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CooA: A CO Sensing Protein

We chose the CooA carbon monoxide sensing protein. We thought this choice would be the most interesting since we had all heard of GFP, but none of us had heard of CooA. Also, we know that CO has drastic consequences for the body, as the binding of heme to CO is orders of magnitude stronger than the binding of heme to oxygen due to pi-backbonding. We were especially interested in this protein because we thought that a potential application of a CO sensing protein might eventually be in producing better carbon monoxide detectors to protect people from CO leaks. Also, from the researched metallo-proteins, CooA is the first known to have a biological role in CO recognition.[1]

In the case of CooA, the binding of CO changes the conformation from a state that does not bind DNA to a state that does.[1] The protein has two heme ligands, each of which interacts with a histidine and a proline of the two peptide chains. One of these heme sites is shown in Fig. 1 with coordinates loaded from the appropriate pdb file.[2] When CO is present, the CO displaces one of these amino acids to complex the heme iron. With the present 2.6 Å resolution, one cannot definitively claim which of these amino acids is displaced for the CO coordination to occur.[1] In one scenario, the shape change could displace the Pro ligand; however, movement of the heme would allow the Pro to remain complexed while the His was instead displaced. Future models will hopefully be able address this uncertainty.[1]

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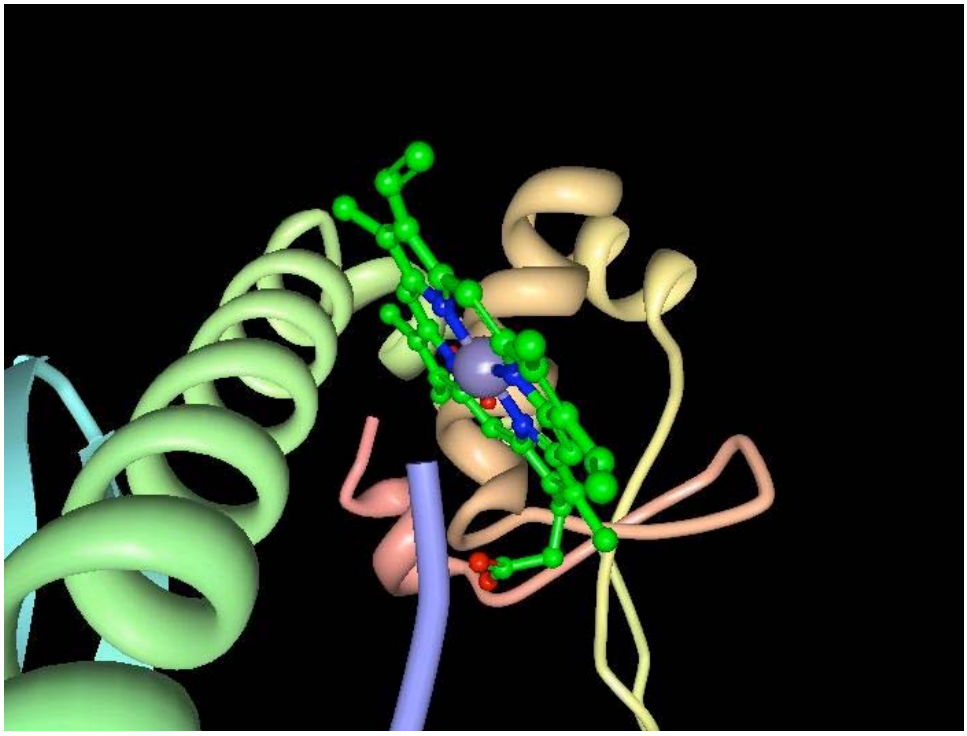

Fig. 1 CooA Active Site: Fe complexation with Pro and His ligands. The Fe is bound to its ligands in an octahedral geometry, making all bond angles 90º. The Pro nitrogen to Fe distance is 2.123 Å and the His nitrogen to Fe distance is 2.136 Å. The four binding sites between the heme nitrogen atoms and the central Fe are each 1.991 Å.

