ANAEROBIC

by Frank Deis

The word anaerobic literally means "without air" but it is used to mean "without oxygen." In Biochemistry, there are many different anaerobic processes – some that simply don't require oxygen, and others that are harmed by oxygen. Why are anaerobic pathways so common? In fact, most single-celled organisms are anaerobic, meaning they can live without oxygen. Why is this?

The answer is a little surprising the first time you hear it. The Earth is about 4.5 billion years old. For the first half of its history, the entire planet was an anaerobic environment. There are microfossils and other evidence that life existed on earth at least 3.8 billion years ago. It appears that oxygen entered the atmosphere as a permanent major constituent roughly 2.5 billion years ago. So for about a billion years, single celled life forms lived and reproduced in the absence of oxygen. The best evidence that all of this is true comes from geology. In layers that are about 2.5 billion years old, we find deposits of banded iron. These sediments appeared because of a chemical reaction. Oxygen, produced by photosynthesis, turned the water-soluble ferrous chloride salts of the world's oceans into insoluble ferric oxides (rust). The process has been called "the rusting of the Earth."

So it turns out that many living micro-organisms may be survivors (or "fossils") of the time of no oxygen. And furthermore, we are all descendants of anaerobes. So it's not too surprising that human cells metabolize glucose using an anaerobic pathway, "Glycolysis," which turns out to be essentially universal, found in every living cell on the Earth. When you work your muscles hard, they secrete lactic acid into the bloodstream. Bacteria generally do the same thing when they digest glucose.

Not all single celled organisms are bacteria. There are the "archaea" which live in extreme environments – hot, cold, salty, acidic. And there are eukaryotic cells. These are like our cells, with a nucleus and various complicated compartments inside, but they are still single-celled. The group includes the protozoans (amoebas, paramecia, etc.), some kinds of algae, some disease organisms (malaria, elephantiasis), and yeast. When thinking about Biochemistry, it's important to remember that yeast and other fungi are fairly close to us genetically.

Yeast fermentation of glucose includes the Glycolysis pathway, but has a couple of differences. All forms of Glycolysis convert Glucose (6 carbons) into Pyruvate (3 carbons). Yeast then break off one carbon as CO_2 (carbon dioxide) and excrete the other 2 carbons as alcohol (ethanol). Ethanol provides the sweet smell of rising bread, and also the alcohol found in wines and spirits. Recent research seems to indicate that this fermentation is younger than one would imagine. Glucose became much more available with the development of flowering plants and sweet fruits in the Cretaceous, 80 million years ago, when dinosaurs walked the Earth. Genome studies imply that this is when yeast "learned" the trick of fermentation to alcohol.