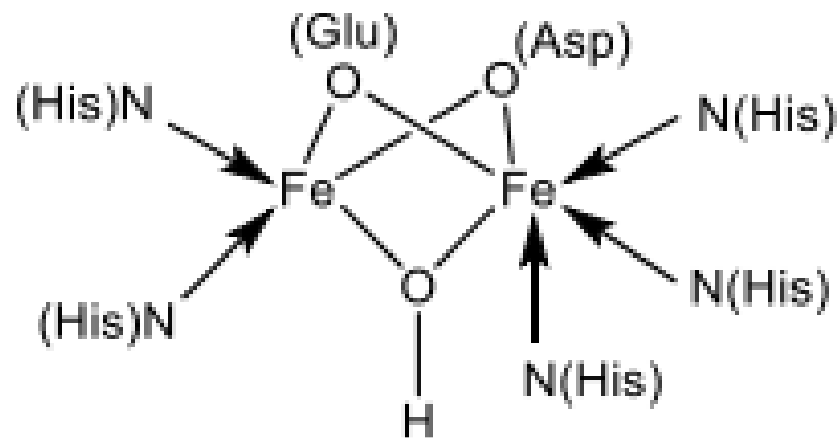


Hemerythrin is an oligomeric iron-containing protein responsible for oxygen (O_2) transport in marine invertebrates. The structure of hemerythrin is shown below.

- (i) Hemerythrin is not considered as a heme iron-containing protein. Explain.
- (ii) Describe the changes that happened to the iron spin and the Fe-Fe bond length when hemerythrin binds with oxygen.



1. When $pO_2 = p_{50}$ of myoglobin, the fractional saturation (Y_{O_2}) is about:

- A. 0.1
- B. 0.3
- C. 0.5
- D. 0.7
- E. 0.9

2. In deoxy hemoglobin (Hb), the Fe (II) is 5-coordinated to

- A. four nitrogens of heme and to the proximal His of Hb.
- B. four nitrogens of heme and to a water molecule.
- C. four nitrogens of heme and to an O_2 molecule.
- D. two nitrogens of heme and to three His residues in Hb.
- E. two nitrogens of heme and to three water molecules.

3. Spontaneous oxidation of the heme-bound Fe(II) to Fe(III) is prevented in hemoglobin by

- A. the symmetry of its quaternary structure.
- B. the four heme-protein covalent bonds.
- C. a highly-ordered water molecule within the heme pocket.
- D. the surrounding protein structure in each subunit.
- E. methemoglobin reductase.

4. When $p_{O_2} = 10 \times p_{50}$ of myoglobin, the fractional saturation (Y_{O_2}) is about:

- A. 0.1
- B. 0.3
- C. 0.5
- D. 0.7
- E. 0.9

5. When $p_{O_2} = 0.1 \times p_{50}$ of myoglobin, the fractional saturation (Y_{O_2}) is about:

- A. 0.1
- B. 0.3
- C. 0.5
- D. 0.7
- E. 0.9



Calculation

1. **State the equation:** The fractional saturation for myoglobin is given by the equation:

$$Y_{O_2} = \frac{p_{O_2}}{p_{50} + p_{O_2}}.$$

2. **Substitute the given condition:** The problem states that $p_{O_2} = 10 \times p_{50}$. Substitute this into the equation:

$$Y_{O_2} = \frac{10 \times p_{50}}{p_{50} + (10 \times p_{50})}$$

3. **Simplify the expression:**

$$Y_{O_2} = \frac{10 \times p_{50}}{11 \times p_{50}}$$

4. **Solve for Y_{O_2} :** The p_{50} terms cancel out:

$$Y_{O_2} = \frac{10}{11} \approx 0.909.$$

1. Why nature made hemoglobin's oxygen binding capacity to be pH dependent? Describe the pH dependence of binding of oxygen to hemoglobin.
2. Why myoglobin is made to reside in cells to uptake oxygen from hemoglobin. Assuming the exchange of roles, explain based on the binding affinity of hemoglobin and myoglobin would myoglobin be a suitable oxygen transporter from lungs to cells. Justify your answer.
3. How CO_2 is transported back to lungs?
4. Very briefly, comment on the biological roles of (i) hemerythrin, (ii) hemoglobin and myoglobin. Draw structures of deoxy- and oxy-form of hemerythrin.

