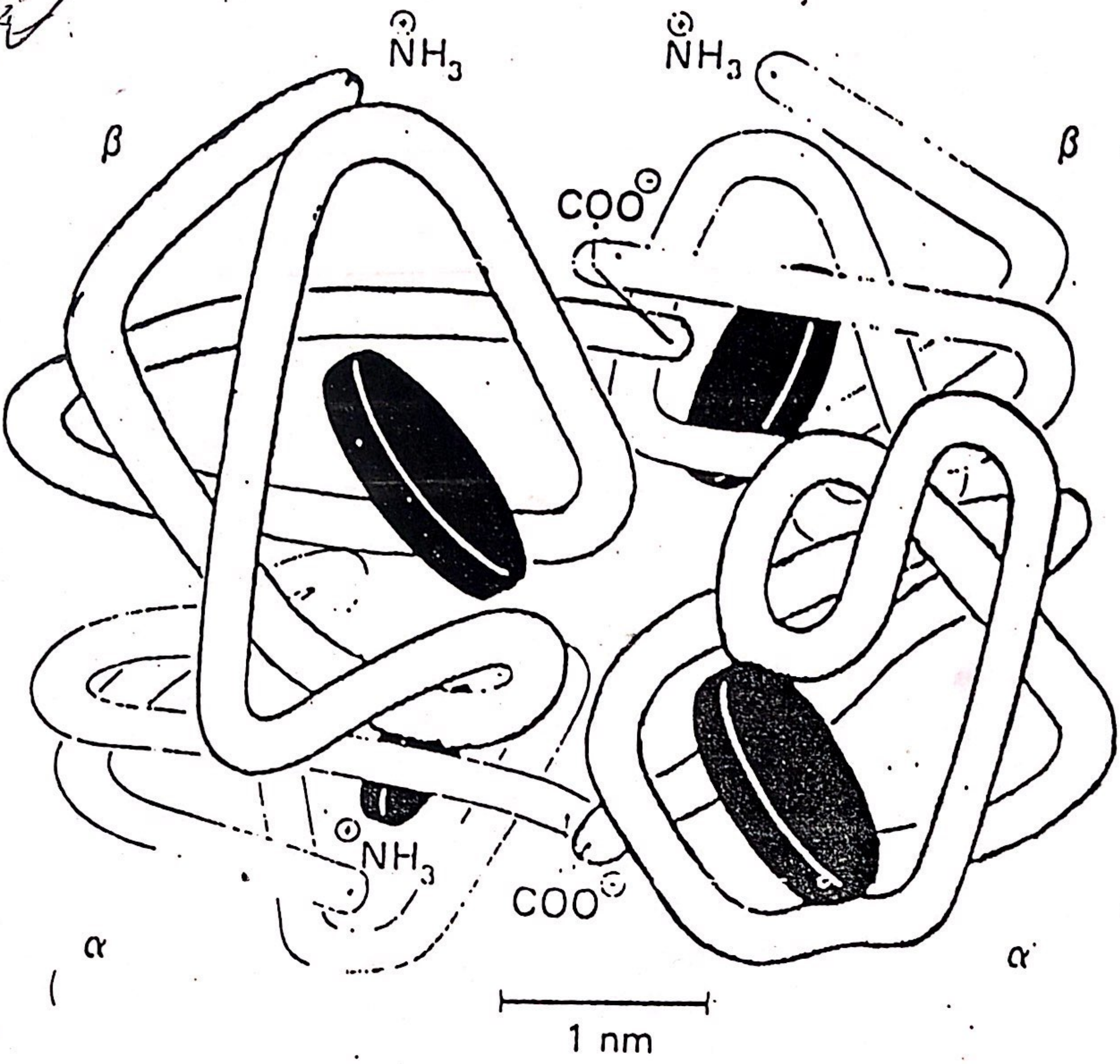


Figure 27–10. Diagrammatic representation of a molecule of hemoglobin A, showing the 4 subunits. There are two α and two β polypeptide chains, each containing a heme moiety. These moieties are represented by the disks. (Reproduced, with permission, from Harper HA et al: *Physiologische Chemie*. Springer-Verlag, 1975.)

