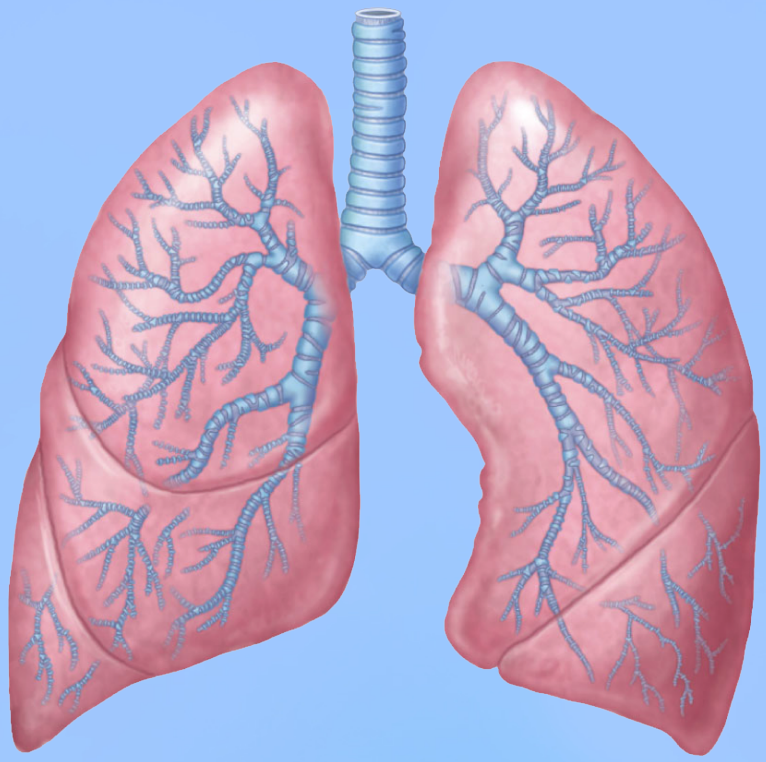
6 Oxygen and carbon dioxide transport



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Respiratory Block

Objectives:

1. Understand the forms of oxygen transport in the blood, the importance of each.

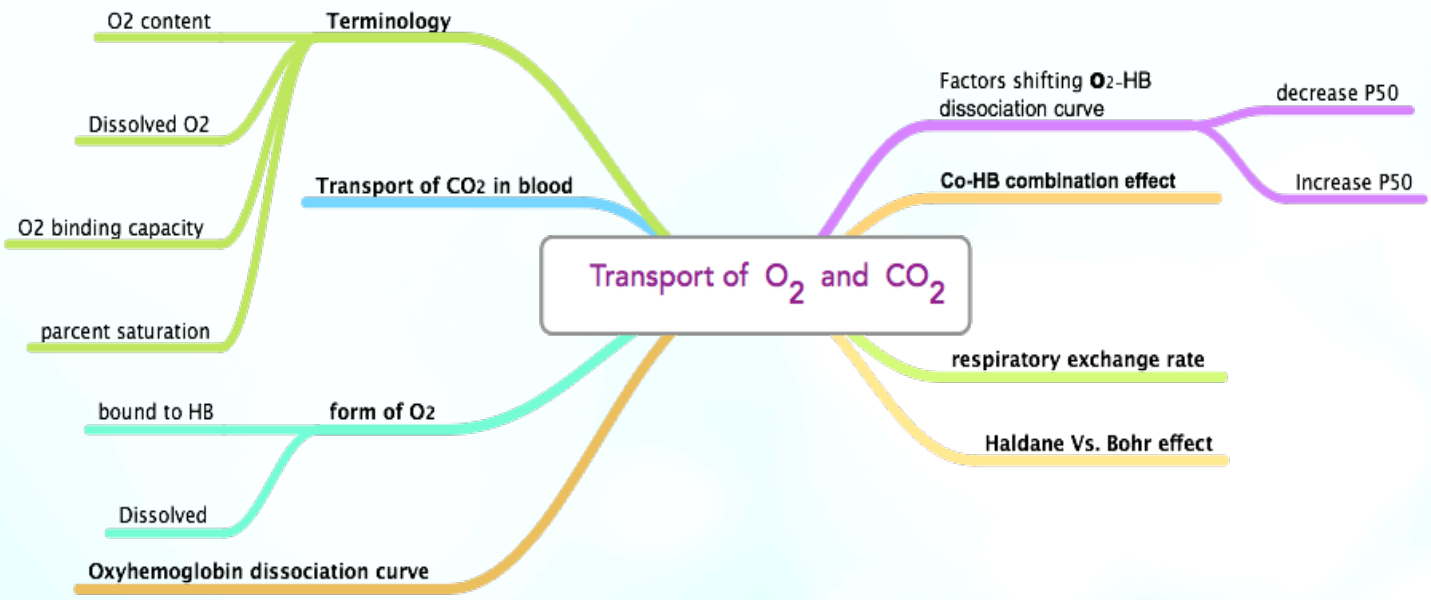
2. Differentiate between O2 capacity, O2 content and O2 saturation.

