State whether each of the following will increase or decrease the affinity of hemoglobin for oxygen.

- Change in blood pH from 7.2 to 6.8
- Change in pCO₂ from 36 torrs to 12 torrs
- Change in the blood 2,3-bisphosphoglycerate [BPG] concentration from $2 \times 10^{-4}$ M to $8 \times 10^{-4}$ M
- Climbing up Mount Everest from 1,000 meters above sea level to 4,000 meters above sea level
- Change in blood proton [H⁺] concentration from $1.8 \times 10^{-7}$ M to $2.1 \times 10^{-6}$ M

Indicate whether each of the following statements about hemoglobin and myoglobin is true or false.

- Hemoglobin is present in red blood cells (erythrocytes)
- Myoglobin is abundant in mammalian muscle tissue.
- Myoglobin is a tetrameric protein with four protein subunits.
- Hemoglobin is a structural protein whose function is to give erythrocytes their disk shape.
- Hemoglobin has four identical protein subunits, each designated as alpha (α).
- Hemoglobin and myoglobin both contain a prosthetic group called a heme.
- Hemoglobin utilizes a bound zinc (Zn²⁺) ion to bind oxygen.
- Hemoglobin has a higher affinity for oxygen at pH 7.2 than at pH 7.6.
- Hemoglobin has a lower affinity for oxygen when CO₂ is present in high concentrations in the blood.

Indicate whether each statement is TRUE or FALSE by circling either T for TRUE or F for FALSE

- T F Hemoglobin contains four identical protein subunits
- T F Hemoglobin can bind four molecules of 2,3-bisphosphoglycerate, one to each protein subunit.
- T F Hemoglobin can bind four molecules of oxygen (O₂), one to each protein subunit.
- T F Hemoglobin contains a single heme which is buried at the interface between four protein subunits.
- T F Hemoglobin is found predominantly in muscle cells and serves as an oxygen storage protein.
What is the biological role of proteins called chaperonins? Describe how the structure of the chaperonin protein GroEL enables it to fulfill its biological function.

Describe the following proteins, considering primary, secondary, tertiary, and quaternary structure of each. Also, explain the role and properties of each protein.  A) Collagen, B) Myoglobin, C) Hemoglobin, D) GroEL/GroES complex

The structural protein collagen has a repeating amino acid sequence of Gly – X – Pro where X is any amino acid residue. Why is this repeating sequence important for the function of collagen?

Collagen contains a high percentage of hydroxylysine residues. Why are these hydroxylysines important for the structure of collagen?
Classes of enzymes

Discussed in class were six classes of enzymes. Starting with pyruvate, structure drawn below, illustrate two separate reactions that can take place to transform the substrate pyruvate into a different product molecule. Two molecules of pyruvate are drawn, one for each of the reactions. You may add any other substrate to your theoretical reaction that you like. Then, state what class of enzyme you have illustrated.

Type of reaction _______________________

Type of reaction _______________________

\[
\begin{array}{c}
\text{COO}^\ominus \\
| \\
\text{C=} \text{O} \\
| \\
\text{CH}_3 \\
\end{array}
\quad \leftrightarrow \quad
\begin{array}{c}
\text{COO}^\ominus \\
| \\
\text{C=} \text{O} \\
| \\
\text{CH}_3 \\
\end{array}
\]
A non amino acid portion of an enzyme needed for catalysis, often a coenzyme or metal ion, is called a
A. prosthetic group
B. apoenzyme
C. isomerase
D. substrate

The reaction below is likely catalyzed by which class of enzyme?
A. lyase
B. hydrolase
C. transferase
D. oxidoreductase

\[
\text{COO}^\ominus \quad \text{CH}_3 \\
\text{C} = \text{O} + \text{NAD}^\ominus + \text{H}^\ominus \\ \\
\text{CH}_3 \\
\text{HO} - \text{C} - \text{H} + \text{NAD}^\ominus
\]

The reaction below is likely catalyzed by which class of enzyme?
A. ligase
B. isomerase
C. hydrolase
D. transferase

