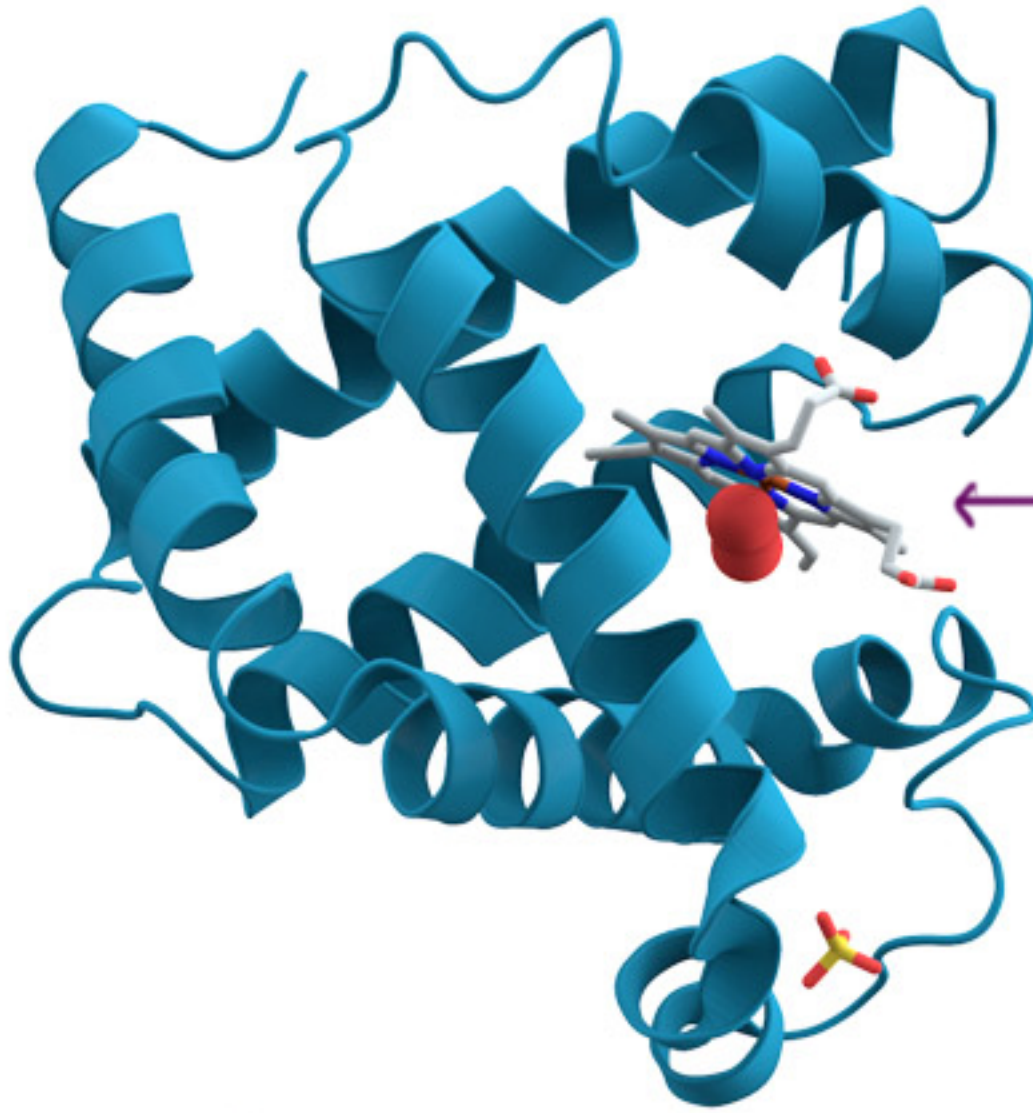
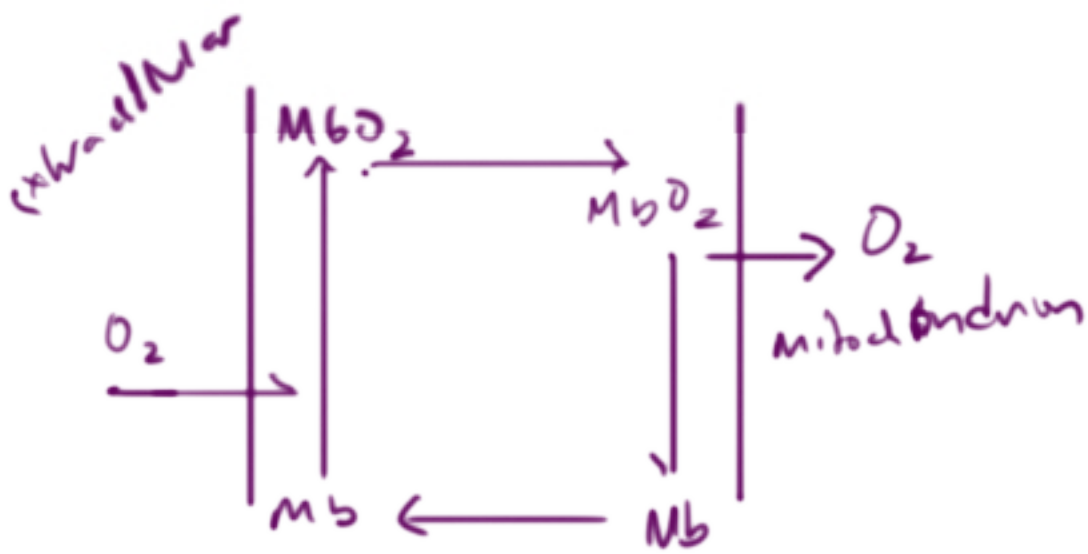
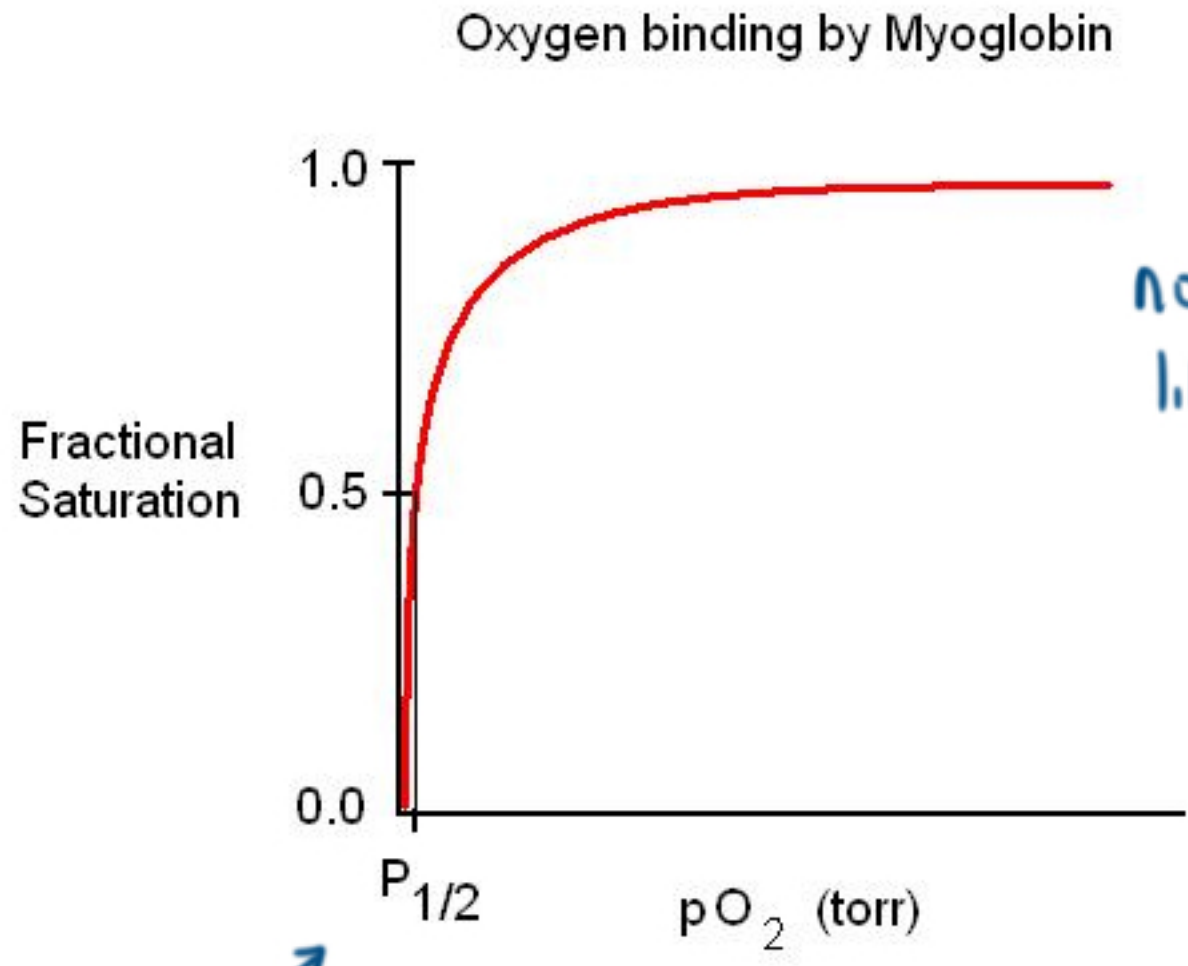
Hemoglobin
(with coordination chemisry)