ach α = 141 a.a

ach β = 146 a.a

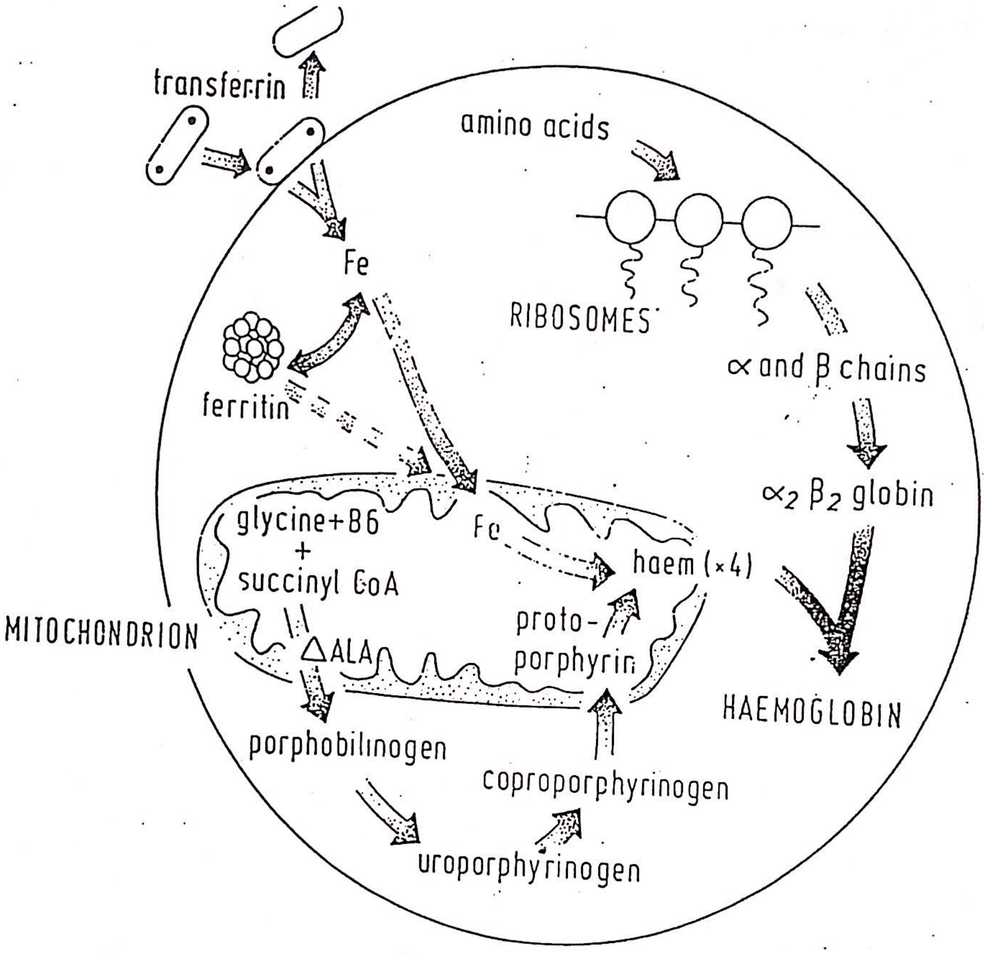


Fig. 1.7 Haemoglobin synthesis in the developing red cell. The mitochondria are the main site of protoporphyrin synthesis, iron is supplied from circulating transferrin and globin chains are synthesised on ribosomes. ΔALA = delta-amino laevolinic acid.

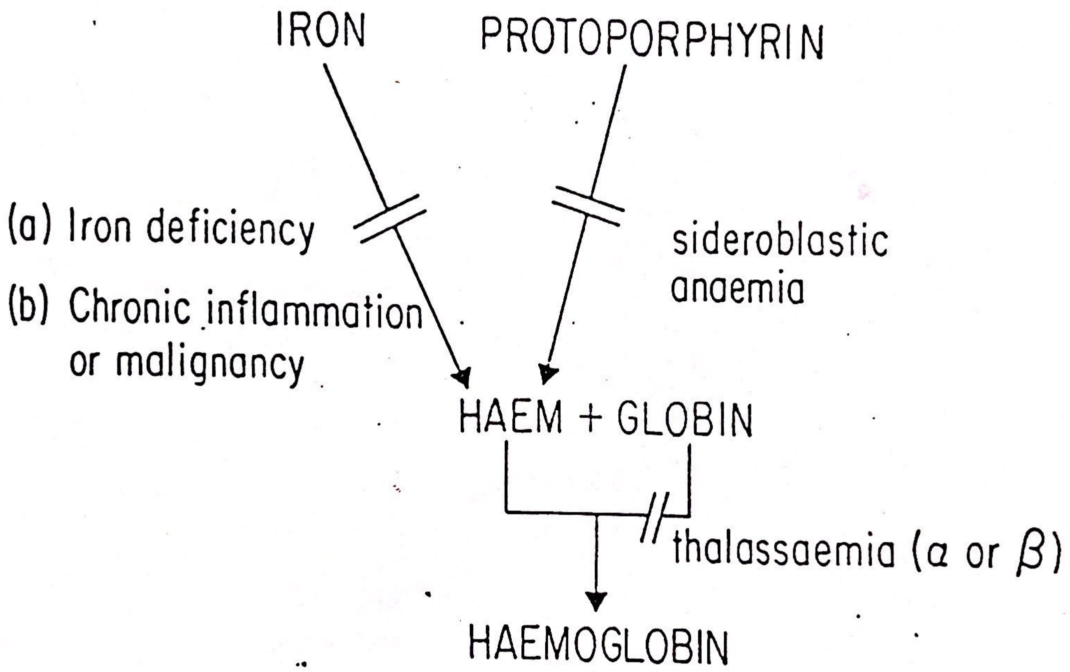


Fig. 2.1 The causes of a hypochromic microcytic anaemia. These include lack of iron (iron deficiency) or of iron release from macrophages to serum (anaemia of chronic inflammation or malignancy), failure of protoporphyrin synthesis (sideroblastic anaemia) or of globin synthesis (α or β-thalassaemia). Lead also inhibits haem and globin synthesis.

