TA13 - Metalloproteins

Metalloprotein is a term for a protein that contains a metal ion cofactor; usually coordinated by nitrogen, oxygen, or sulfur. These make up a large proportion of proteins, including hemoglobin and cytochrome. Globular metalloproteins in particular are incredibly important in the catalysis of most complex processes.

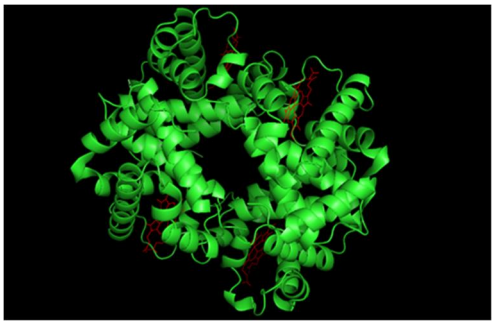
Irving-Williams Series

Some metals have a greater affinity to bind to proteins than others, thus form stronger complexes. The Irving-Williams series is a ranking of divalent metal in terms of preference to bind.

Descending Order of Preference
Copper
Zinc
Nickel
Cobalt
Iron
Manganese
Calcium
Magnesium

Hemoglobin and Hemocyanin

Hemoglobin is responsible for transporting oxygen around the body in red blood cells. With iron at its centre, the heme group is red in colour when bound to oxygen, and blue-red when unbound to oxygen. Since each hemoglobin has 4 heme groups, with each able to reversibly bind with 1 oxygen molecule, 4 oxygen molecules can be carried at one time. Once one oxygen molecule is bound, it facilitates the binding of more oxygen.



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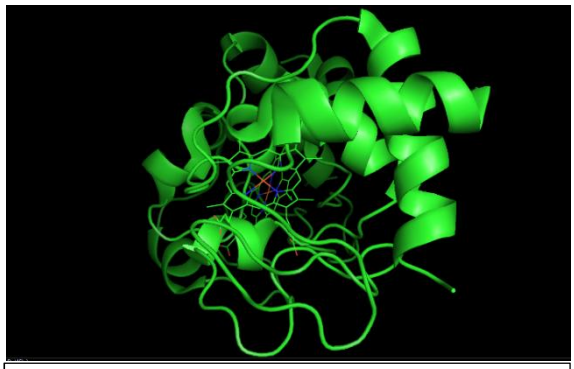
Hemocyanin is hemoglobin's equivalent in invertebrates; unlike hemoglobin, hemocyanin is not bound to blood cells but is suspended in the hemolymph. Each hemocyanin contains two atoms of copper, where 1 oxygen molecule binds, producing a colour change from the colourless Cu (I) to the blue Cu (II). Hemocyanin from the giant keyhole limpet is used in medicine and research as a vaccine carrier protein.

Produced by Alex Greer at Newcastle University as part of a Nuffield Research Placement.

Cytochrome C

Like hemoglobin, cytochrome C is also hemoprotein (a protein with a prosthetic heme group). It contains the group heme c, which allows the protein to carry out many functions, particularly in facilitating oxidation and reduction. Its ability to have different reduction potentials, determines the kinetics and thermodynamics of an electron transfer reaction.



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Metalloenzymes

In a bioinformatics survey of 1,371 different enzymes, 47% required metals with 41% containing metallic catalytic centres. Metals often form the basis of an enzyme's binding site and facilitate the formation of the enzyme-substrate complexes. Within metalloenzymes, magnesium is the most common metal, although is usually not involved with catalysis but to form a complex with substrates such as ATP.

References

Andreini, C. et al., 2008. Metal ions in biological catalysis: from enzyme databases. *Journal of Biological Inorganic Chemistry* .

Copper Development Association, 2017. *Copper for Life: Haemocyanin.* [Online]
Available at: http://copperalliance.org.uk/education-and-careers/education-resources/copper-for-life-haemocyanin
[Accessed 3 August 2017].

Lu, Y., Yeung, N., Sieracki, N. & Marshall, N. M., 2009. *Design of Functional Metalloproteins.* [Online]
Available at: http://www.nature.com/nature/journal/v460/n7257/full/nature08304.html
[Accessed 3 August 2017].

McDowall, J., n.d. *Haemoglobin.* [Online]
Available at: https://www.ebi.ac.uk/interpro/potm/2005_10/Page1.htm
[Accessed 3 August 2017].

Nature, 2009. *Metalloproteins.* [Online]
Available at: http://www.nature.com/nature/supplements/insights/metalloproteins/index.html?foxtrotcallback=true
[Accessed 3 August 2017].

Waldron, K. J., Rutherford, J. C., Ford, D. & Robinson, N. J., 2009. *Metalloproteins and metal sensing.* [Online]

Available at: http://www.nature.com/nature/journal/v460/n7257/pdf/nature08300.pdf [Accessed 3 August 2017].