Session Slides
with Notes

Myoglobin





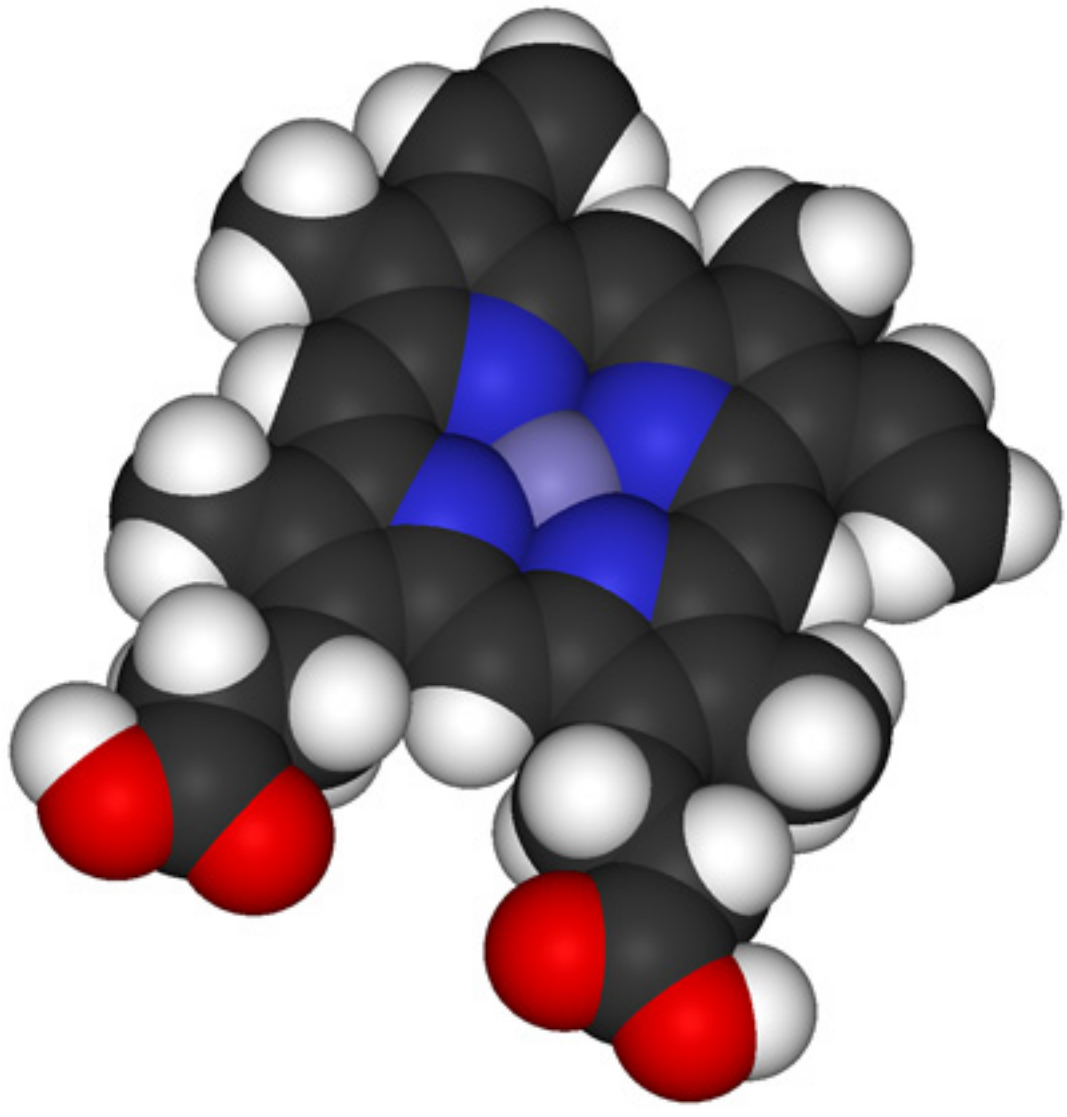


not sigmoidal like hemoglobin

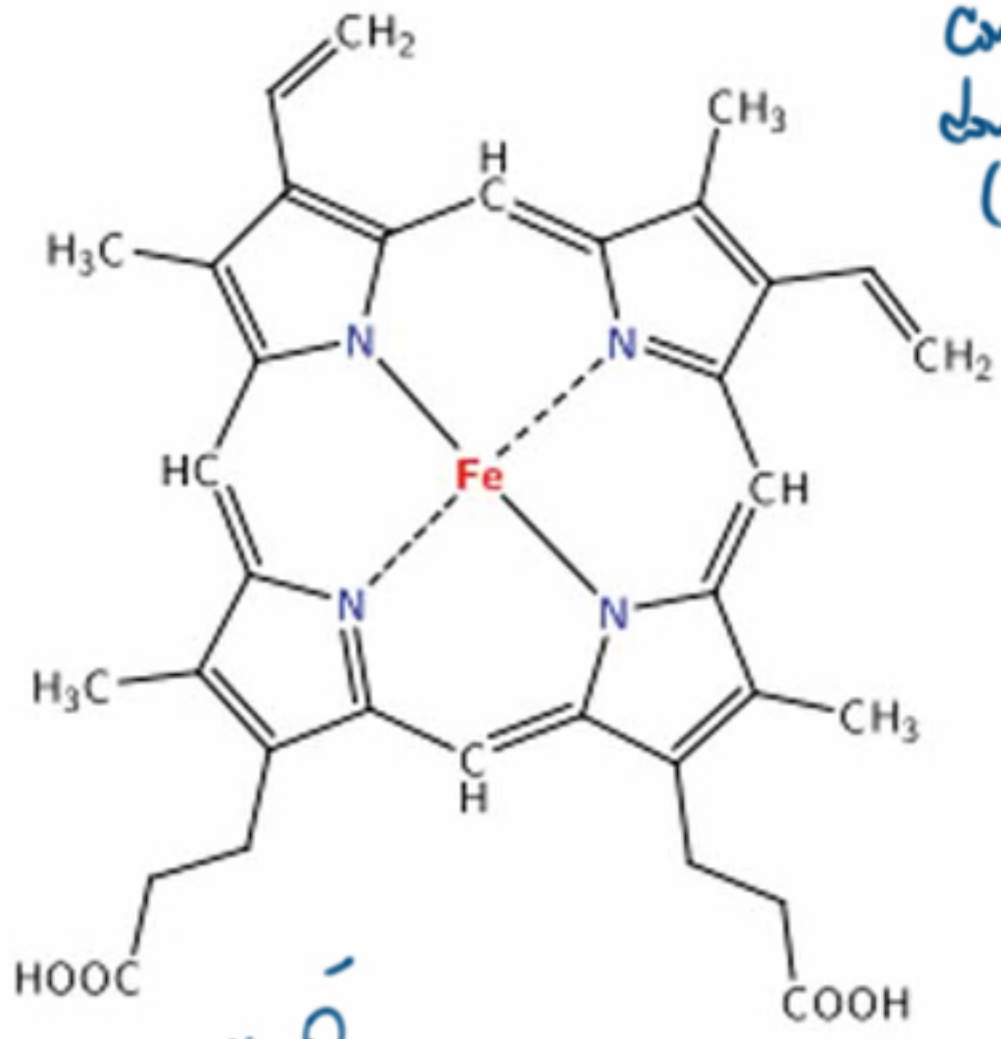
2.75 torr

P_{50} ← concentration at half saturation

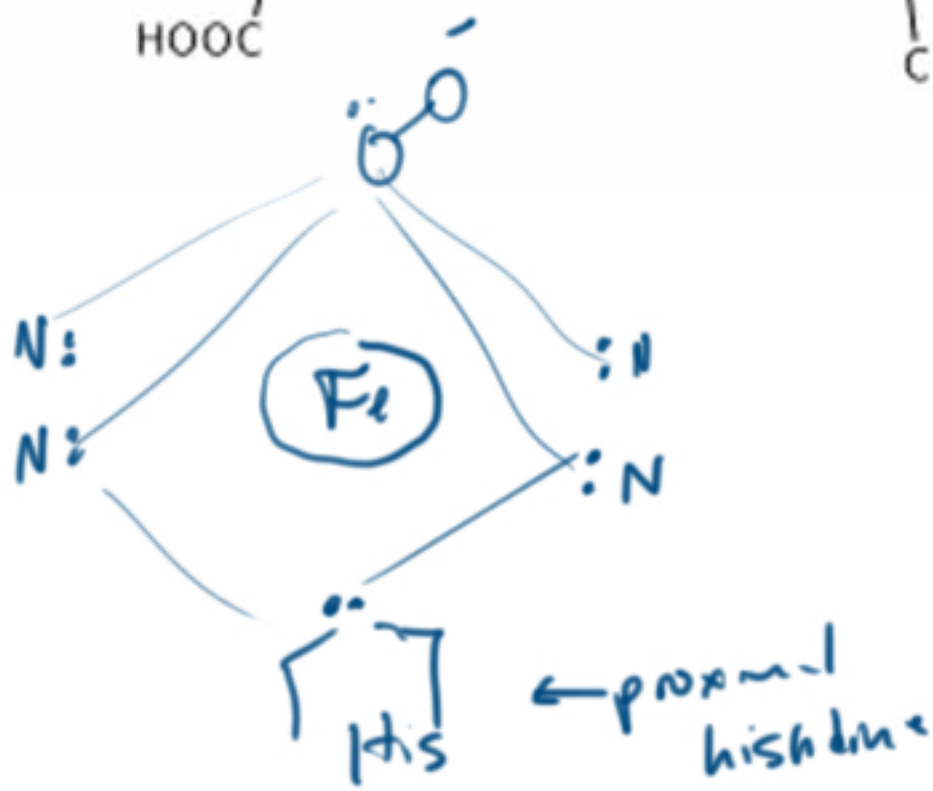
with hemoglobin P_{50} ≈ 27 torr



Heme = porphyrin + iron



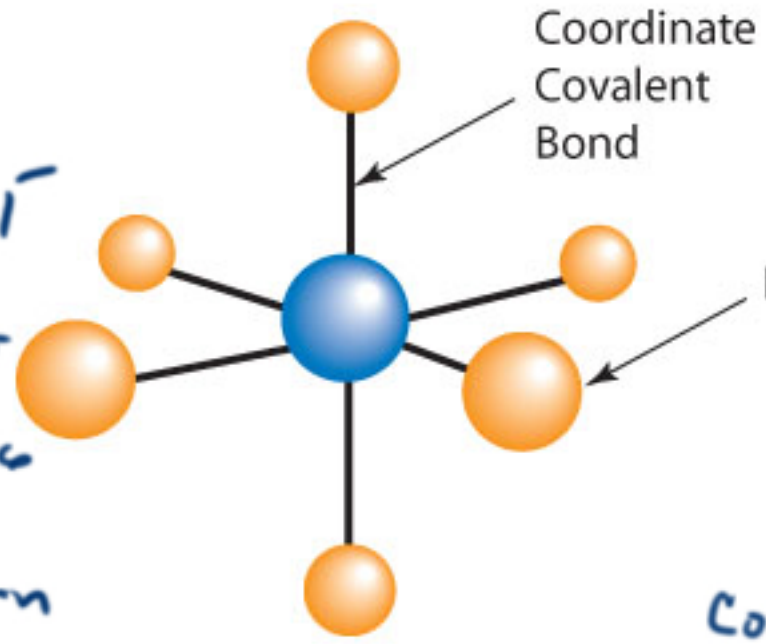
Conjugated double bonds (extensive) means it is a pigment



Coordination Complex

← proximal histidine

brief coordination chemistry primer



Coordination Complex

$CoCl_3 \rightleftharpoons Co^{3+} + 3Cl^-$

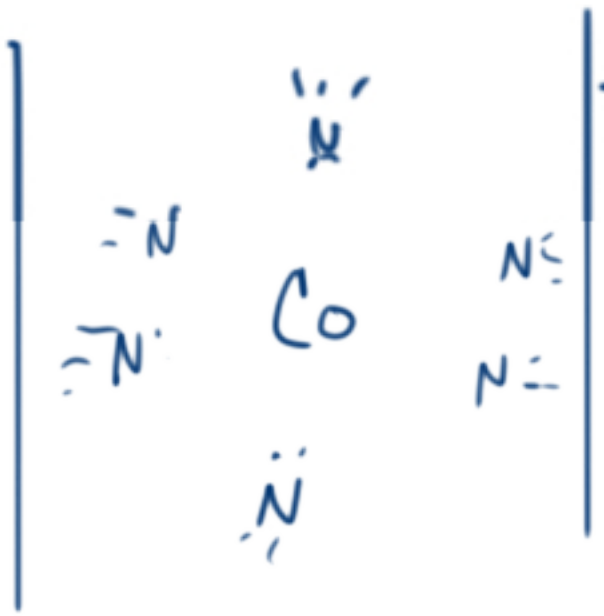
$Co^{3+} + 6NH_3 \rightleftharpoons Co(NH_3)_6^{3+}$