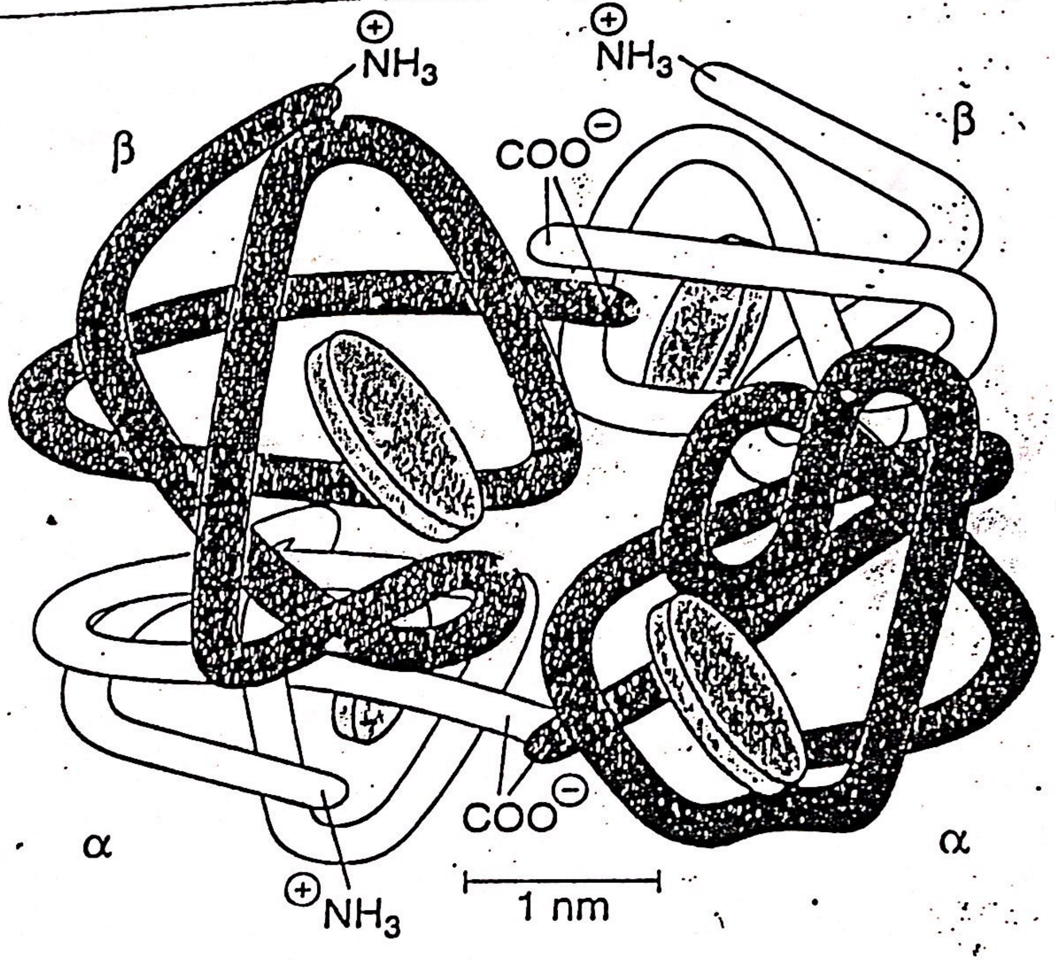


Figure 27–12. Diagrammatic representation of a molecule of hemoglobin A, showing the 4 subunits. There are 2 α and 2 β polypeptide chains, each containing a heme moiety. These moieties are represented by the disks. (Reproduced, with permission, from Harper HA et al: *Physiologische Chemie*. Springer-Verlag, 1975.)

Table 4-4. Normal Human Hemoglobins—Genetic Variants

Name	*Designation*	*Molecular Structure*	*Proportion in*	
			Adults	*Newborns*
Adult hemoglobin	A	$\alpha_2\beta_2$	97%	20%
Hemoglobin A_2	A_2	$\alpha_2\delta_2$	2.5%	0.5%
Fetal hemoglobin	F	$\alpha_2\gamma_2$	$<1\%$	80%
Portland		$\zeta_2\gamma_2$	0	0
Gower I		$\zeta_2\epsilon_2$	0	0
Gower II		$\alpha_2\epsilon_2$	0	0