Q: What is Manganese SOD (MnSOD) and what is its primary function?

Ans: Manganese superoxide dismutase is a critical antioxidant enzyme located exclusively in the mitochondrial matrix of all aerobic organisms, from bacteria to humans. Its primary function is to neutralize the superoxide radical ($O_2^{\bullet-}$), a highly reactive oxygen species (ROS), by converting it into hydrogen peroxide H_2O_2 and molecular oxygen O_2 .

Q: Why is the location of MnSOD in the mitochondria significant?

Ans: The mitochondrial matrix is the main site of cellular respiration and, consequently, the largest source of endogenous reactive oxygen species (ROS). The strategic localization of MnSOD is essential for protecting mitochondria—and by extension, the entire cell—from the damaging effects of superoxide radicals produced during normal metabolic processes. Protecting this vital organelle is critical for ATP production, apoptosis regulation, and preventing oxidative damage.

Q: What is the role of MnSOD in human health and disease?

Ans: MnSOD's role in maintaining cellular redox homeostasis is vital for overall health, and its dysfunction may be implicated in diseases where ROS is responsible like neurodegenerative diseases, cardiovascular diseases, Cancer and other metabolic disorders related to excess ROS.

TUTORIAL -2

1. Hemerythrin differs from Hemoglobin because:

- A. It contains Fe^{3+} instead of Fe^{2+}
- B. It does not contain a heme group
- C. It contains Cu instead of Fe
- D. It cannot bind oxygen

Answer:- B. It does not contain a heme group

Explanation: Hemerythrin is a **non-heme iron protein** that binds O_2 directly to Fe centres bridged by oxygen atoms.

2. Which statement about hematin is *incorrect*?

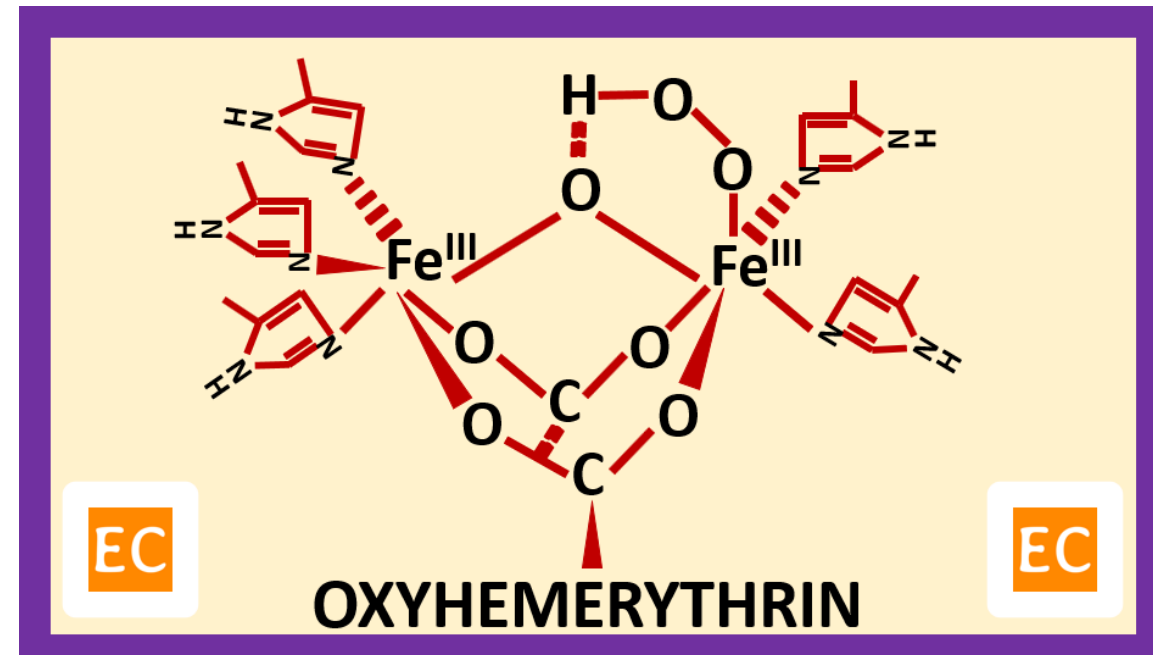
- A) It is insoluble in water but soluble in alkali
- B) It can form μ -oxo dimers
- C) It can reversibly bind O_2
- D) It shows strong absorption near 400 nm (Soret band)