complex ion

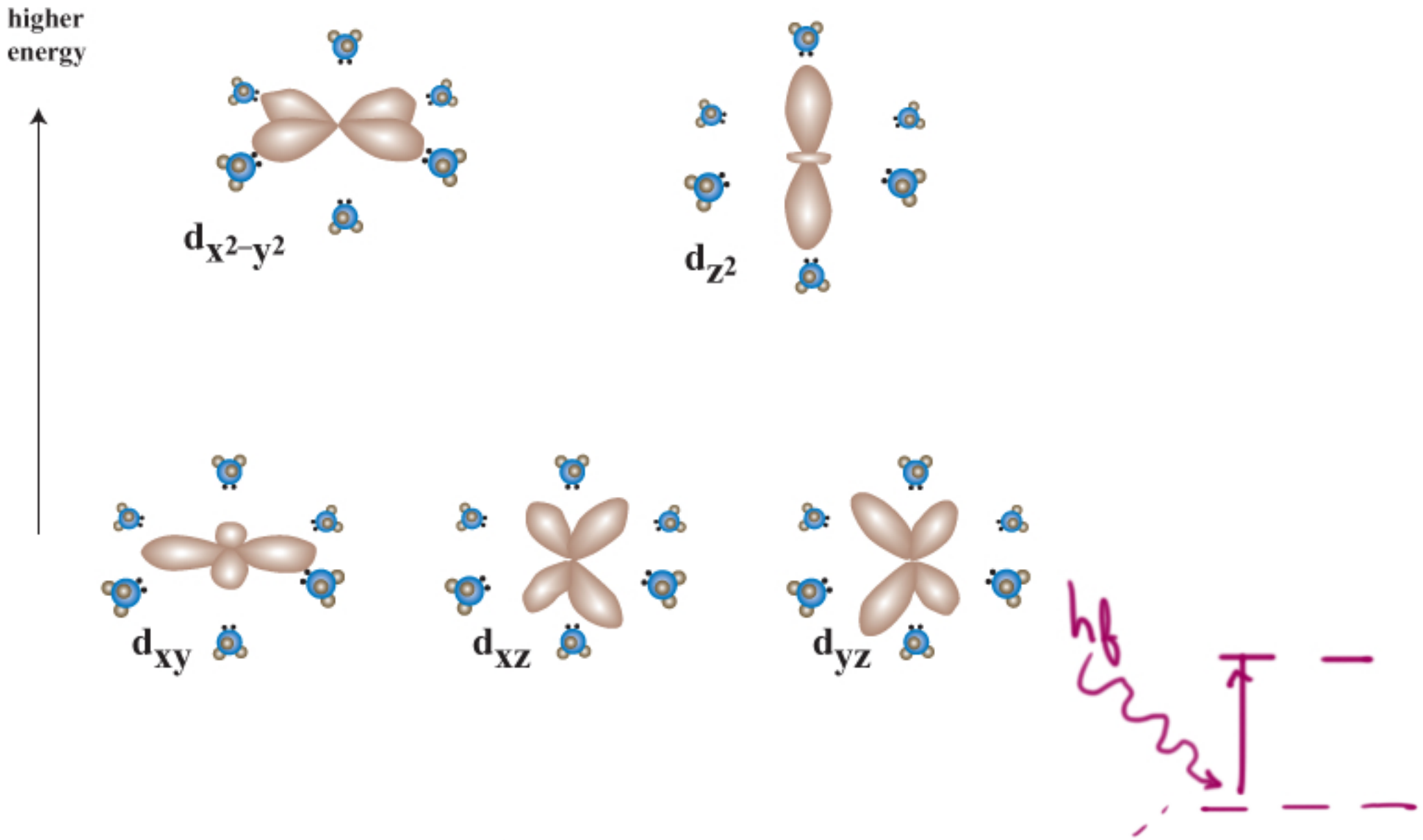
Ligand ← Lewis base

H_2O, NH_3, Cl^- etc

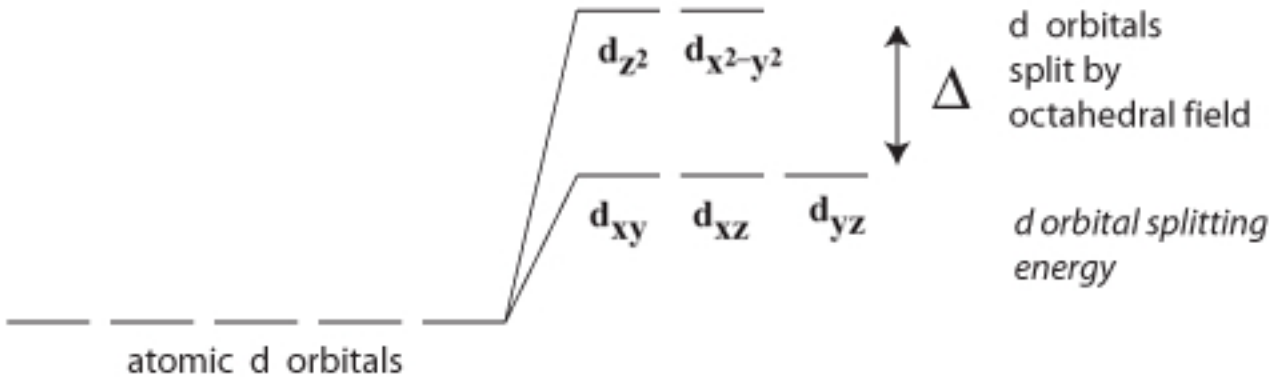
Coordination # is the # of electron pairs involved. (may be polydentate ligands)

