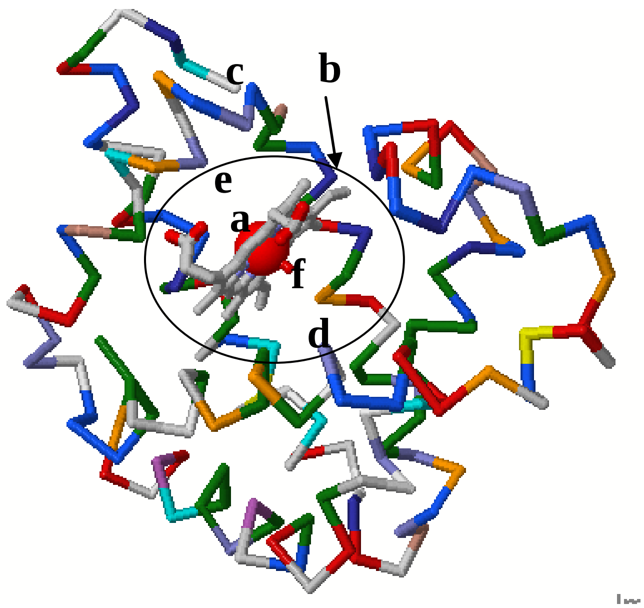
NAME: ________________________ANSWERS____________________

Quiz 2 October 7, 2009

1. Shown below is the backbone of the protein myoglobin. **The positions of the alpha carbons of the two histidines that are important in iron binding are shown with an asterisk, though the side groups are not drawn in**. (6 points)

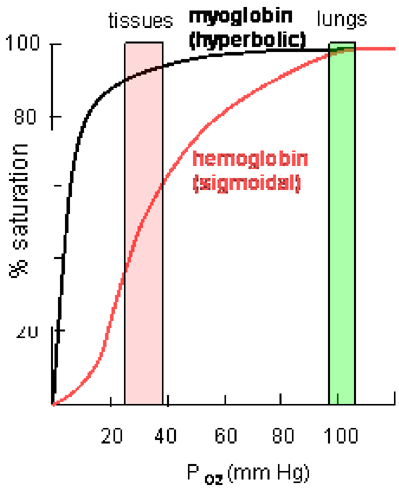
   Identify the following landmarks in this image by writing very small letters a-f on the image:
   a) the iron atom
   b) the heme group
   c) the white gly carboxy terminus
   d) the distal His (keeps O_2 bent)
   e) the proximal His (ligates metal)
   f) the oxygen ligand (it's TEENY)



2. First give a definition, and then identify the forces (i.e. covalent, H-bonds, disulfide, van der Waals, salt bridges) and magnitude (weakest, weak, strong) that stabilize primary, secondary, tertiary, and quaternary structures? (20 points)

Structure Level for MYOGLOBIN	Definition (2 pts each)	Forces (2 pts ea)	Magnitude (1 pt ea)
Primary:	The sequence of amino acids N to C terminal bound together by peptide bonds.	covalent	strong
Secondary	The individual shapes such as α helix and β strands that a stretch of amino acids can adopt.	H bonds	weak
Tertiary	The manner in which individual shapes (helices, sheets) pack up against one another.	Van der waals, H bonds, some covalent disulfide	Weakest, weak, and strong
Quaternary	Interactions made between subunits in a multi-subunit protein.	Why none? There are no subunits in Mb.	Weak to strong

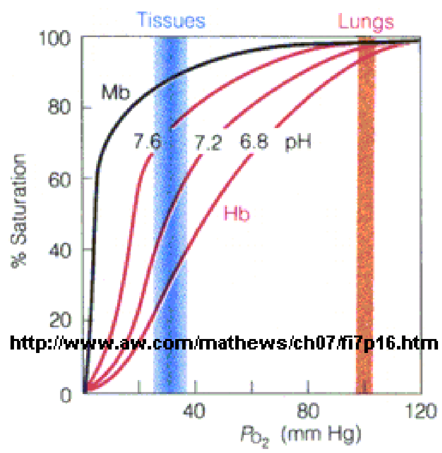
3. Binding Curves for Myoglobin and Hemoglobin (16 points)



a. Explain the directionality of the transport of O_2 in the tissues at normal blood/lymph pH of 7.4 using the graph at left. (Hint: your answer should begin with the phrase….As you can see from the graph..) 4 pts