In the interaction of an uncompetitive inhibitor with an enzyme
A. the enzyme will be covalently modified by the inhibitor
B. the enzyme will have a higher $V_{\text{max}}$ value due to a change in conformation
C. the enzyme will catalyze the reaction at a lower rate due to the inhibitor binding at the active site
D. the $K_m$ and $V_{\text{max}}$ values for the substrate will decrease

A competitive inhibitor
A. binds to the enzyme-substrate complex (ES).
B. decreases the maximal velocity attainable by the enzyme.
C. often has a structure similar to the substrate.
D. binds to the enzyme at a site distinct from the active site.

For the enzyme whose activity is illustrated in the plot, which statement is true?
A. The $V_{\text{max}}$ is approximately 18 mM/sec and the $K_m$ for ATP is approximately 35 mM.
B. The enzyme is competitively inhibited by 2,3-bisphosphoglycerate.
C. The $K_m$ for ATP is approximately 18 mM and the $V_{\text{max}}$ is approximately 35 mM/sec.
D. The $K_m$ for ATP is approximately 100 mM and the $V_{\text{max}}$ is approximately 18 mM/sec.

The drug mevinolin, a cholesterol lowering medication, inhibits the enzyme HMG-CoA reductase. As a scientist working for Merck, you determine mevinolin binds noncovalently to the enzyme, lowering $V_{\text{max}}$ and $K_m$ for the normal enzyme substrate coenzyme A.
What type of inhibitor is mevinolin?
A. competitive
B. uncompetitive
C. irreversible
D. nonspecific
For the enzyme illustrated in the following graph, approximate, to the best of your ability, the kinetic parameters $V_{\text{max}}$ and $K_{m}$.

Draw a line on the graph illustrating the effect of a competitive inhibitor on enzyme activity. State which kinetic parameters will change in the presence of a competitive inhibitor and whether the parameters will increase or decrease.
Enzyme Kinetics

You have assayed enzyme X and determined the initial rate of the reaction \( V_o \) at varying concentrations of substrate \([S]\). The data that result are shown below. You have plotted the initial rate vs \([S]\) and a double reciprocal plot. For the double reciprocal plot you have done linear regression analysis and determined the equation for the line that fits the data.

<table>
<thead>
<tr>
<th>([S]) (mM)</th>
<th>(V_o) (nmoles/min/mg)</th>
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<tr>
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</tbody>
</table>

\[ y = 0.032x + 0.0353 \]

ANSWER THE FOLLOWING QUESTIONS WITH RESPECT TO CATALYSIS BY ENZYME X.

Write the Michaelis-Menten equation. Define and describe each term of the equation.

Write the double reciprocal form of the Michaelis-Menten equation in the form of a straight line.

For enzyme X what is the \(V_{\text{max}}\) value with respect to substrate \([S]\)?

For enzyme X what is the \(K_m\) value with respect to substrate \([S]\)? (2 points)

You again assay enzyme X at the same substrate concentrations. However, the assays are now done in the presence of a competitive inhibitor. Approximate and draw the lines that result from this experiment on each of the above plots, the \(V_o\) versus \([S]\) plot AND the \(1/V_o\) versus \(1/[S]\) plots. What kinetic parameter(s) change upon addition of a competitive inhibitor? Do the parameter(s) increase or decrease?
Classes of Enzymes

For each of the following reactions indicate whether the enzyme that catalyzes the reaction is an example of (1) oxidoreductase, (2) isomerase, (3) transferase, (4) hydrolase, (5) ligase, or (6) lyase.

1. ___________________

2. ___________________

3. ___________________

4. ___________________

5. ___________________
As a physician you encounter a patient that has been experiencing stomach pain after eating high protein meals. You suspect a mutation in an enzyme is responsible for this problem. After conducting genetic testing you confirm that, in fact, the patient has a single amino acid mutated in a specific enzyme. Take an educated guess which enzyme is mutated and what amino acid in that enzyme is mutated. Then explain why you answered the way you did.