Answer:- C) It can reversibly bind O_2

3. What type of oxygen-binding mode is found in oxyhemerythrin?

- A) Superoxide (O_2^-) bound to one Fe
- B) Peroxo (μ -OOH $^-$) bridge between two Fe
- C) Molecular O_2 coordinated end-on
- D) None of these

Answer:- B) Peroxo (μ -OOH $^-$) bridge between two Fe



4. The structural transformation during O₂ binding

involves:

Answer:- B) Electron transfer from Fe(II)–Fe(II) to O₂

- A) Electron transfer from O₂ to Fe
- B) Electron transfer from Fe(II)–Fe(II) to O₂
- C) No electron transfer
- D) Both Fe and O₂ remain unchanged

5. Myoglobin binds with O₂ depending on:

- A. Concentration of O₂
- B. The hemoglobin concentration
- C. The affinity of myoglobin for O₂
- D. A and C
- E. A and B
- F. A, B and C

Answer:- D) A and C

6. You see a patient on an initial visit and are struck by the bluish coloring of the skin and mucous membranes. you are told that it is a blood problem that the patient has had for his or her entire life. The patient's father had a similar condition. This condition could result from which one of the following changes within the erythrocyte?

- a) An increased oxidation of heme iron to the +3 state
- b) Enhanced oxygen binding to hemoglobin
- c) A mutated hemoglobin that no longer exhibited the Bohr effect
- d) Insufficient Iron on diet

Answer:- a) An increased oxidation of heme iron to the +3 state

Explanation- The patient is exhibiting **methemoglobinemia**, in which an increased percentage of his hemoglobin has the iron in the +3 oxidation state (normal is +2), which is a form that cannot bind oxygen.

7. Methemoglobin is formed as a result of the oxidation of hemoglobin by oxidising agent:-

Answer:- c) Potassium Ferricyanide

- a) Oxygen of air,
- b) Hydrogen peroxide,
- c) Potassium Ferricyanide,
- d) Potassium permanganate.

8. What is apoferritin?

Answer:- Ferritin that is having iron stored inside it is called apoferritin.

9. Ferritin primarily stores iron in the form of:

- a) Ferrous (Fe^{2+})
- b) Ferric (Fe^{3+})
- c) Elemental (Fe)
- d) Iron oxide

Answer:- b) Ferric (Fe^{3+})

10. Hemoglobin transports oxygen from:

- a) Muscles to lungs
- b) Lungs to tissues
- c) Tissues to blood
- d) Digestive tract to liver

Answer:- b) Lungs to tissues

Explanation:- Hemoglobin binds oxygen in the lungs and delivers it to tissues throughout the body for cellular respiration.

