Earth Forms & Life Begins

Big Picture

Humans and other organisms did not suddenly appear on Earth; instead, they evolved from earlier organisms. The first life forms appeared about 4 billion years ago and were microscopic, single-celled organisms. Earth started out as a jumble of gases and inorganic materials that later reacted together and formed organic materials, which made way for prokaryotic cells and later eukaryotic cells to form. We know this by looking at the fossil record, and we measure the age of the fossil through absolute and relative dating

Key Terms

RNA World Hypothesis: RNA was the first genetic material to appear on earth.

Last Universal Common Ancestor (LUCA): A prokaryotic cell that paved the way for all life on Earth to form.

Oxygen Catastrophe: As some early cells began making their own food via photosynthesis, cells that could not tolerate living in an oxygen environment (because oxygen is a waste product of photosynthesis) died, but there were also cells that evolved to use the oxygen for things like cellular respiration.

Endosymbiosis: Formed when an organism lives within another organism.

Fossil: What's left of an organism after it has died, usually the bones or teeth. Even though the soft parts of the body often decompose soon after an animal's death, the hard parts of the body can leave an imprint on rock or dirt, which means that the imprinted rock can be found millions of years later, after everything else has decomposed.

Relative Dating: If the fossil is lower in the rock, then the fossil is older. This does not give an exact age to the fossil.

Absolute Dating: By understanding a half-life of carbon-14, scientists can measure the amount of carbon-14 left in an organism to figure out how old it is.

Half-Life: Time it takes for 50% of atoms to decay.

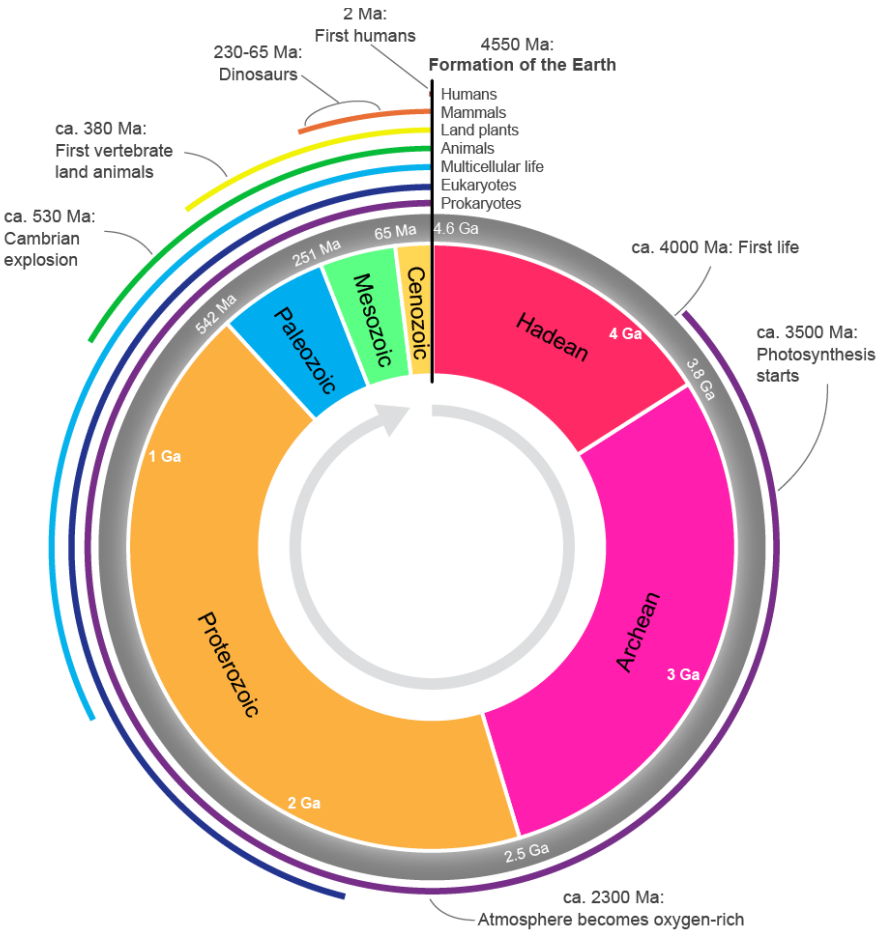
Timeline of Earth's History

Here is a figure depicting the history of the Earth, displaying each milestone.

- Earth formed about 4.6 billion years ago
- Life first appeared about 4 billion years ago

Notice how relatively recent humans' appearance onto Earth was, and how much time passed by before photosynthesis began on Earth.

Ma = million years ago
Ga = billion years ago



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Earth Forms & Life Begins cont.

Origin of Life

Living things are made up of organic molecules. The first organic molecules were thought to have formed from lightning passing through Earth's early atmosphere.

- In the Miller and Ulrich experiment, these two scientists took all the materials (inorganic chemicals) that they believed were in Earth's early atmosphere and passed sparks through the gases. They found that amino acids and other organic molecules were created, showing that inorganic chemicals can indeed form organic molecules.
- Since the exact composition of Earth's atmosphere is uncertain, we don't know the process that created the first organic molecules.

According to the **RNA world hypothesis**, RNA was the first organic molecule to evolve.

- RNA can act like DNA by forming proteins and can act like proteins by carrying out chemical reactions.

Of the different early cells and molecules, scientists think that all life today evolved from one cell called the **Last Universal Common Ancestor (LUCA)**.

- Would not have a nucleus or other membrane-bound organelles
- Probably existed about 3.5 billion years ago

About 2.5 billion years ago, the **oxygen catastrophe** took place.

- Oxygen produced from photosynthesis had been accumulating in the atmosphere. This accumulation of oxygen killed many early cells.
- The few cells that survived evolved in a way to use oxygen (via cellular respiration)

Eukaryotic cells probably evolved about 2 billion years ago by forming **endosymbioses** (plural of endosymbiosis).

- The theory is that a small cell was eaten by a large cell but was not entirely digested.
- These two cells lived together and benefited as a result.
- Because this arrangement was advantageous, this cell went on and eventually evolved to become the modern eukaryote with organelles.

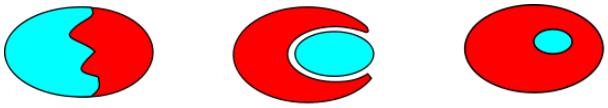

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Figure: This picture shows how two cells can come together, how the smaller cell becomes engulfed by the larger cell, and how both cells eventually become one cell with organelles.

Carbon Dating

Fossils are used to piece together the history of life on Earth. There are two ways to determine how old the fossil is:

- **Relative dating**: can determine the relative age if one fossil is older than another by looking at the fossil's position in the rock
- **Absolute dating:** can determine the age based on carbon dating

When an organism is alive, it has a certain percentage of carbon-14 atoms. Once the organism has died, the number of carbon-14 atoms decays over time.

We can determine how long ago the organism died if we know the **half-life** of carbon-14. The half-life of carbon-14 is about 5,730 years. Taking the fossil remains, we could figure how much carbon-14 is in the remains and compare that amount with how much carbon-14 is in a living organism.

We can then figure out how many half-lives the remains went through. When we have that information, we can multiply the number of half-lives with how many years are in a half-life to determine the approximate time of when the organism died.

Carbon dating is important to figuring out the age of the fossil. However, after a certain point, the amount of carbon-14 remaining is so small that it is undetectable, or not enough to predict how many half lives an organism has gone through. Therefore, carbon dating is only useful for dating back 60,000 years.

Notes