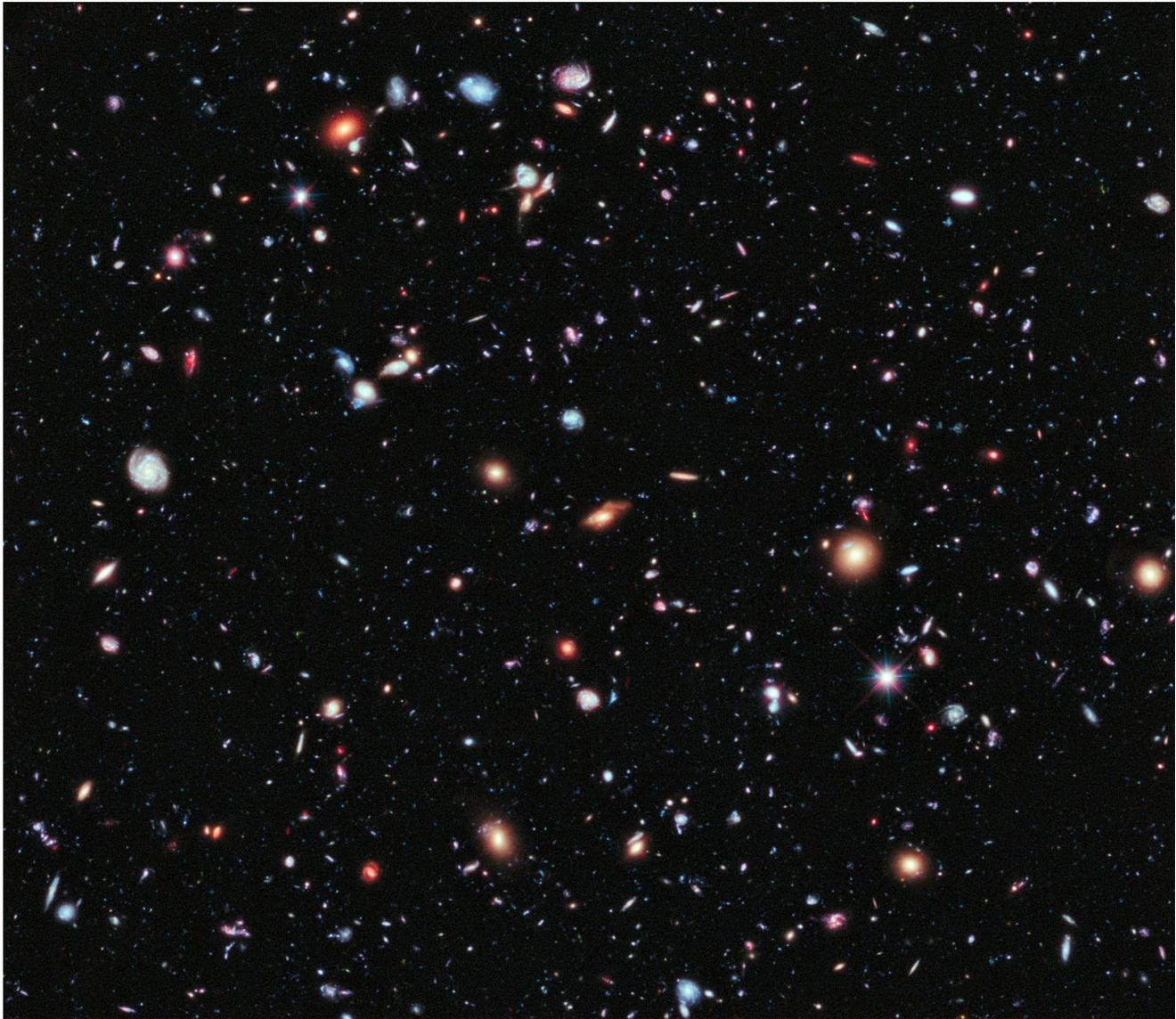


# The Big Bang

**13700 Million years ago (13.7 Billion years ago)**

In the beginning, there was the “singularity”, a tiny, invisible, infinitely hot and dense speck of nothing. The singularity exploded creating the universe. Due to gravity, tiny particles - matter - attracted other particles, and clumped together to forming clouds of gas - then from these clouds, stars and galaxies. Scientists estimate there are over 200 billion galaxies in the universe.

