The Archaean Age

It is three thousand eight hundred millions of years ago. The earth has existed for nearly a billion years. Imagine we are inland, standing on the bare rocks that form the surface of the planet. There is no dirt or soil, because there are no organisms on land. There is very little sand or pebbles, because the temperatures rarely reach freezing around here, and without ice expanding as it forms, there is little to break these rocks up.

Over to the left, two streams join together to form a small river. The riverbed itself is covered with sand and pebbles, where the slow friction of water rubbing against rocks as it flows to the ocean has broken the volcanic stones into smaller and smaller pieces. If we follow the river, the crashing roar of the waves soon becomes audible. We are nearing the edge of this early continent. We are nearing one of the oceans.

Liquid water has been accumulating since the end of the Hadean Eon, raining and gathering and pooling into the oceans that cover much of the planet. Here, at the beach, the river merges with the ocean. Sand is plentiful here, made as waves rush forward and lift rocks up from the beach, only to smash them as the waves halt and recede. The air smells salty, but it lacks the bitter tang of iodine you would find on a modern beach. There aren't many organisms here to collect and concentrate nutrients like iodine. Nor is there a fishy smell, for there are no fish yet to be washed up rotting on the beach.

Not far from the shore is the dominant life-form on this early earth: stromatolites. Stroma is a reference to the layers these are made of, and lites comes from the greek lithos, meaning rock. Today, you can still find stromatolites, although only in relatively toxic environments where other organisms are unlikely to venture along and eat them. Stromatolites are large formations that look like boulders. They occur when a group of cyanobacteria settle and form a mat in shallow waters. The cyanobacteria are photosynthetic prokaryotes, and at this point in the Archaean Eon, they have evolved to live in colonies next to each other. As they divide and grow, they form a layer of cells that absorbs the sunlight that penetrates through the shallow waters. They have evolved the ability to secrete a thick mucus that helps them stick in place without being washed away by the waves. As the cells in a layer age and die, their daughter cells form a new layer on top of them. As time passes, each new generation of cells forms a new layer, until layers are stacked on top of each other to form a large boulder. Through most of the billion years of the Archaean Eon, the fossils of these stromatolites are the only evidence of life.

If you could look closely at these mats of cyanobacteria, you would see that they are using up carbon dioxide that is dissolved into the water, and they are releasing oxygen. As soon as the oxygen is released, it quickly reacts with iron dissolved in the water. The resulting iron oxide forms a solid that falls to the seafloor, forming thick layers of the mineral called hematite. If we were to jump to the present day, and start digging, we might be lucky enough to find those reddish rustlike layers in deeply buried rocks.

Eventually, all the iron in the oceans will get used up, and oxygen will begin to diffuse into the atmosphere. Until then, there will be no oxygen to breathe. This is just as well, because back then, the sun was not yet at it's fully glory. During the Archaean, the sun is only giving off maybe 80% of its full light and heat. The extra carbon dioxide in the atmosphere helps trap heat, keeping the planet fairly warm even though volcanic activity is beginning to subside and meteor impacts are far less frequent.

Once there is enough oxygen in the atmosphere, there will be a revolution in life on this planet. You see, in order to release the energy locked in glucose sugars, it is necessary to break the sugar apart. This can be done without oxygen in a process called fermentation. Sadly, fermentation isn't very efficient, and it doesn't release much energy. If oxygen is present, then it is possible for an organism's metabolism to use *respiration* instead of fermentation. In respiration, oxygen is used, and the process of breaking sugars down can release roughly four times as much energy as in fermentation!

Once respiration became possible, there was enough energy available to allow cells to grow much larger. The first step was the creation of eukaryotic cells. Eukaryotes were cells that grew hundreds of times larger than their prokaryote ancestors. With such large cells, there was a selective advantage in having compartments inside the cell where specific reactions could take place. This was the birth of organelles. At some point, some prokaryotes moved inside the new, larger cells, presumably because the environment inside was safer and more stable. This is probably where chloroplasts came from, as well as mitochondria. One of the reasons we believe this is because these organelles act like tiny cells inside our cells. They even have their own DNA, and replicate on their own schedule!

The discovery of the first eukaryote fossils marks the beginning of the next Eon in earth's history. We have entered the Proterozoic.