the Red Blood Cell: Measures of Oxygen Delivery

Bleeding Hearts

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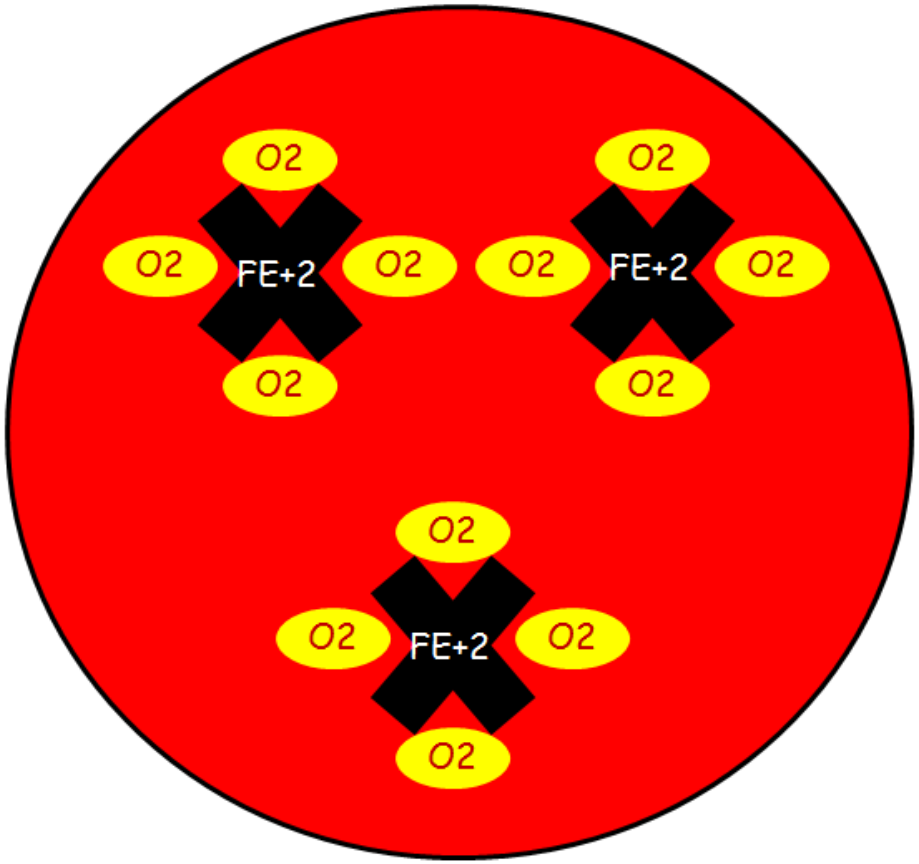
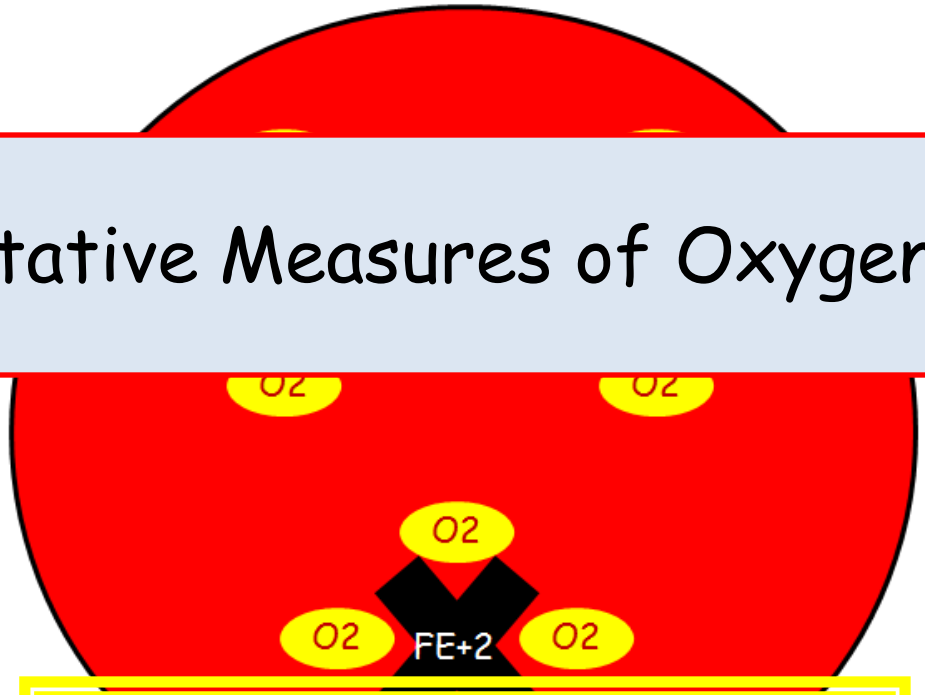
Key Point: the RBC Transports Oxygen



