OXYGEN TRANSPORT IN BLOOD

A. Dissolved O_2 (physical solution)
   1. amount directly proportional to P_{O2} (oxygen partial pressure)
   2. not generally insignificant at normal P_{O2} since O2 is not very soluble
   3. can become significant in hyperbaric conditions (very high P_{O2})

B. Bound to Hemoglobin (Hb)

   1. Reaction

$$Hb + 4O_2 = Hb(O_2)_4$$

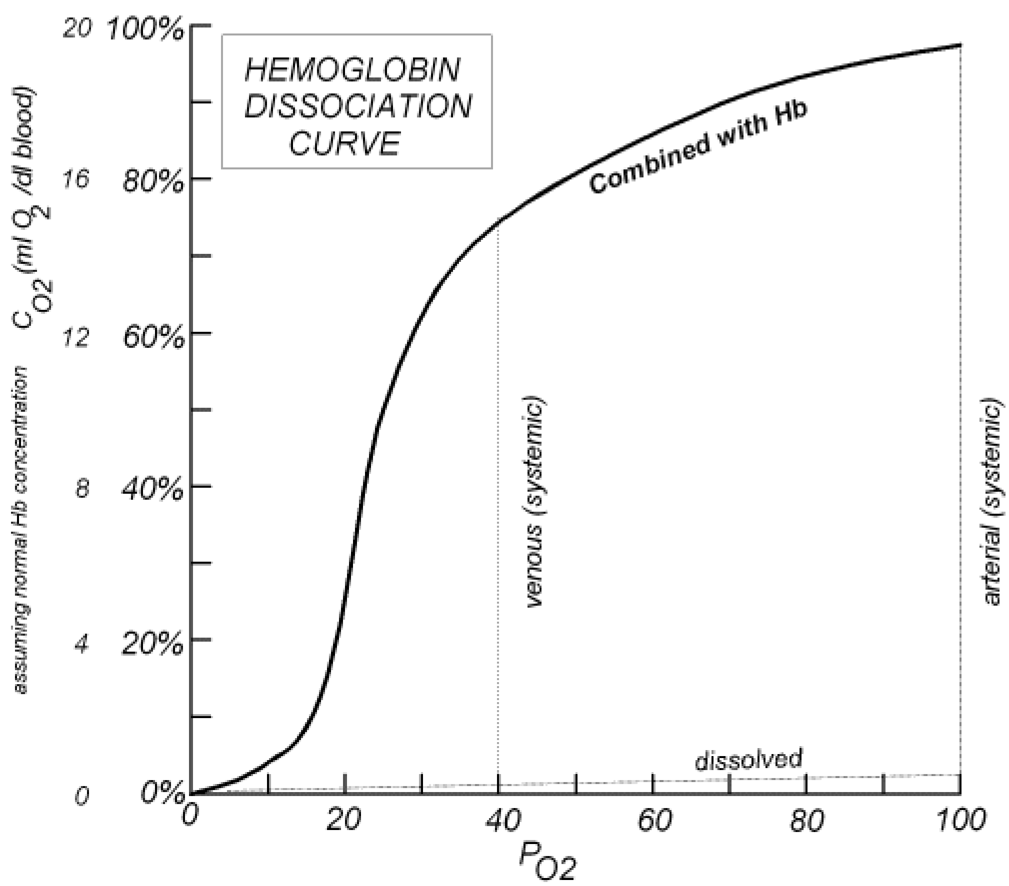
1 gm 1.34 ml

Hb = Reduced hemoglobin (deoxygenated, blue or cyan)
HbO_2 = Oxygenated hemoglobin, oxyhemoglobin (red)

Note: <u>Cyanosis</u> (bluish color of skin or mucosa) occurs when blood concentration of reduced Hb > 60-80 gm/l (6-8 gm/dl)
Note affinity of Hb for carbon monoxide (200x O_2 affinity)

   2. Binding Capacity
   1 gm of normal Hb can bind a maximum of 1.34 ml O_2 (100% saturation)

   3. Shape of Hb-O_2 <u>dissociation</u> (or saturation) curve
   Expressed as % of Hb maximum capacity as a function of P_{O2}



OXYGEN TRANSPORT (continued)

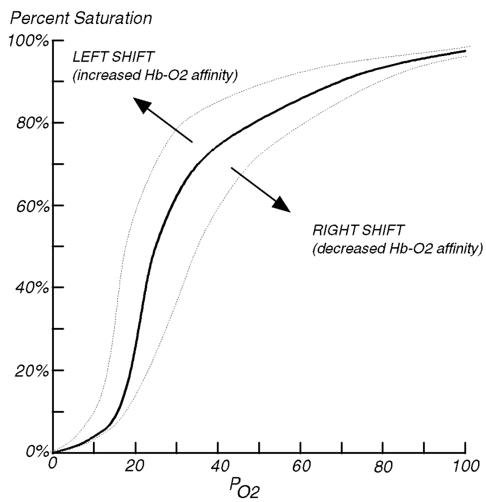
Note points

P_{O2} = 40 mmHg ⇒ Saturation = 75%
P_{O2} = 100 mmHg ⇒ Saturation = 97.5%

Note that blood is almost completely saturated at normal alveolar P_{O2}

4. Changes in shape ("shifts" of Hb-O2 dissociation curve)

Curve not constant but can shift with changes in physiological conditions



B. 5. Influences on the Dissociation Curve

a. pH: when H^+ combines with Hb, Hb-O_2 attraction is reduced (noncompetitive inhibition)