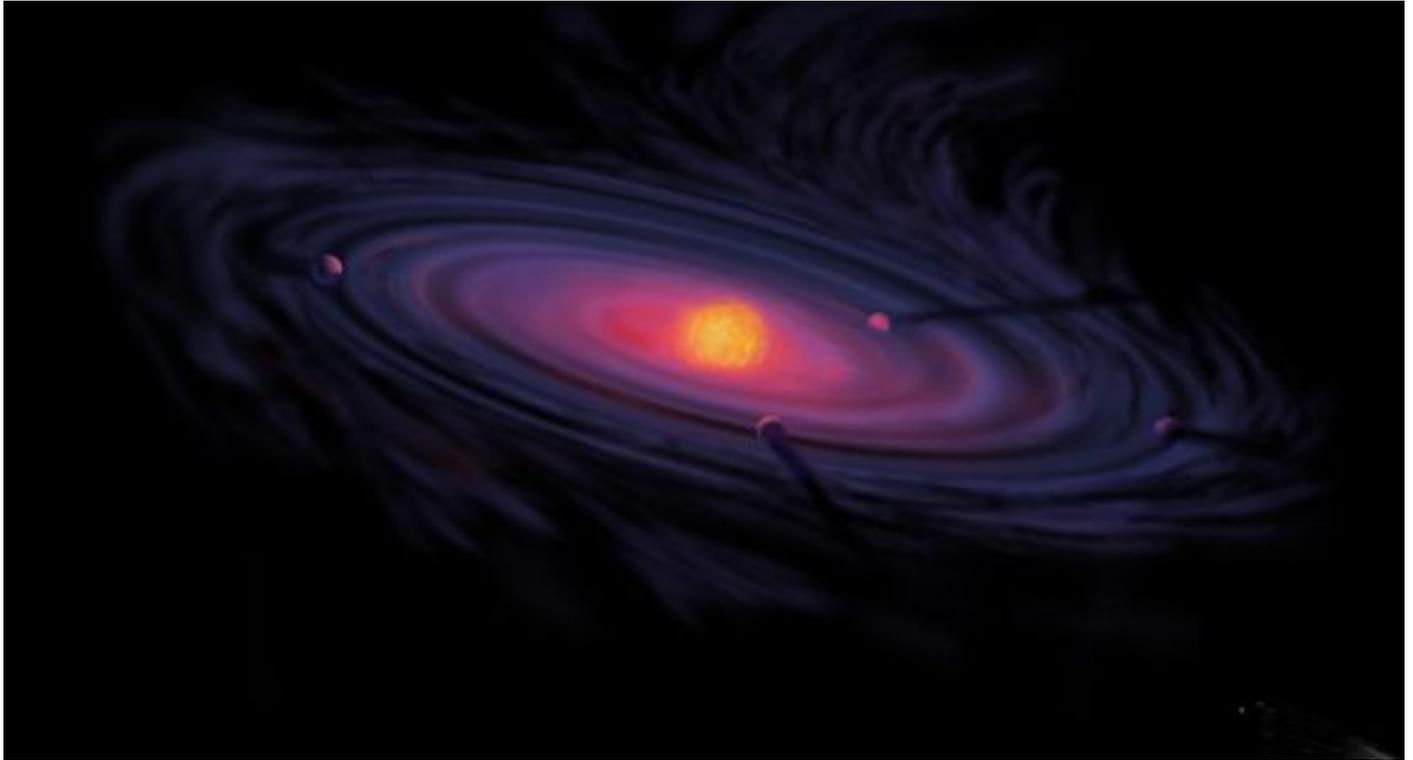


A view of the universe by the Hubble Telescope - each dot of light is a galaxy. Source: "Constellation Fornax, EXtreme Deep Field" by NASA; ESA; G. Illingworth, D. Magee, and P. Oesch, University of California, Santa Cruz; R. Bouwens, Leiden University; and the HUDF09 Team - <http://hubblesite.org/newscenter/archive/releases/2012/37/image/a/warn/>, [http://www.nasa.gov/images/content/690958main\\_p1237a1.jpg](http://www.nasa.gov/images/content/690958main_p1237a1.jpg). Licensed under Public Domain via Commons - [https://commons.wikimedia.org/wiki/File:Constellation\\_Fornax,\\_EXtreme\\_Deep\\_Field.jpg#/media/File:Constellation\\_Fornax,\\_EXtreme\\_Deep\\_Field.jpg](https://commons.wikimedia.org/wiki/File:Constellation_Fornax,_EXtreme_Deep_Field.jpg#/media/File:Constellation_Fornax,_EXtreme_Deep_Field.jpg)

# The Earth forms

**4600 Million years ago (4.6 Billion years ago)**

Out of a cloud of swirling gases left over from exploded stars (supernovae), our solar system and the early Earth - a "protoplanet" - form. Early earth is NOT a pleasant place to be - it is a ball of liquid rock and metal.

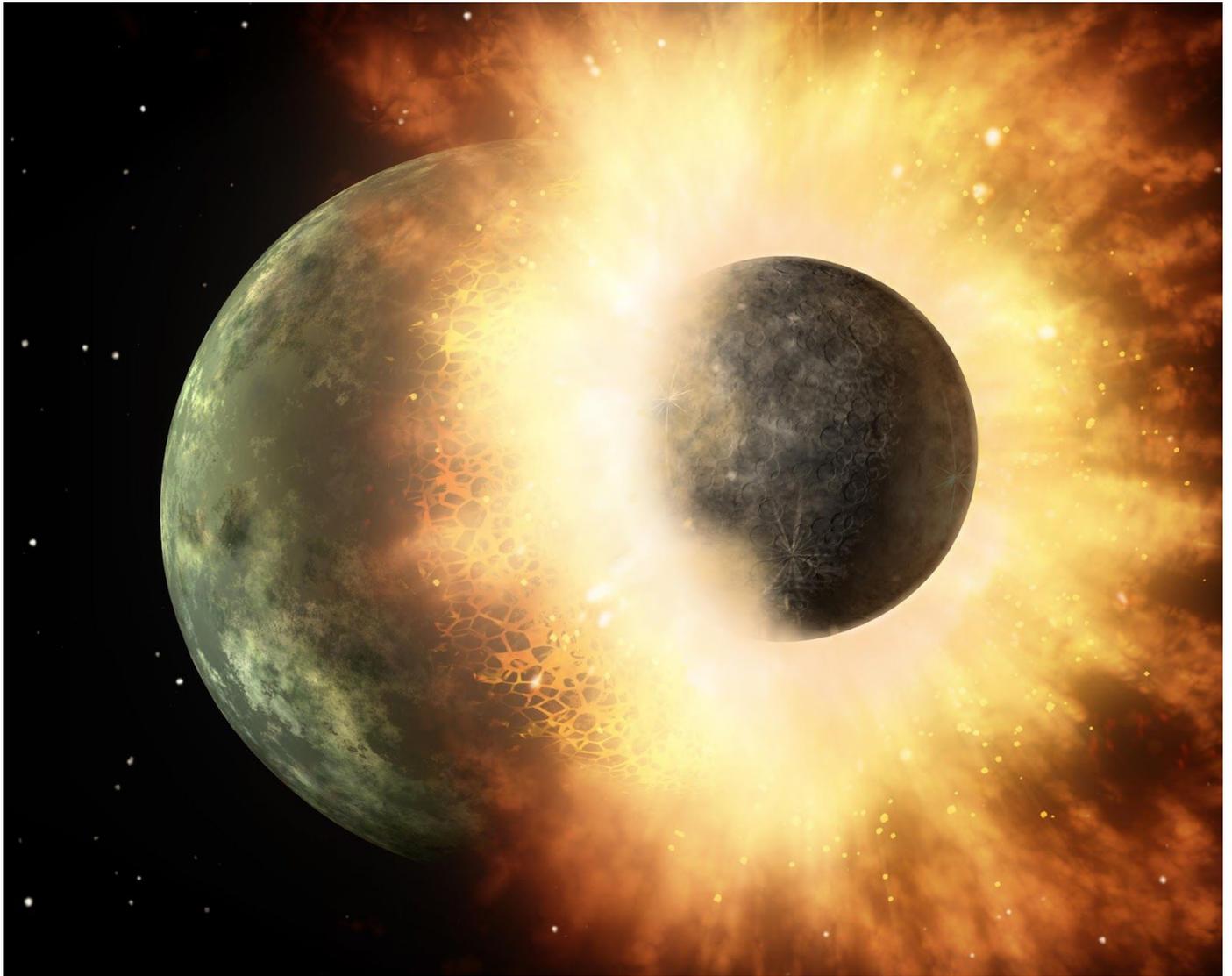


Artist's concept of a [protoplanetary disk](#), where particles of dust and grit collide and accrete forming planets or asteroids Source: "Protoplanetary-disk" by NASA - NASA; <http://origins.jpl.nasa.gov/stars-planets/ra4.html>. Licensed under Public Domain via Commons - <https://commons.wikimedia.org/wiki/File:Protoplanetary-disk.jpg#/media/File:Protoplanetary-disk.jpg>

## Collision Between Two Protoplanets Creates the Moon

4500 Million years ago (4.5 Billion years ago)

The early Earth collides with another, smaller protoplanet - Theia. Earth survives, and the particles from the massive explosion are trapped by earth's gravity and coalesce to form the moon.