3. Describe (Oxygen- hemoglobin dissociation curve)

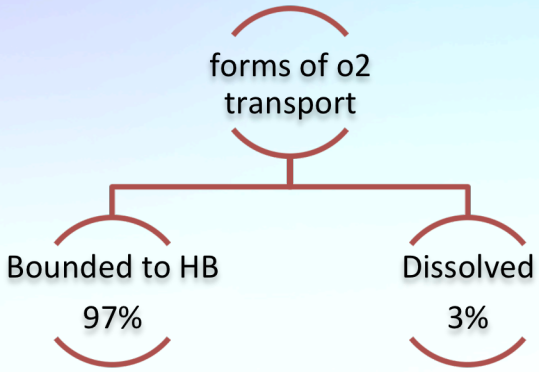
4. Define the P50 and its significance.

5. How DPG, temperature, H+ ions and PCO2 affect affinity of O2 for Hemoglobin and the physiological importance of these effects.

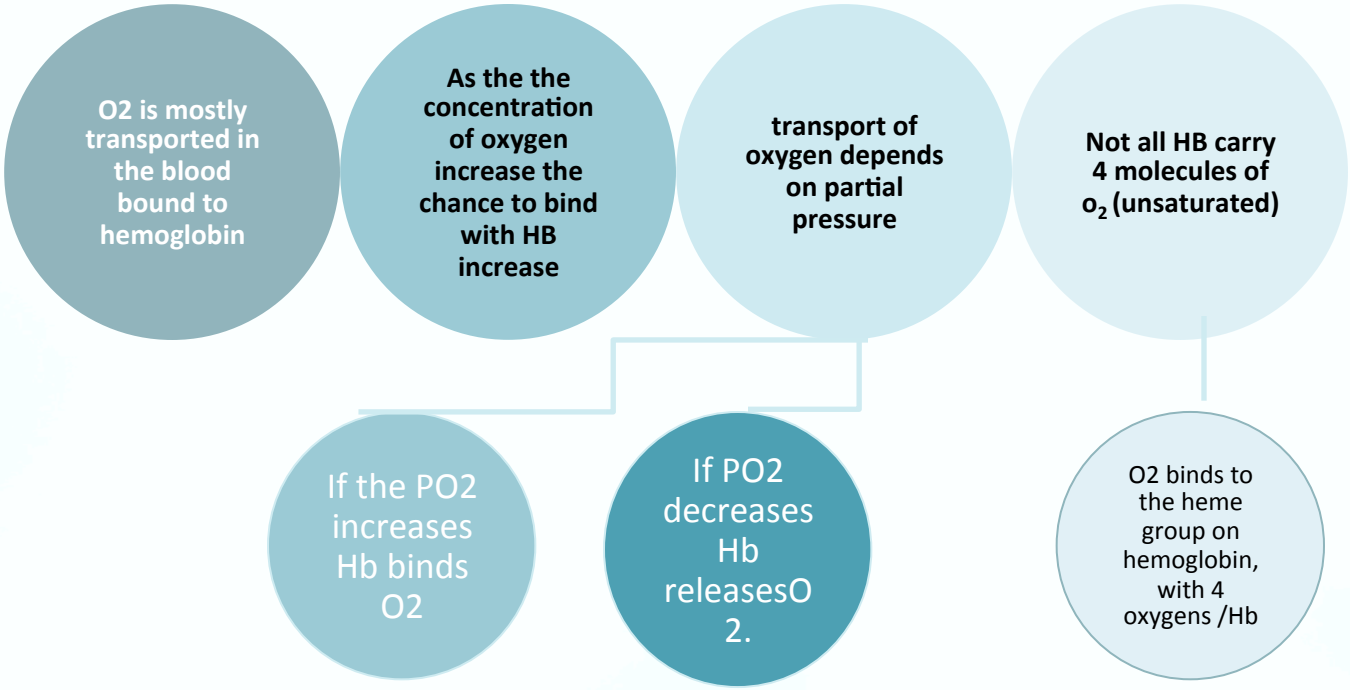
Mind Map:



FORMS OF O2 TRANSPORT



TRANSPORT OF O_2 AND CO_2 IN THE BLOOD AND BODY FLU



TERMINOLOGY

O2 content	• amount of O2 in blood (mL O2/100 mL blood)
O2-binding capacity	• maximum amount of O2 bound to hemoglobin (mL O2/100 mL blood) measured at 100% saturation.
Dissolved O2	• Unbound O2 in blood (mL O2/100 mL blood).
percent saturation	• % of heme groups bound to O2
% saturation of HB	$\frac{\text{oxygen content}}{\text{oxygen capacity}} \times 100$

TRANSPORT OF O_2 AND CO_2 IN THE BLOOD AND BODY FLU

When blood is 100% saturated with O2:

- ach ml of Hb carry 1.34 ml O2 So O2 content = 15g Hb x 1.34 O2=20 ml.

But when the blood is only 97% saturated with O2:

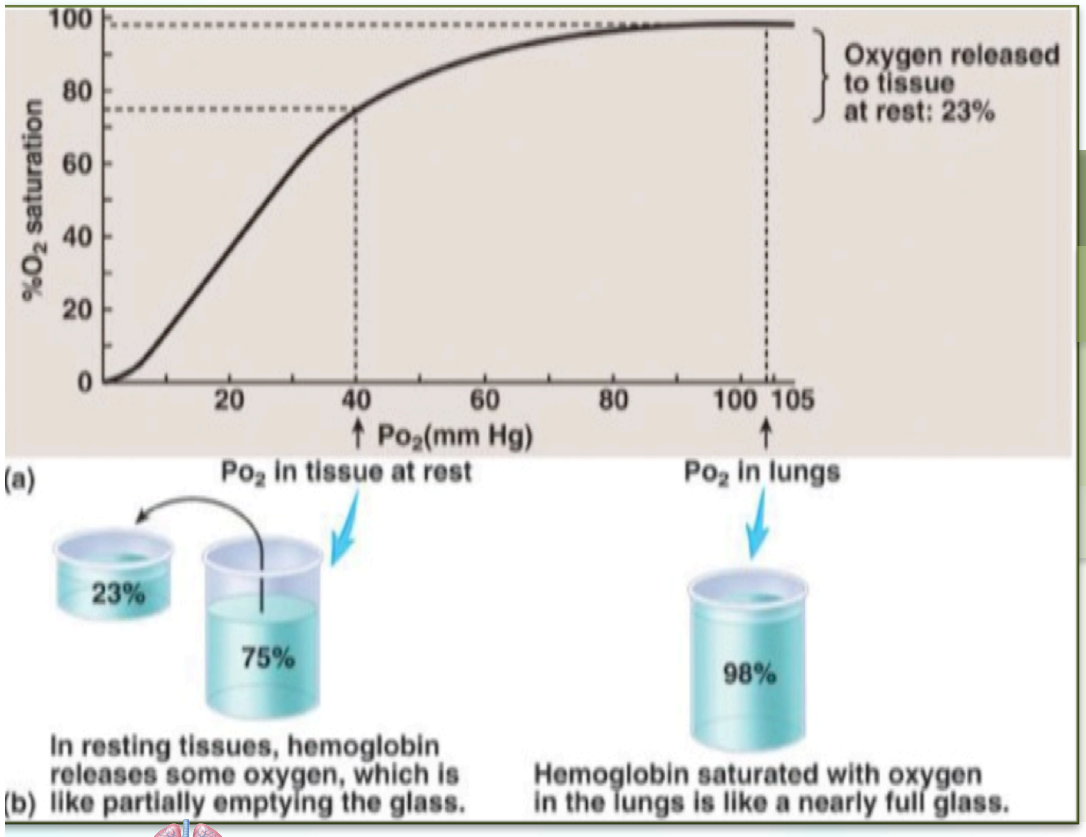
- each 100 ml blood contain 19.4 ml O2).
- So O2 content in venous blood =19.4-5= 14.4 ml.
- Amount of oxygen released from the hemoglobin to the tissues is 5ml O2 per each 100ml blood.

