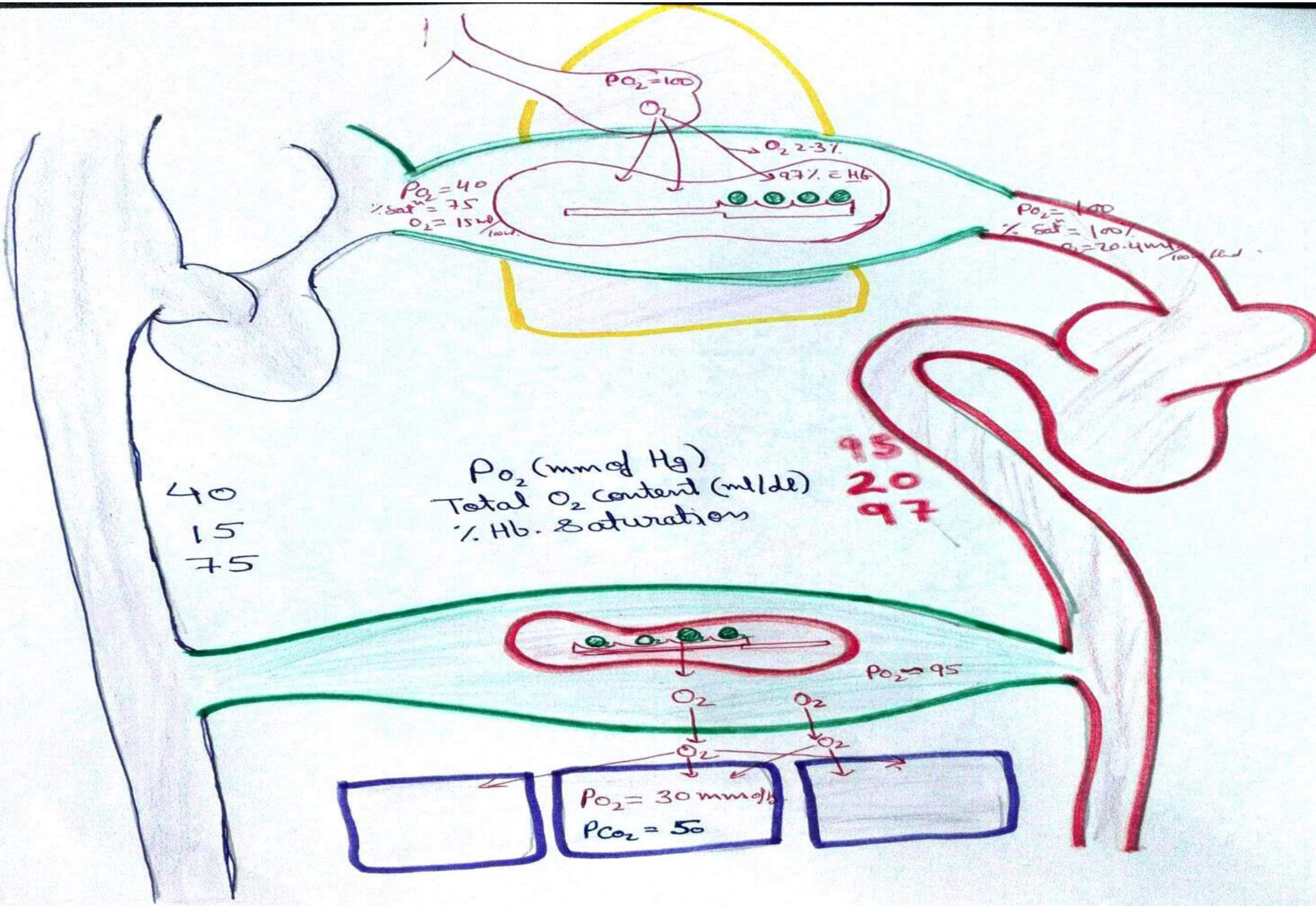
Dissociation Curve

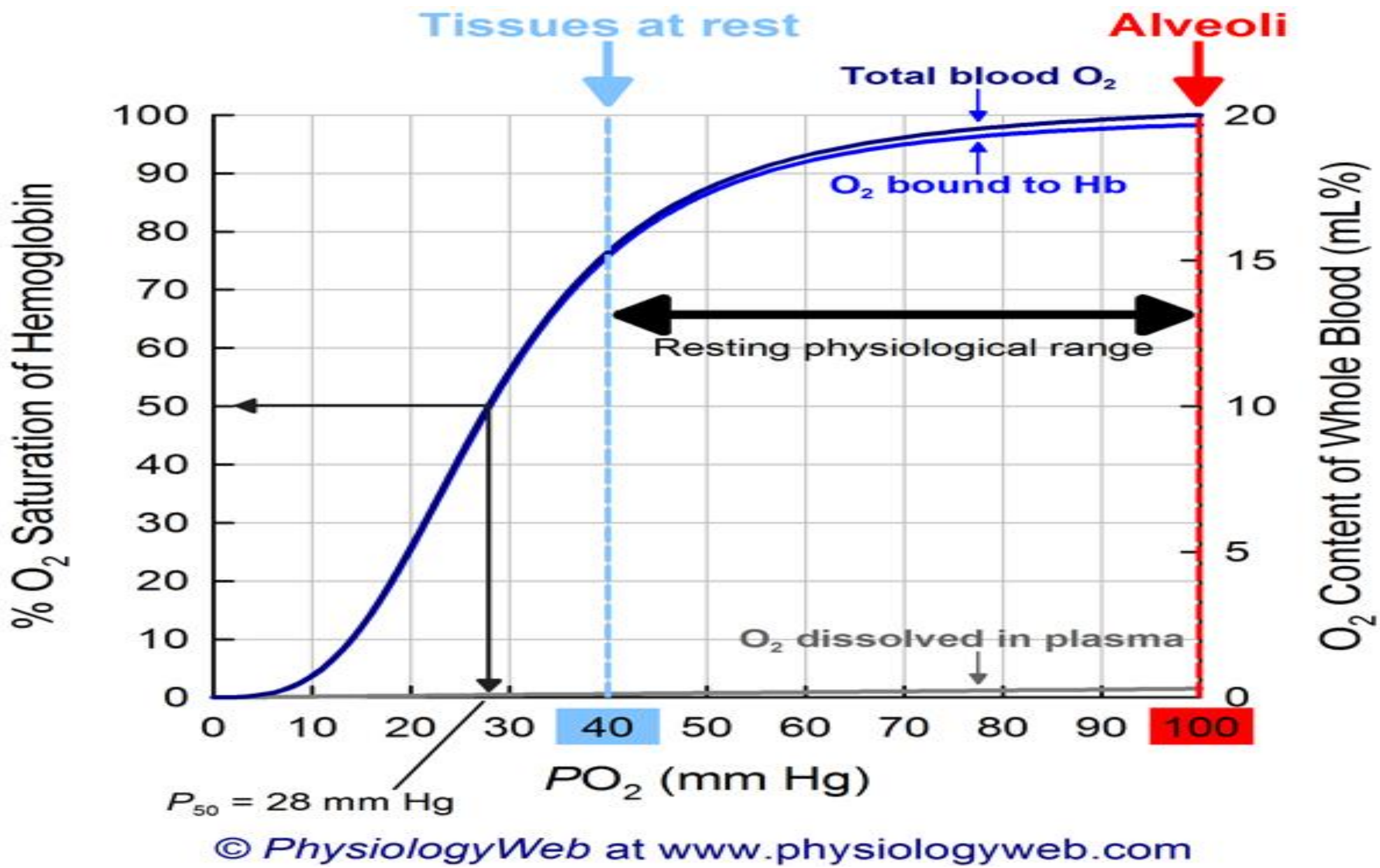
- **Oxy-Haemoglobin Dissociation Curve**
- **Bohr's Effect**
- **CO_2 Equilibration Curve**
- **C-D-H effect**

Oxy-Haemoglobin Dissociation Curve

- The loading and unloading of O_2 from Hb is described by oxy–haemoglobin dissociation curve.
- If Hb is allowed to equilibrate with various partial pressures of O_2 and the values are expressed in a graph plotted between the percentages of Hb on the ordinate against the partial pressure of O_2 on the abscissa, the curve obtained is called **oxyhaemoglobin dissociation curve.**
- For oxy-Hb the curve is "S" shaped


PO2=100
O2
O2 2-3%
97% ē Hb
PO2=40
% Satn = 75
O2= 15ml
PO2= 100
% Satn = 100%
O2=20.4ml
PO2 (mm of Hg)
Total O2 content (ml/dl)
% Hb. Saturation
40
15
75
95
20
97
PO2≃95
O2
O2
O2
O2
PO2= 30 mm of Hg
PCO2 = 50

Dissociation Curve



- For myoglobin (a muscle pigment capable of combining with O_2) the dissociation curve is rectangular hyperbola
- Under normal conditions, at a PO_2 of 100-mm Hg, blood leaving the lungs is 95–98 % saturated with O_2. Further increase in PO_2 do not increase O_2 carrying capacity of blood and the increased PO_2 increase the amount of O_2 in physical solution according to Henry's law.
- Because the hemoglobin is almost saturated when it leaves the lungs, it is the hemoglobin concentration that determines the amount of O_2 transported in blood