Ball-and-stick, stick, and space-filling models of the active site of CooA prior to and after ligand displacement by CO are presented in Fig. 2 and the original data was loaded from a pdb file.[2] As might be anticipated, red atoms symbolize oxygen, blue nitrogen, grey carbon, and brown iron(II). The first row of Fig. 2 symbolizes the heme-ligand complex prior to ligand displacement by CO. In addition to the four nitrogen atoms in the heme molecule, the iron cation complexes with a nitrogen atom from the histidine and a nitrogen atom from the proline. The second row of Fig. 2 symbolizes the heme-ligand complex after CO displaces the Pro ligand.[1] CO complexes through its carbon atom, as the carbon atom bears a partial negative charge.

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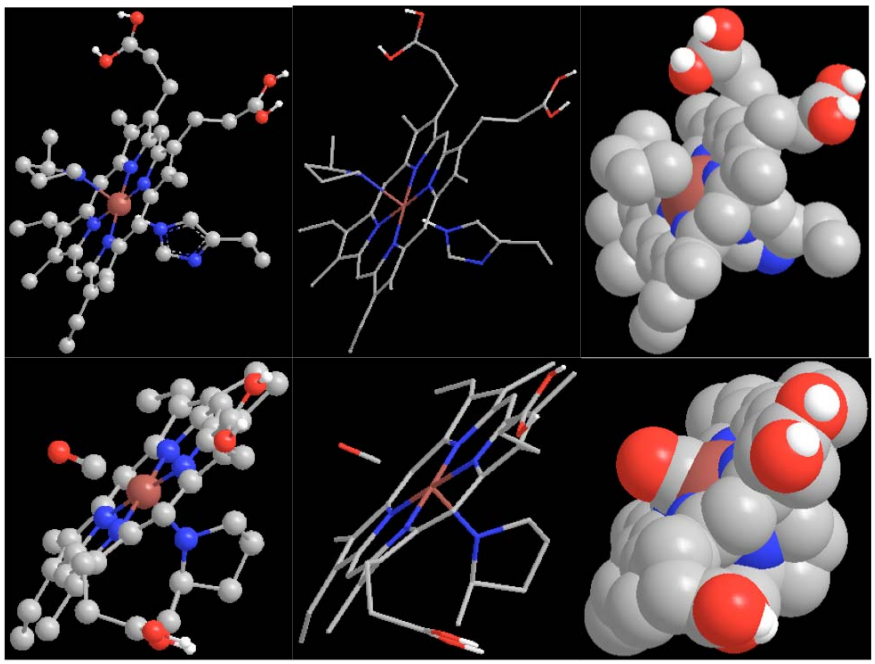

Fig. 2 Heme-Ligand Interactions in CooA: ***a***, Ball-and-stick model of the active site of CooA. ***b***, Stick model of the active site of CooA. ***c***, Space-filling model of the active site of CooA. The length of the bond between the Pro N atom and Fe cation is 2.123 Å. The His N-Fe cation bond length is 2.136 Å. The heme N-Fe cation bond length is 1.991 Å. The length of the bond between the CO C atom and Fe cation is approximately 1.8 Å. The Fe cation forms an octahedral complex with its ligands. The four N atoms in heme comprise the equatorial plane. Relative to the Fe cation, adjacent heme N atoms are 90° from one another. The N atoms in the Pro and His as well as the carbon atom in CO are oriented perpendicularly to the equatorial plane.

References

(1) Lanzilotta, W. N.; Schuller, D. J.; Thorsteinsson, M.V.; Kerby, R. L.; Roberts, G. P.; Poulos, T. L. Structure of the CO sensing transcription activator CooA. *Nature Structural Biology* **2000**, *7*, 876-880.

(2) Protein Data Bank. http://www.pdb.org/pdb/explore/explore.do?structureId=1FT9 (accessed March 19, 2011).