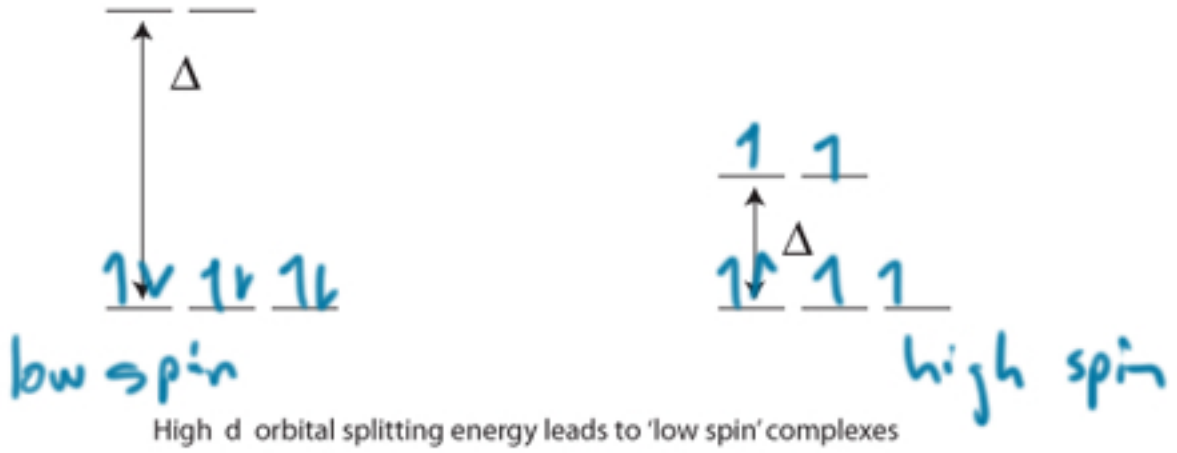


Complex ion

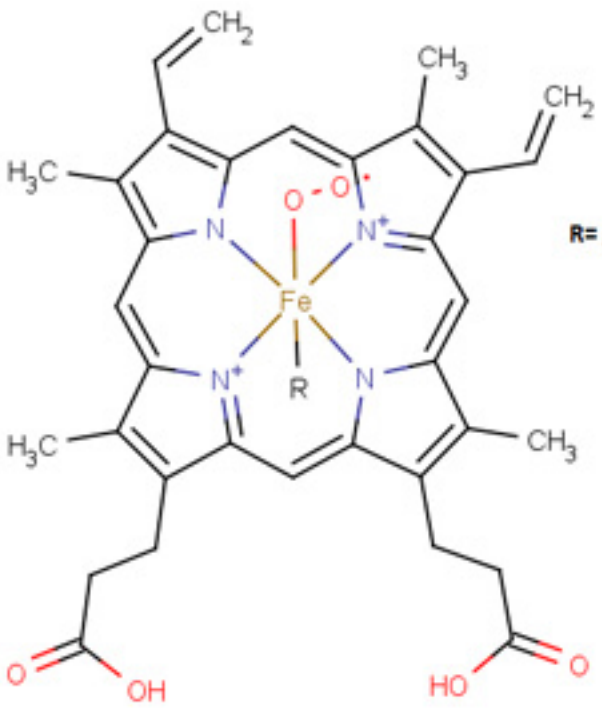


Coordination complexes are often brightly colored





High d orbital splitting energy leads to 'low spin' complexes



R= globin protein

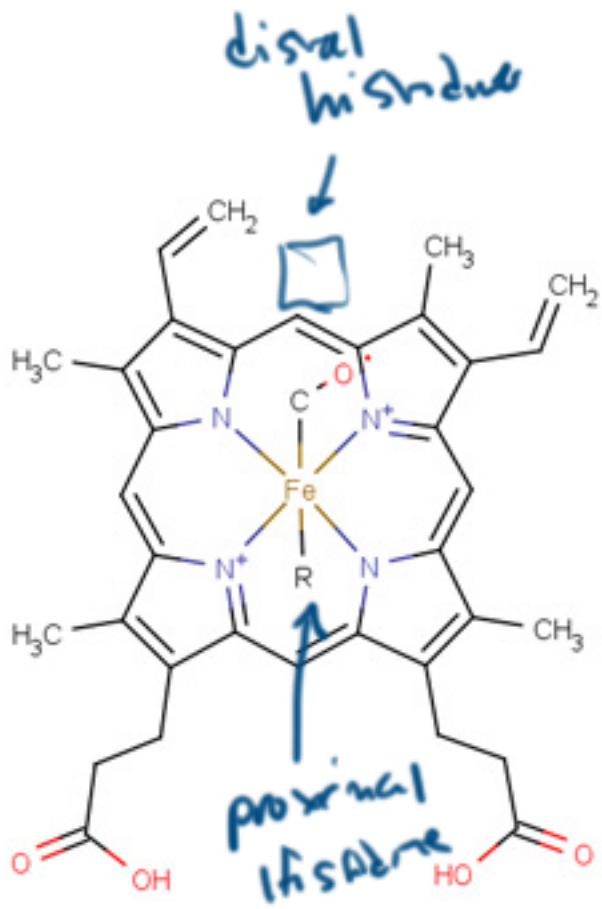
Oxyhemoglobin

— — superoxide electron coupling

↿⇂ ↿⇂ 1↿

In oxyhemoglobin
low spin Fe^{III}

- yet HbO_2 is diamagnetic

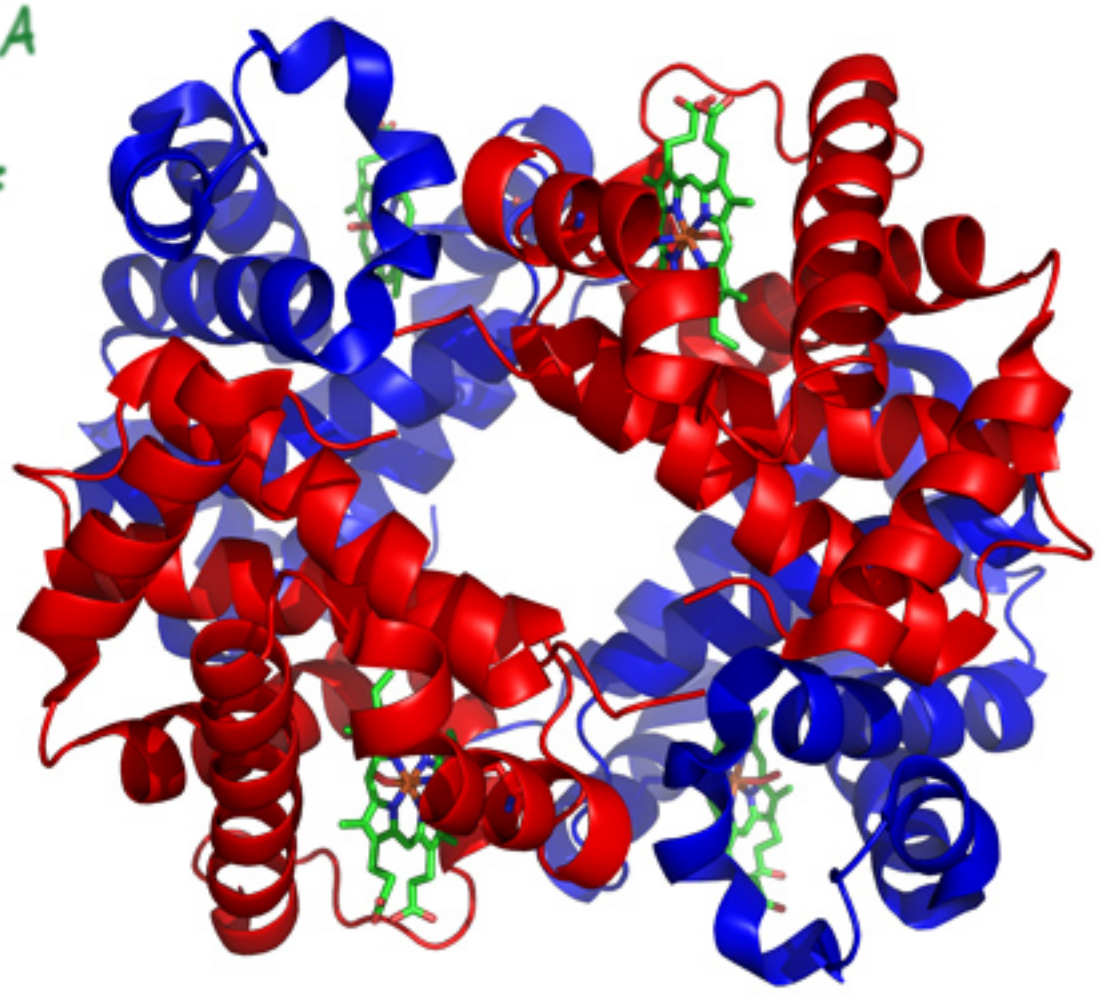


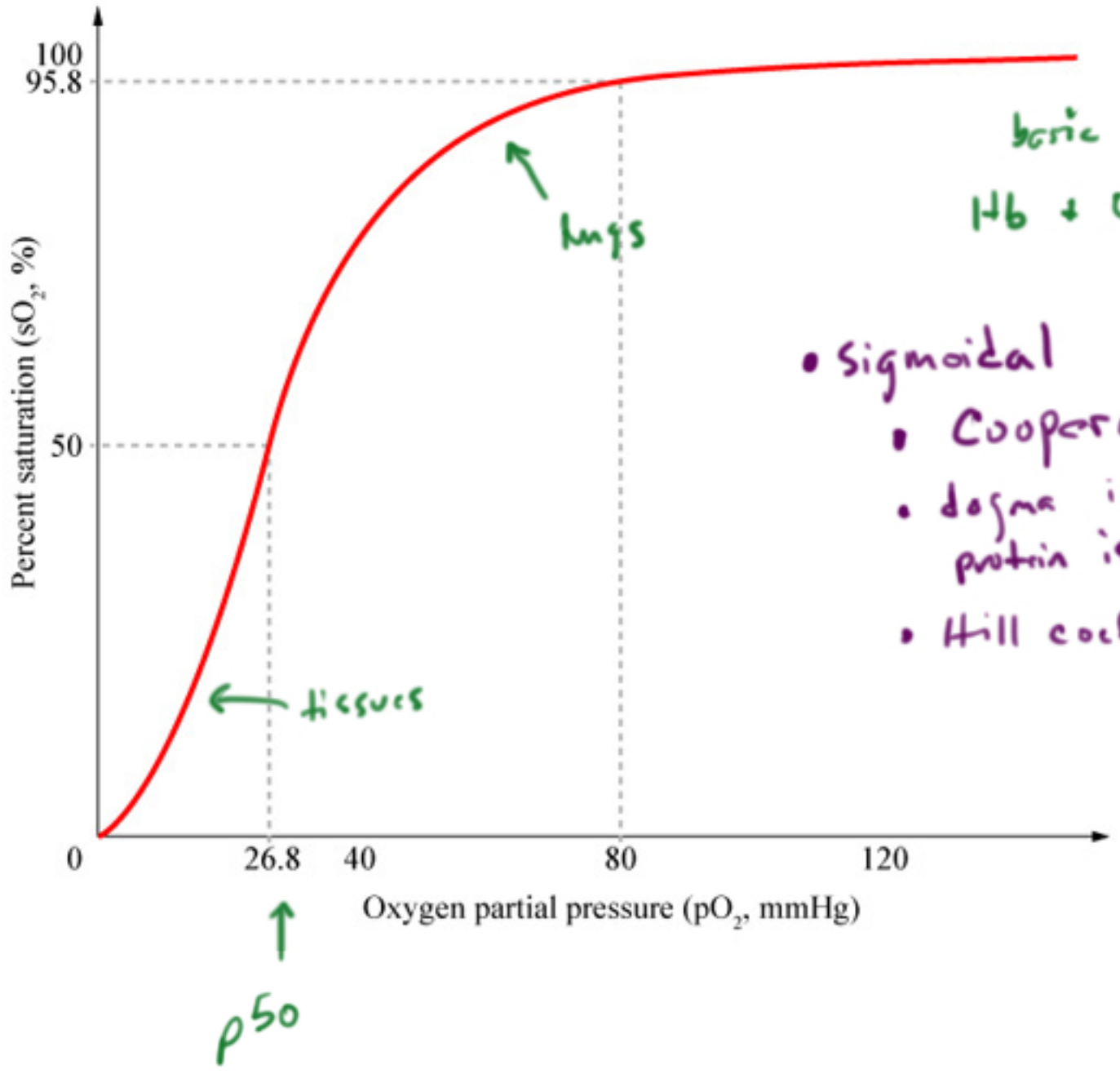
Carboxyhemoglobin

$\alpha_2\beta_2$ HbA

$\alpha_2\gamma_2$ HbF

Hemoglobin



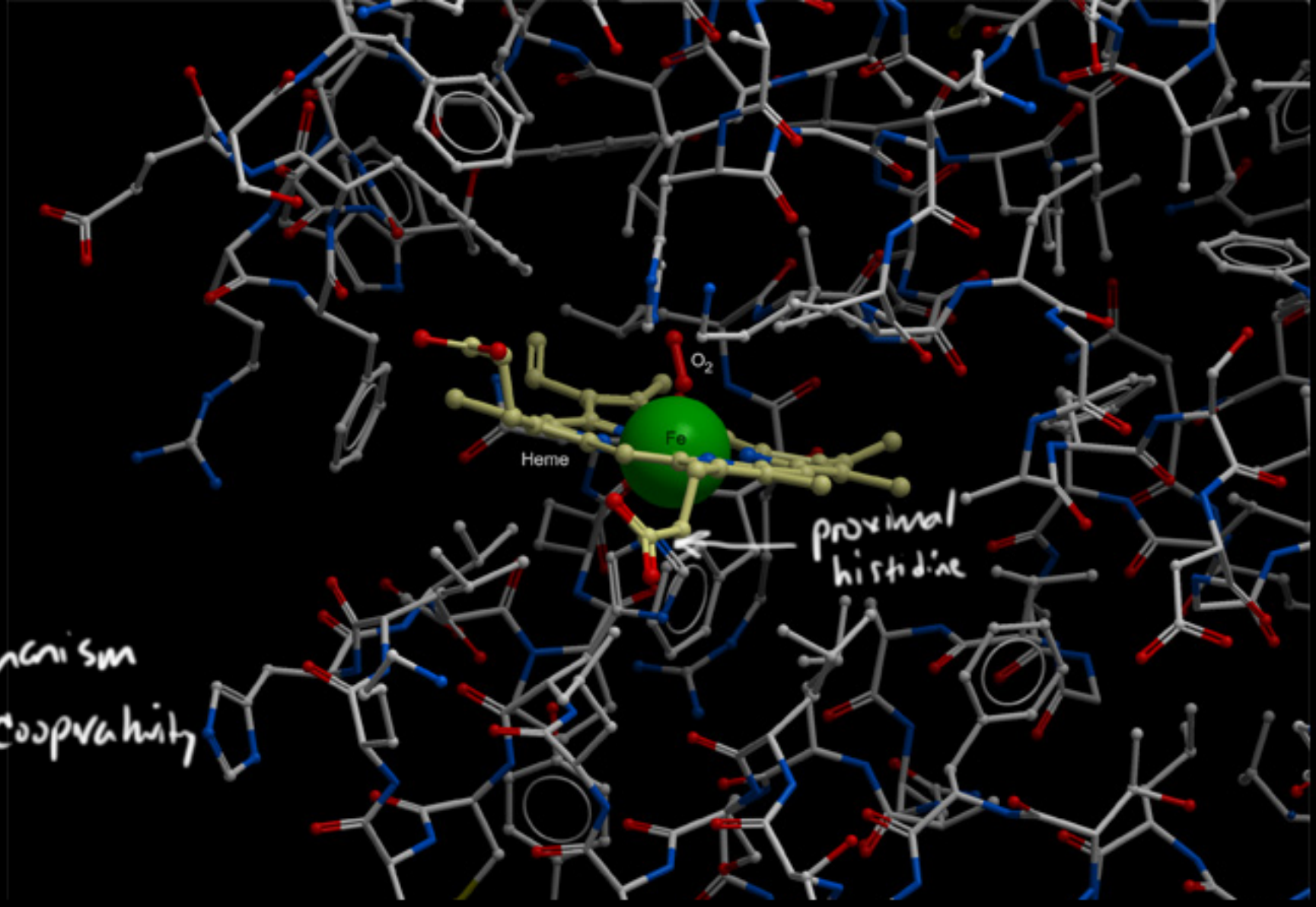


basic picture