As you can see from the graph, at P_{O2} of 25-40 mm Hg, the Hb is only about 25% saturated while Mb is about 95% saturated. This suggests that the Hb has released the O_2 and the Mb has taken it up, which is as it should be as the Hb's job is to transport AND RELEASE O_2 to the tissues for Mb to take it up and bring it to the mitochondria for aerobic respiration.

b. What do the three curves below tell you about how Hb's oxygen binding affinity changes as the pH drops from 7.6 to 7.2 to 6.8? Your answer should include a comparison of how the Kds change for Hb as the pH drops. 4 pts



As the pH drops, the Hb binding curve is shifting to the right. This means that if we compare the saturation of Hb with O_2 (Y value) at any one X value, we see that the saturation decreases as the pH decreases. This also means that Hb is becoming a poorer and poorer binder of O_2, or that the Kd (dissociation) is increasing as the pH is decreasing.

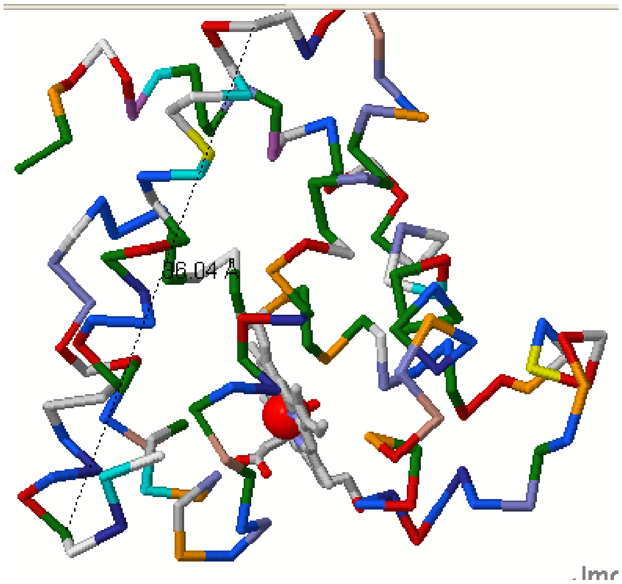
c. What "state" (R or T) of the Hb is most prevalent in the tissues at pH 6.8? Explain. 4 pts

Since the deoxygenated state is more prevalent at lower pH, this suggests that the T state, or tense deoxy state predominates. This makes sense because these tissues are stressed and need oxygen! NOW

d. What are some of the small molecules or ions that bind to this state of Hb? 4 pts

H^+, bisphosphoglycerate (DPG or BPG), CO_2 all bind to the T state of Hb

4. The last of the eight helices in Mb is very long one, extending from Ala125 to Leu149. The end to end distance of this helix is shown as a dotted line on this image below (rotated from the view on the first page) and measured to be 36.04 Å. (8 points)



a. How many amino acids are in this helix? (note the answer to this is a whole number, which never limits the significant figures) 1 pt
Ala 149 to Leu 125 is 149-125+1=25 amino acids

b. The length of the helix was given above as 36.04 Å. Using the conversion factors on the back calculate the length in picometers, nanometers, micrometers, and meters. Pay attention to significant figures. 4 pts

36.04Å(10^{-10}m/1Å)(10^{12}pm/1m)= $\underline{3.604*10^{3}\text{ pm}}$
36.04Å(10^{-10}m/1Å)(10^{9}nm/1m)= $\underline{3.604\text{ nm}}$
36.04Å(10^{-10}m/1Å)(10^{6}um/1m)= $\underline{3.604*10^{-3}\text{ um}}$
36.04 Å *(10^{-10} m/1Å) = $\underline{3.604 * 10^{-9}\text{ m}}$
All answers above have four sig figs

c. Calculate the distance per amino acid for this helix (use distance units of Å). Pay attention to significant figures. 1.5 pts

36.04 Å/25 = 1.4416 Å or 1.442 Å to the correct (4) significant figures

d. These amino acids find themselves in an alpha helix, which is a fairly compressed structure for the amino acid backbone. IF these amino acids found themselves in a beta strand (3.4 Å per amino acid), how long would the strand be? Watch your significant figures. 1.5 pts
3.4 Å x 25 = 85 Å (note two significant figures in answer)

These conversion factors are exact, and will not limit the number of significant figures in your answer:

1 m = 10^2 cm = 10^3 mm = 10^6 um = 10^9 nm = 10^{12} pm

1 Å = 10^{-10} m = 10^{-8} cm