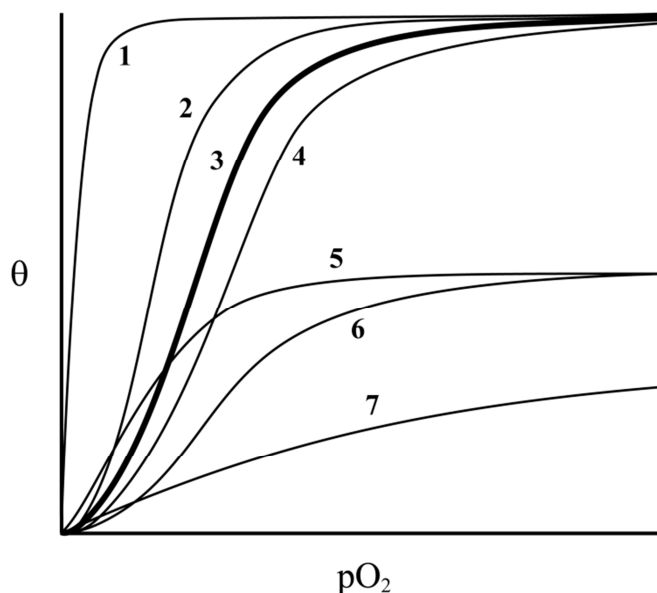


1. Shown below are several O_2 binding curves. The curve in bold (#3) represents O_2 binding by red blood cells of an average person living at sea level. Which curve below best represents O_2 binding:
 - a. For a resident of Tibet, who has a higher-than-average BPG concentration.
 - b. For an elite athlete, who has a higher-than-average red blood cell count.
 - c. For an altered hemoglobin that can only adopt the R state.
 - d. For hemoglobin with half of its binding sites bound by carbon monoxide.



2. An alien race on a far-away planet has evolved to resemble earth's dolphins. Because of the different air composition, the aliens' oxygen-binding molecules, called flipperglobin and goglobin, have different O_2 binding affinities than myoglobin and hemoglobin. Using the information below, draw the O_2 binding curves for these two molecules, and label them 'G' for goglobin, and 'F' for flipperglobin.
 - The pO_2 in the aliens' air-exchange organs is 200 torr.
 - The pO_2 in the aliens' internal tissues is 80 torr.
 - Goglobin fills 90% of its binding sites in the air-exchange organs, and releases oxygen from 60% of its binding sites in the tissues.
 - Flipperglobin, found in some of the alien's tissues, has a P_{50} of 20 torr.
3. True or False?
 - a. Heme is a cofactor necessary to the function of myoglobin.
 - b. In proteins exhibiting positive cooperativity, small changes in ligand concentration can result in large changes in the proportion of bound sites.
 - c. A reaction that happens very rarely can be highly spontaneous.
 - d. Two different enzymes may catalyze the same reaction using different mechanisms, but the rate of the reaction must be the same.

4. Given the following factors:

- A. Increased concentration of oxygen
- B. Decreased concentration of oxygen
- C. Increased concentration of nitrogen
- D. Decreased concentration of nitrogen
- E. Increased concentration of carbon dioxide
- F. Decreased concentration of carbon dioxide
- G. Catalytic activity of carbonic anhydrase
- H. Catalytic activity of rubisco
- I. High binding affinity of oxygen to myoglobin
- J. High binding affinity of oxygen to the R-state of hemoglobin
- K. Low binding affinity of oxygen to the T-state of hemoglobin
- L. High levels of catabolic processes in muscle cells
- M. Increased pH
- N. Decreased pH
- O. Reversible binding of 2,3-BPG to hemoglobin
- P. Increased blood sugar level
- Q. Decreased blood sugar level
- R. Positive cooperativity of oxygen binding by hemoglobin
- S. Ion pairs of hemoglobin's T-state

- a. Which aid in the binding of oxygen to hemoglobin in the lungs? List all that apply.
- b. Which aid in the release of oxygen from hemoglobin in the peripheral tissues? List all that apply.

5. A woman undergoes many physiological changes during pregnancy, including an increase in her blood volume (of ~40%), necessary to carry oxygen to the developing baby (fetus). With the increased blood volume comes an increase in the number of red blood cells.

- a. True or False? The described changes to a pregnant woman's blood do not affect her hemoglobin's ability to bind oxygen. Explain your answer in 15 words or fewer.
- b. True or False? The described changes do not affect the amount of oxygen that can be carried by a pregnant woman's blood. Explain your answer in 15 words or fewer.
- c. True or False? These changes increase the woman's susceptibility to poisoning by carbon monoxide.

In order to allow for greater transfer of oxygen, the fetus produces its own hemoglobin, combining the normal two α -chains with two different, γ -chains. This different hemoglobin, called 'fetal' or 'F' hemoglobin, binds 2,3-BPG with *much lower* affinity than adult hemoglobin. The transfer of O₂ from the mother's blood stream to that of the fetus occurs in the placenta.

- d. Which one of the following amino acid substitutions (β -chain \rightarrow γ -chain) would you expect to be most important in the altered affinity to 2,3-BPG?
 - A. His \rightarrow Ile
 - B. Glu \rightarrow Val
 - C. Gly \rightarrow Thr
 - D. Ala \rightarrow Lys
 - E. Lys \rightarrow Arg
- e. Explain how the reduced ability of fetal hemoglobin to bind 2,3-BPG enhances its ability to bring oxygen to fetal tissues (50 words or fewer).

6. What functional groups of hemoglobin bind directly to O₂?
7. Consider how enzymes compare to chemical catalysts. Which one of the following is *not* true?
 - a. Enzymes act on and produce specific stereoisomers.
 - b. Enzymes can be subject to multiple types of regulation.
 - c. Enzymes function over a wide range of reaction conditions.
 - d. Enzymes can potentially catalyze many different types of reactions.
 - e. Enzymes can achieve higher rates of catalysis than chemical catalysts.