Lecture Notes

UJ | SCHOOL OF MED

PHYSIOLOGY

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O2-Hb dissociation curve

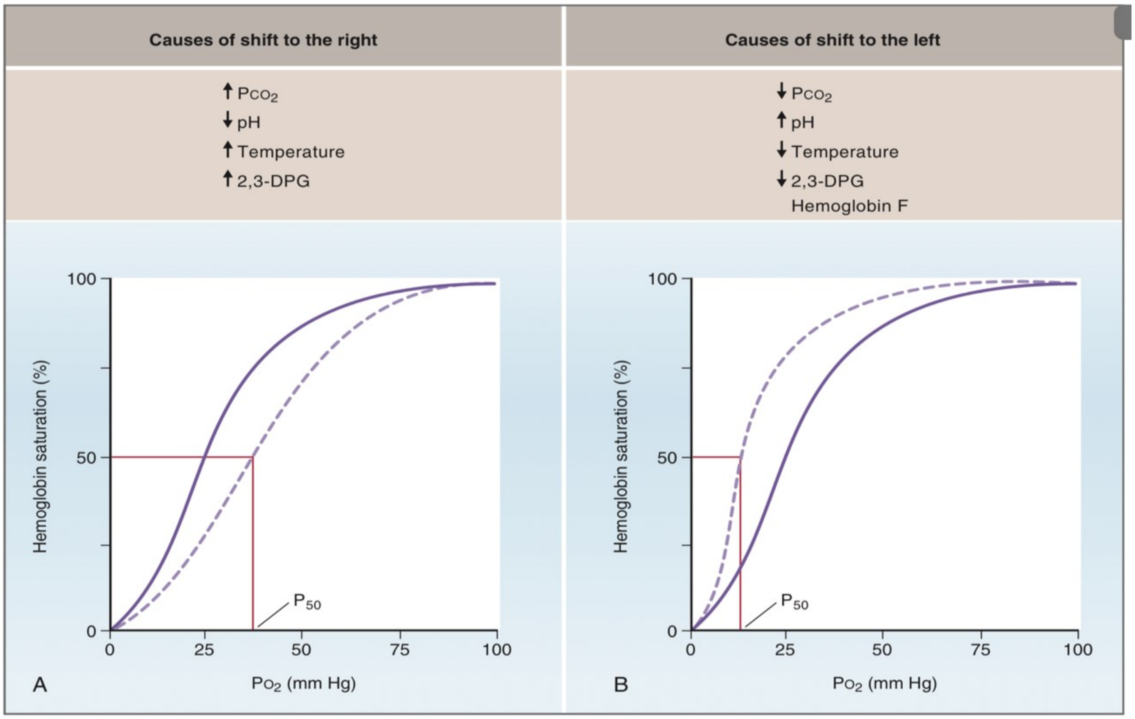


Fig. 5.22 Shifts of the O_2-hemoglobin dissociation curve. A, Shifts to the right are associated with increased P_{50} and decreased affinity. **B,** Shifts to the left are associated with decreased P_{50} and increased affinity. *2,3-DPG,* 2,3-diphosphoglycerate.

- Notes on the curve above:
  1) Sometimes in physiological conditions this curve is shifted to the right which means p50 is high and the affinity towards O2 is low (decreases), this makes the release of O2 easier → The body needs O2.
  2) Sometimes the curve shifts to the left which means p50 is decreased (less than 26 mm Hg) and the affinity towards o2 is high (increases) and that makes the release of o2 difficult.

- Factors that shift the curve to the right:
  1) Increase in pCO2.
  2) Decrease in the pH.
  3) Increase in the temperature.
  4) Increase in 2,3 BPG.