✓

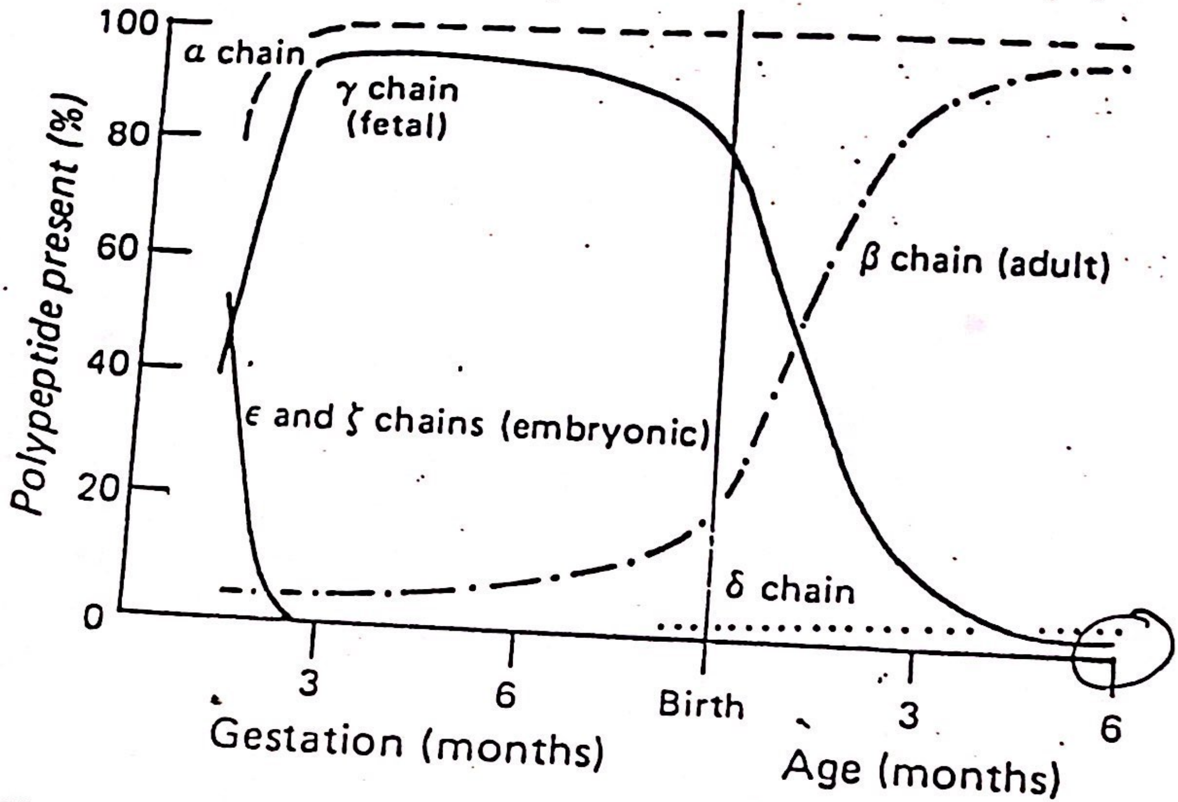


Figure 27–14. Development of human hemoglobin chains.

Figure 14.24 Plasma and whole blood that are brought into equilibrium with the same gas mixture have the same pO_2 and thus the same amount of dissolved oxygen molecules (shown with black dots). The oxygen content of whole blood, however, is much higher than that of plasma because of the binding of oxygen to hemoglobin.

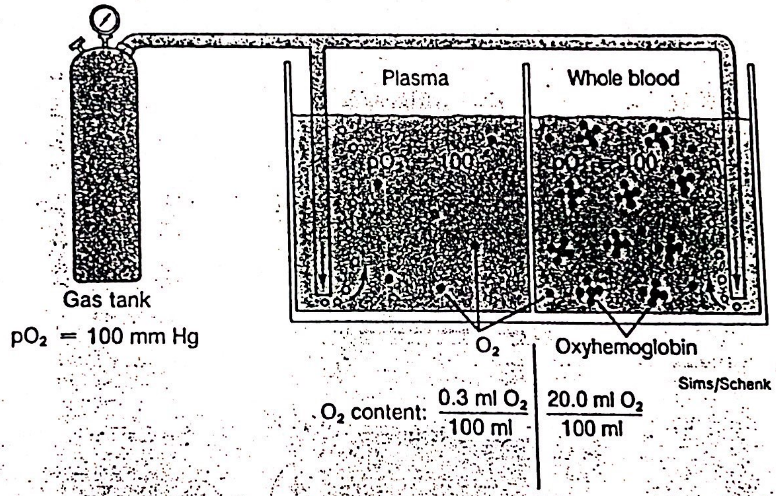


Table 35–1. Gas content of blood.

Gas	mL/dL of Blood Containing 15 g of Hemoglobin			
	Arterial Blood (P_{O_2} 95 mm Hg; P_{CO_2} 40 mm Hg; Hb 97% Saturated)		Venous Blood (P_{O_2} 40 mm Hg; P_{CO_2} 46 mm Hg; Hb 75% Saturated)	
	Dissolved	Combined	Dissolved	Combined
O_2	0.29	19.5	0.12	15.1
CO_2	2.62	46.4	2.98	49.7
N_2	0.98	0	0.98	0

✓

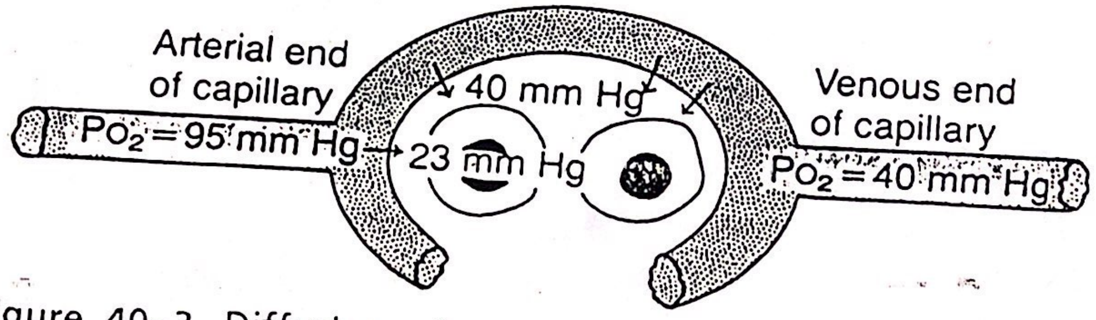


Figure 40–3. Diffusion of oxygen from a tissue capillary to the cells.