During strenuous exercise

The oxygen uptake by the tissue increases 3 folds so 15 ml O2 is given /100 ml blood So O2 content in venous blood =19.4-15=4.4 ml O2 /100ml blood.

At rest tissues consume 250 ml O2 /min and produce 200ml CO2

OXYGEN TRANSPORT IN THE BLOOD



FEATURES OF THIS CURVE

The relation between PO2 and Hb-O2 is not linear.

To measure how well is binding between oxygen and HB

The curve is called Oxyhemoglobin Saturation Curve

It is S- shaped or sigmoid

Higher Po_2 = higher saturation of Hb with O_2

Loading of O_2 in the lung & unloading in the tissue (lower pressure)

NOTE

The reason why the percentage of saturation is 97 is because of the physiological shunt that let a little amount of venous blood (unsaturated) get in the circulation.

OXYGEN TRANSPORT IN THE BLOOD

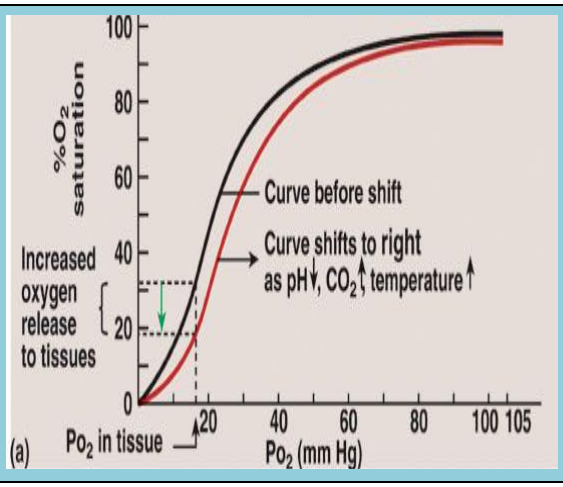
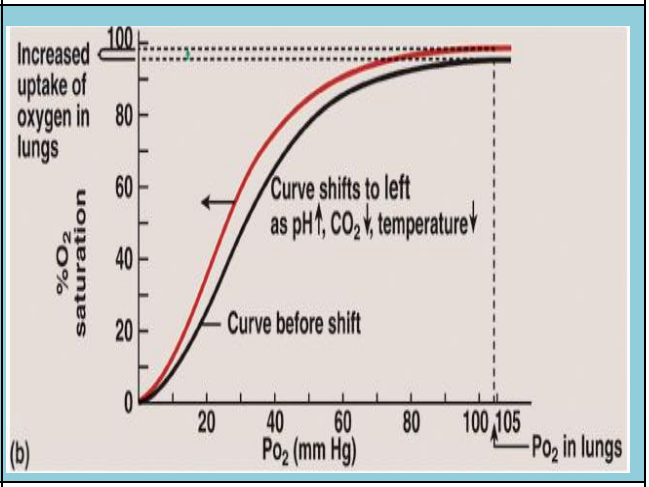
The position of the dissociation curve can be determined by measuring the P50

P50: The arterial PO2 at which 50% of the Hb is saturated with O2, **normally P50= 26.5**