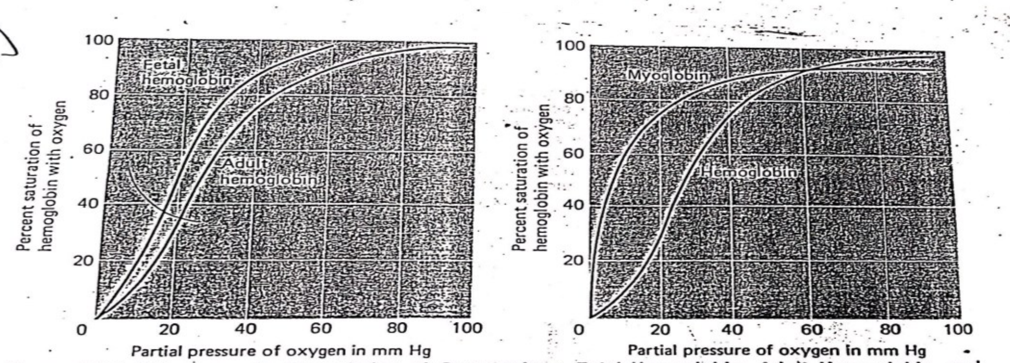


Figure 17.19 Differences in Dissociation of Oxygen from Fetal Hemoglobin, Adult Hemoglobin, and Myoglobin. The dissociation curve for fetal hemoglobin is to the left of that for maternal hemoglobin, indicating that fetal hemoglobin has a higher affinity for oxygen. Thus, when the mother's blood enters the placenta, it transfers oxygen to the fetus's blood. The dissociation curve for myoglobin (muscle hemoglobin) is far to the left of that for adult hemoglobin and has a hyperbolic shape. Thus, hemoglobin transfers oxygen readily to myoglobin. The myoglobin stores this oxygen until the oxygen pressure drops, as in exercise. Then the myoglobin releases its oxygen for use in cellular respiration. (Modified and reproduced with permission from J. H. Comroe, Jr., *Physiology of Respiration*, 2d ed., p. 185. Copyright © 1974 by Year Book Medical Publishers, Inc., Chicago.)

Notice that these curves illustrate the difference in dissociation of O2 from fetal Hb , adult Hb and myoglobin.

- Noticing the difference between the adult Hb and fetal Hb we can say that the affinity of fetal Hb towards O2 is higher than the adult Hb.
- This is also applied on myoglobin compared to adult Hb.
- When we compare the myoglobin and fetal Hb we notice that the affinity of myoglobin to O2 is higher than the affinity of fetal Hb towards O2.
- You can notice that the curve is shifted to the right under the effect of 2,3 BPG

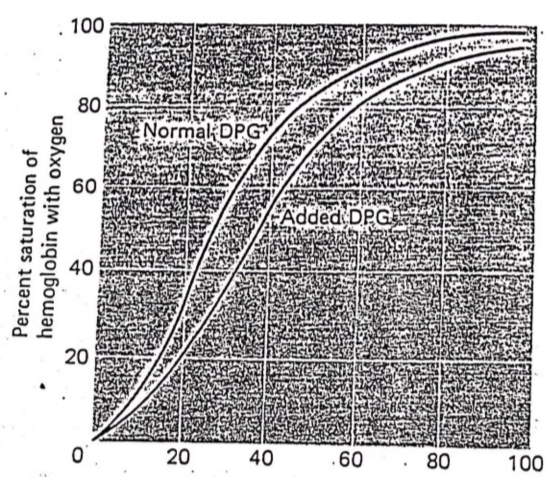
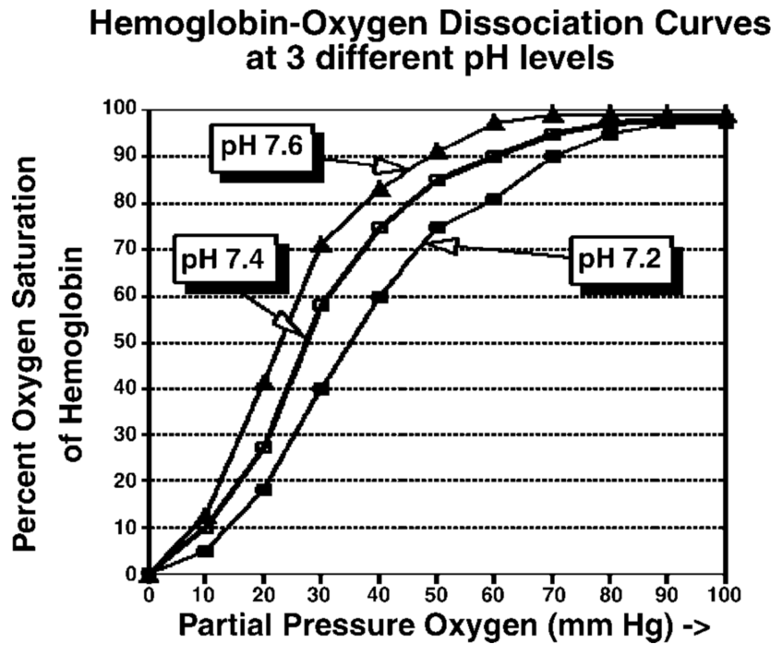
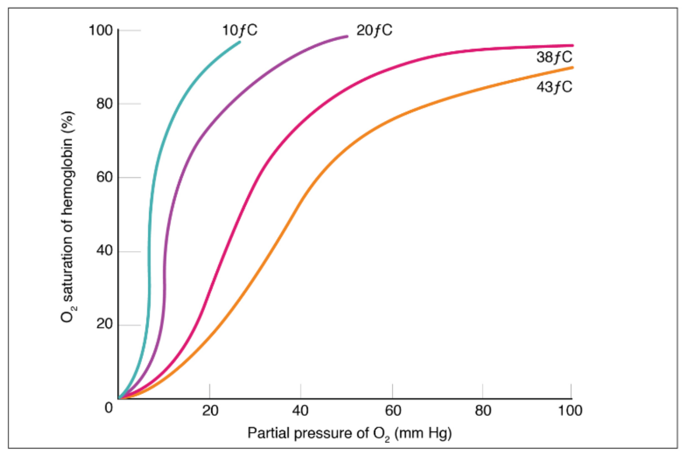