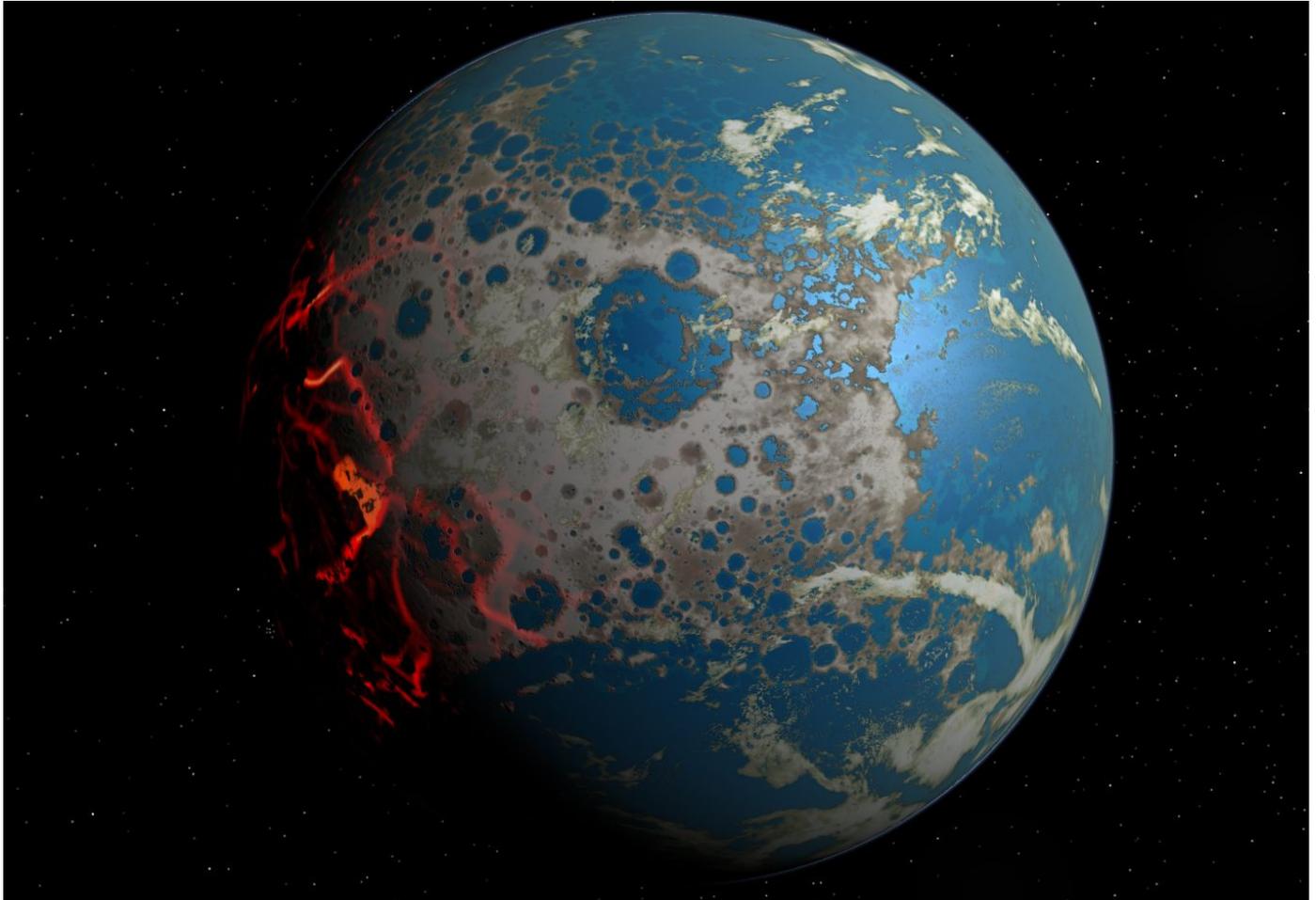


Artist's depiction of a collision between two planetary bodies. Such an impact between the Earth and a [Mars-sized object](#), Theia, likely formed the Moon. Source: "Artist's concept of collision at HD 172555" by NASA/JPL-Caltech - [http://www.nasa.gov/multimedia/imagegallery/image\\_feature\\_1454.html](http://www.nasa.gov/multimedia/imagegallery/image_feature_1454.html). Licensed under Public Domain via Commons - [https://commons.wikimedia.org/wiki/File:Artist%27s\\_concept\\_of\\_collision\\_at\\_HD\\_172555.jpg#/media/File:Artist%27s\\_concept\\_of\\_collision\\_at\\_HD\\_172555.jpg](https://commons.wikimedia.org/wiki/File:Artist%27s_concept_of_collision_at_HD_172555.jpg#/media/File:Artist%27s_concept_of_collision_at_HD_172555.jpg)

## Earth's Surface, Oceans form

4000 Million years ago (4.0 Billion years ago)

As the Earth cools, heavier material sank to form the core, and the lighter material left at the surface begin to solidify, forming the earth's crust. Meteorite impacts and volcanic eruptions fill the oceans with water and the atmosphere with gas - nitrogen and carbon dioxide - but not oxygen.



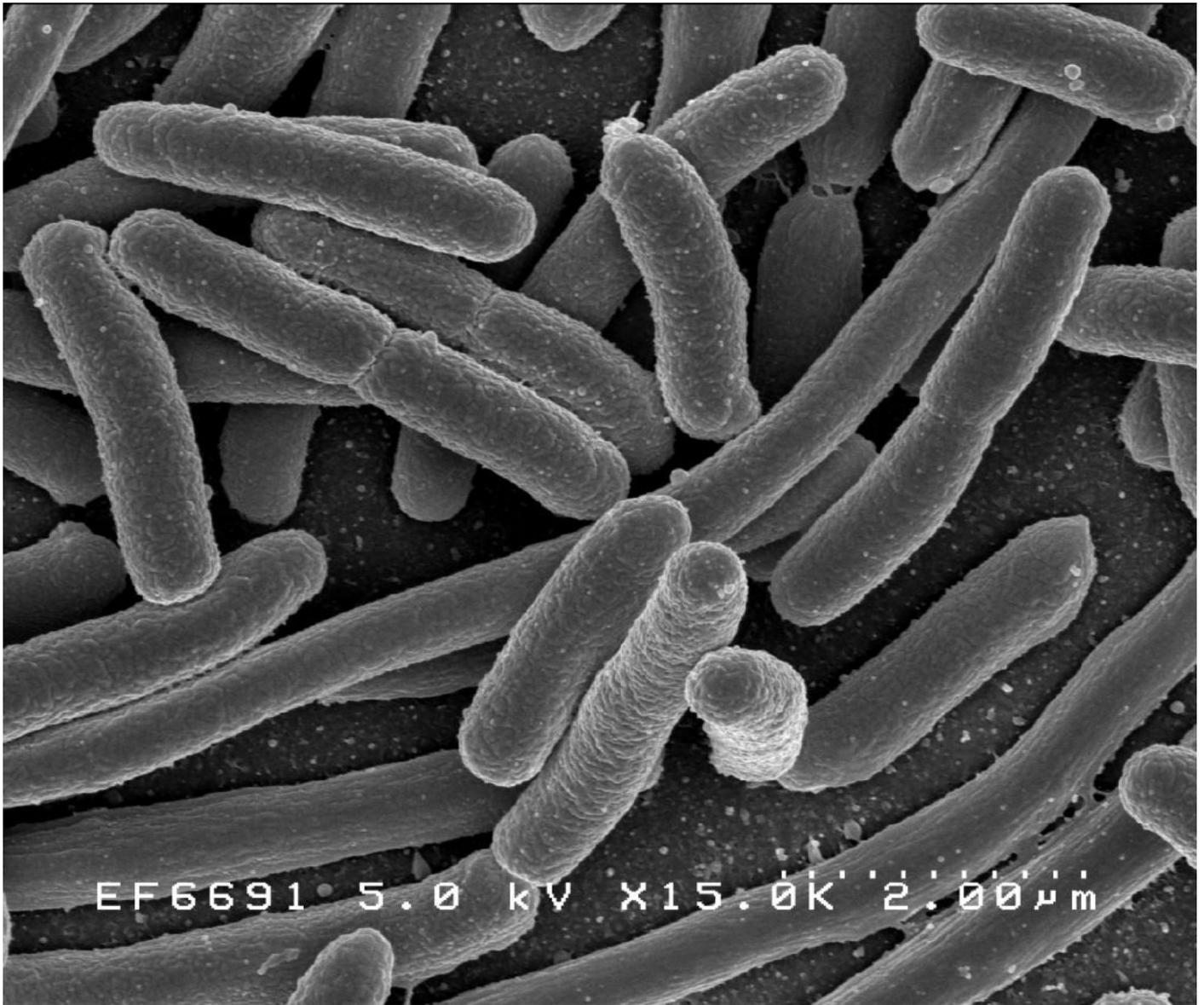
An artist's illustration of the young Earth, 4 billion years ago.