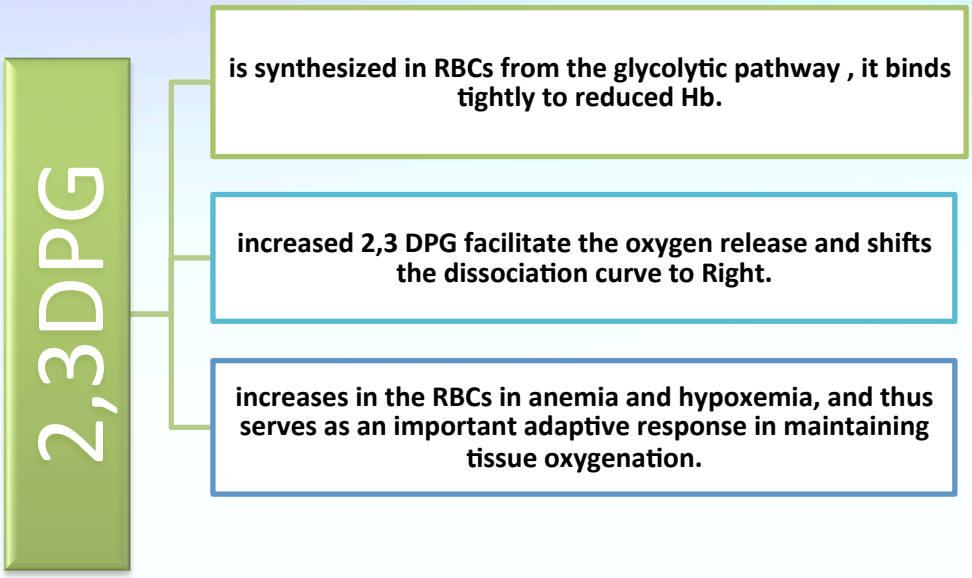
Increased P50 means decreased affinity or shift of the curve to right

Decreased P50 means increased affinity of Hb to O2 or shift of the curve to left

OXYHEMOGLOBIN DISSOCIATION CURVE

	Right shift	Lift shift
What is it?	Right shift means the oxygen is unloaded to the tissues from Hb.	Light shift means loading or attachment of oxygen to Hb.
It's curve		
Other factors causing it (other than P50)	**Increase :** ✓ Temp. ✓ PCO_2 ✓ 2,3-DFG(will be exlaine in the next pages) ✓ H+ **Dcrease:** ✓ PH	**Dcrease**: ✓ Temp. ✓ PCO_2 ✓ 2,3-DFG ✓ H+ **Increase**: ✓ PH
Affinity (between O2 HB)	lowe	High (because it is saturated with less partial pressure)
Which one has more benefit for the tissue	for the benefit of the tissue because it release more O_2 to the tissue(due to the lowe affinity)	Not for the benifite of the tissue becuse the oxygen reaching the tissue is amount of decreased (due to the high affinity)
Conditions wher it happens	during exercise	✓ fetas ✓ Combination of Hb with Co

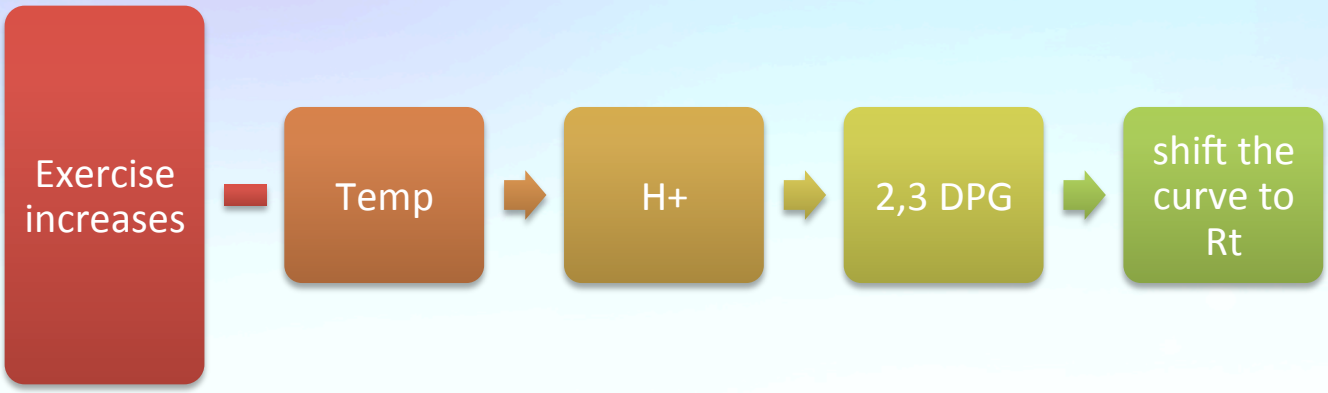
2,3 DPG (DIPHOSPHOGLYCRATE)



