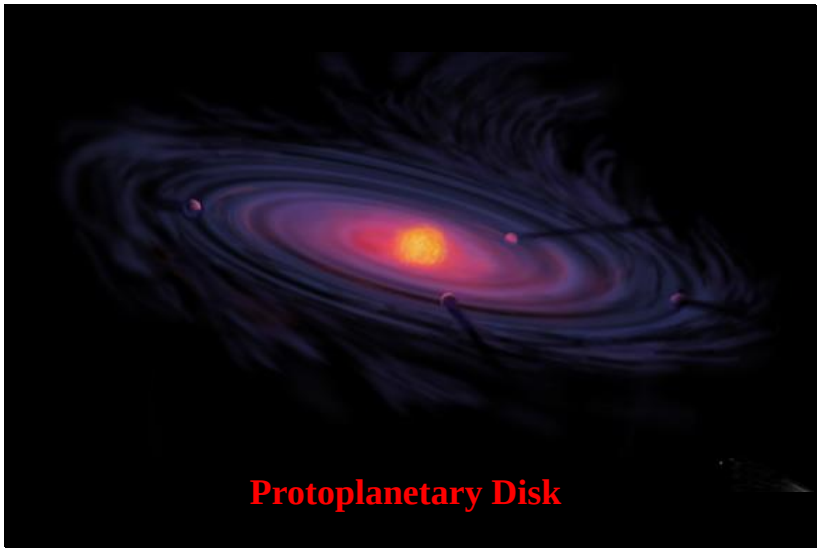
One key date is the origin of writing. Before that date, and in most places long after that date, history was oral. Most scholars suggest that the book of Genesis was written down in its present form in the 6^{th}-5^{th} Centuries BCE. There may have been earlier written versions dating back to Solomon's time (10^{th} Century BCE).



The diagrams are from Wikipedia
https://en.wikipedia.org/wiki/Geologic_time_scale

Eons are named after the categories of life:
Proterozoic – earlier life (single-celled organisms and then simple multi-celled organisms)
Phanerozoic – visible life – following the "Cambrian explosion" of life forms: arthropods, molluscs, fish
Phanerozoic is divided into paleo- (ancient), meso- (middle) and ceno- (recent)

The first date in the sequence of geologic time is the formation of the Earth.



We discussed the initial singularity in the session on Cosmos. After the initial singularity had exploded, the particles fused to form hydrogen nuclei. These collapsed to form stars and galaxies. The gravitational collapse of stars led to the formation of heavier elements. Some of the collapsing stars exploded as supernovae scattering dust into space. Clouds of dust accumulated as a disc around other stars, and the dust accreted to form planets.

The dust that did not accrete into planets formed meteorites. The age when the planets were formed can thus be estimated by the age of meteorites. These were studied using the uranium-lead isotope techniques by the American geologist Clair Cameron Patterson and published in 1956. The Earth began around 4.5 billion years ago.
The oldest rock systems on Earth – in the Canadian Shield – have been dated to around 4 billion years, which is compatible with the meteorite data.

Despite this evidence, many people believe the Earth is much younger.

Ark Encounter, Kentucky, 2016

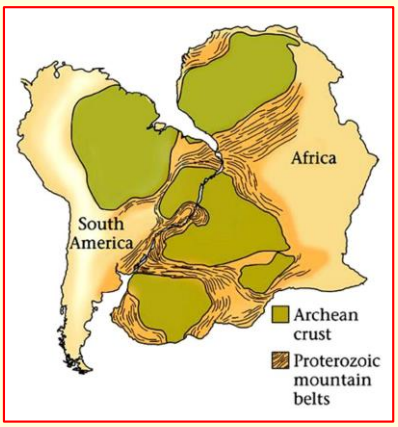
Young Earth Creationism

Many people still believe in a literal interpretation of Genesis. The question is usually asked in terms of evolution: Do you believe that "God created human beings in their present form within the last 10,000 years." In the USA about 40% answer "yes," in Canada 22% and in Britain 19%.

The illustration shows a representation of Noah's Ark just before it was opened in July 2016. It was built by the organization Answers in Genesis, founded by Ken Ham. This group also runs a nearby Creation Museum. Ken Ham has produced many arguments for why the geological evidence is wrong. Perhaps the rate of isotope decay changes over the years? His basic stance is that the geology is all inferential. The creation of the Earth was not directly observed by human beings – we were not there. He quotes from Job 38:4

> Where wast thou when I laid the foundations of the earth?
> declare, if thou hast understanding.

