

Oxygen binding to Mb & Hb & Hb-O₂ dissociation curve

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Oxygen Binding to Myoglobin and Hemoglobin

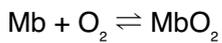
Heme Structure

Hemoglobin (Hb) and Myoglobin (Mb) are heme-containing proteins that bind oxygen.

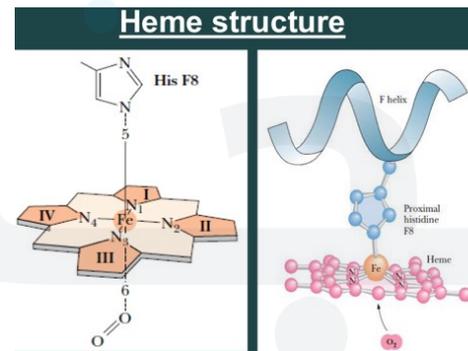
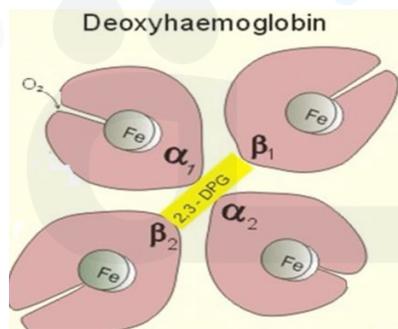
Oxygen is accessible only to the heme groups of the **α -chains** when hemoglobin is in the **T (tense) state**.

Myoglobin

- Myoglobin is designed to **bind oxygen released by hemoglobin at the low pO₂ found in muscle**.
- It then releases oxygen within the muscle cell in response to oxygen demand.
- Myoglobin binds one molecule of oxygen only, forming a simple equilibrium:



- **The oxygen dissociation curve for myoglobin is hyperbolic**, reflecting its simple reversible binding.
- This means oxygenated (MbO₂) and deoxygenated (Mb) forms exist in equilibrium, which shifts right or left as O₂ is added or removed.
- As an oxygen storage protein, **myoglobin has a greater affinity for O₂ than hemoglobin at all oxygen pressures**.



Hemoglobin Structure and Cooperativity

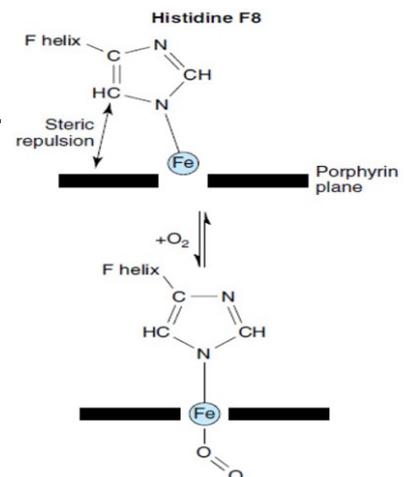
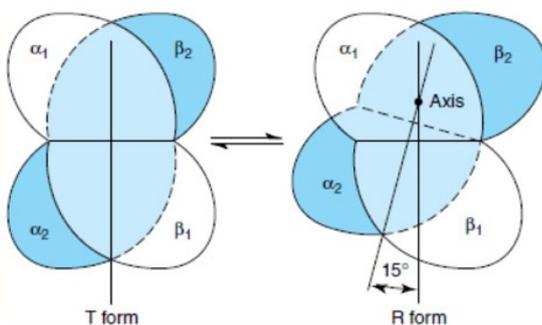
- Hemoglobin consists of four subunits, each with a heme group capable of binding one oxygen molecule.
- Oxygen binding is **cooperative**—the binding of one O₂ molecule increases the affinity for the next.
- This cooperativity gives the Hb-O₂ dissociation curve its **sigmoidal (S-shaped)** form.

Steric Repulsion

When atoms get very close, their electron clouds overlap, causing repulsion forces (steric repulsion). This plays a role in structural changes during oxygen binding.