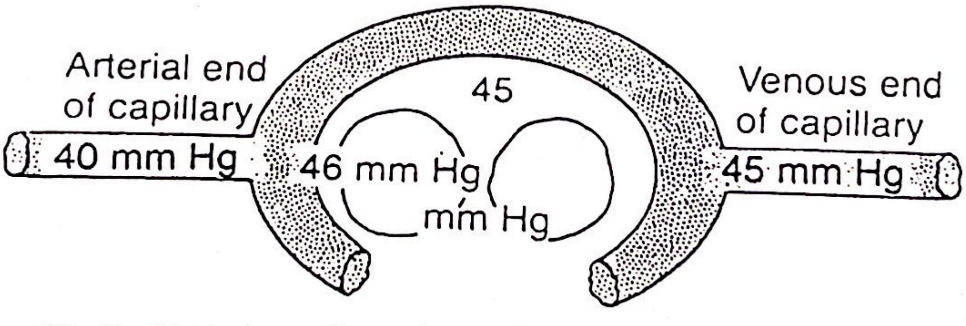


Figure 40–5. Uptake of carbon dioxide by the blood in the capillaries.

✓

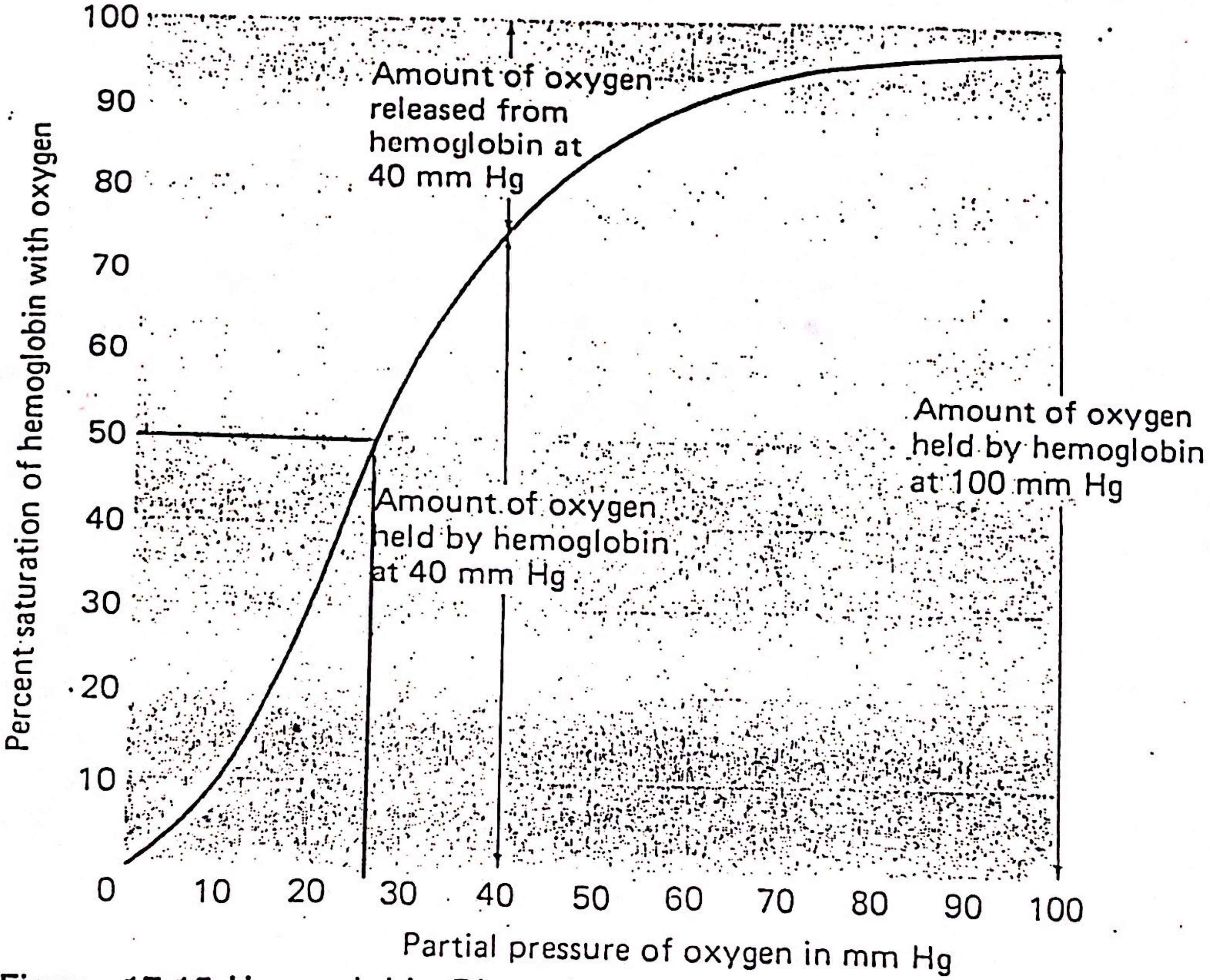


Figure 17.15 Hemoglobin Dissociation Curve for Oxygen in an Adult Human. The curve shows the extent to which hemoglobin picks up or releases oxygen as the oxygen pressure in the blood changes. ① When blood passes through the lungs, where the partial pressure of oxygen is about 100 mm Hg, the hemoglobin becomes about 97 percent saturated with oxygen. ② But when blood passes through distant tissues, where the partial pressure of oxygen is ordinarily about 40 mm Hg, the hemoglobin releases about 25 percent of its oxygen. (Adapted from J. W. Severinghaus, *J. Appl. Physiol.* 21 [1966]:1111.)