Continental Drift



The geological processes discussed by Lyell could not easily explain the tremendous distortion of the strata. Volcanic eruptions and earthquakes could alter the local strata but could not explain large mountain ranges.

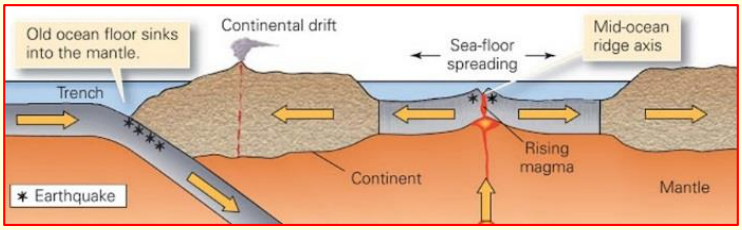
The first step toward an explanation was the 1912 hypothesis of Alfred Wegener (1880-1930) that the continents have moved over the past millions of years. Wegner showed that the continents on either side of the Atlantic Ocean could fit together both in terms of shape and types of rock.

Another later set of evidence for continental drift was the finding of 1) similar dinosaur remains in the different continents indicating that they had once been joined and 2) different dinosaur remains in the different continents indicating that the dinosaurs had evolved separately after the continents had split.

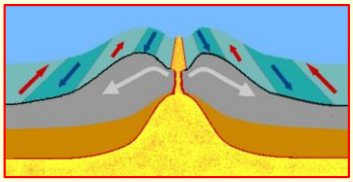
Pangaea

Wegener hypothesized that all the present continental land masses had once been joined in a supercontinent that he called the *Urkontinent* (original continent) or *Pangaea* (all land). Wegner's ideas were met with skepticisim. The main problem was how the continents moved. Wegener thought that the land masses were moved by oceanic forces. These seemed inadequate.

Sea Floor Spreading

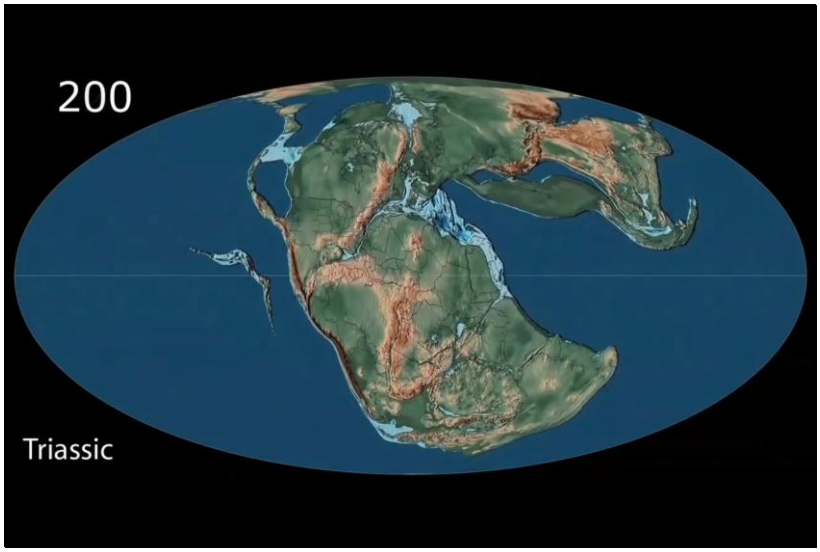


In the 1960s Harry Hess described how rift zones in the oceans caused the sea floor to spread. These ideas were supported by measurements of the magnetic orientation of the rocks adjacent to the rift.



The Earth's magnetic field has undergone rapid reversals over the millions of years of Earth's history. Molten rock that cools will orient its magnetic components to the magnetic fields present when it solidifies. Measuring these different orientations (magnetic stripes) can thus be used to follow the spread of rock away from the rift.

The spread moves giant land masses called tectonic (from Greek *techne* build) plates. These are composed of stiff rock (lithosphere). They move over more malleable rock (asthenosphere). Two types of borders occur between plates. One is divergent – like the mid-Atlantic rift zone. The other is convergent. At a convergent border between plates one sinks below the other. This may cause the uprising of large mountain ranges, or the formation of deep sea trenches.