Figure 17.17 Effect of 2,3-Diphosphoglycerate (DPG) on Oxygen Dissociation from Hemoglobin. The formation of extra DPG in red blood cells, as occurs at high altitudes, shifts the dissociation curve to the right. In other words, DPG promotes the release of oxygen from hemoglobin. (Modified and reproduced with permission from J. H. Comroe, Jr., *Physiology of Respiration*, 2d ed., p. 185. Copyright © 1974 by Year Book Medical Publishers, Inc., Chicago.)

- Effect of Acidity : decrease in the pH causes the curve to be shifted to the right.



- High temperature causes the curve to shift to the right (decreases the affinity).
- Low temperature causes the curve to shift to the left (increases the affinity).



O2-Hb dissociation curve to different species.

- In the mouse there is a huge shift to the right while in the elephant there is a huge shift to the left.
- So, there is an effect for the mammalian size on oxygen dissociation from hemoglobin (different amount of activities in each animal).

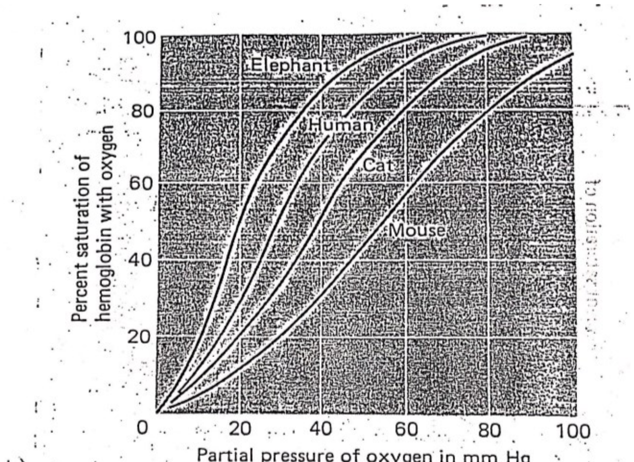


Figure 17.18 Effects of Mammalian Size on Oxygen Dissociation from Hemoglobin. Small mammals release oxygen more readily from hemoglobin than do large mammals. This difference is probably related to the greater need for oxygen in small mammals to support a greater heat production per unit of body weight. (Reprinted from K. Schmidt-Nielsen, *Federation Proceedings* 29 [1970]:1529.)

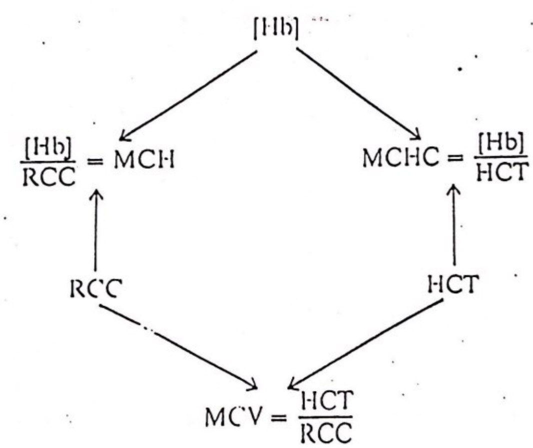
Erythrocyte parameters (indices)

What we already know:

1) Hb concentration: 15 g/100 ml in males ; 14 g/ 100 ml in females
2) HCT: 45% in males; < 40% in females
3) MCV: between 80-90 (few below 80 and few above 90 is normal) (yet, it's more accurate to say 80-100)
4) RCC: 5 millions in males; 4 millions in females

- By calculations we can conclude the other parameters (MCH , MCHC)