H^+⇑ ⇒ Right shift of dissociation curve

b. P_{CO2}: when CO_2 combines with Hb, Hb-O_2 attraction is reduced (noncompetitive inhibition)

P_{CO2}⇑ ⇒ Right shift of dissociation curve

c. Blood temperature: increased temperature reduces Hb-O_2 attraction

Temperature⇑ ⇒ Right shift of dissociation curve

Note: a, b, and c above aid in releasing O_2 from Hb in rapidly metabolizing tissue; also aid in uptake of O_2 by Hb in the lungs

BLOOD OXYGEN TRANSPORT (continued)

B. 5. Influences on the Dissociation Curve (continued)

d. Diphosphoglycerate (DPG): When present, binds to Hb, interfering with O_2 uptake

DPG⇑ ⇒ Right shift of dissociation curve

DPG produced in red cell

In response to chronic hypoxia, DPG production increases; aids in release of O_2 from Hb

e. Molecular species of Hb: fetal Hb binds O_2 more tightly then adult Hb (less sensitive to DPG)

Note: Enables fetal Hb to better compete with maternal Hb for O_2 in the placenta

C. Normal Hb Concentration in Blood

Male	160 gm Hb / liter blood (16 gm / dl or 16 gm / 100 ml blood)
Female	140 gm Hb / liter blood (14 gm / dl)
"Physiological"	150 gm Hb / liter blood (15 gm / dl)

Note: In chronic hypoxia, release of the hormone erythropoietin leads to production of more red blood cells (erythrocytes) and increase Hb concentration

D. Total Blood Oxygen Content: sum of dissolved (generally minor) and bound to Hb (most)

1. Systemic arterial blood: with a normal concentration of Hb and a saturation of 97.5% at P_{O2} of 100 mmHg, arterial oxygen content is about 200 ml O2 / liter blood (20 ml O2/dl blood)

2. Systemic venous blood: at rest, with a normal tissue utilization of O2 and a normal blood flow, about 50 ml of O2 is taken from each liter of blood, leaving venous blood with about 75% saturation and an O2 partial pressure of 40 mmHg

Note O_2 reserve in blood

Note effect of increased O_2 uptake, as in exercise

Note effect of anemia (low blood Hb)

Note effect of polycythemia (high blood Hb)

AC Brown
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CARBON DIOXIDE TRANSPORT

A. Mechanisms of Transport

1. <u>Physical solution</u>

   a. proportional to P_{CO2}
   b. about 25 x more soluble than O_2

2. <u>Combined with proteins</u> in the plasma

   a. termed <u>carbamino-CO_2</u>
   b. combines mainly with Hb
      CO_2 + Hb = Hb-CO_2
   c. when CO_2 combines with Hb, it tends to reduce Hb affinity for O_2
   d. when O_2 combines with Hb, it tends to reduce Hb affinity for CO_2

3. Combined with water to form <u>carbonic acid</u>

   a. $CO_2 + H_2O = H_2CO_3$

   b. the enzyme <u>carbonic anhydrase</u> is required for this reaction to go to completion during passage through the capillary bed

      Note: carbonic anhydrase in the blood is mainly in red cells

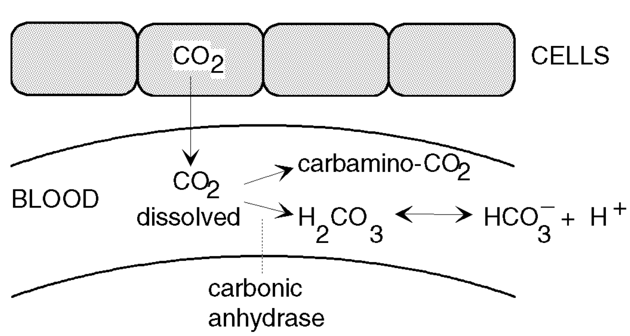
4. <u>Bicarbonate ion</u>, from dissociation of carbonic acid

   a. $H_2CO_3 = H^+ + HCO_3^-$

   b. spontaneous reaction, catalyst not required

   c. equilibrium at normal blood pH is very much toward formation of HCO_3^-

   Systemic Tissue:



CARBON DIOXIDE TRANSPORT (continued)

A. 5. Distribution of CO_2 in blood

	ml CO_2 / liter	Fraction of total blood CO_2
Dissolved CO_2	30-50	5-10%
Carbamino-CO_2	30-50	5-10%
H_2CO_3	small	< 1%
HCO_3^-	400-500	80-90%

B. Blood Carbon Dioxide Content

1. Systemic arterial blood (normal)

   a. $P_{a\text{-}CO2}$ = 40 mmHg (equilibrate with alveolar P_{CO2})

2. Systemic venous blood (normal, at rest)

   b. $P_{v\text{-}CO2}$ = 46 mmHg (from dissociation curve)