Source: "NewHadeanEarth" by MarioProtIV - Own work. Licensed under CC BY-SA 4.0 via Commons - <https://commons.wikimedia.org/wiki/File:NewHadeanEarth.jpg#/media/File:NewHadeanEarth.jpg>

## Living in a Bacterial World- Life Appears

3800 Million years ago (3.8 Billion years ago)

Soon after the surface of the earth cools, life appears, in the form of bacteria. Bacteria are simple, microscopic cells, which consist of a molecule that can replicate itself surrounded by a cell wall. These early bacteria did not depend on oxygen; more likely they used sulphur.



Scanning electron micrograph of bacteria (Escherichia coli)

Source: "EscherichiaColi NIAID" by Credit: Rocky Mountain Laboratories, NIAID, NIH - NIAID: Licensed under Public Domain via Commons - [https://commons.wikimedia.org/wiki/File:EscherichiaColi\\_NIAID.jpg#/media/File:EscherichiaColi\\_NIAID.jpg](https://commons.wikimedia.org/wiki/File:EscherichiaColi_NIAID.jpg#/media/File:EscherichiaColi_NIAID.jpg)

# Food from Sunlight - Photosynthesis Begins

3000 Million years ago (3.0 Billion years ago)

Some types of bacteria, the cyanobacteria, start to photosynthesize, that is, take energy from the sun and carbon dioxide from the atmosphere to make food. Oxygen is produced as a waste product of this process. These early cyanobacteria live in sticky mats on rocky structures called stromatolites, and are the dominant form of life on earth for billions of years.



Modern stromatolites (photosynthetic microbial mats) in Australia.

Source: "StromatolitheAustralie6" by C Eeckhout - Photograph taken by C. Eeckhout. Licensed under CC BY 3.0 via Wikimedia Commons - <https://commons.wikimedia.org/wiki/File:StromatolitheAustralie6.jpeg#/media/File:StromatolitheAustralie6.jpeg>

# Oxygen Accumulates in the Atmosphere

**2300 Million years ago (2.3 Billion years ago)**

At first, oxygen from photosynthesis was used up in reactions with dissolved iron in the ocean, producing distinctive, banded, iron-rich sedimentary rocks. Then, oxygen began to accumulate in the atmosphere, allowing the evolution of new, oxygen-based forms of life.



A 2.1 billion year old banded iron stone

Source: "Black-band ironstone (aka)" by André Karwath aka Aka - Own work. Licensed under CC BY-SA 2.5 via Wikimedia Commons - [https://commons.wikimedia.org/wiki/File:Black-band\\_ironstone\\_\(aka\).jpg#/media/File:Black-band\\_ironstone\\_\(aka\).jpg](https://commons.wikimedia.org/wiki/File:Black-band_ironstone_(aka).jpg#/media/File:Black-band_ironstone_(aka).jpg)

# Extreme Cold - Snowball Earth I

**2100 Million years ago (2.1 Billion years ago)**

Extreme cold periods, or ice ages, occurred early in Earth's history. During these times, nicknamed "Snowball Earth" most of the planet was covered in ice, perhaps even the equatorial areas. These frigid conditions created challenging conditions for early life, but also created new opportunities as the planet later warmed. This first Snowball Earth was likely triggered by rising levels of oxygen in the atmosphere.



During the "Snowball Earth" periods, the planet was almost completely covered with ice.

Source: "AntarcticaDomeCSnow" by Stephen Hudson - Own work. Licensed under CC BY 2.5 via Commons - <https://commons.wikimedia.org/wiki/File:AntarcticaDomeCSnow.jpg#/media/File:AntarcticaDomeCSnow.jpg>

## Complex Cells

**1800 Million years ago (1.8 Billion years ago)**

Life is still microscopic and single-celled, but as the planet warms and oxygen in the atmosphere increases, cells become more complex, developing specialized structures with different functions within them and reproducing in more complicated ways. Later, more complex organisms will develop from these more complex cells.