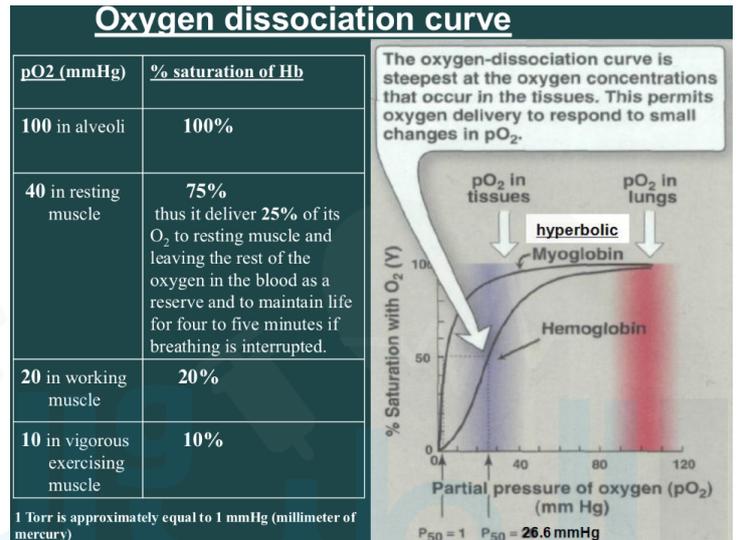
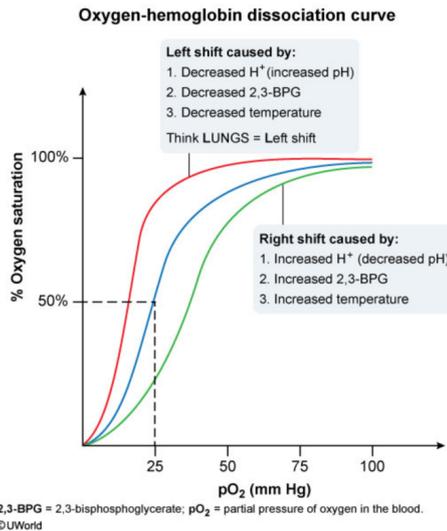
T (Tense) to R (Relaxed) Transition

- In the T structure, subunits are **linked by salt bridges (ion-pair bonds)**.
- As oxygen binds, these salt bridges **progressively break**.
- During this transition, **one pair of subunits rotates about 15° relative to the other**.
- **The R state has a higher affinity for oxygen than the T state**.



Oxygen Dissociation Curve

- The oxygen dissociation curve describes the **relationship** between the **partial pressure of oxygen (x-axis)** and the **oxygen saturation (y-axis)** of hemoglobin.
- Oxygen saturation** = $(O_2 \text{ bound to Hb}) / (O_2 \text{ carrying capacity of Hb})$.
- Hemoglobin's affinity for oxygen increases as more oxygen molecules bind (cooperativity).**
- The curve is **sigmoidal (S-shaped)** due to cooperative binding.



P50 Value

- P50 is the partial pressure of O_2 at which 50% of Hb is saturated.
- Normal adult range: **24–28 mmHg**.
- P50 is important for understanding tissue oxygenation.
- Changes in P50 can indicate diseases such as pediatric acute respiratory syndrome, anemia, or RBC disorders.

Agents Affecting Oxygen Binding

- 2,3-Bisphosphoglycerate (2,3-BPG or 2,3-DPG)
 - 2,3-BPG binds to Hb and promotes O_2 release.
 - It reduces Hb's affinity for oxygen**, shifting the curve to the **right**.
 - Low 2,3-BPG levels** cause a **left shift** (increased affinity).
 - This allows hemoglobin to unload oxygen efficiently at tissue pO_2 .

Key Points:

- Without 2,3-BPG**, hemoglobin would be fully saturated even at low pO_2 (20 mmHg) and **would not release O_2 to tissues.**
- Increased 2,3-BPG \rightarrow \downarrow Hb- O_2 affinity \rightarrow right shift.
- Decreased 2,3-BPG \rightarrow \uparrow Hb- O_2 affinity \rightarrow left shift.