BOHR EFFECT & HALDANE EFFECT

	Bohr effect	Haldane effect
Difenation	Effect of carbon dioxide and hydrogen ions on the curve	When Oxygen binds with hemoglobin, carbon dioxide is released- to increase CO2 transport
At lung	Movement of CO2 from blood to alveoli will decrease blood CO2 &H+ →shift the curve to left and increase O2 affinity to Hb allowing more O2 transport to tissues	Binding of Hb with O2 at the lung causes the Hb to become a stronger acid and , this in turn displaces CO2 from the blood and into the alveoli
At tissue	The reverse occur	
		Change in blood acidity during CO2 transport: Arterial blood has a PH of 7.41 that of venous blood with higher PCO2 falls to 7.37 (i.e change of 0.04 unit takes place)

Shifts of dissociation curve during exercise:



UTILIZATION COEFFICIENT

Utilization Coefficient

- The percentage of the blood that gives up its oxygen as it passes through the tissues capillaries

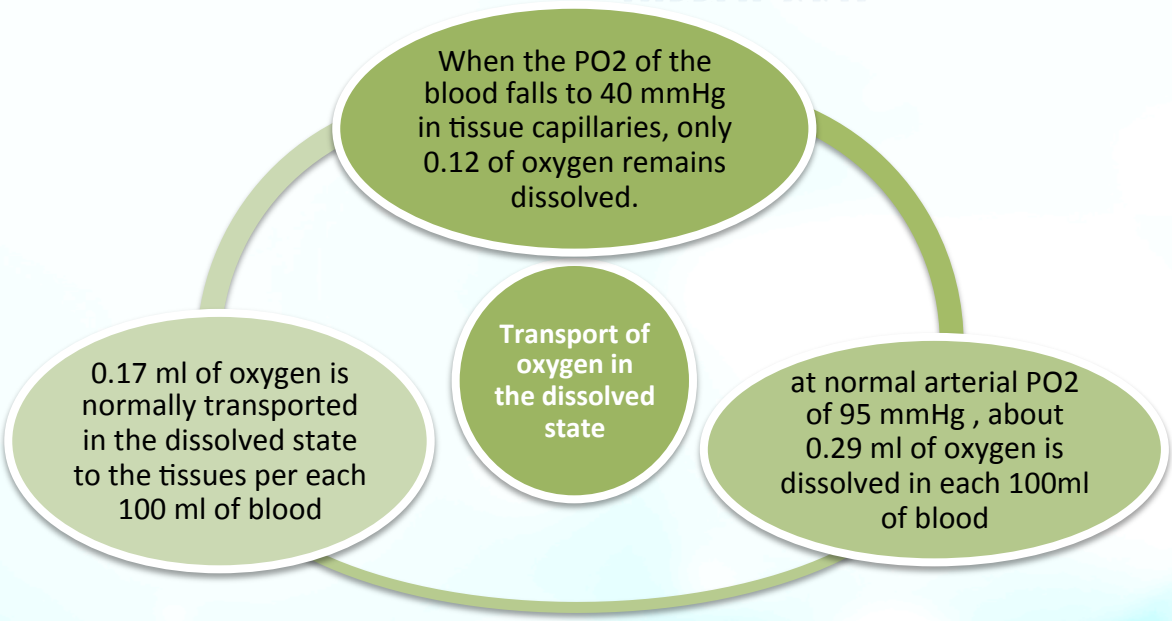
counting it:

$$= \frac{O2\ DELIVERED\ TO\ THE\ TISSUE}{O2\ CONTENT\ OF\ ARTERIAL\ BLOOD}$$

Values

- ✓ Normally at rest = 5ml/20 ml= 25%
- ✓ During exercise it = 15 ml/20 ml= 75 % - 85%