$Hb + O_2 \rightleftharpoons HbO_2$

- sigmoidal
  - Cooperativity
  - dogma is that the protein is multisubunit
  - Hill coefficient > 1

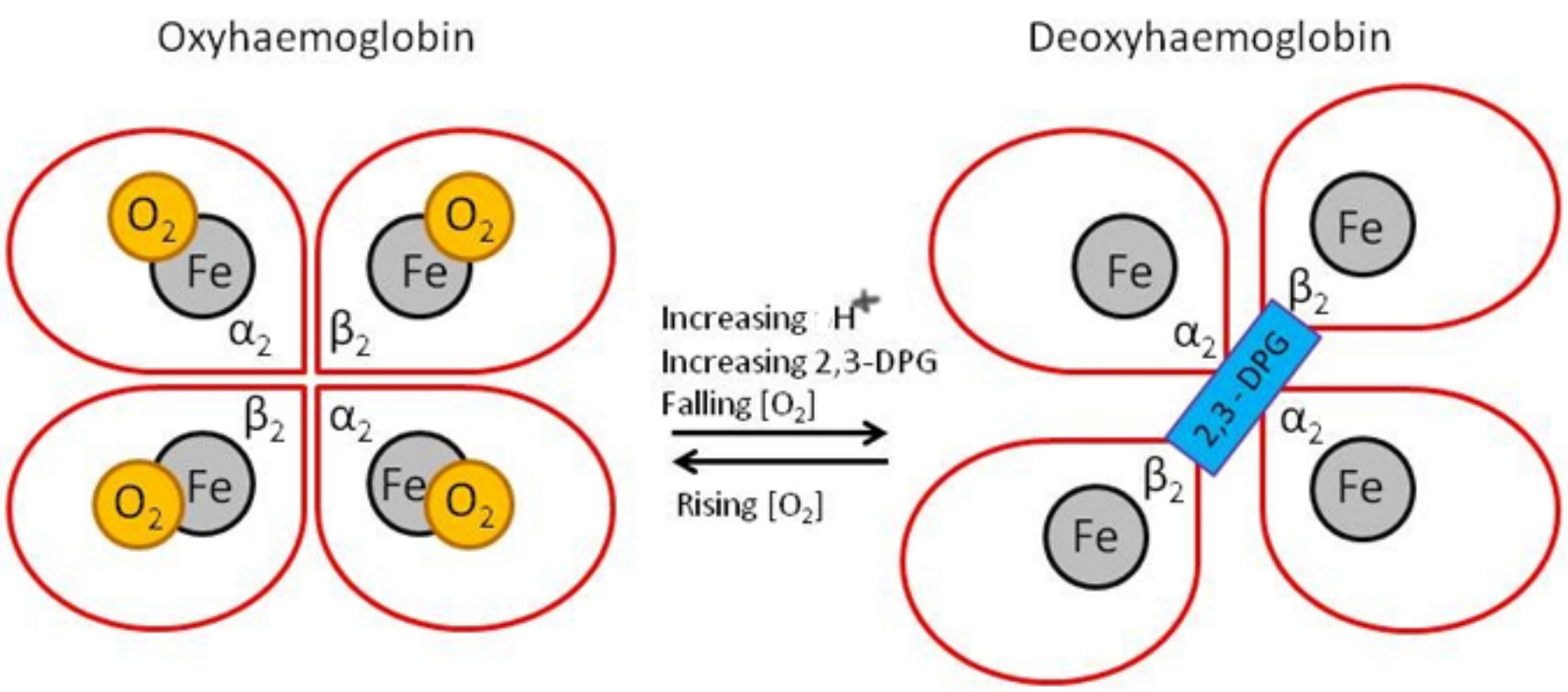
Mechanism of cooperativity



When O_2 binds, the Fe shifts into the porphyrin plane, pulling the proximal histidine. This triggers a conformational change. One $\alpha\beta$ shifts 15° to the other. All the other binding sites are now more facilitative.

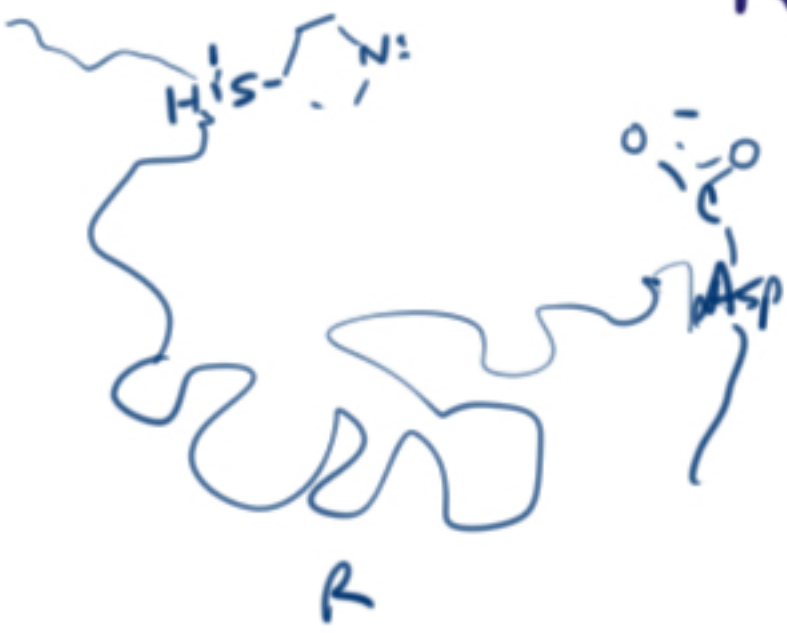
Oxygen Binding and Unloading

Monod Jacob Model



$R \rightleftharpoons T$

Bohr effect - H^+ stabilizer the tight structure. (ako CO_2, DPG)



