

Supplementary Problem Set: Myoglobin and Hemoglobin

Reminder: Work assigned problems in Chapter 7

1. Where is myoglobin found and what is its biological function? Answer the same question for hemoglobin.
2. Derive the equation for the proportion of myoglobin that is bound to oxygen (**1**) using the notation MbO_2 and Mb . Substitute for Mb in terms of MbO_2 and show the alternative form of the equation with the notation $[O_2]$ and P_{50} .
3. Repeat #2 for hemoglobin.
4. Choose one equation from #2 or #3 and show the derivation for the Hill equation. Indicate what form this equation has (linear, hyperbolic, sigmoidal) and sketch the Hill plot for the equation you choose labeling the axes properly.
5. What is the numerical value for n in the equation for **1** for myoglobin and how is this value determined from the Hill plot? What does this value of n represent for myoglobin?
6. At low pO_2 and at high pO_2 , the value of n in the Hill equation is 1.0, but at intermediate values of pO_2 , the value is ~ 3.0 . What property of hemoglobin accounts for the change in n going from low pO_2 to intermediate pO_2 to high pO_2 ?
7. How does the two state model for binding of O_2 to hemoglobin explain the sigmoidal dependence of the binding of O_2 to this protein?
8. Describe the changes that happen to the following groups or interactions in hemoglobin when oxygen binds to deoxyhemoglobin.
 - a. Salt bridge between groups on the H and F-helices: $H\text{-asp-CO}_2 \cdots \cdots \cdots \text{HN} \langle \text{his-F}$
 - b. Position of the F-helix with respect to the heme plane
 - b. Proximal histidine with respect to the heme plane
 - c. Position of Fe^{2+} with respect to the heme plane
 - d. Number of salt bridges in the $\alpha_1\beta_2$ and $\alpha_2\beta_1$ interfaces
 - e. Binding of BPG in a cavity formed by positively charged groups on the β_1 and β_2 chains.
9. Explain why the changes you listed in 8a occur at the salt bridge between groups on the H and F-helices upon the binding of O_2 to deoxyhemoglobin.
10. Describe the Bohr effect and how it is important for the function of hemoglobin. Explain why myoglobin does not exhibit a Bohr effect.
11. What is the function of 2,3-bisphosphoglycerate (BPG)? Why do red blood cells have large amounts of BPG?
12. Why are myoglobin and hemoglobin highly colored red?
13. Describe why the genetic change of a glu (Hb-A) for a val (Hb-S) results in the condition called "sickle cell anemia".