4.1

THE EARLY ATMOSPHERE

0:10–1:03

VIOLENT BEGINNINGS

When the Earth first formed, the Solar System was a violent place. Giant hunks of rock, metal and ice slammed into the Earth's surface. As material collided and fused, there is intense heat and pressure. Matter vaporized on impact leaving puddles of magma. Many of the collisions released water vapor and other gases, which gradually formed a blanket of steam around the early Earth.

This thickened over time becoming the first atmosphere. Some of the lighter gases like hydrogen leaked into space, but the denser steam collected and had a greenhouse effect insulating, heating and melting the surface of the planet.

Over time, the Earth, in a process called differentiation, separated into layers and it's crust cooled. Steam in the atmosphere collapsed and formed the oceans, covering much of the planet in chemical-rich waters.

1:03-1:38

OUR MOON

The young Earth settled down, but then something about the size of Mars is thought to have slammed into the planet, causing immense change. The two bodies coalesced and material was blasted outward. Debris from the impact formed a ring of matter that orbited the Earth and eventually became the moon. The surface of the Earth became molten again from the intense heat, and the oceans reformed a steamed atmosphere.

When things finally cooled down again, the Earth's crust hardened and steam settled back down to reform the oceans. The moon stabilized the Earth's tilt and helped to regulate climate.

1:38-2:39

EARLY CONDITIONS

This part of Earth's history is uncertain because there is no surviving sedimentary rock to offer clues about the environment. There may have been several large asteroid or comet impacts, but none as big as the one that formed the moon. Molten rock or magma oozed in some places and blasted out in others. Volcanic activity released heavier gases like carbon dioxide and methane. There were still very little oxygen in the atmosphere.

The oldest sedimentary rocks found in Greenland tell us a lot about the Earth at this time. There were oceans, lands, rivers, and beaches. Deep in the ocean, chemical-rich hydrothermal venting may have contributed to the first forms of life on Earth. These first

microbial organisms are thought to have eventually spread throughout the Earth's oceans. Some microbes consumed hydrogen gas and others produced methane as a waste product.

2:39–3:19

PHOTOSYNTHESIS BEGINS

Biology began to affect the atmosphere. By about 3.5 billion years ago, stromatolites—mounds made by microbes—populated the world's beaches. Some early microbes used the sun's energy for photosynthesis, but the first photosynthesizers didn't release oxygen.

However, by 2.8 billion years ago, life forms evolved that could use sunlight to split water molecules and release oxygen as a waste product. These were the cyanobacteria that still prosper in today's oceans. Most of the new oxygen combined with organic carbon to recreate carbon dioxide molecules, and some was used up another chemical reactions.

3:19–4:11

OXYGEN HOLOCAUST

But eventually, oxygen flooded the atmosphere and touched off a mass of ecological disaster from many of the anaerobic life forms that were poisoned by the abundance of oxygen. Other life forms adapted to thrive in the new conditions.

The rock record offers proof. Oxidized iron compounds are reddish and rust colored. In certain layers of sedimentary rock, they demonstrate the predominance of oxygen after 2.4 billion years ago.

At this time, oxygen formed the ozone layer about 20 to 30 kilometers above the ground, protecting life on the Earth's surface from the sun's harmful ultraviolet rays. The rise of oxygen was coupled with the reduction in greenhouse gases like methane and carbon dioxide, so the Earth retained less of the sun's heat, and the global climate became significantly colder.

4:11-4:43

SNOWBALL EARTH

There was mass glaciation and the Earth was encased in ice, often called a Snowball Earth. The icy shell reflected sunlight, making it colder and colder, but volcanoes punched through the ice and volcanic carbon dioxide gradually built up in the atmosphere. When the greenhouse effect became strong enough, the planet warmed and the ice melted.

Scientists think that there were three Snowball Earth cycles over a period of time from 2.4 to 2.2 billion years ago, and then a period of about one billion years in which the atmosphere and climate were fairly stable.

4:43-5:31

LIFE PERSISTS

More recently, the planet experienced other Snowball Earth events, but some life forms were able to survive the cold. The current eon, the Phanerozoic, brought a proliferation of plant and animal life. Vascular plants with tissues for conducting water and nutrients colonized the land about 400 million years ago and their photosynthesis caused oxygen levels in the atmosphere to rise.

By about 300 million years ago, extensive forest covered the Earth. They pushed the oxygen levels higher and enabled an even greater diversity of life. Biology, geology, astronomical events and periodic changes in the Earth's position in orbit influenced the climate, but overall, the atmosphere remained stable enough for life to persist.