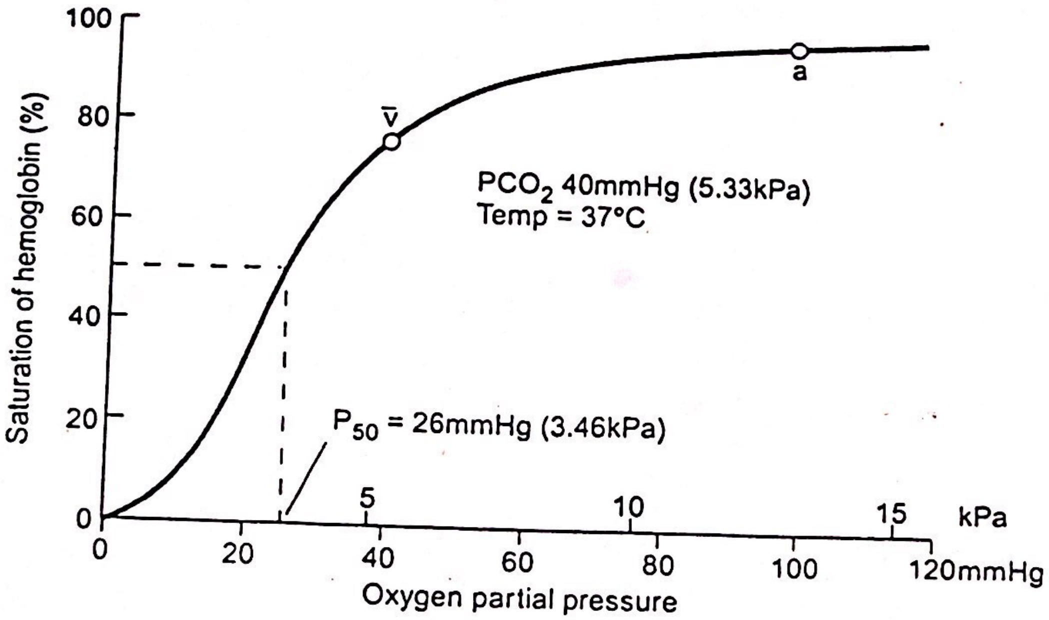
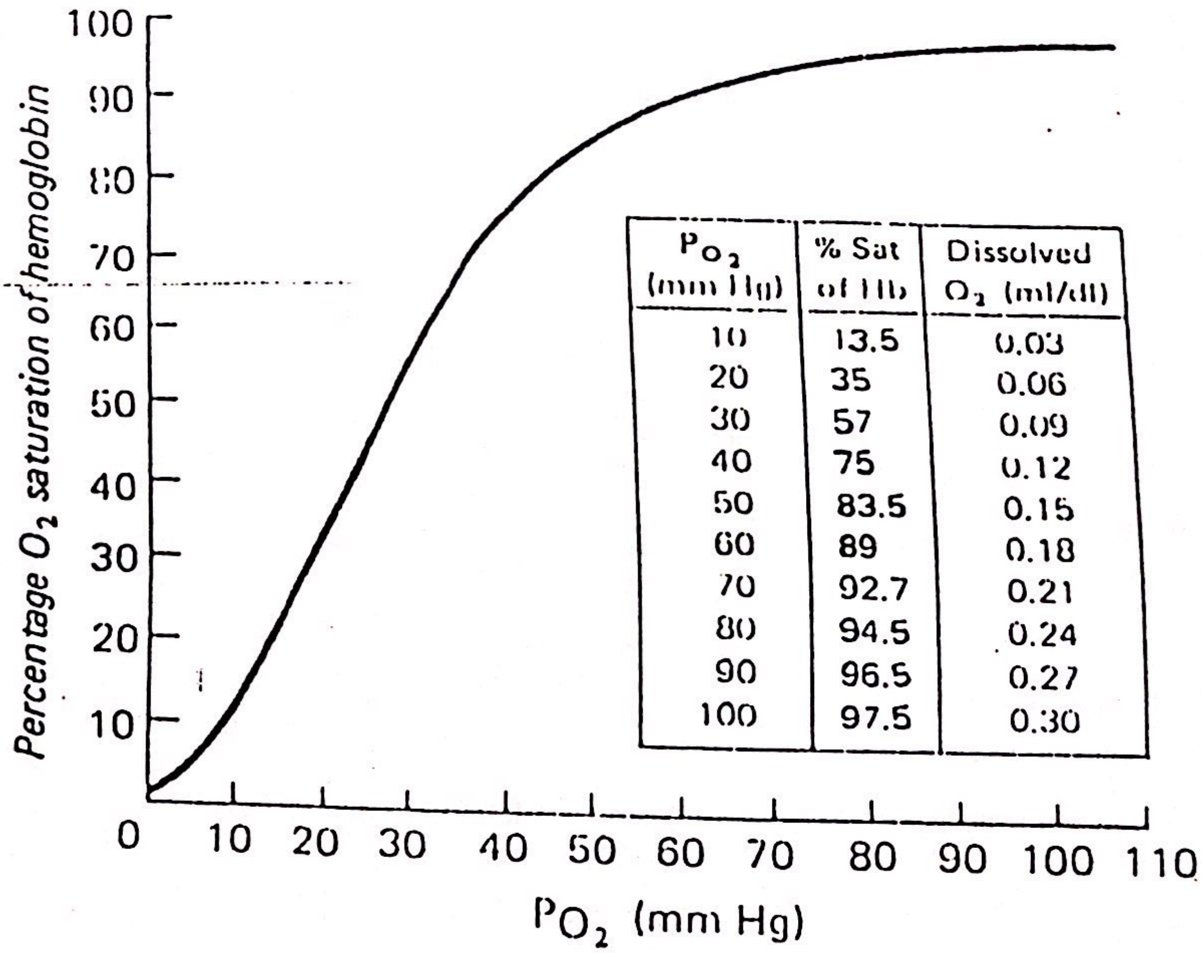