carbonic acid

tissues → $CO_2 + H_2O \rightleftharpoons H_2CO_3$ ← carbonic anhydrase

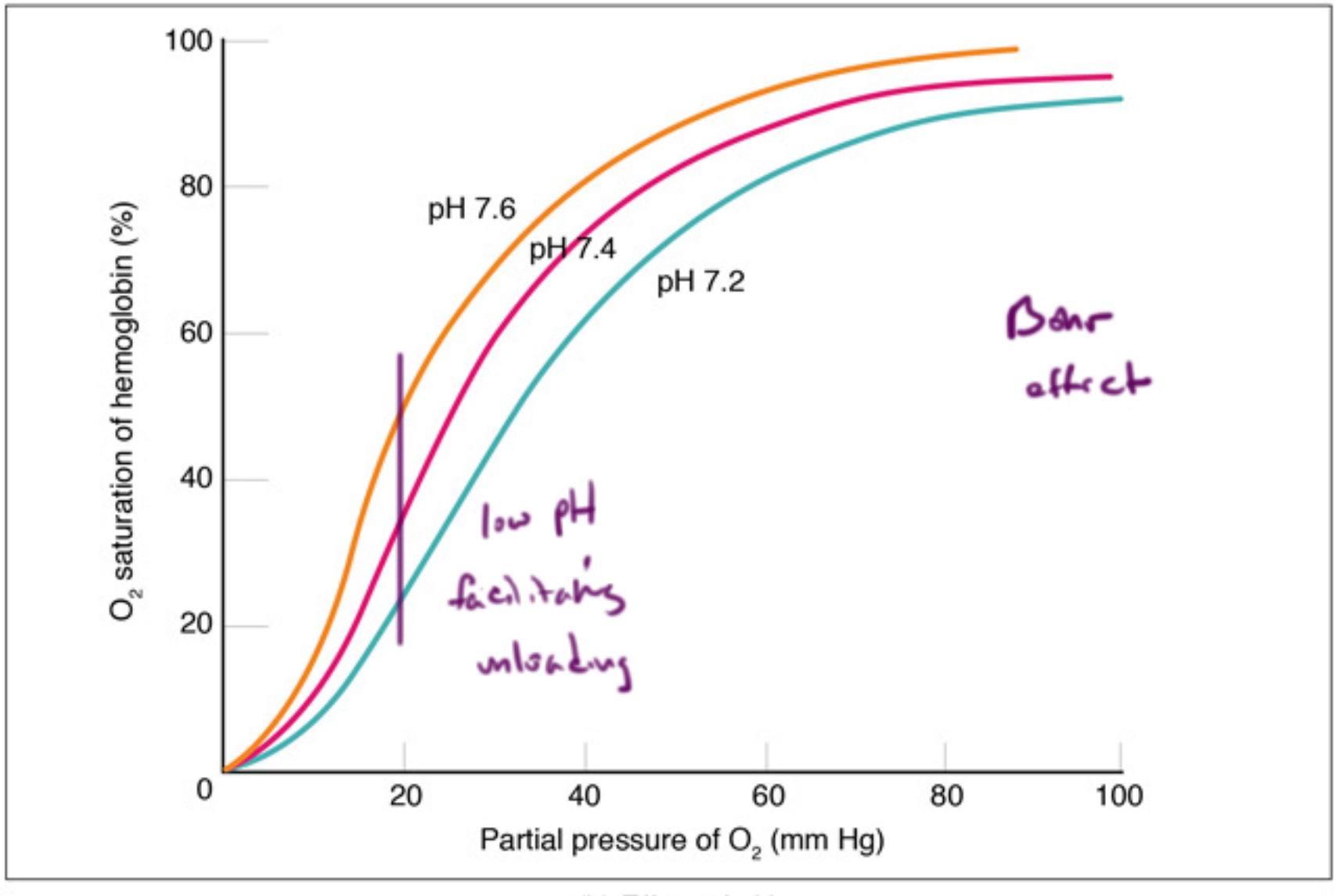
$H_2CO_3 \rightleftharpoons HCO_3^- + H^+$