Volume of O_2 combined with haemoglobin

- One molecule of Hb can combine with 4 molecules of O_2
- One gram of Hb can transport 1.34ml of O_2
- The volume of O_2 combined with Hb in each 100 ml blood is = Haemoglobin concentration (g %) X volume of O_2 in each gram of Hb (ml/g) X Oxygen saturation (decimal) at the partial pressure of measurement.
- If Hb = 15g%, O_2 saturation 97.5 %,
- then 100 ml blood can transport 15 X 1.34 X 0.975 = 19.6 ml/100 ml or 19.6 volumes percent.

- *100 ml of blood carries 19.9 ml* of O_2 i.e. 19.6 ml in combination with haemoglobin and 0.3 ml in physical solution (98-99 % O_2 is transported in combination with haemoglobin).
- If Hb were not present, it would take 66.3 times more blood to transport the same amount of O_2.
- At a PO_2 of 100 mmHg in arterial blood, Hb is 97.5% saturated with O_2 and can transport 19.6 volumes percent O_2, when Hb concentration is 15g/100 ml blood.
- As the arterial blood reaches the tissue, O_2 is unloaded from the blood to tissues, the O_2 saturation falls to about 72 % in venous blood.
- At 72 % saturation of O_2, the blood will have 14.5 ml O_2 (Hb. 15g %). Each 100-ml blood unloads approximately 5 volume percent of O_2 and this is called *arterio-venous O_2 difference*.
- PO_2 of venous blood is 40 mm Hg.
- P_{50} of hemoglobin is that PO_2 at which haemoglobin is 50 % saturated with O_2. In human it is 26.6mmHg. It indicates affinity of hemoglobin for O_2
- P_{50} is similar for all Hb concentrations.

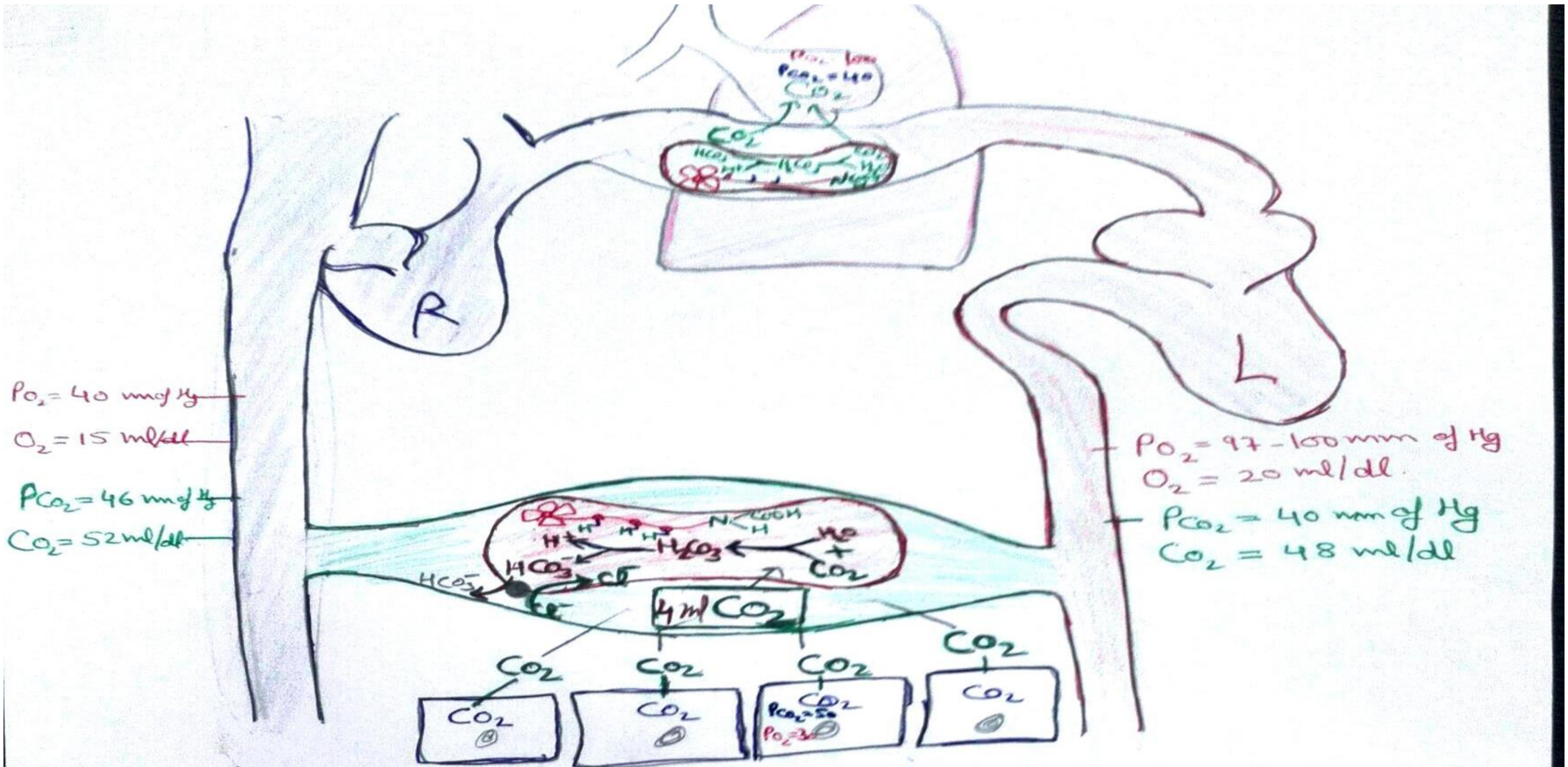
- Shift of dissociation curve to right results is greater release of O_2 from oxy Hb, i.e. a shift to right decrease the affinity of Hb to O_2.
- A shift to left increases the affinity of Hb to O_2. Hence, O_2 released from Hb is decreased.
- The extent of dissociation depends on (i.e.,) the positioning of the oxy haemoglobin dissociation curve is influences by.
  - **O_2 tension**
  - **CO_2 tension**
  - **H^+ ion concentration**
  - **Temperature**
- Concentration of BPG (2-3 bisphosphoglycerate) in erythrocytes
- Increase in H^+ ion concentration and CO_2 level shifts the curve to down and right as also increase in temperature and 2-3 BPG.