Fig. 13.6 The oxyhemoglobin dissociation curve for a $P\mathrm{CO}_2$ of 5.33 kPa (40 mmHg) at 37 °C. Under these conditions, the P_{50} value is 3.46 kPa (26 mmHg). a, the $P\mathrm{O}_2$ in arterial blood (97 per cent saturated); $\bar{v}$, the $P\mathrm{O}_2$ for mixed venous blood (5.33 kPa or 40 mmHg) at which value the hemoglobin is still 75 per cent saturated. Note that as the $P\mathrm{O}_2$ falls below 8 kPa (60 mmHg) the curve becomes progressively steeper.



P_{O_2} (mm Hg)	% Sat of Hb	Dissolved O_2 (ml/dl)
10	13.5	0.03
20	35	0.06
30	57	0.09
40	75	0.12
50	83.5	0.15
60	89	0.18
70	92.7	0.21
80	94.5	0.24
90	96.5	0.27
100	97.5	0.30

Figure 35–2. Oxygen-hemoglobin dissociation curve. pH 7.40, temperature 38°C. (Redrawn and reproduced, with permission, from Comroe JH Jr et al: *The Lung: Clinical Physiology and Pulmonary Function Tests*, 2nd ed. Year Book, 1962.)

$$\begin{aligned} Hb_4 + O_2 &\rightleftarrows Hb_4O_2 \\ Hb_4O_2 + O_2 &\rightleftarrows Hb_4O_4 \\ Hb_4O_4 + O_2 &\rightleftarrows Hb_4O_6 \\ Hb_4O_6 + O_2 &\rightleftarrows Hb_4O_8 \end{aligned}$$

Combination of the first heme in the Hb molecule with O_2 increases the affinity of the second heme for O_2, and oxygenation of the second increases the affinity of the third, etc, so that the affinity of Hb for the fourth O_2 molecule is many times that for the first.

[illegible]
[illegible] Shift in the
Oxyhemoglobin Dissociation Curve

Factor	*Source*
Decreased pH	Results from increased production of CO_2 and lactic acid in active tissues
Increased P_{CO_2}	Increased in venous blood from tissues with high rate of oxidative metabolism; acts by formation of carbaminohemoglobin
Increased temperature	Higher in fever and in active tissues, especially skeletal muscle
Increased 2,3 DPG	Produced by red blood cells; increased in anemia and high-altitude adaptation