$H^+ + HbO_2 \rightleftharpoons HbH^+ + O_2$ ← lungs

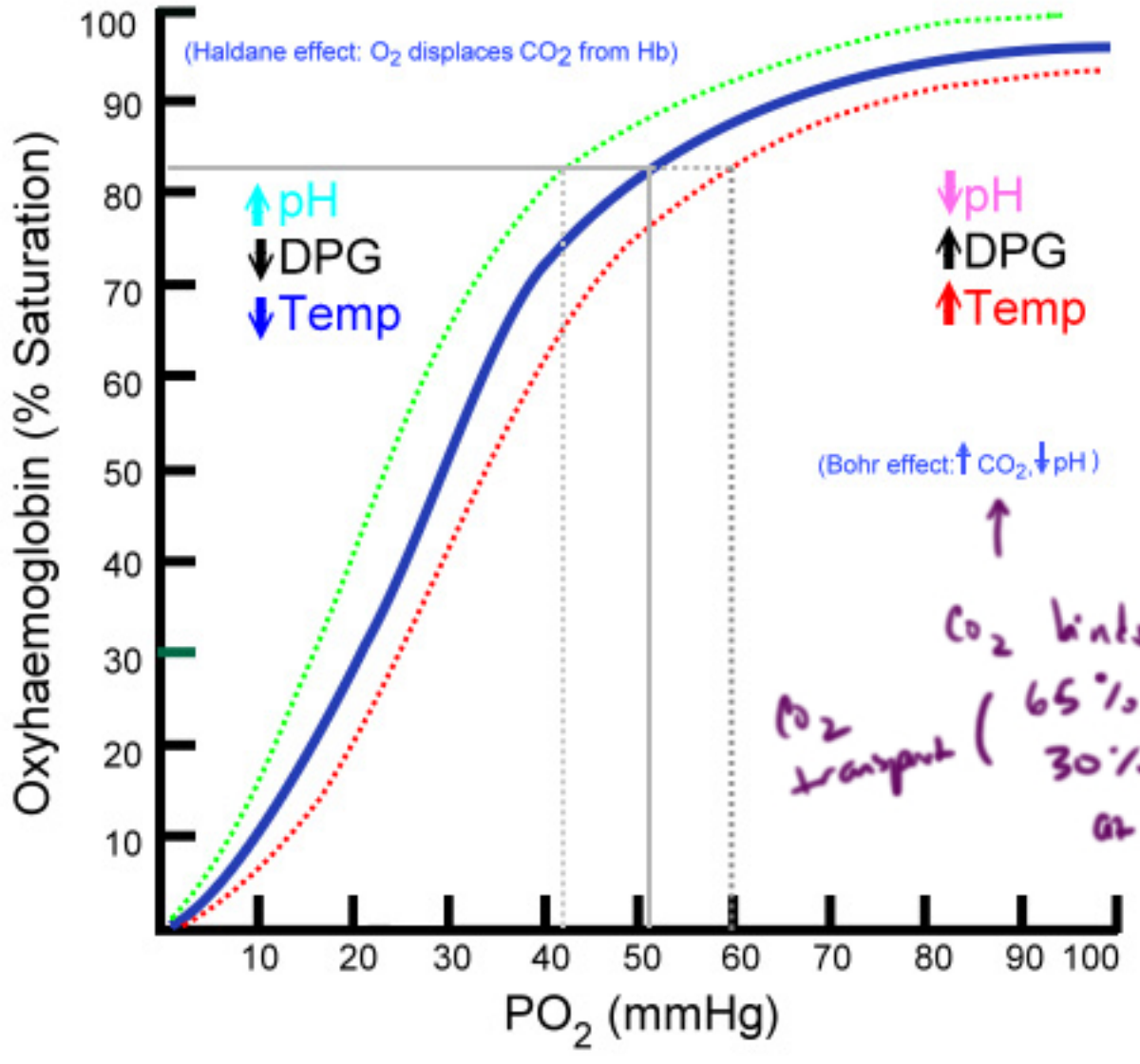
pK_a H_2CO_3 = 6.3

$$pH = pK_a + \log\left(\frac{[A^-]}{[HA]}\right)$$

$$7.3 = 6.3 + \log\left(\frac{10}{1}\right)$$



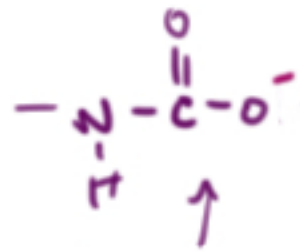
(b) Effect of pH



↑

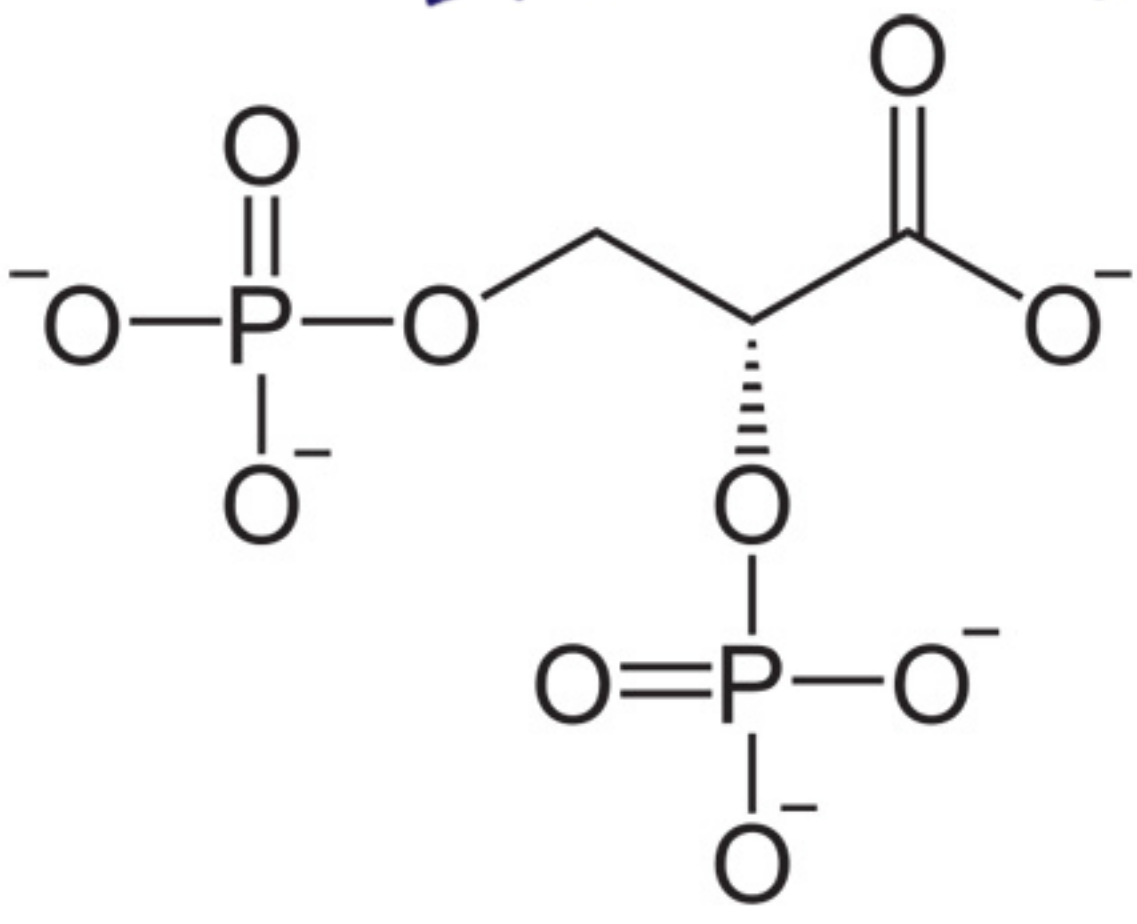
CO_2 binds Hb

CO_2 transport (65% as $^-HCO_3$
30% bound directly
at N termini:

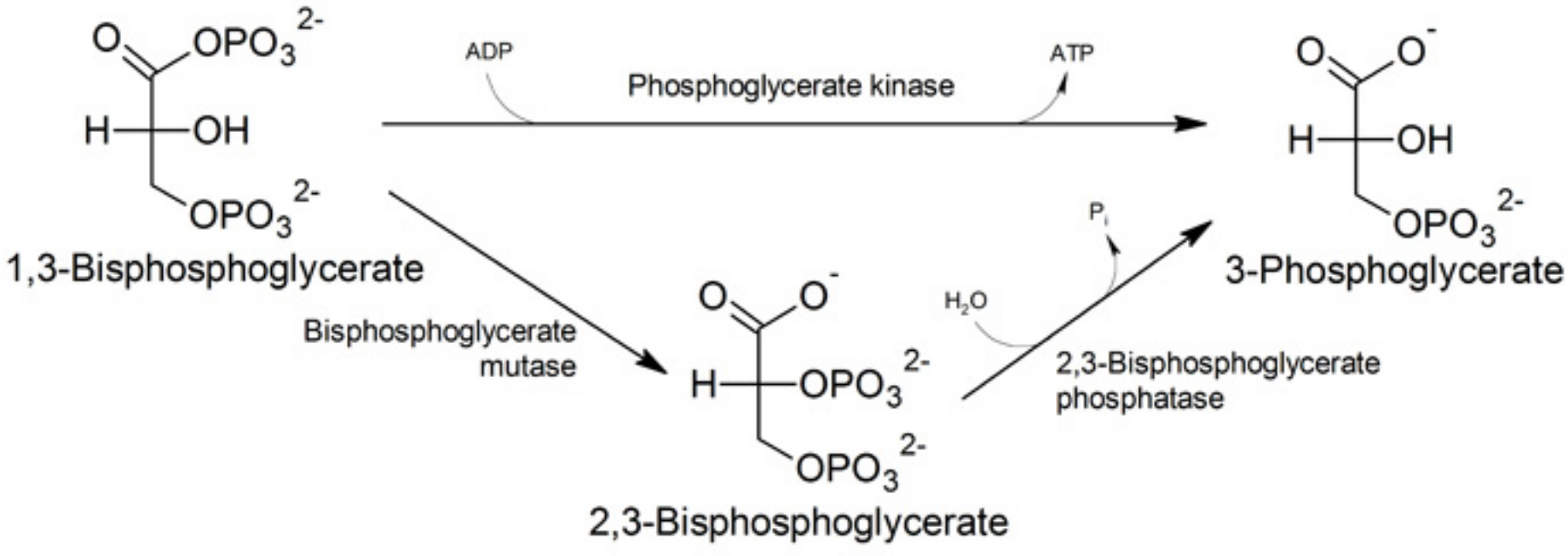