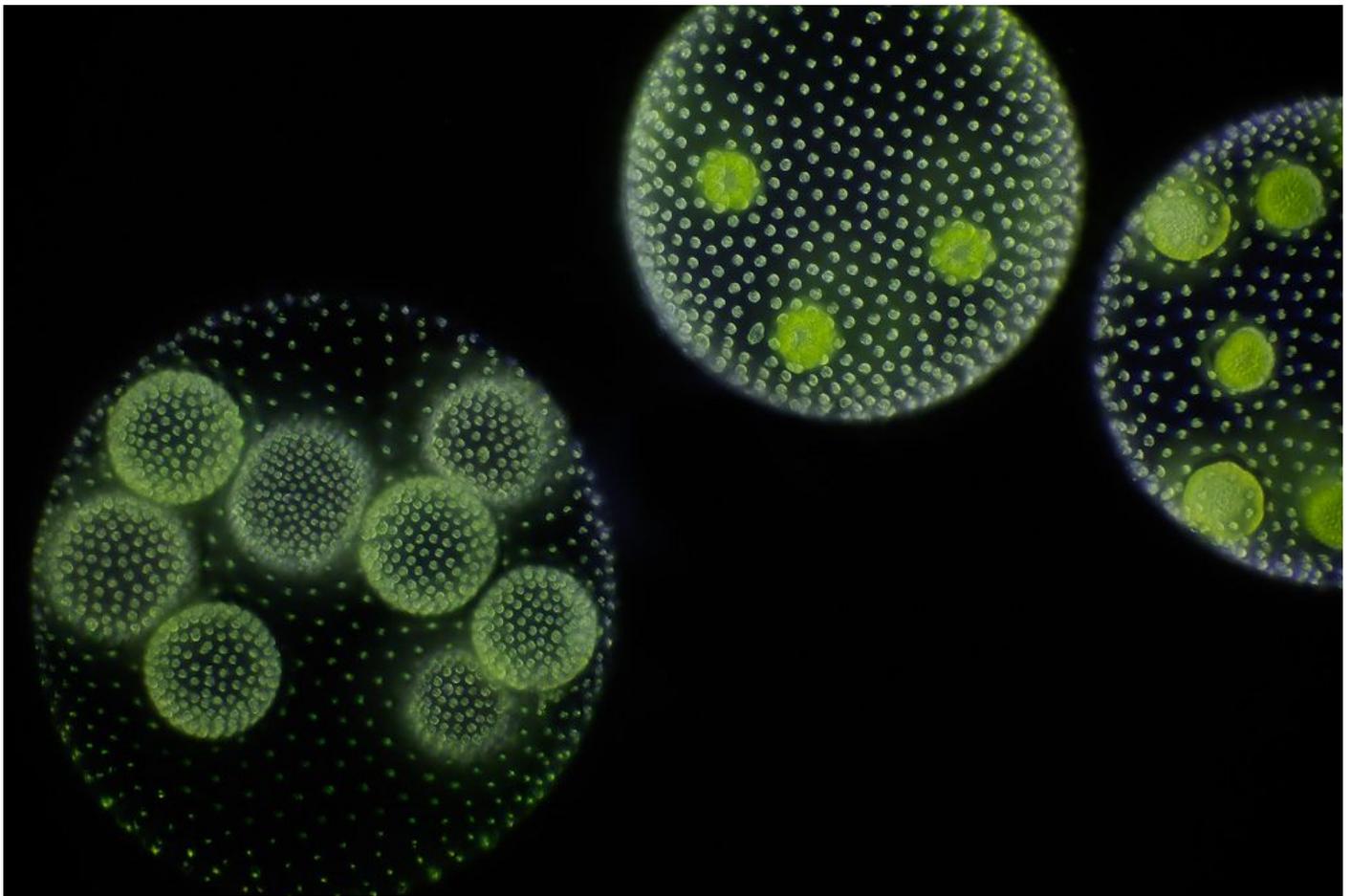
A complex cell

Source: "Mikrofoto.de-Blepharisma japonicum 15" by Frank Fox - <http://www.mikro-foto.de>. Licensed under CC BY-SA 3.0 de via Commons - [https://commons.wikimedia.org/wiki/File:Mikrofoto.de-Blepharisma\\_japonicum\\_15.jpg#/media/File:Mikrofoto.de-Blepharisma\\_japonicum\\_15.jpg](https://commons.wikimedia.org/wiki/File:Mikrofoto.de-Blepharisma_japonicum_15.jpg#/media/File:Mikrofoto.de-Blepharisma_japonicum_15.jpg)

# Cooperation and Communication - Multicellular Organisms

1500 Million years ago (1.5 Billion years ago)

In an important innovation, single cells live together in colonies and filaments, becoming the first multicellular organisms, and the ancestors of animals, plants and fungi.



Spherical colonies of green algae. Some colonies consist of up to 50,000 cells

Source: "Black-band ironstone (aka)" by André Karwath aka Aka - Own work. Licensed under CC BY-SA 2.5 via Wikimedia Commons - [https://commons.wikimedia.org/wiki/File:Black-band\\_ironstone\\_\(aka\).jpg#/media/File:Black-band\\_ironstone\\_\(aka\).jpg](https://commons.wikimedia.org/wiki/File:Black-band_ironstone_(aka).jpg#/media/File:Black-band_ironstone_(aka).jpg)

## Extreme Cold - Snowball Earth II

700 Million years ago

Extreme cold periods, or ice ages, occurred early in Earth's history. During these times, nicknamed "Snowball Earth" most of the planet was covered in ice, perhaps even the equatorial areas. These frigid conditions created challenging conditions for early life, but also created new opportunities as the planet later warmed.



During the "Snowball Earth" periods, the planet was almost completely covered with ice.

Source: "AntarcticaDomeCSnow" by Stephen Hudson - Own work. Licensed under CC BY 2.5 via Commons - <https://commons.wikimedia.org/wiki/File:AntarcticaDomeCSnow.jpg#/media/File:AntarcticaDomeCSnow.jpg>

## Animals Become Visible and More Complex

680 Million years ago

After the earth warms, new animals evolve in the oceans, perhaps due to still rising oxygen levels, and/or the beginnings of predation (animals eating animals). They are large and soft-bodied, meaning that they lack shells, teeth, and skeletons. Scientists do not agree on exactly what type of animals they are; they could be primitive sponges, jellyfish, or worms - or perhaps they are extinct groups that have no modern relatives.



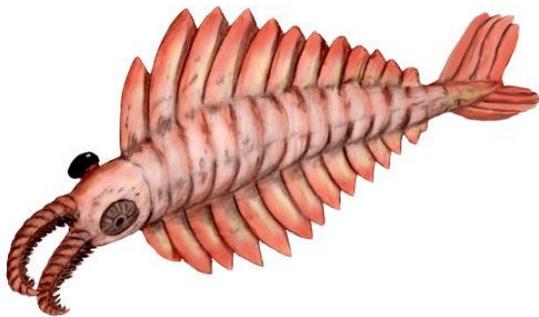
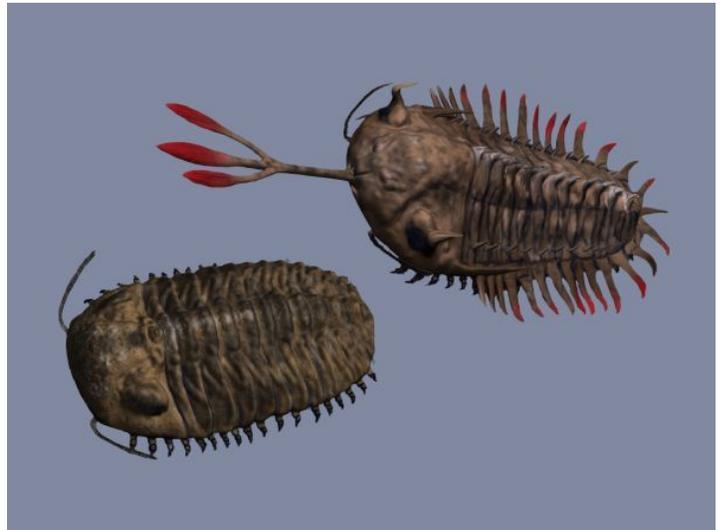
### An enigmatic early animal from the Edicaran fauna

Source: "DickinsoniaCostata" by Verisimilus at English Wikipedia. Licensed under CC BY 2.5 via Commons - <https://commons.wikimedia.org/wiki/File:DickinsoniaCostata.jpg#/media/File:DickinsoniaCostata.jpg>

# The Cambrian “Explosion”

540 Million years ago

The animal kingdom is divided into two groups, the invertebrates, which lack backbones, and the vertebrates, with backbones. In the Cambrian “explosion” a wide diversity of invertebrates suddenly appear. Some would seem very familiar to us, like the molluscs, while others are quite bizarre. Important innovations at this time include hard parts, such as shells and other outer coverings, which provide protection, and complex eyes, which help animals to be effective predators.



