Like a hungry teen, life on Earth had big growth spurts

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Twice in the Earth's history, living creatures underwent astonishing growth spurts, and each time, new organisms emerged that were a million times larger than anything that had existed before.

Scientists say that's the way life on our planet expanded from tiny single-celled microbes billions of years ago to the ponderous whales and lofty sequoia trees that are today's biggest living things.

Rather than a gradual increase in maximum body size, as scientists used to think, they now think that growth was a two-step process. The first spurt happened about 1.85 billion years ago, and the second about 580 million years ago, long before dinosaurs walked the Earth.

Scientists say the main driver of each growth step was a massive increase in the supply of oxygen, which is needed to convert food to the additional energy required for larger, more complex life forms.

"The two most rapid increases in maximum size correspond closely with the two primary episodes of increase in the concentration of atmospheric oxygen," Jonathan Payne, a paleobiologist at Stanford University, reported in the Proceedings of the National Academy of Sciences.

"Size rules life," John Bonner, a retired professor of evolutionary biology at Princeton University, wrote in his book, "Why Size Matters." "It is the supreme and universal determinant of what any organism can be and can do."

Larger creatures are better able to capture prey, fight or escape predators and survive hard times. On the other hand, they need more food and water, depend on their mothers longer and are slower to adapt to environmental changes than their smaller cousins are.

Based on fossil evidence, biologists think that life on Earth began in the ocean at least 3.5 billion years ago, a billion years after the birth of our planet. The earliest microbes didn't need oxygen, but fed by scavenging molecules of carbon, iron, sulfur and other minerals they found in the sea.

After a billion or more years, pioneer organisms known as cyanobacteria -- resembling today's pond scum -- learned how to capture energy from the sun through photosynthesis. A byproduct was oxygen.

"All of the oxygen in the atmosphere ultimately exists because of the evolution of cyanobacteria," Payne said. "There is no other process on the planet that can generate oxygen in sufficient quantities."

By analyzing traces of minerals in ancient rocks, scientists figured out a rough chronology for the surges in oxygen levels. They began to rise slowly about 2.35 billion years ago and reached a peak 1.85 billion years ago, according to Donald Canfield, a biologist at the University of Southern Denmark in Odense.

By that time, enough oxygen had accumulated to fuel Earth's first great growth spurt and change the way living creatures worked.

Some cells developed nuclei, separate pockets to hold their DNA and perform other useful functions. These advanced cells, called eukaryotes (pronounced "you-CAR-ree-oats"), allowed some organisms to grow as much as a million times larger than their ancestors that lacked nuclei.

"You need a eukaryotic cell to make that first size jump," Payne said.

Things continued pretty much the same for more than another billion years. Until about 600 million years ago, the world's population consisted of single-celled organisms swimming in water.

Then oxygen supplies began their second great leap, reaching a new peak some 20 million years later.

The causes of the second oxygenation event are poorly understood.

One theory, by David Johnston, an evolutionary biologist at Harvard University, is that a change in ocean chemistry allowed cyanobactria to proliferate and churn out more oxygen.

The chemical change may have been the result of a massive melt-off of glaciers at the end of one of the Earth's periodic ice ages 580 million years ago. The melting glaciers dumped nutrients into the ocean, making photosynthetic organisms more productive.

"Immediately after this ice age there is evidence for a huge increase in atmospheric oxygen to at least 15 percent of modern levels, and these sediments also contain evidence of the oldest large animal fossils," Guy Narbonne, a paleontologist at Queen's University in Kingston, Ontario, reported in *Science* magazine.

Fueled by more oxygen, eukaryotes took another enormously significant stride: They started to combine into larger organisms containing multiple cells, organs and tissues.

Narbonne, Canfield and colleagues found some ancient fossils of these multicelled creatures three years ago on the colorfully named Mistaken Point, on the rocky coast of Newfoundland. Narbonne called them "the earliest large and architecturally complex eukaryote fossils known anywhere in the world."

At first, these ancient animals were soft-bodied, like modern jellyfish. Around 542 million years ago, however, some animals developed shells and skeletons and grew larger.

This was the famous "Cambrian Explosion" of complex life forms, which led to today's species, the biggest of them another million times larger than their single-celled ancestors.

Fish, reptiles, birds, amphibians, plants, mammals and human beings were finally on their way, and the Earth's largest living thing, the sequoia tree, is 10 million billion times bigger than the first tiny microbe in the sea.