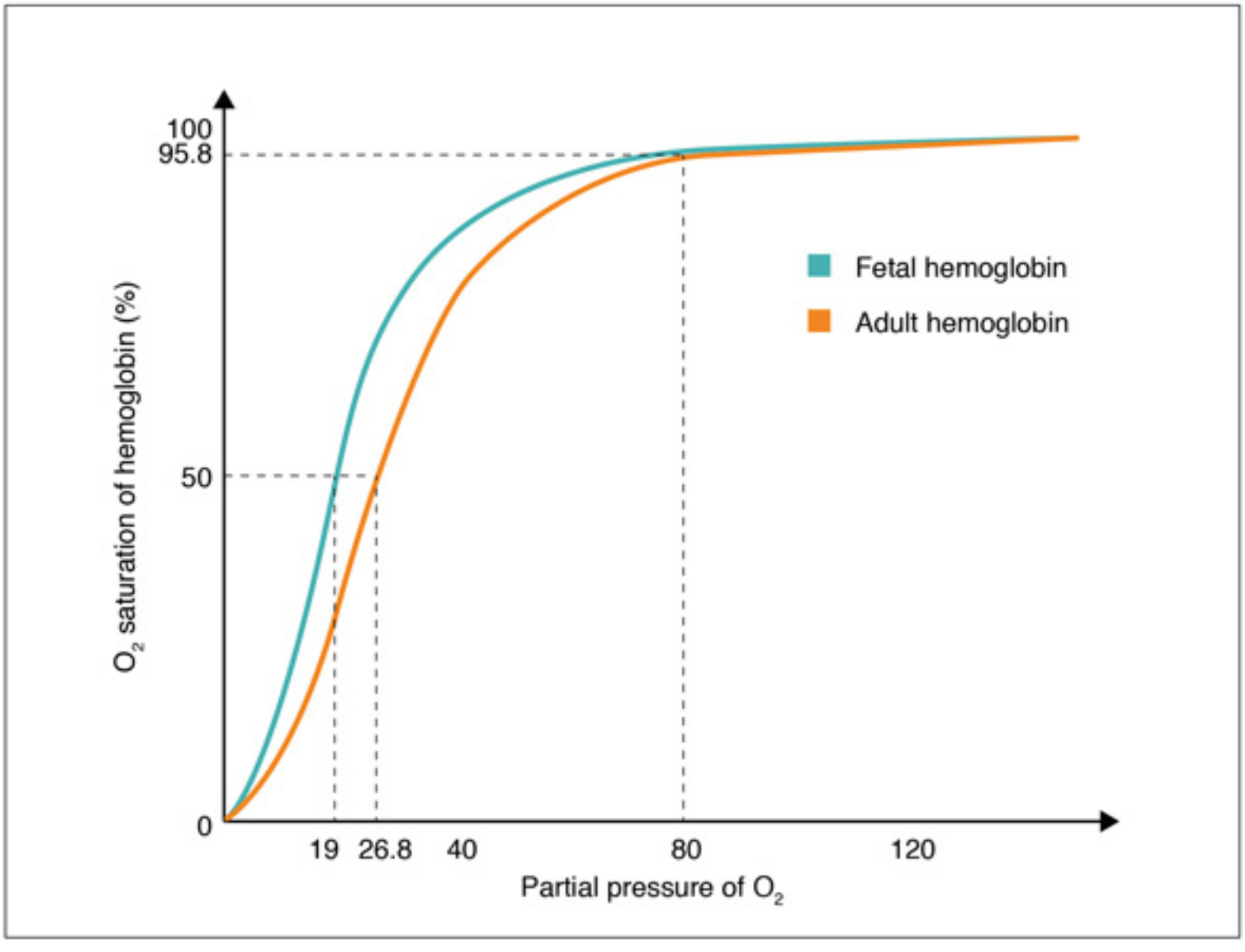
bound carbamide

DPG



- stabilizes the tight structure
- reduces the O_2 affinity
- facilitates unloading


ADP
Phosphoglycerate kinase
ATP
1,3-Bisphosphoglycerate
3-Phosphoglycerate
Bisphosphoglycerate
mutase
H_2O
P_i
2,3-Bisphosphoglycerate
phosphatase
2,3-Bisphosphoglycerate


100
95.8
50
0
O_2 saturation of hemoglobin (%)
19
26.8
40
80
120
Partial pressure of O_2
Fetal hemoglobin
Adult hemoglobin