Cambrian animals: Opabinia, trilobite, Anomalocerus, mollusk

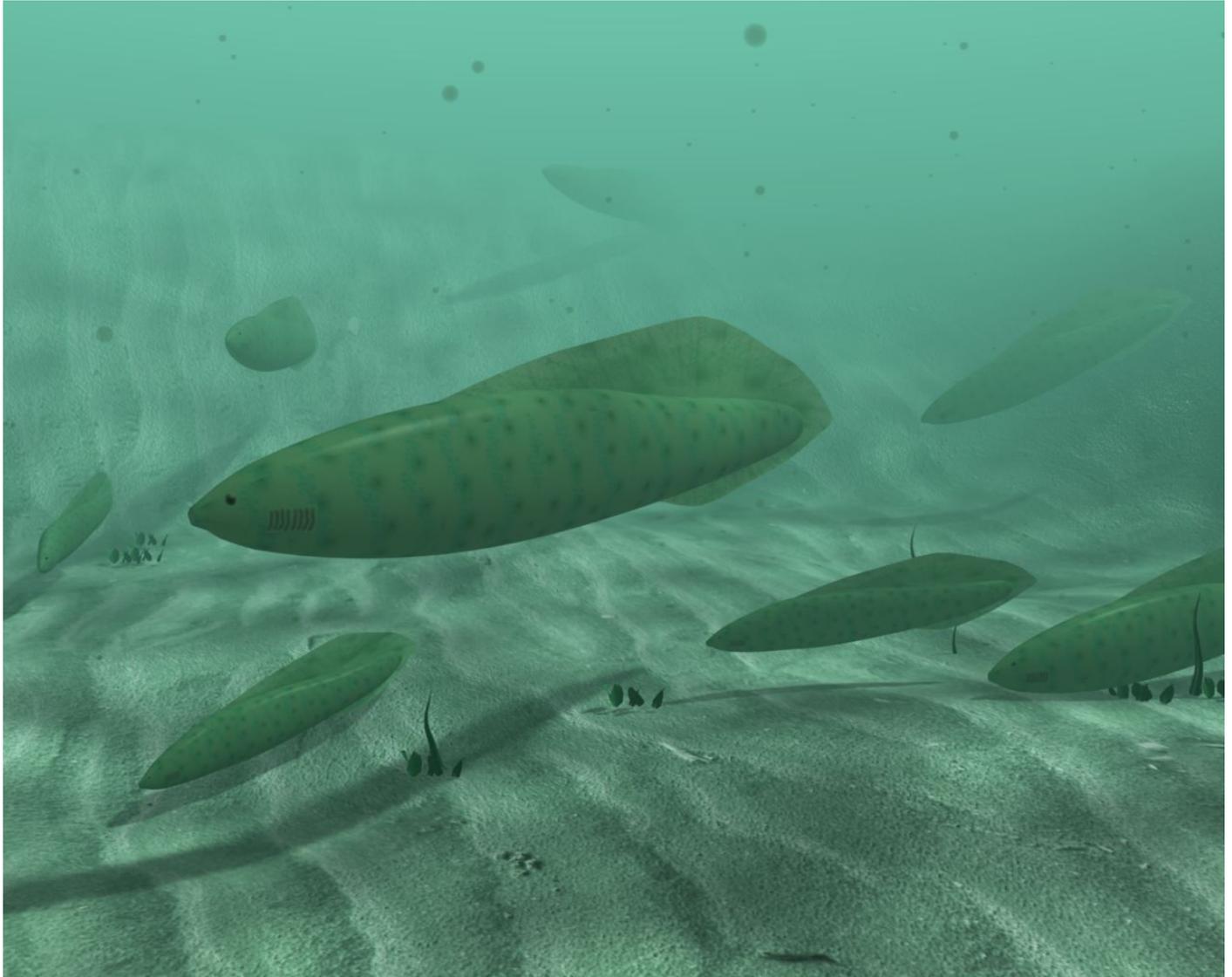
Source: "Opabinia BW2, "Phacops and Walliserops" Anomalocaris BW, Helcionellid NT" by Nobu Tamura (<http://spinops.blogspot.com>) - Own work.

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# The First Vertebrates

525 Million years ago

The first vertebrates to evolve were jawless fish. Today, vertebrates make up about 2% of all animal species - and include humans.



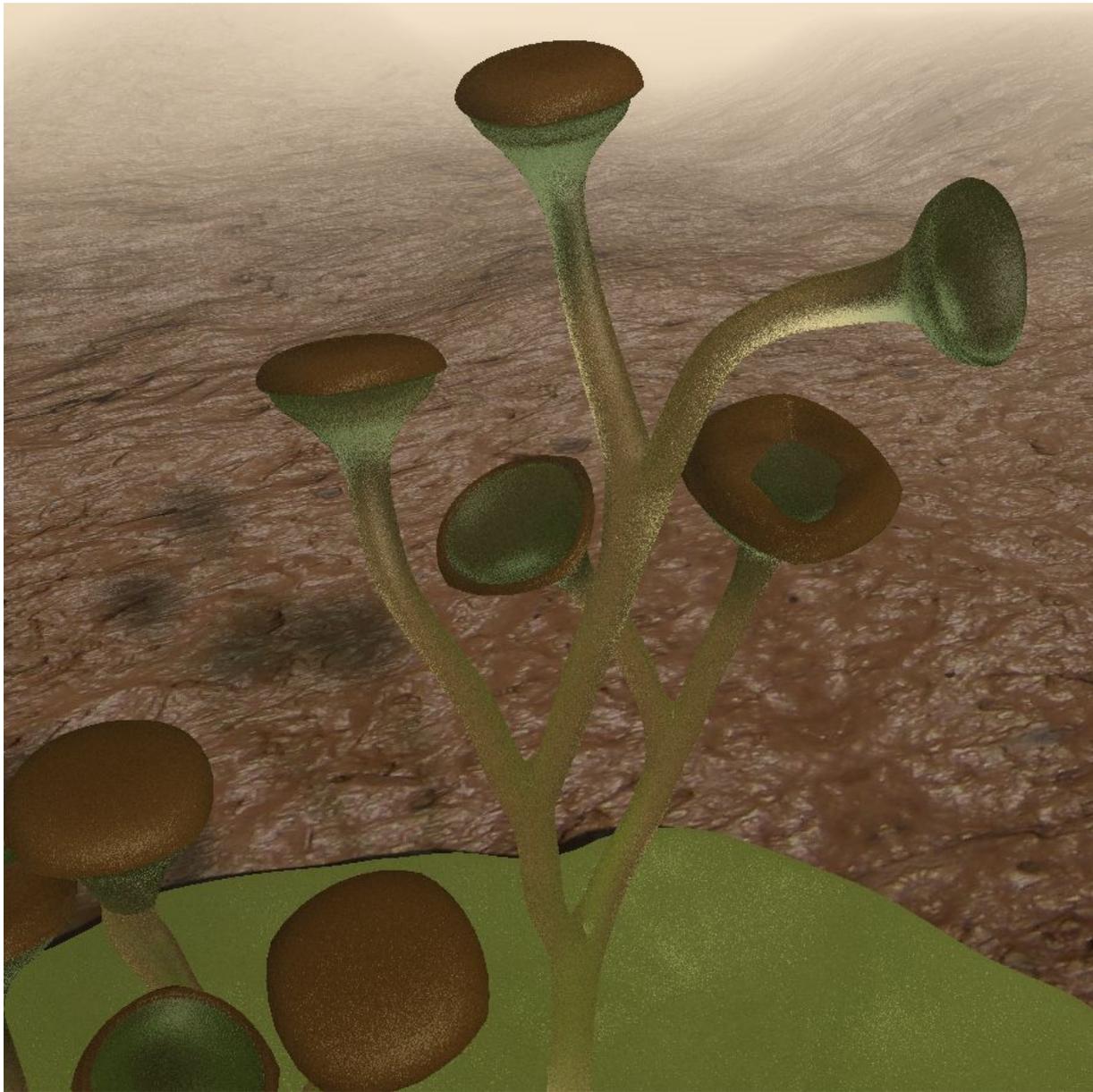
Our ancestor - an early jawless fish.