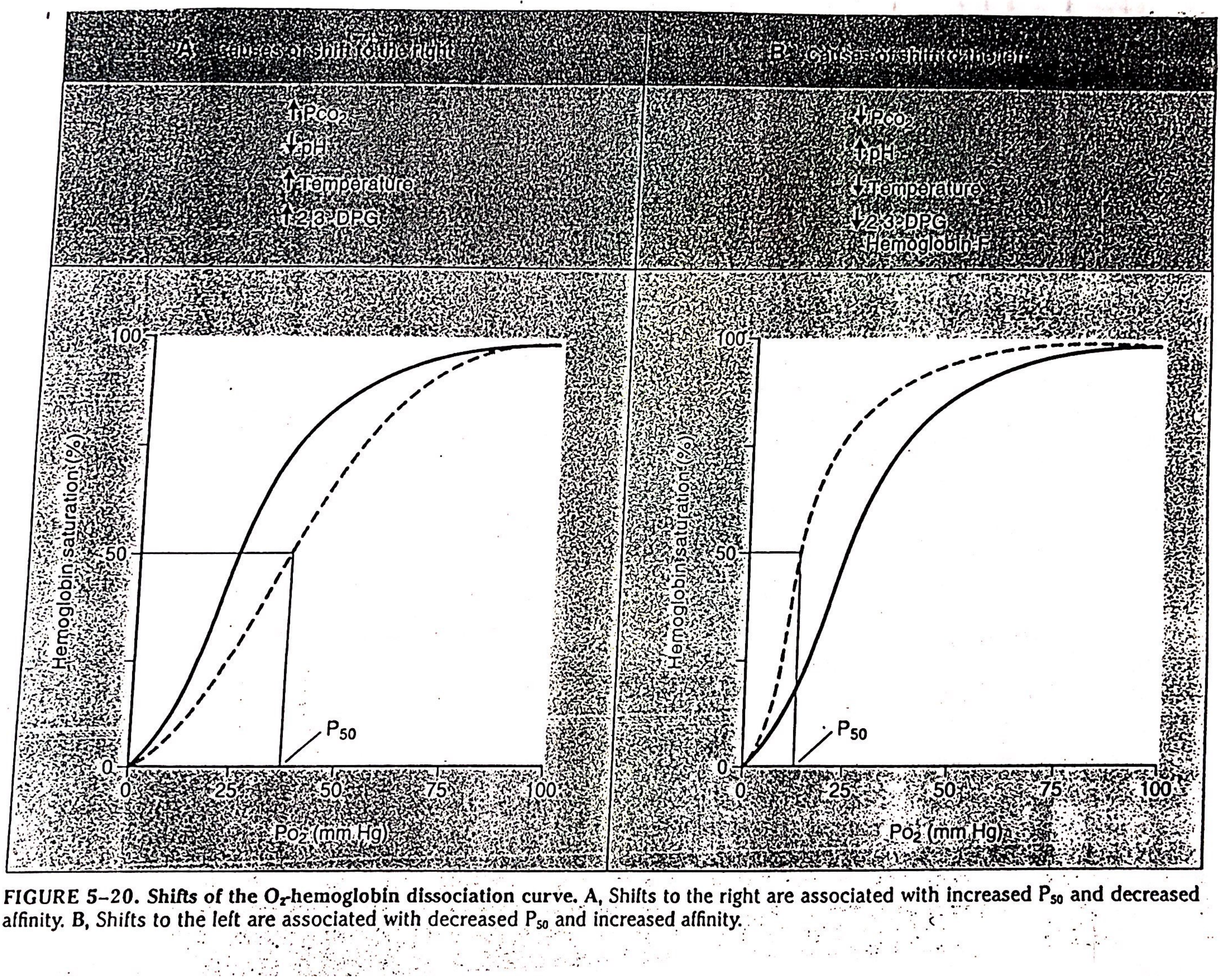


FIGURE 5–20. Shifts of the O_2-hemoglobin dissociation curve. A, *Shifts to the right are associated with increased* P_{50} *and decreased affinity.* B, *Shifts to the left are associated with decreased* P_{50} *and increased affinity.*

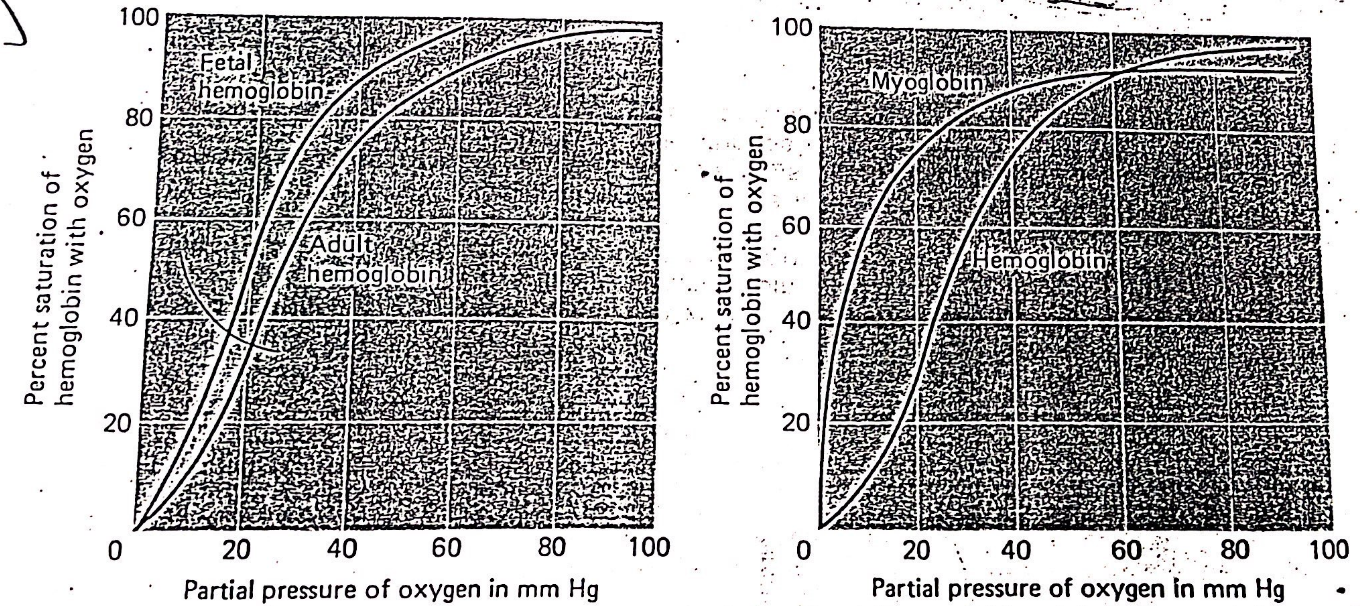


Figure 17.19 **Differences in Dissociation of Oxygen from Fetal Hemoglobin, Adult Hemoglobin, and Myoglobin.** The dissociation curve for fetal hemoglobin is to the left of that for maternal hemoglobin, indicating that fetal hemoglobin has a higher affinity for oxygen. Thus, when the mother's blood enters 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.)