Increased 2,3-BPG occurs in:

- Chronic hypoxia (e.g., obstructive pulmonary emphysema)
- High altitude exposure
- Chronic anemia

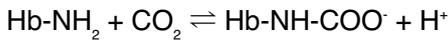
These conditions lower O_2 affinity and improve O_2 unloading to tissues.

Binding of CO₂

Carbon dioxide affects Hb-O₂ binding in two ways:

A. Formation of Carbaminohemoglobin

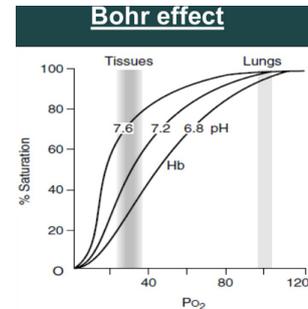
- About **20%** of CO₂ is carried as carbaminohemoglobin, bound to the uncharged α-amino groups of Hb:



- This binding **stabilizes the T (deoxy) form of hemoglobin**, **decreasing its O₂ affinity**.
- Deoxyhemoglobin** resists oxygenation because it is stabilized by **hydrogen bonds and salt bridges**.

Transport of CO₂ in Blood:

- 10% dissolved as CO₂ gas
- 20% as carbaminohemoglobin
- 70% as carbonic acid (H₂CO₃)
- H⁺ from this reaction binds to Hb, aiding oxygen release.**



B. Bohr Effect

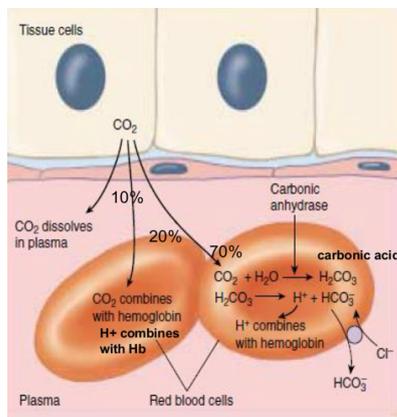
- The Bohr effect describes **how CO₂ and pH affect the O₂ dissociation curve**.
- ↑ pH or ↓ CO₂ → ↑ Hb affinity for O₂ → **Left shift**
- ↓ pH or ↑ CO₂ → ↓ Hb affinity for O₂ → **Right shift**
- As blood enters tissues, CO₂ from metabolism lowers pH, promoting oxygen release from Hb.**

Temperature

- ↑ **Temperature** → curve shifts to the **right** (↓ O₂ affinity).
- ↓ **Temperature** → curve shifts to the **left** (↑ O₂ affinity).
- During exercise, muscle temperature rises above 37°C, enhancing O₂ unloading.**
- This occurs **because high temperature weakens the bond** between oxygen and hemoglobin.

Atmospheric Oxygen and Partial Pressure

- Atmospheric air ≈ **79% N₂** and **21% O₂**, with trace water vapor, CO₂, and inert gases.
- The total (barometric) pressure at sea level = 760 mmHg.
- The partial pressure of oxygen (PO₂) = 0.21 × 760 = 160 mmHg at sea level.
- Barometric pressure decreases with altitude and varies with weather, affecting oxygen availability.



✓ Summary Table

Result	Effect on Hb-O ₂ Curve	Concept
↓ O ₂ affinity, more O ₂ released	Right shift	↑ 2,3-BPG
More O ₂ released to tissues	Right shift	↑ CO ₂ / ↓ pH (Bohr Effect)
More O ₂ released	Right shift	↑ Temperature
↑ O ₂ affinity, less O ₂ released	Left shift	↓ 2,3-BPG / ↓ CO ₂ / ↑ pH / ↓ Temp



OXYHEMOGLOBIN DISSOCIATION CURVE