11. Oxygen activation in P450 proceeds via:

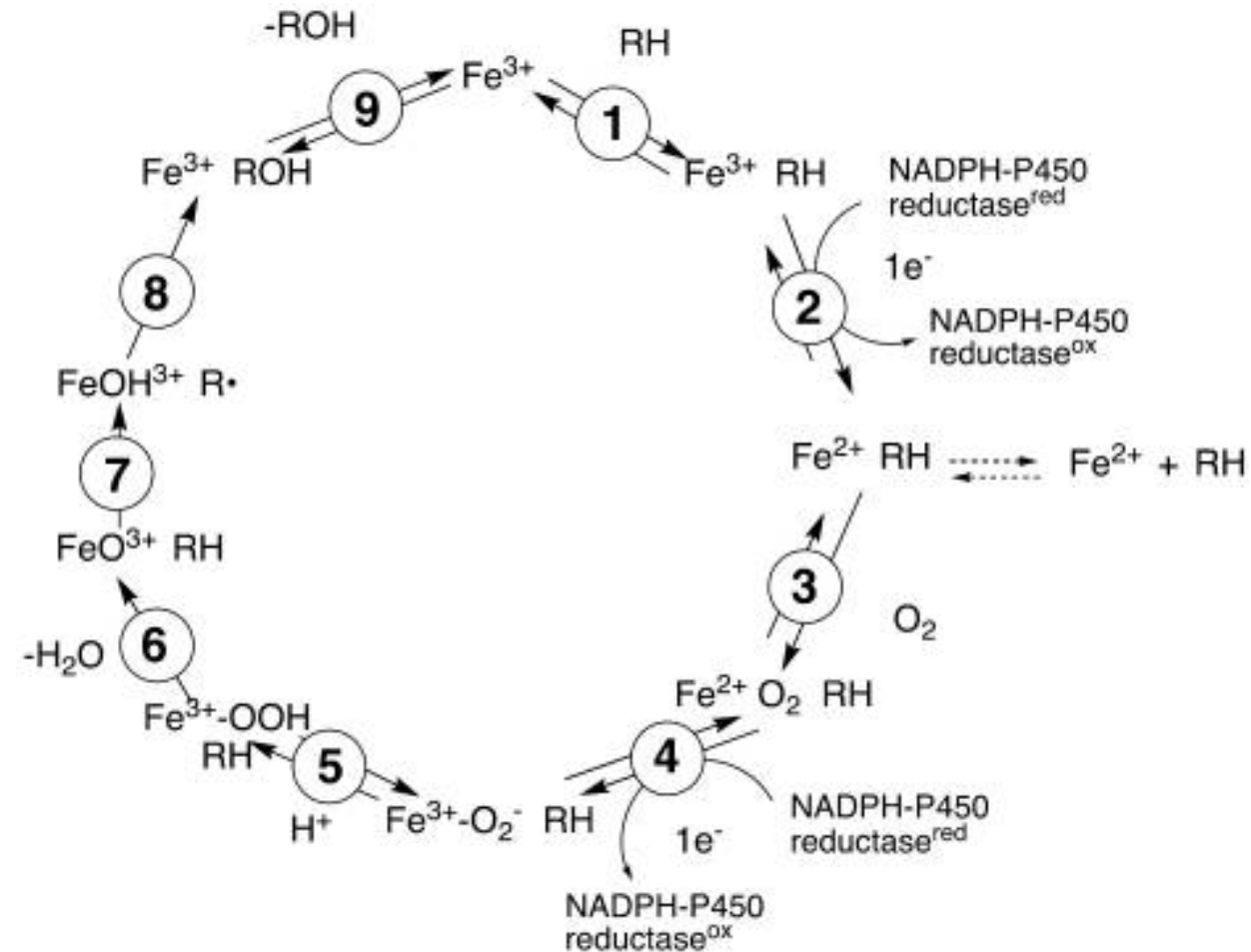
- A) Radical pathway
- B) Formation of Fe–O–O and heterolytic cleavage
- C) Direct oxygen insertion
- D) Photochemical reaction