- The 2-3 BPG is normally present in erythrocytes in higher level than in other cells, it is a by product of glycolytic pathway and its level increases further **during chronic hypoxia** as during exposure to **high altitude, anemia, increased physical exertion etc.** When 2-3 BPG binds with hemoglobin, affinity of hemoglobin for O_2 is reduced and O_2 unloading is increased. Shifting the curve to down and right causes increase in release of O_2 from the Hb. Ruminant hemoglobin is unresponsive to 2-3 BPG.
- When metabolic rate of a tissue is increased, both pCO_2 and H^+ concentration increases; increased metabolic rate also increases heat production and temperature.
- The reduction in pH and rise in temperature reduces the affinity of hemoglobin for O_2 shifting the oxy-hemoglobin curve to the right, thereby increasing the unloading of O_2 at the tissue level. When the pH is reduced from 7.4 to 7.2, the hemoglobin saturation is reduced from **72 to 60%** indicating greater unloading of O_2.

- **The shift of oxy-Hb dissociation curve to down and right by increased CO_2 tension and H^+ ion concentration is termed as Bohr's effect.** An increasing concentration of H^+ and/or CO_2 will reduce the affinity of haemoglobin to O_2.
- This facilitates more O_2 unloading in the tissues especially in tissues with greater demand for O_2 like when a tissue's metabolic rate is increased with increase in CO_2 production.
- The pH of the tissue decreases, and it promotes the dissociation of O_2 from hemoglobin to the tissue, allowing the tissue to obtain enough O_2 to meet its demands.
- Conversely, in the lungs, where O_2 concentration is high, binding of O_2 causes hemoglobin to release H^+, which combines with HCO_3 to drive off CO_2 to alveoli.
- Since these two reactions are closely matched, there is little change in blood pH.