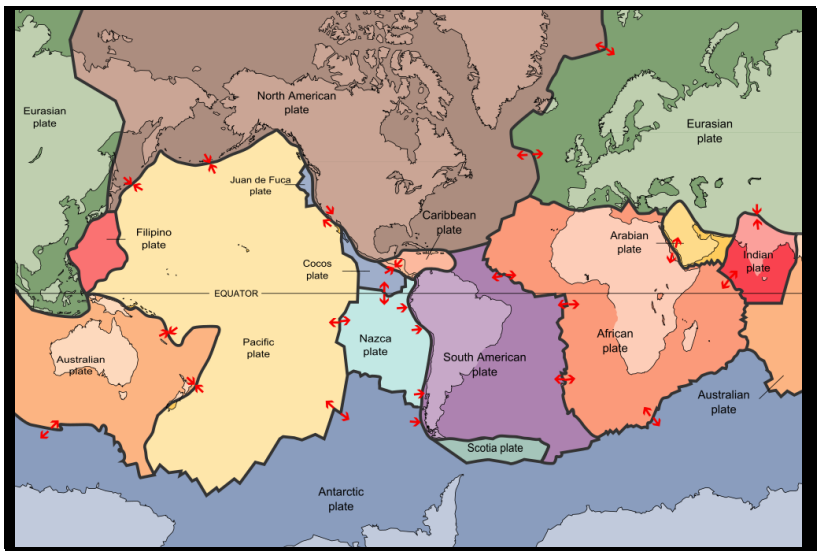
Continental Drift over the last 200 million years

https://www.youtube.com/watch?v=g_iEWvtKcuQ

This is the work of Christopher Scotese. I have used only the second half of the video and doubled the speed. I have also changed the music to Sibelius Symphony #5 Third Movement. The theme was supposedly triggered by hearing the sounds of a flight of swans taking off from a lake – much like the continents fleeing Pangaea. Donald Tovey called the theme the Hammer of Thor – appropriate to the breaking up of continents.

Of note are the formation of the North Atlantic (beginning 150 Mya), the South Atlantic (100 Mya), great inland sea in North America (90 Mya) and the uprising of the Himalayas (40 Mya) and the last Ice Age (peaking just before the present)

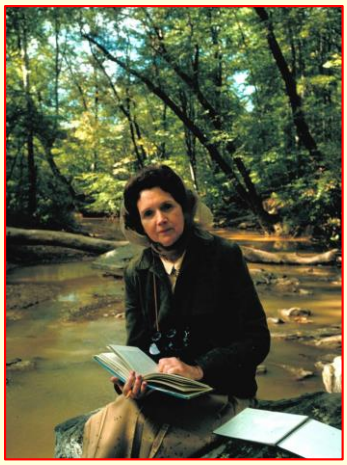
Note that many tectonic movements happened before 200 million years ago – see the full Scotese video. The earlier events led to the uplifting of the mountain ranges that are already present in Pangaea.



This map gives the present positions of the tectonic plates that form the surface of the Earth. There are eight major plates: Pacific, North American, Eurasian, African, Antarctic, South American, Australian, and Indian. The boundaries between the plates may be divergent like the mid-oceanic ridges or convergent like the Mariana Trench (between Pacific and Filipino plates) or the Himalayas (between Indian and Eurasian plates). Earthquakes and volcanic activity occur most frequently at the active boundaries between plates. Not all volcanoes – some like those in Hawaii seem to occur at a location where the crust has been penetrated by a plume of magma.

Rachel Carson (1907-1964)

After studying biology at Johns Hopkins University, Carson wrote articles on marine biology for the Baltimore Sun and then a book *The Sea Around Us* in 1950. She then became aware of the toxic effects of pesticides and published *Silent Spring* in 1962. The title referred to the future absence of birdsong due to the decrease in bird populations related to pesticide use. Despite suffering from breast cancer and the concerted opposition of the chemical companies, she testified at many US government hearings urging the government to limit pesticide use.



Portrait by Alfred Eisenstaedt

Extensive information about Carson is available at
http://www.rachelcarson.org/

Carson was accused of being a communist and a “fanatic defender of the cult of the balance of nature.”

A crop-duster spreading DDT on a ranch in Oregon in 1948.

Carson campaigned extensively against the indiscriminate use of dichlorodiphenyltrichloroethane (DDT) to control insects.
In Canada extensive spraying of the forests with DDT to control spruce budworm has had unknown ecological effects. Spraying is still done though not with DDT.

DDT was first produced in 1939 by a Swiss chemist Paul Müller. It was used to control malaria by killing off the mosquitoes. Müller received the 1948 Nobel Prize.

DDT was finally banned in US in 1972.