Answer:- B) Formation of Fe–O–O and heterolytic cleavage

12. The number of electrons required to reduce O_2 in the P450 cycle is:

- A) 1
- B) 2
- C) 3
- D) 4

Answer:- B) 2



13. The red shift in the Soret band upon CO binding to reduced P450 is due to:

- A) Enhanced Fe–CO π -backbonding
- B) CO σ -donation
- C) Loss of thiolate bonding
- D) Charge transfer from porphyrin

Answer:- A) Enhanced Fe–CO π -backbonding

Explanation :-The electron-donating Cys-S ligand on the opposite (proximal) side significantly enhances the electron density on the Fe^{2+} center, which in turn strengthens the π -backdonation to the ligand.

14. Which statement about Cytochrome P450 is *incorrect*?

- A. It contains a heme-thiolate active site
- B. It forms a Fe–CO complex absorbing at 450 nm
- C. It catalyzes dioxygenase reactions, inserting both O atoms
- D. It participates in drug metabolism

Answer:- C) It catalyzes dioxygenase reactions, inserting both O atoms

Explanation:-

P450s are **monooxygenases**, not dioxygenases. They insert only one O atom into the substrate; the other becomes water

15. In the hydrogen abstraction step, what species is generated on the substrate?

- A. Carbocation (R^+)
- B. Carbanion (R^-)
- C. Carbon radical ($R\bullet$)
- D. Peroxy radical ($ROO\bullet$)

Answer:- C) Carbon radical ($R\bullet$)

Explanation:

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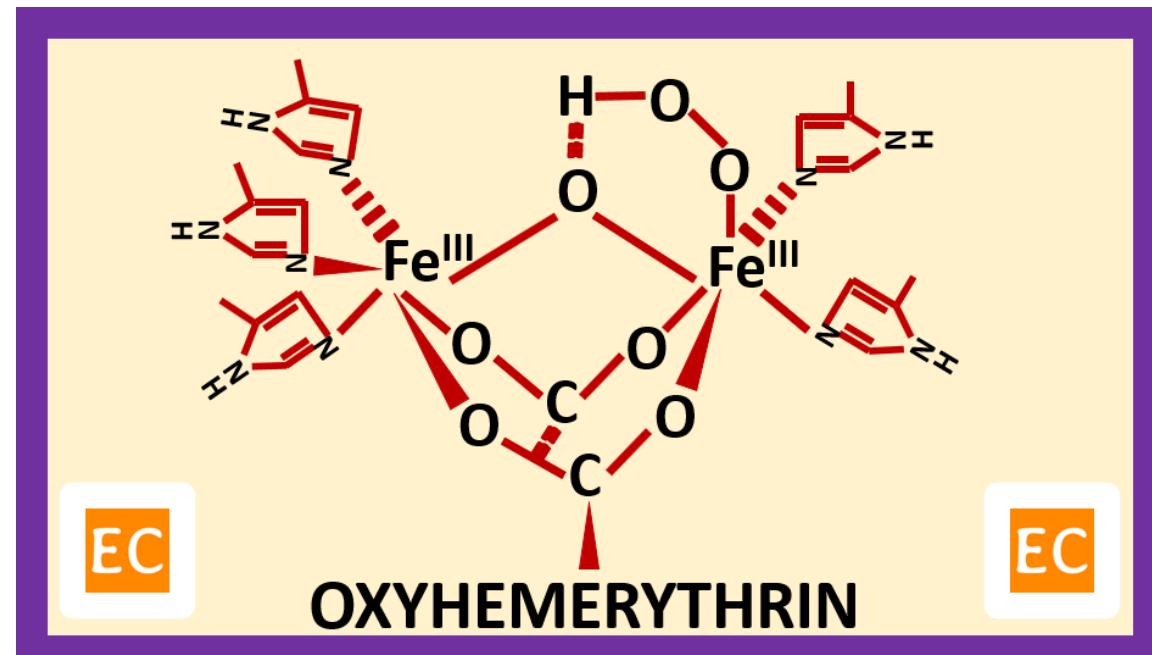
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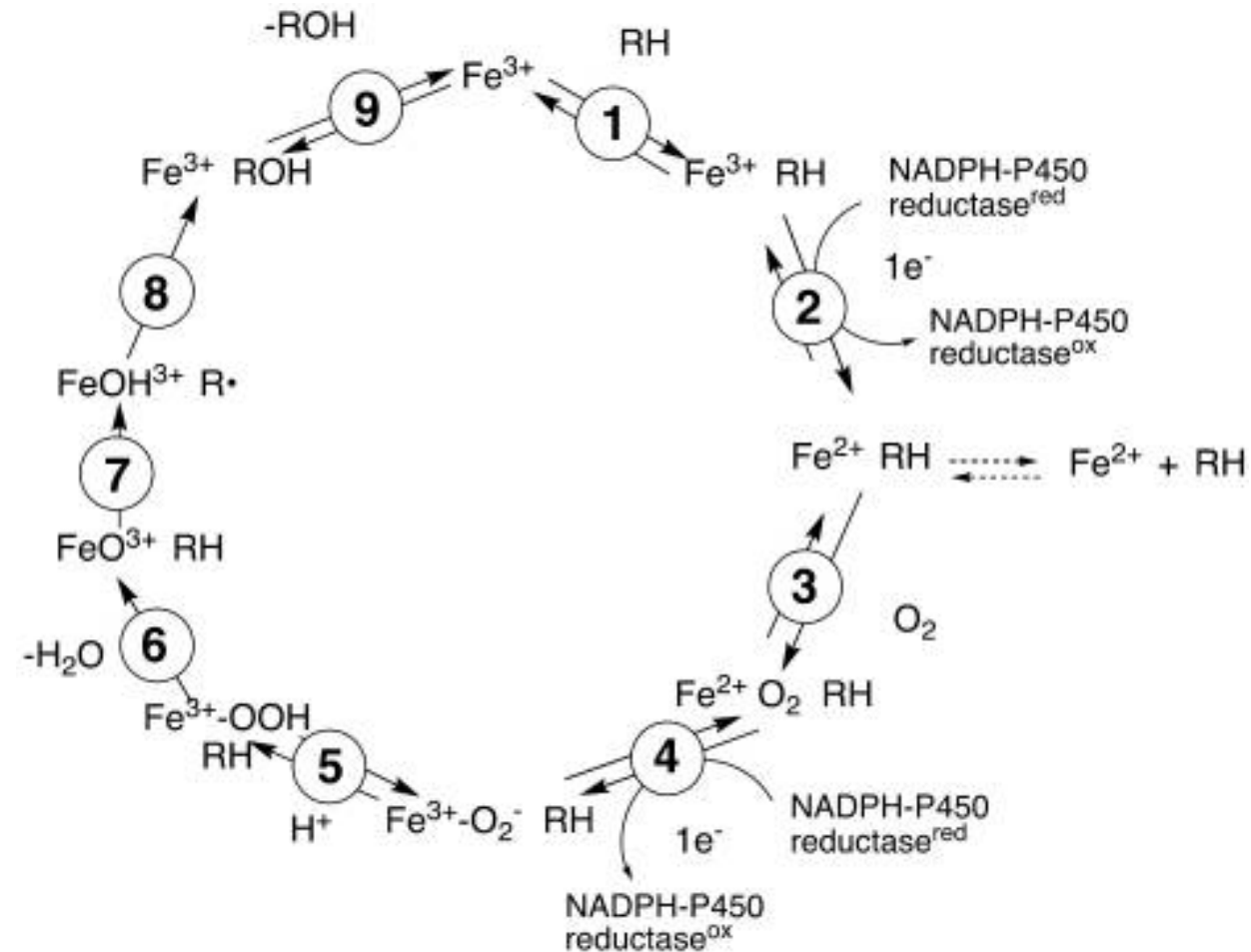
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