Relationships between the erythrocyte parameters. For the diagnostic evaluation of erythrocyte function it is usually necessary to measure three quantities: the *red cell count* RCC (μl^{-1}), the *hemoglobin concentration of the blood* [Hb] (g/l), and the *hematocrit* HCT. From these, three other characteristic parameters can be derived: the *mean corpuscular hemoglobin* MCH, the *mean corpuscular hemoglobin concentration* MCHC, and the *mean corpuscular volume* MCV. The relationships underlying these calculations are reflected directly in the definitions of the parameters and are summarized in the following diagram:



Given, for example, that RCC = $5 \cdot 10^6 \mu l$, [Hb] = 150 g/l and HCT = 0.45, the other parameters are as follows: MCH = 30 pg, MCHC = 333 g/l, and MCV = $0.09 \cdot 10^{-6} \mu l$ = 90 fl (femtoliters) = 90 μm^3 (the conversion among units is given on pp. 796f.).

* Values for Central Europe; for North America (according to Wintrobe) MCH = 29 pg

TABLE 32–2 Characteristics of human red cells.[a]

		Male	Female
Hematocrit (Hct) (%)		47	42
Red blood cells (RBC) ($10^6/\mu L$)		5.4	4.8
Hemoglobin (Hb) (g/dL)		16	14
Mean corpuscular volume (MCV) (fL)	$= \frac{Hct \times 10}{RBC\ (10^6/\mu L)}$	87	87
Mean corpuscular hemoglobin (MCH) (pg)	$= \frac{Hb \times 10}{RBC\ (10^6/\mu L)}$	29	29
Mean corpuscular hemoglobin concentration (MCHC) (g/dL)	$= \frac{Hb \times 100}{Hct}$	34	34
Mean cell diameter (MCD) (μm)	= Mean diameter of 500 cells in smear	7.5	7.5

[a]Cells with MCVs > 95 fL are called macrocytes; cells with MCVs < 80 fL are called microcytes; cells with MCHs < 25 g/dL are called hypochromic.

Table 27–5. Characteristics of human red cells.[1]

		Male	Female
Hematocrit (Hct)(%)		47	42
Red blood cells (RBC) ($10^6/\mu L$)		5.4	4.8
Hemoglobin (Hb) (g/dL)		16	14
Mean corpuscular volume (MCV) (fL)	$= \frac{Hct \times 10}{RBC\ (10^6/\mu L)}$	87	87
Mean corpuscular hemoglobin (MCH) (pg)	$= \frac{Hb \times 10}{RBC\ (10^6/\mu L)}$	29	29
Mean corpuscular hemoglobin concentration (MCHC) (g/dL)	$= \frac{Hb \times 100}{Hct}$	34	34
Mean cell diameter (MCD) (μm)	= Mean diameter of 500 cells in smear	7.5	7.5

[1]Cells with MCVs > 95 fL are called macrocytes; cells with MCVs < 80 fL are called microcytes; cells with MCHs < 25 g/dL are called hypochromic.

*The red blood cell indices are used as an aid in differentiating anemias. When these indices are combined with an examination of the red blood cells on the stained smear, a clear picture of red blood cell morphology may be obtained.

What should we know by now ?

1) The values for HCT , RCC , Hb and MCV.
2) We can calculate the MCH , MCHC according to the calculations above.
3) MCH Is the weight of Hb in one RBC.
4) MCH is not an important indices and the normal range is between 28-32.
5) MCHC is how much of the Hb in one RBC occupies the MCV .
6) MCHC is an important indices (content of the cell) and ranges between 32%-36%
7) There are no differencs between males and females regarding MCH and MCHC.

focus on what is highlighted in red above

- MCV
  1. (mean cell volume) = (hematocrit*10)/ RCC in millions fl
  2. Normal range is from 80-95.
  3. MCV indicates whether the RBCs are normal sized or not. Less than 80 is microcytic and more than 95 is macrocytic. So MCV indicates the volume of RBCs.

- MHC
  1. (mean cell hemoglobin) = (hemoglobin*10)/ RCC in millions pg
  2. Normally, values are between 28-32.
  3. MCH indicates the amount of hemoglobin in red blood cells and should always correlate with the MCV and MCHC. An MCH lower than 27 pg is found in microcytic anemia and with normocytic, hypochromic RBCS. An elevated MCH occurs in macrocytic anemias and in some cases of spherocytosis in which hyperchromia may be present.

- MCHC
  1. (mean cell hemoglobin concentration) = (hemoglobin*100)/ hematocrit
  2. Normal values are from 32%-36%
  3. MCHC indicates whether the RBCS are normochromic, hypochromic, or hyperchromic. MCHC below 32% indicates hypochromia. An MCHC above 36% indicates hyperchromia, and red blood cells with a normal MCHC are termed normochromic.

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