A chapter from Dr. C. Senan's book
Pages 35 & 36

BLOOD

Life's most wondrous transportation system

A sanguine journey examining the complexities of this magical, crimson fluid in all its florid glory

First published in November 2011 by
Literati Publishing, North Wales, United Kingdom
http://www.literatipublishing.com
Enquiries: mail@literatipublishing.com

ISBN: 978-0-9569281-2-2

RESPIRATION IS RUSTING

One of the most important and common reactions in the world, the burning of iron (a.k.a. rusting) is akin to respiration because the latter begins with a single step that corresponds to the combustion of iron. In that step, the iron atoms in the hemoglobin molecules of the red blood cells combine with atmospheric oxygen. It is therefore not surprising that blood is rust-coloured because respiration is a kind of rusting.[1]

Rust is iron oxide, Fe_20_3, an extremely common compound because iron combines very readily with oxygen – to the extent that pure iron is only rarely found in nature.[2] The process of rusting can be defined as the electrochemical corrosion of iron (or steel) caused by the flow of an electric current between different parts of the metal serving as anodes and cathodes of a cell. Rusting, however, requires both water and oxygen to occur and is accelerated in the presence of acids and other electrolytes.[3] It is thus not unreasonable to enquire why the iron in our blood (which contains both oxygen and water) does not rust. Michael Onken's extremely plausible and lucid explanation which I relate below is hard to beat.

The iron in blood transports oxygen from the lungs to the tissues by virtue of each iron atom being linked to a bulky, multi-ringed molecule, giving rise to heme – the deep red, non-protein, ferrous component of hemoglobin which has the formula $C_{34}H_{32}FeN_4O_4$. Each heme is attached to a subunit of the respiratory pigment, hemoglobin, itself a protein. As there are four of these subunits for every hemoglobin, each entire hemoglobin molecule comprises the same number of bound iron atoms, enabling it to carry four oxygen molecules.

To be able to bind the heme ring and still have electrons left over for latching onto oxygen, the iron atoms must be oxidised to the ferrous state, Fe(II). In other words, the iron prevalent in our blood is not in the metallic state. Instead, it is iron that has already been 'rusted' or oxidised prior to encountering oxygen. As it latches onto oxygen in the lungs, the ferrous iron atom bequeaths an electron, and in the process transforms into the ferric state, Fe(III) i.e. as oxygen attaches to hemoglobin, the

already oxidised iron contained in the respiratory pigment is further oxidised or 'rusted.'

The images below show rusting of a 5ft. tall sculpture, 'Heart of Steel (Hemoglobin)' – 2005 created by Julian Voss-Andreae

At installation **10 days later** **After several months exposure**

As blood permeates the tissues, hemoglobin discharges its oxygen into the blood, thereby sustaining the tissues. With oxygen being surrendered from the ferric iron atoms, the latter now extract their donated electron, becoming ferrous atoms once again. Thus, the iron atoms alternate between being more rusty when linked to oxygen and less so when not. However, oxygen is not unique in being able to change iron from the ferrous to the ferric state in blood as other oxidants (oxidising agents) can do so too. Several blood toxins (cyanide included) operate by oxidising hemoglobin when oxygen levels are depleted. The ensuing ferric iron-harbouring, unoxygenated hemoglobin is known as methemoglobin. As the latter cannot latch onto oxygen, increasing blood methemoglobin levels result in decreasing amounts of oxygen being transported to the tissues – resembling blood asphyxiation.[4]

For those of us who like this sort of information, there is enough iron in the average human body to produce a 3 inch nail! Our remarkable body also has sufficient sulphur to eliminate all the fleas living on the average dog; adequate fat reserves to make 7 soap bars; bountiful carbon deposits that can yield 900 pencils; plentiful phosphorous stores for the manufacture of 2,200 match heads; water levels sufficient to fill a ten-gallon tank and enough potassium to fire a toy cannon! How's that for self-sufficiency![5]

Text: See text references
Image:
Sculpture 'Heart of Steel' (Hemoglobin) – Permission to use under a Creative Commons License – See image credits for details

Julian Voss-Andreae's image is also referenced at the back of Dr. C. Senan's book in the 'Image Credits' section as follows:

Respiration Is Rusting

Sculpture 'Heart of Steel' (Hemoglobin): courtesy of user Brainmachine: http://en.wikipedia.org/wiki/File:Heart_of_Steel_(Hemoglobin).jpg. Permission to use under the Creative Commons Attribution-Share Alike 3.0 Unported license. Photographer: Julian Voss-Andreae.