W. Eugene Smith, *Tomoko in Her Bath, Minamata, Japan*, 1972

The release of methylmercury into the water of Minamata Bay from 1932-1968 by the Chisso chemical company led to severe neurological poisoning in many of the residents of the surrounding area. The disease was recognized in 1958 and the cause identified in 1959. The

company paid compensation to the patients, but did not cease from polluting the water. The company continues to this day. Its website does not acknowledge the disease.

The problem of methylmercury toxicity and its cover-up is also much in evidence in Canada, particularly in relation to the Grassy Narrows Reservation in Ontario.

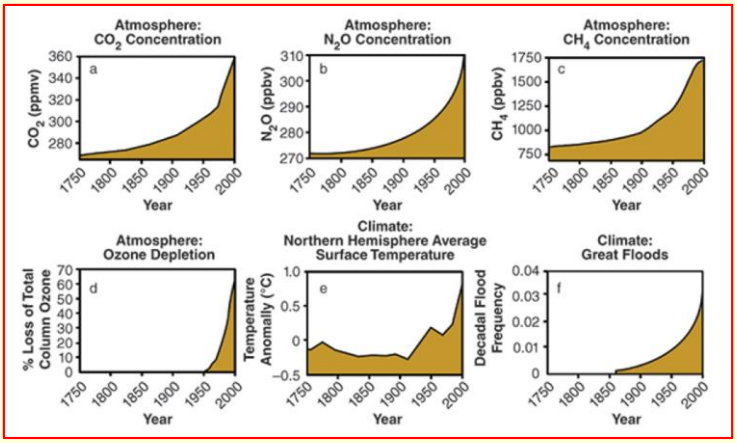
Ecology

Although the word was coined from the Greek *oikos* (house/home), it was not until the mid 20th Century that we began to study the interactions between the Earth and its inhabitants. Soon it became clear that we had significantly disturbed the balance of nature, and that this could have cataclysmic results.

Earth as seen from Apollo 17, 1972

The Blue Marble photograph was a definite force it making us aware of the fragility of the Earth as our home in space.

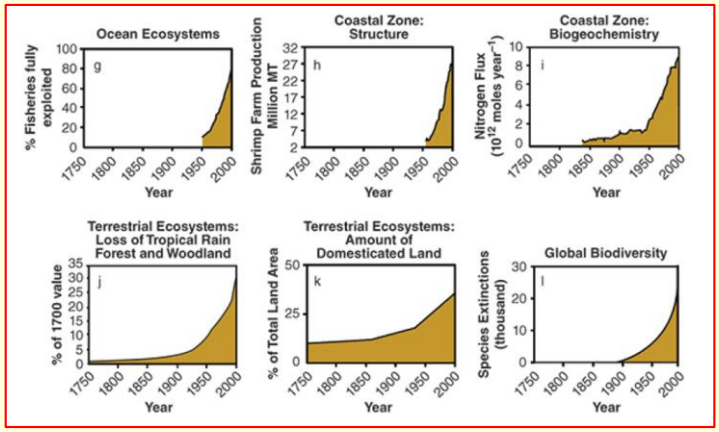
The Anthropocene: the Great Acceleration



Over the past century or two and accelerating over the last 50 years, there have been huge changes in life on this world. These have had tremendous impact on the environment. The term "great acceleration" comes from

Mcneill, J. R. (2014). *The Great Acceleration: An Environmental History of the Anthropocene since 1945*. Cambridge: Harvard University Press.

The term "Anthropocene" used to describe a possible new geologic epoch determined by the effect of man on the world was popularized by Paul Crutzen and Eugene Stoermer in the 1980s. .



Graphs from Ellis, E. (2018). *Anthropocene: A Very Short Introduction*. Oxford University Press

Global Warming

Photographs comparing a glacier in Svalbard, a Norwegian island archipelago in the Arctic Ocean (74-81 degrees latitude) between 1900 and 2003 (Christian Åslund).

One of the greatest changes in recent years is global warming. Glaciers retreat and sea levels rise. Floods become more frequent and hurricanes more destructive.
Photographs are from
http://www.christian.se/global-warming-retreating-glaciers

One of the main determinants of global warming is deforestation. Trees serve to convert carbon dioxide into various organic compounds.

Photograph by T. J. Watt of the sole Douglas Fir left after a clear cutting operation on Victoria Island. The tree is 66 meters tall. The base is 12 meters in circumference. The tree was saved by Dennis Cronin, a logging supervisor, who decided that they should leave this giant.
https://thewalrus.ca/big-lonely-doug/

Earth

Sunset on Everest, Thomas Fanghaenel, 2007

The Himalaya (abodes of snow) are the greatest achievement of the tectonic plates.