

Globular Proteins / Hemoglobin / Affinity / Diseases

40 Difficult MCQs

1) Which statement best explains why myoglobin has a higher oxygen affinity than hemoglobin?

- A. Myoglobin contains four heme groups and exhibits cooperativity
- B. Myoglobin has a single polypeptide chain and lacks subunit interactions
- C. Myoglobin binds 2,3-BPG more strongly than hemoglobin
- D. Myoglobin releases oxygen more readily in peripheral tissues

2) The oxygen-binding curve of myoglobin is best described as:

- A. Sigmoidal because of cooperative binding
- B. Hyperbolic because it binds oxygen independently
- C. Biphasic because it binds both oxygen and carbon dioxide
- D. Linear because affinity does not change with saturation

3) The sigmoidal shape of the oxygen dissociation curve of hemoglobin is primarily due to:

- A. Its monomeric structure
- B. The presence of ferric iron
- C. Cooperative interaction among subunits
- D. Irreversible oxygen binding

4) Which of the following is the best definition of “cooperativity” in hemoglobin?

- A. Binding of carbon dioxide increases heme synthesis
- B. Binding of one oxygen molecule increases the affinity for subsequent oxygen molecules
- C. Binding of one oxygen molecule decreases the affinity of all remaining subunits
- D. Oxygen binds equally to all four subunits from the beginning

5) Which structural transition occurs when oxygen binds to hemoglobin?

- A. T (tense) state to R (relaxed) state
- B. R (relaxed) state to T (tense) state
- C. α -helix to β -sheet conversion
- D. Ferric to ferrous conversion of iron

6) In the deoxyhemoglobin (T) state, hemoglobin is characterized by:

- A. High oxygen affinity and relaxed conformation
- B. Low oxygen affinity and increased salt bridge stabilization
- C. Complete saturation with oxygen
- D. Inability to bind protons

7) Which of the following favors the T (tense) form of hemoglobin?

- A. High pH
- B. Low $p\text{CO}_2$
- C. Binding of 2,3-BPG
- D. High oxygen saturation in the lungs

8) A rightward shift in the oxygen dissociation curve indicates that hemoglobin:

- A. Has increased affinity for oxygen
- B. Releases oxygen less readily
- C. Has decreased affinity for oxygen
- D. Is unable to bind oxygen

9) Which combination most strongly promotes oxygen unloading in tissues?

- A. High pH, low CO_2 , low temperature
- B. Low pH, high CO_2 , increased 2,3-BPG
- C. Low $p\text{CO}_2$, high pH, low 2,3-BPG
- D. High oxygen tension, low temperature, alkalosis

10) The Bohr effect refers to the influence of which two factors on oxygen binding by hemoglobin?

- A. Sodium and chloride
- B. pH and carbon dioxide
- C. Calcium and magnesium
- D. Iron and copper

11) According to the Bohr effect, a decrease in pH will:

- A. Increase hemoglobin's affinity for oxygen
- B. Stabilize oxyhemoglobin
- C. Enhance oxygen release from hemoglobin
- D. Prevent proton binding to hemoglobin

12) Increased $p\text{CO}_2$ promotes oxygen release from hemoglobin mainly because it:

- A. Converts Fe^{2+} to Fe^{3+}
- B. Stabilizes the T state and contributes to proton generation
- C. Prevents heme formation
- D. Destroys globin chains

13) Which statement about 2,3-bisphosphoglycerate (2,3-BPG) is CORRECT?

- A. It increases oxygen affinity by binding oxyhemoglobin
- B. It decreases oxygen affinity by binding deoxyhemoglobin

- C. It binds myoglobin with high affinity
- D. It shifts the oxygen dissociation curve to the left

14) 2,3-BPG is physiologically important because it:

- A. Prevents oxygen from entering red blood cells
- B. Facilitates oxygen delivery to tissues
- C. Converts adult hemoglobin into fetal hemoglobin
- D. Oxidizes hemoglobin iron

15) Which of the following conditions would most likely increase red blood cell 2,3-BPG levels?

- A. Hyperoxia
- B. Chronic hypoxia
- C. Carbon monoxide removal
- D. Acute alkalosis with normal oxygenation

16) A patient living at high altitude develops an adaptive increase in 2,3-BPG. What is the main effect?

- A. Increased oxygen affinity and reduced tissue delivery
- B. Decreased oxygen affinity and enhanced tissue delivery
- C. Conversion of hemoglobin into methemoglobin
- D. Reduced carbon dioxide transport

17) Which hemoglobin binds 2,3-BPG less effectively and therefore has a higher oxygen affinity?

- A. Hemoglobin A
- B. Hemoglobin S
- C. Fetal hemoglobin (HbF)
- D. Methemoglobin

18) The higher oxygen affinity of fetal hemoglobin is physiologically important because it allows:

- A. Fetal blood to unload oxygen more efficiently than maternal blood
- B. Fetal blood to extract oxygen from maternal circulation
- C. Carbon monoxide detoxification in the fetus
- D. Complete independence from placental gas exchange

19) Carbon monoxide (CO) is dangerous because it:

- A. Oxidizes heme iron to ferric state only
- B. Competes weakly with oxygen and is easily displaced
- C. Binds tightly to hemoglobin and reduces oxygen delivery
- D. Only affects carbon dioxide transport

20) In carbon monoxide poisoning, tissue hypoxia occurs primarily because CO:

- A. Prevents erythropoiesis
- B. Lowers blood pH dramatically
- C. Occupies oxygen-binding sites and increases affinity of remaining sites for oxygen
- D. Destroys all hemoglobin molecules irreversibly

21) Which statement best describes the effect of carbon monoxide on the oxygen dissociation curve?

