Early Earth's Atmosphere

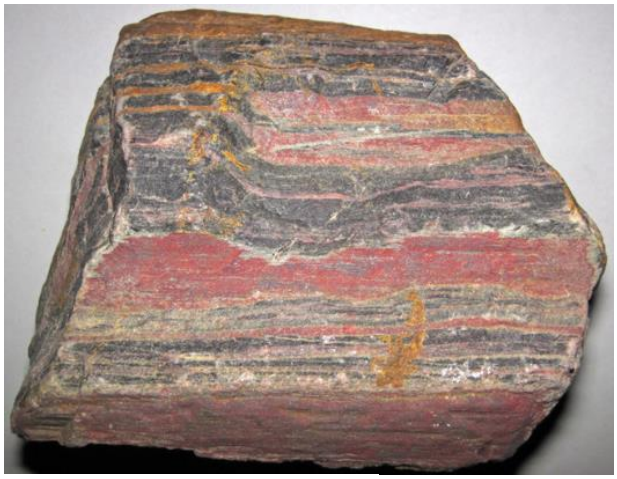
Artist's depiction of early Earth

What would our planet be like with no oxygen in the atmosphere? Life would be very different. In fact, there might not be any life at all!

It might surprise you to know that there was little to no oxygen in the atmosphere for billions of years of Earth's history. In fact, early Earth's atmosphere was very similar to that of Venus. First, it was likely mostly water vapor which condensed to form the world's oceans. Then the atmosphere was heavy and toxic, full of large amounts of carbon dioxide, nitrogen, and sulfur due to volcanic activity. What changed?

Clues in Earth's Rock Layers

To explain the change in atmosphere, we have to go back billions of years. Much of what we know about Earth's vast history comes from layers of rock. Large rock formations with alternating bands of silver to black iron oxides and shales, cherts and microbands of iron oxides have been found all over the world, including some discovered in Australia and Minnesota.



Banded-iron Formation

Besides being very distinct to look at, these banded-iron formations are also very old. Scientists have dated some of them all the way back to over 3.7 billion years ago! They believe that these rocks were formed in seawater when oxygen combined with dissolved iron in Earth's oceans.

Stromatolites are another distinctive kind of rock layer. They are formed by cyanobacteria. Cyanobacteria are the only type of bacteria that obtain energy through photosynthesis. In shallow water, these bacteria trap, bind, and cement sedimentary particles. Over time, layers of sediment build up to create formations. These stromatolites are considered some of the world's oldest fossils. They too occur throughout the world and have been found in the U.S. in Minnesota and Wisconsin. Scientists have dated the oldest of these formations to nearly 3.7 billion years ago.

Modern stromatolites in Shark Bay, Australia

Early Life and Photosynthesis

Early life on Earth dates to around 4 billion years ago. Simple and unicellular, these organisms took nutrients from rocks and water. Then cyanobacteria evolved and began absorbing first infrared and then visible light from sun radiation and giving off oxygen. Stromatolites are evidence of early photosynthesis!

Scientists think that life then began to have a major impact on the environment. By producing oxygen through photosynthesis, our atmosphere changed over time. Oxygen is a very reactive gas so as organisms first released it, it bonded with dissolved iron in the ocean. Banded-iron formations are evidence of that. Then by 2.7 billion years ago, there is evidence of oxygen nearing the breathable levels of today. Eventually, life diversified. With oxygen available, a greater variety of metabolic pathways evolved. Also, the oxygen in the atmosphere was acted on by sunlight to form a protective ozone layer. This protected potential life on land from the sun's harmful UV radiation. Around 475 million years ago, we have evidence of the first plants on land.

Take a deep breath and inhale. Now exhale. Give thanks to all photosynthesizing life: trees, grass, phytoplankton and more. Without photosynthesizing life, Earth would be a very different place.

Resources:

- *Timeline of Photosynthesis on Earth*
  https://www.scientificamerican.com/article/timeline-of-photosynthesis-on-earth/
- *Evolution of the Atmosphere: Composition, Structure and Energy*
  https://globalchange.umich.edu/globalchange1/current/lectures/Perry_Samson_lectures/evolution_atm/
- *How Phosphorus Helped Oxygenate Earth's Atmosphere*
  https://astrobiology.nasa.gov/news/how-phospohorus-helped-oxygenate-earths-atmosphere/