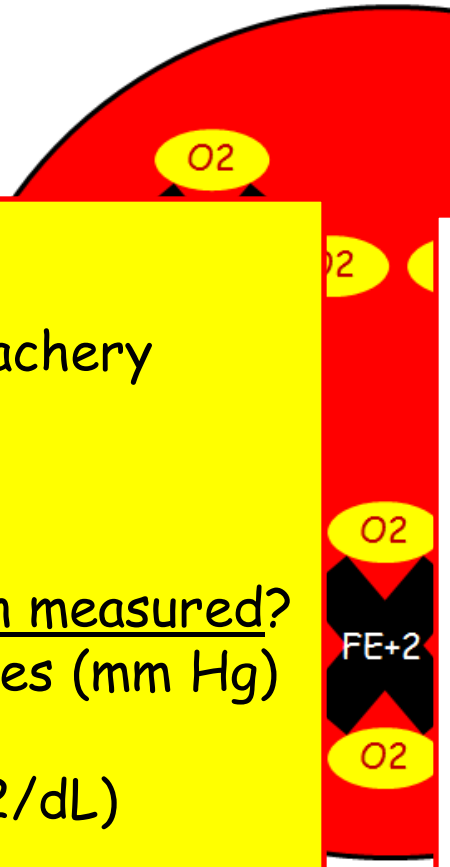
Lots of Derivatives
Lots of Treachery

Key Point: the RBC Transports Oxygen

Quantitative Measures of Oxygen Delivery



Key Point: The RBC Transports Oxygen



Lots of Treachery

↓

<u>How is the oxygen measured</u>?

Partial Pressures (mm Hg)
Saturation (%)
Content (ml O2/dL)

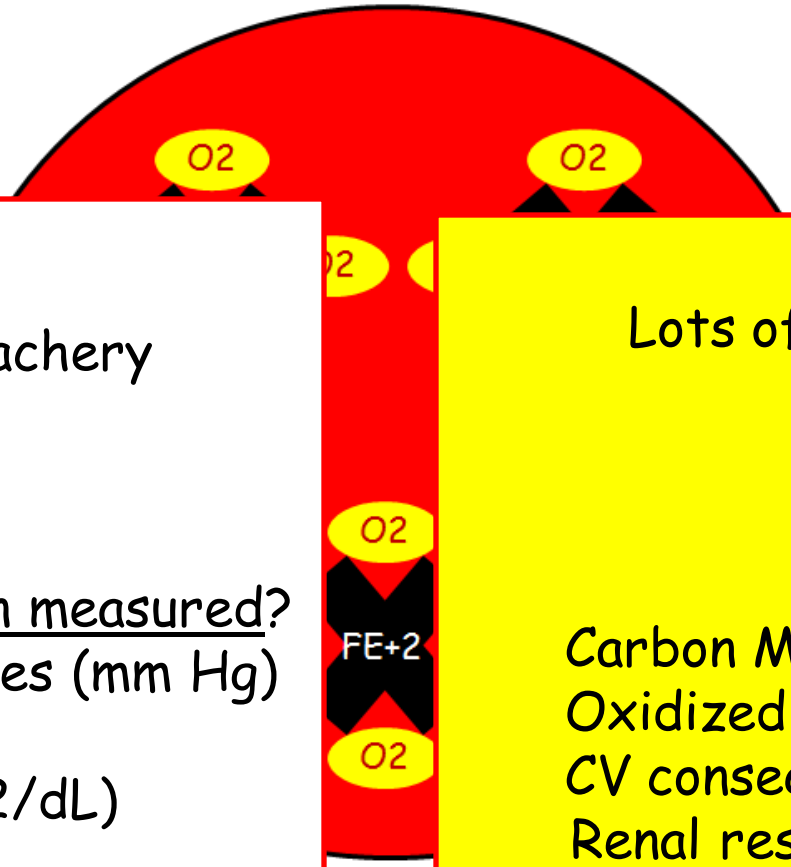
Lots of Derivatives

↓

Carbon Monoxide
Oxidized Iron (Fe+3)
CV consequences of anemia
Renal response to anemia

The Language of Several Key Disorders

Key Point: The RBC Transports Oxygen



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Key Formula: Oxygen Content

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Hgb (gm/dl) x 1.**34** ml O_2/gm Hb x **SaO_2** + **PaO_2** x (.003 ml O_2/mm Hg/dl)