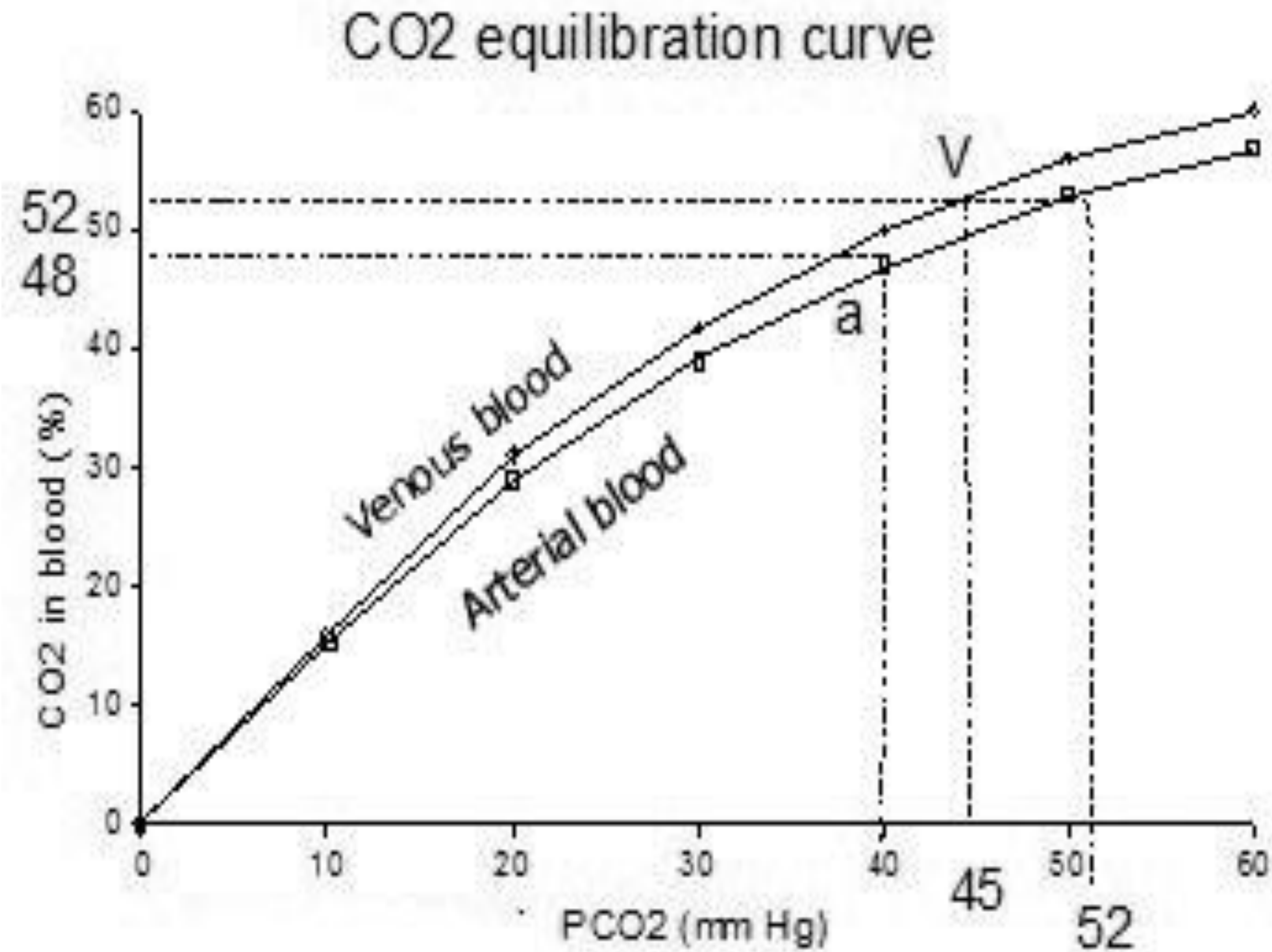
CO_2 Equilibration Curve

- The total quantity of CO_2 combined with blood in all forms of transport of CO_2 depends on PCO_2, which can be expressed through the CO_2 equilibration curve.
- Normal blood PCO_2 is **40 mm Hg in arterial blood** containing **48 volumes percent CO_2.**
- In venous blood PCO_2 is **45 mmHg** containing **52 volumes percent CO_2** and 4 volumes percent of CO_2 is actually exchanged in the process of transporting CO_2 from tissues to lungs. Valedictory



CO_2 Transportation :

- 90% HCO_3^-
- 5% Dissolved form
- 5% Carbamino form.



CO2 equilibration curve
CO2 in blood (%)
PCO2 (mm Hg)
Venous blood
Arterial blood
V
a
52
48
45
52
0
10
20
30
40
50
60

- The effect of O_2 on H^+ ion and CO_2 loading and unloading from haemoglobin is known as **Haldane effect or *C-D-H effect*.** i.e. oxygenation of hemoglobin reduces it's ability to bind with CO_2 Deoxygenation of the hemoglobin increases its ability to carry CO_2.
- This is a consequence of the fact that reduced (deoxygenated) hemoglobin is a better proton (H^+) acceptor than the oxygenated form.
- The upper part of the curve indicates that for every mm Hg increase in PCO_2, a greater volume of CO_2 is transported in venous blood than arterial blood which is due to the **Haldane effect.**
- If Haldane effect were not there, to transport the 4 volumes percent, PCO_2 of venous blood would have to be raised to 52 mm Hg.