Source: "Haikouichthys 3d" by Talifero - Own work. Licensed under CC BY-SA 3.0 via Commons - [https://commons.wikimedia.org/wiki/File:Haikouichthys\\_3d.png#/media/File:Haikouichthys\\_3d.png](https://commons.wikimedia.org/wiki/File:Haikouichthys_3d.png#/media/File:Haikouichthys_3d.png)

## First Land Plants

450 Million years ago

Plants develop a “plumbing system,” which transports water and nutrients around their body. This innovation allows them to start moving further and further from the water’s edge and to start colonizing the land.



Early land plants. Source: "Cooksonia pertoni" by Smith609 Ground texture from Image:Mud closeup.jpg - Own work by uploader. Created with Blender.. Licensed under CC BY 3.0 via Commons - [https://commons.wikimedia.org/wiki/File:Cooksonia\\_pertoni.png#/media/File:Cooksonia\\_pertoni.png](https://commons.wikimedia.org/wiki/File:Cooksonia_pertoni.png#/media/File:Cooksonia_pertoni.png)

## Animals Move onto Land

380 Million years ago

Some fish develop leg-like fins and primitive lungs, helping them to survive in shallow water, but also allowing them to crawl on land.



Some fish propped themselves up on their fins - like this modern mudskipper - and moved onto land source: "Periophthalmodon schlosseri" by Bernhard Luth - Photo by Bernhard Luth, Gross a. Sihlsee. Licensed under CC BY-SA 2.0 de via Commons - [https://commons.wikimedia.org/wiki/File:Periophthalmodon\\_schlosseri.jpg#/media/File:Periophthalmodon\\_schlosseri.jpg](https://commons.wikimedia.org/wiki/File:Periophthalmodon_schlosseri.jpg#/media/File:Periophthalmodon_schlosseri.jpg)

# Great Forests and Winged Insects

362 Million years ago

Land plants develop better “plumbing systems” along with roots, leaves, seeds, and vast forests cover the land. They are populated by giant insects and amphibians (vertebrate animals which lay their eggs in water but live on land - like frogs and salamanders).

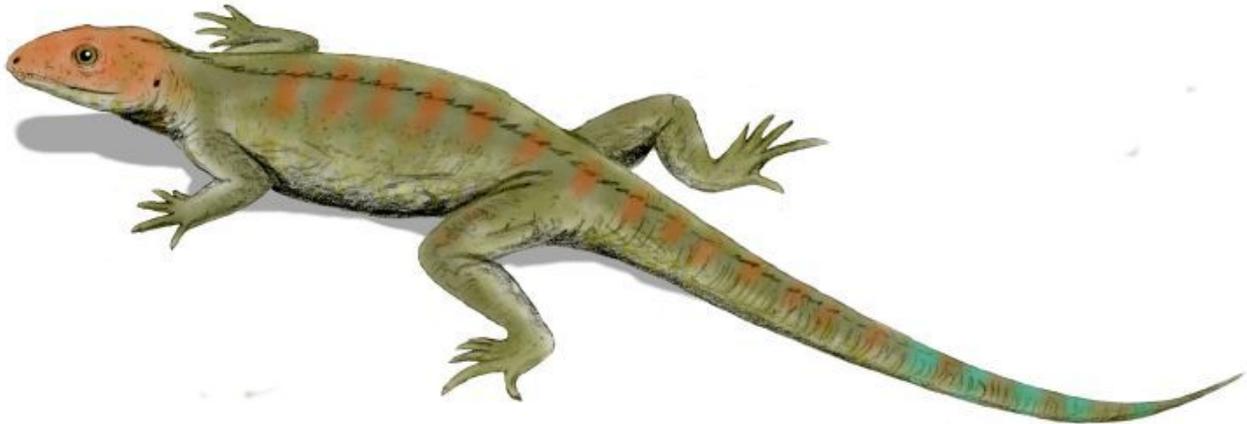


The first forests were dominated by ancient forms of plants called tree ferns - and may have looked like these modern Australian forests. Source: "Marriott Falls Vegetation" by JJ Harrison (jjharrison89@facebook.com) - Own work. Licensed under CC BY-SA 3.0 via Commons - [https://commons.wikimedia.org/wiki/File:Marriott\\_Falls\\_Vegetation.jpg#/media/File:Marriott\\_Falls\\_Vegetation.jpg](https://commons.wikimedia.org/wiki/File:Marriott_Falls_Vegetation.jpg#/media/File:Marriott_Falls_Vegetation.jpg)

## First Reptiles

300 Million years ago

A new group of vertebrate animals evolves from amphibians - the reptiles. Reptiles lay eggs with tough, protective shells, allowing them to live on land all the time - and thus to expand into new habitats. Reptiles are the ancestors of all land animals.



An early reptile. Source: "Hylonomus BW" by Nobu Tamura (<http://spinops.blogspot.com>) - Own work. Licensed under CC BY 2.5 via Commons - [https://commons.wikimedia.org/wiki/File:Hylonomus\\_BW.jpg#/media/File:Hylonomus\\_BW.jpg](https://commons.wikimedia.org/wiki/File:Hylonomus_BW.jpg#/media/File:Hylonomus_BW.jpg)

# Permian Mass Extinction

252 Million years ago

The “Great Permian Extinction” also known as the “Great Dying” was the most severe extinction event known to have occurred on Earth. Up to 96% of ocean organisms went extinct, along with 70% of amphibians and reptiles. Many insect groups also went extinct. Scientists are not sure of the reason for the extinction - it might have been because of an meteor impact, massive volcanic activity, or global warming caused by a change in ocean chemistry.



Many organisms of the early seas disappeared forever in the Permian extinction - including Trilobites Source: "Kainops invius lateral and ventral" by Moussa Direct Ltd. - Moussa Direct Ltd. image archive. Licensed under CC BY-SA 3.0 via Commons - [https://commons.wikimedia.org/wiki/File:Kainops\\_invius\\_lateral\\_and\\_ventral.JPG#/media/File:Kainops\\_invius\\_lateral\\_and\\_ventral.JPG](https://commons.wikimedia.org/wiki/File:Kainops_invius_lateral_and_ventral.JPG#/media/File:Kainops_invius_lateral_and_ventral.JPG)

# Age of the Dinosaurs

225 Million years ago

Dinosaurs evolved from small reptiles that walked on their back legs. While reptiles have legs that splay out to the sides of their body (like crocodiles), dinosaurs developed longer, more upright legs that were good for running and supporting heavy bodies. They diversified and became the dominant land vertebrates for over 150 million years!



**Tyrannosaurus Rex** Source:"Trexg" by Ryanz720 - Own work. Licensed under Public Domain via Wikimedia Commons - <https://commons.wikimedia.org/wiki/File:Trexg.jpg#/media/File:Trexg.jpg>

## First Bird

155 Million years ago

Dinosaurs probably developed feathers as a way to keep warm. A small group of dinosaurs learn to fly and evolve into birds.



Archaeopteryx, a bird-like dinosaur, and ancestor of modern birds. It was about the size of a raven.

Source:"Archaeopteryx NT" by NobuTamura <http://paleoexhibit.blogspot.com/> <http://spinops.blogspot.com/> - Own work. Licensed under CC BY-SA 3.0 via Commons - [https://commons.wikimedia.org/wiki/File:Archaeopteryx\\_NT.jpg#/media/File:Archaeopteryx\\_NT.jpg](https://commons.wikimedia.org/wiki/File:Archaeopteryx_NT.jpg#/media/File:Archaeopteryx_NT.jpg)

## Flowering Plants

100 Million years ago

Plants with fruits and flowers evolved, and became very numerous; there are over 250,000 species of flowering plants, compared to only 630 cone-bearing species (conifers).