TRANSPORT OF OXYGEN IN THE DISSOLVED STATE (3%)



COMBINATION OF HB WITH CO DISPLACEMENT OF OXYGEN:

CO combines with Hb at the same point on the Hb molecule, as does oxygen

Co binds with Hb about 250 times as much as O2 (affinity of Hb to CO is very high (250 times) that to O2.It causes Left shift of the O2-Hb curve.

TRANSPORT OF CARBON DIOXIDE IN THE

CARBON DIOXIDE IS TRANSPORTED IN THREE FORMS.

- Dissolved CO2 7%
- bicarbonate ions 70 %
- Carbaminohemoglobin[(1)] (with Hb) 23%.

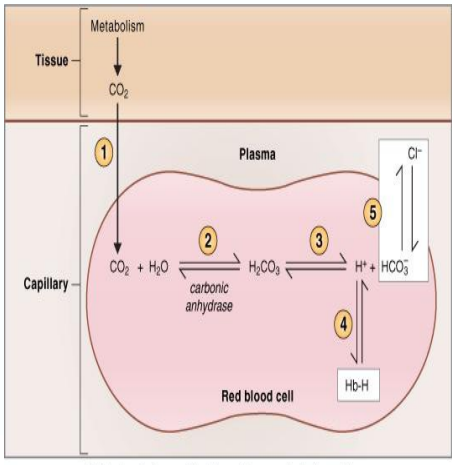
NOTE

(1) NOTE that it's not carboxihemoglobin(which is binding of monoxide with HB)

✓ Each 100 ml of blood carry 4 ml of CO2 from the tissues/min.

FORMATION HCO3 - AND CHLORIDE SHIFT:

1- **After formation of Carbon dioxide in the tissue, it has to enter the RBCs**
2- **CO_2 will diffuse and enters the capillaries**
3- **In plasma part of CO_2 will dissolve**
4- **Other part of CO2 will enter the RBC and bind to the H2O in it, with the present of Carbonic anhydrase Enzyme (only present in the RBCs) to make carbonic acid (which is a weak acid and easily disassociated) when Carbonic acid dissociated it gives Hydrogen and bicarbonate**
5- **When bicarbonate is formed in RBC it will leave the RBC and enters the circulation(plasma) until it reaches the lungs (when bicarbonate leaves the RBCs chloride enters the RBC to maintain equal charges known as chloride shift)**
6- **During it's movement from tissue capillaries to pulmonary capillaries it works as a buffer (know that bicarbonate is one of the chemical buffers of the blood that prevents changes in the PH)**
7- **When it reaches the pulmonary capillaries, it has to change into CO_2 (to remove it from the blood), so it binds with hydrogen to make carbonic acid, which will dissociate in the pulmonary capillaries into CO_2 and water (oppose to what happened in the RBCs)**
8- **Then CO2 will diffuse through pulmonary capillaries into the wall of alveoli (gas exchange) and O_2 will enter (Haldan effect)**



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Respiratory exchange ratio (respiratory quotient):

$$R = \frac{Rate\ of\ carbon\ dioxide\ output}{Rate\ of\ oxygen\ uptake}$$

- Normally it is 4/5= 82%
- When Carbohydrate diet is used R = 1
- When fats only is used R=0.7
- A person on normal diet R=0.825

Q1: if po2 decreased then:

A. Hemoglobin is fully saturated
B. Hemoglobin binds to o2
C. Hemoglobin release o2
D. Po2 has no effect on hemoglobin

Q2: o2 content in venous blood equals:

A. 1.34 ml
B. 20 ml
C. 23 ml
D. 14.4 ml

Q3: a factor that shifts the oxyhemoglobin curve to the right:

A. Increased 2.3 DPG
B. Decreased H
C. Decreased temperature
D. Increased ph.

Q4: the majority of carbon dioxide is transported in blood in the form of :

A. Carbon monoxide
B. Bicarbonate ions
C. Dissolved co2
D. carbaminohemoglobin

Q5: tissue at rest:

A- Consume 300 ml O2/min and produce 250 CO2
B- Consume 250 ml O2/min and produce 200 CO2
C- Consume 200 ml O2/min and produce 250 CO2

Q6: The difference between (Bohr effect and Haldane effect) is :

A- Bohr talk about CO2 and Haldane talk about O2
B- Bohr talk about O2 and Haldane talk about CO2

Q7: When blood is 100% saturated with O2 each ml of Hb carry:

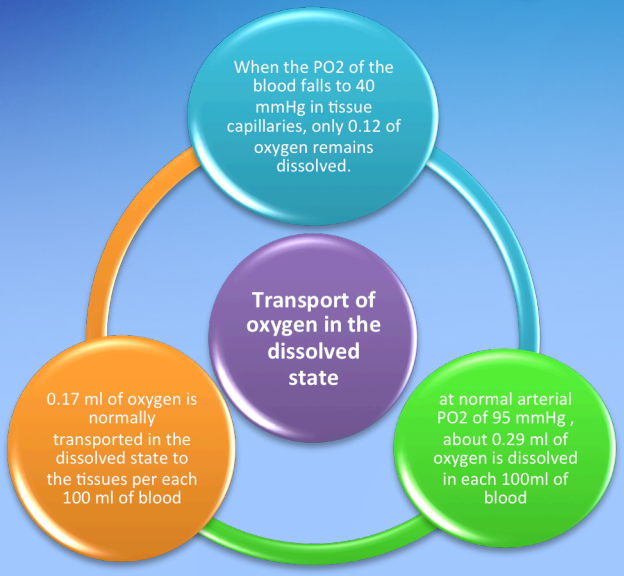
A- 1.34 ml
B- 2,34 ml
C- 1.94 ml

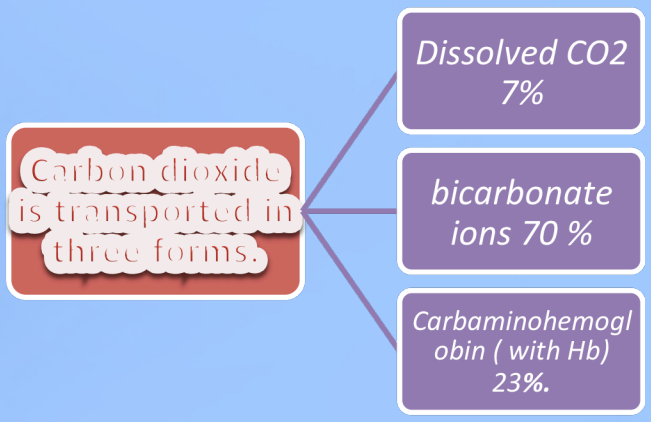
5- When Increased 2,3DPG, H+, Temperature, PCO2 that's mean the curve will shift to:

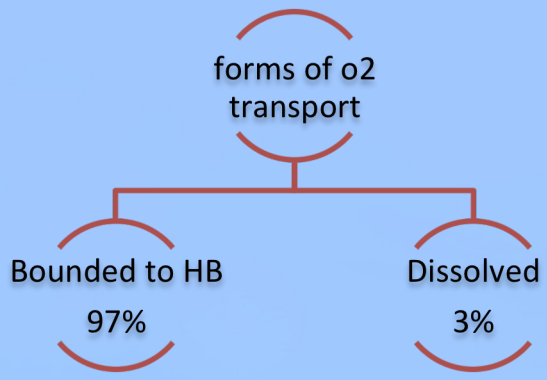
A- Left
B- Normal
C- Right

Answers: 1-C 2- D 3-A 4-B 5-B 6-A 7-A 8-C

Summary







http://www.youtube.com/watch?v=AyUtdqiOgCA