- A. It shifts the curve to the right
- B. It shifts the curve to the left
- C. It makes the curve identical to myoglobin
- D. It has no effect on oxygen affinity

22) Why is a left shift dangerous in carbon monoxide poisoning?

- A. Oxygen cannot bind to hemoglobin at all
- B. Hemoglobin releases oxygen more easily to tissues
- C. Oxygen that is bound is held more tightly and released less readily
- D. Carbon dioxide can no longer be transported as bicarbonate

23) Which of the following best distinguishes hemoglobin from myoglobin?

- A. Hemoglobin stores oxygen in muscle, whereas myoglobin transports oxygen in blood
- B. Myoglobin has quaternary structure, whereas hemoglobin does not
- C. Hemoglobin exhibits cooperativity, whereas myoglobin does not
- D. Myoglobin binds 2,3-BPG, whereas hemoglobin does not

24) Which statement about allosteric effectors of hemoglobin is TRUE?

- A. They bind only to the oxygenated form and increase affinity
- B. They alter oxygen binding by stabilizing specific conformations
- C. They permanently denature hemoglobin
- D. They affect only fetal hemoglobin and not adult hemoglobin

25) Which of the following would produce a left shift of the hemoglobin oxygen dissociation curve?

- A. Increased 2,3-BPG
- B. Increased H^+ concentration
- C. Decreased pCO_2
- D. Increased temperature

26) Which factor would LEAST favor oxygen release to peripheral tissues?

- A. Increased carbon dioxide

- B. Decreased pH
- C. Increased 2,3-BPG
- D. Increased oxygen affinity

27) Sickle cell disease is caused by:

- A. Deletion of two α -globin genes
- B. Substitution of valine for glutamic acid in the β -globin chain
- C. Replacement of histidine by tyrosine in the α -globin chain
- D. Absence of heme synthesis in erythrocytes

28) The molecular basis of sickle cell disease leads to:

- A. Increased solubility of deoxyhemoglobin
- B. Polymerization of deoxyhemoglobin S
- C. Enhanced oxygen binding in all tissues
- D. Failure of hemoglobin tetramer formation

29) Which condition most strongly promotes sickling in a patient with HbS?

- A. High oxygen tension
- B. Increased pH
- C. Decreased oxygen tension
- D. Reduced 2,3-BPG

30) Which of the following factors can enhance sickling of hemoglobin S?

- A. High pH and low pCO₂
- B. Low pH, increased pCO₂, and increased 2,3-BPG
- C. High oxygen saturation and alkalosis
- D. Reduced erythrocyte dehydration only

31) A patient with sickle cell disease is most likely to experience symptoms primarily because of:

- A. Failure of leukocyte production
- B. Vaso-occlusion and hemolytic anemia
- C. Excessive platelet aggregation only
- D. Increased oxygen affinity of hemoglobin S

32) Which of the following is a common clinical manifestation of sickle cell disease?

- A. Cyanosis due to ferric iron formation only
- B. Painful vaso-occlusive crises
- C. Pure iron deficiency without hemolysis
- D. Increased resistance to all infections

33) Methemoglobinemia occurs when hemoglobin iron is oxidized from:

- A. Fe²⁺ to Fe³⁺
- B. Fe³⁺ to Fe²⁺
- C. Fe²⁺ to Fe⁴⁺
- D. Fe³⁺ to Fe²⁺

34) Why is methemoglobin unable to carry oxygen effectively?

- A. It lacks globin chains
- B. Ferric iron (Fe³⁺) cannot bind oxygen properly
- C. It contains no porphyrin ring
- D. It is unable to bind carbon dioxide

35) Which of the following may cause methemoglobinemia?

- A. Deficiency of NADH-cytochrome b5 reductase
- B. Excess synthesis of 2,3-BPG
- C. Decreased carbon dioxide production
- D. Increased fetal hemoglobin only

36) A newborn exposed to oxidizing agents becomes cyanotic and does not improve adequately with oxygen therapy. Which disorder is most likely?

- A. Sickle cell disease
- B. Methemoglobinemia
- C. β-thalassemia major
- D. Carbon monoxide poisoning

37) The bluish discoloration seen in methemoglobinemia is mainly due to:

- A. Excessive bilirubin deposition
- B. Inability of ferric hemoglobin to deliver oxygen efficiently
- C. Increased fetal hemoglobin
- D. Massive carbon dioxide retention only

38) Which disorder is most directly associated with chronic hemolysis, painful crises, and possible tissue infarction?

- A. Carbon monoxide poisoning
- B. Sickle cell disease
- C. Methemoglobinemia
- D. Simple iron deficiency

39) Which disorder is especially worsened by high altitude or unpressurized air travel?

- A. Sickle cell disease

- B. Methemoglobinemia
- C. Carbon monoxide poisoning
- D. Hemoglobin F persistence

40) A patient exposed to smoke inhalation develops headache, dizziness, and tissue hypoxia despite normal pO₂ in plasma. Which is the best explanation?

- A. Decreased heme synthesis
- B. Carbon monoxide poisoning causing carboxyhemoglobin formation
- C. Severe methemoglobinemia due to ferric iron accumulation only
- D. Excess 2,3-BPG production

Answer Key

1. B
2. B
3. C
4. B
5. A
6. B
7. C
8. C
9. B
10. B
11. C
12. B
13. B
14. B
15. B
16. B
17. C
18. B
19. C
20. C
21. B
22. C
23. C
24. B
25. C
26. D
27. B
28. B
29. C
30. B
31. B
32. B
33. B

34. B

35. A

36. B

37. B

38. B

39. A

40. B