Flowering plants provide the treat; insects and mammals disperse their seeds and pollen.

"Cirsium arvense with Bees Richard Bartz" by Richard Bartz, Munich aka Makro Freak - Own work. Licensed under CC BY-SA 2.5 via Commons - [https://commons.wikimedia.org/wiki/File:Cirsium\\_arvense\\_with\\_Bees\\_Richard\\_Bartz.jpg#/media/File:Cirsium\\_arvense\\_with\\_Bees\\_Richard\\_Bartz.jpg](https://commons.wikimedia.org/wiki/File:Cirsium_arvense_with_Bees_Richard_Bartz.jpg#/media/File:Cirsium_arvense_with_Bees_Richard_Bartz.jpg)

## K/T Mass Extinction

## 65 Million years ago

A large comet or asteroid struck the Gulf of Mexico, creating megatsunamis and sending up a cloud of dust that obscured the sun for a year. About 75% of all species went extinct, including all non-avian (bird) dinosaurs.



A massive bolide strikes the Mexican peninsula Source: "Impact event" by The original uploader was Fredrik at English Wikipedia - Transferred from en.wikipedia to Commons by Vojtech.dostal.. Licensed under Public Domain via Commons - [https://commons.wikimedia.org/wiki/File:Impact\\_event.jpg#/media/File:Impact\\_event.jpg](https://commons.wikimedia.org/wiki/File:Impact_event.jpg#/media/File:Impact_event.jpg)

## Rise of the Mammals

50 Million years ago

The first mammals appeared 225 million years ago. They were small, mostly nocturnal creatures. However, after the K/T mass extinction event, mammal size and diversity exploded as they moved into habitats formerly dominated by dinosaurs.



An early mammal eats a small dinosaur Source: "Repenomamus BW" by Nobu Tamura (<http://spinops.blogspot.com>) - Own work. Licensed under CC BY 3.0 via Commons - [https://commons.wikimedia.org/wiki/File:Repenomamus\\_BW.jpg#/media/File:Repenomamus\\_BW.jpg](https://commons.wikimedia.org/wiki/File:Repenomamus_BW.jpg#/media/File:Repenomamus_BW.jpg)

## Modern Man

0.25 Million years ago (250,000 years ago)

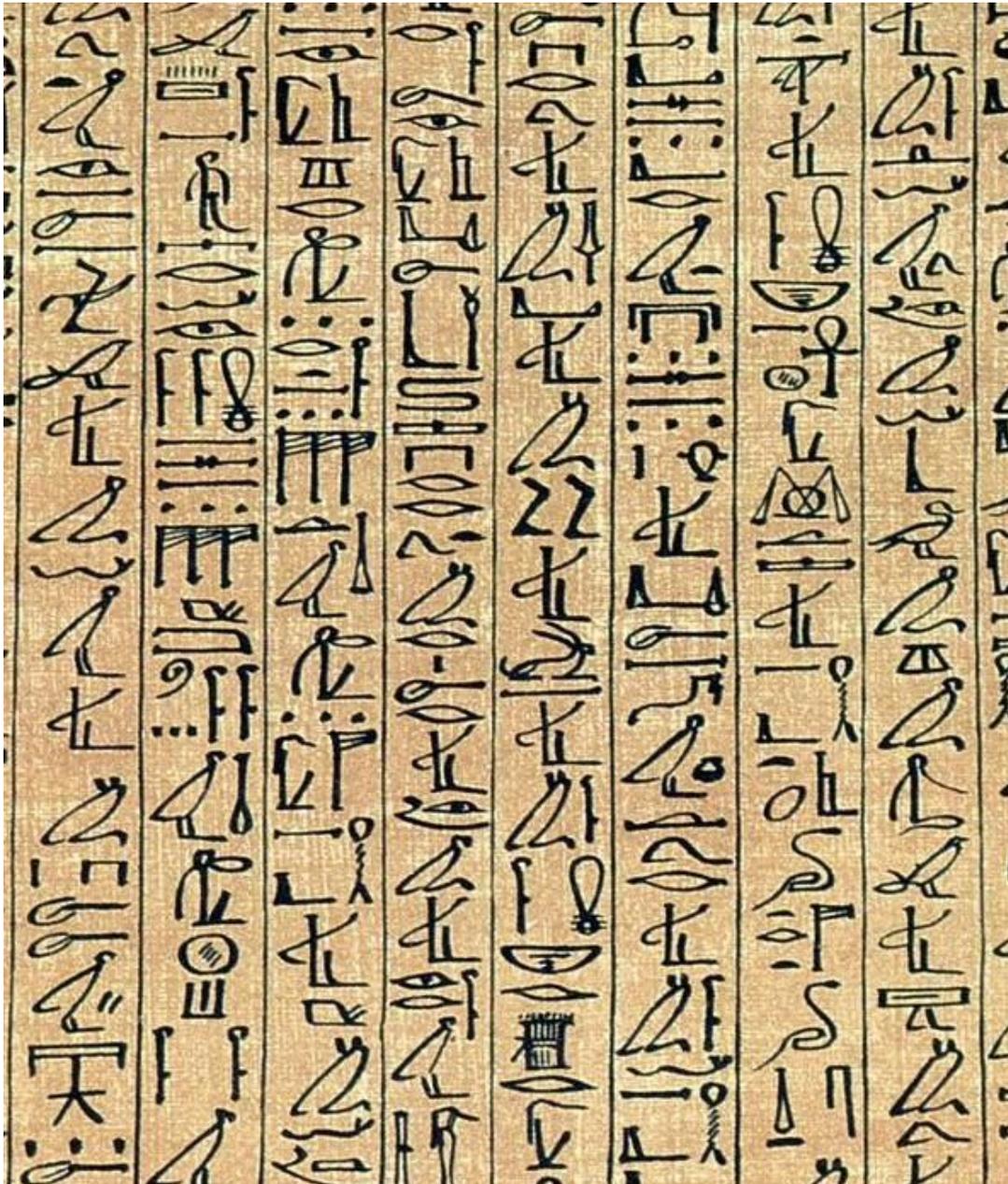


16,000 year old cave paintings from France Source:"Lascaux2" by Cro-Magnon peoples. Licensed under Public Domain via Commons - <https://commons.wikimedia.org/wiki/File:Lascaux2.jpg#/media/File:Lascaux2.jpg>

## Recorded History

0.005 Million years ago (5,000 years ago)

Before the advent of early writing systems, such as Egyptian hieroglyphics and Sumerian script, we must rely on archaeology and geology to decipher history.



Egyptian hieroglyphics Source:"Papyrus Ani curs hiero" by en:user:Flembles - Bridgeman Art Library v. Corel Corp.. Licensed under Public Domain via Commons - [https://commons.wikimedia.org/wiki/File:Papyrus\\_Ani\\_curs\\_hiero.jpg#/media/File:Papyrus\\_Ani\\_curs\\_hiero.jpg](https://commons.wikimedia.org/wiki/File:Papyrus_Ani_curs_hiero.jpg#/media/File:Papyrus_Ani_curs_hiero.jpg)