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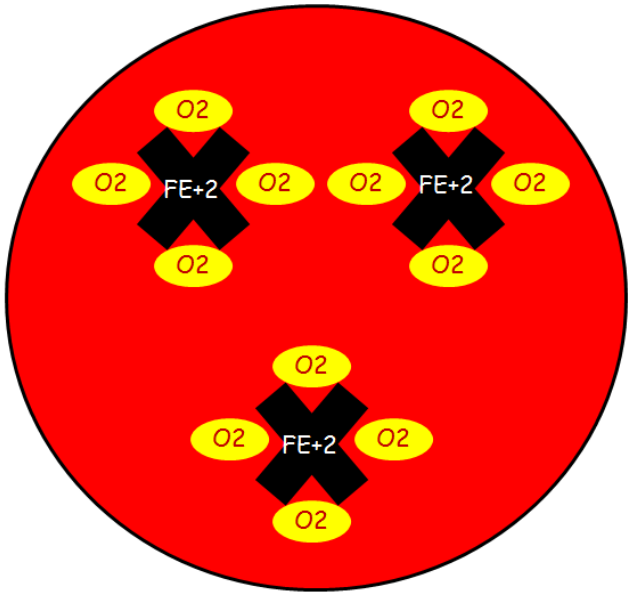
Hgb

SaO2

PaO2



Key Variables for Oxygen Content

Oxygen Content

Hgb (gm/dl) x 1.**34** ml O_2/gm Hb x **SaO_2** + **PaO_2** x (.003 ml O_2/mm Hg/dl)

(Quantitative) Hemoglobin

Hgb (gm/dl) x 1.**34** ml O_2/gm Hgb

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(Quantitative) Hemoglobin

Hgb (gm/dl) x 1.**34** ml O_2/gm Hgb

Oxygen Saturation (heme, A-a gradient)

Hb (gm/dl) x 1.34 ml O_2/gm Hb x **SaO_2**

Key Variables for Oxygen Content

Oxygen Content

Hgb (gm/dl) x 1.**34** ml O_2/gm Hb x **SaO_2** + **PaO_2** x (.003 ml O_2/mm Hg/dl)

(Quantitative) Hemoglobin

Hgb (gm/dl) x 1.**34** ml O_2/gm Hgb

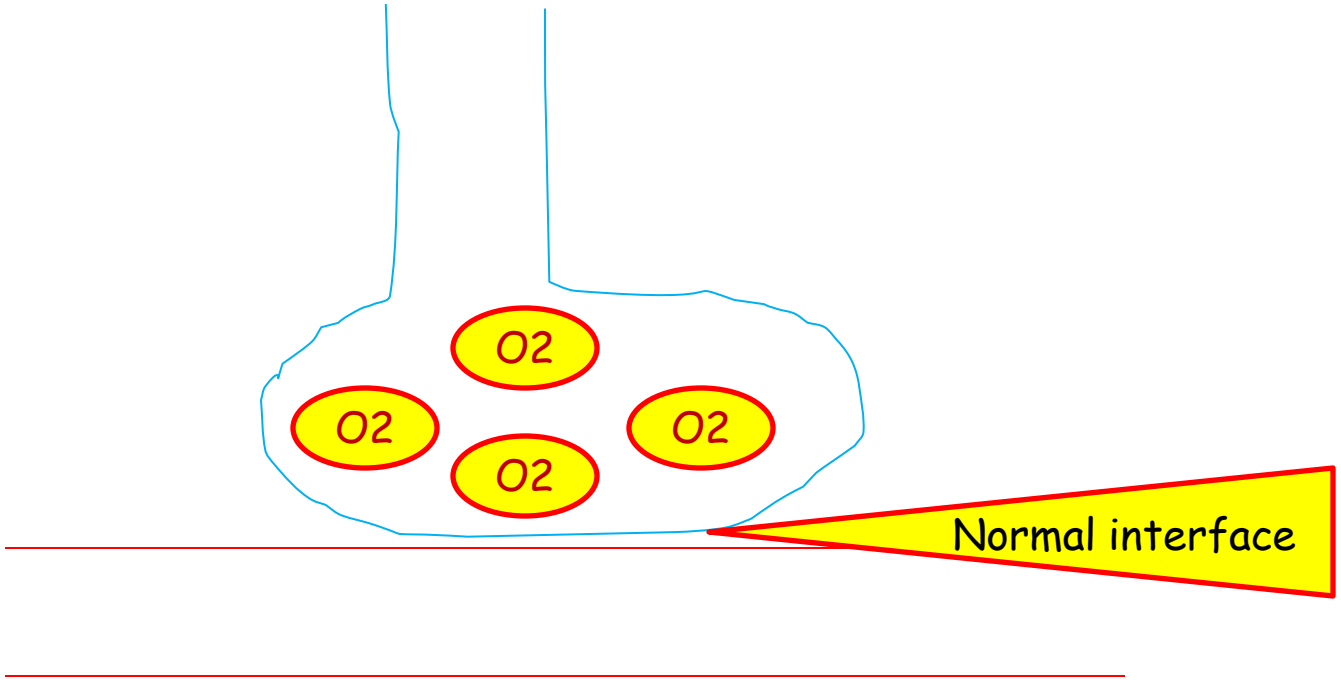
100 mm Hg x 0.003 = 0.3 ml O2/dl

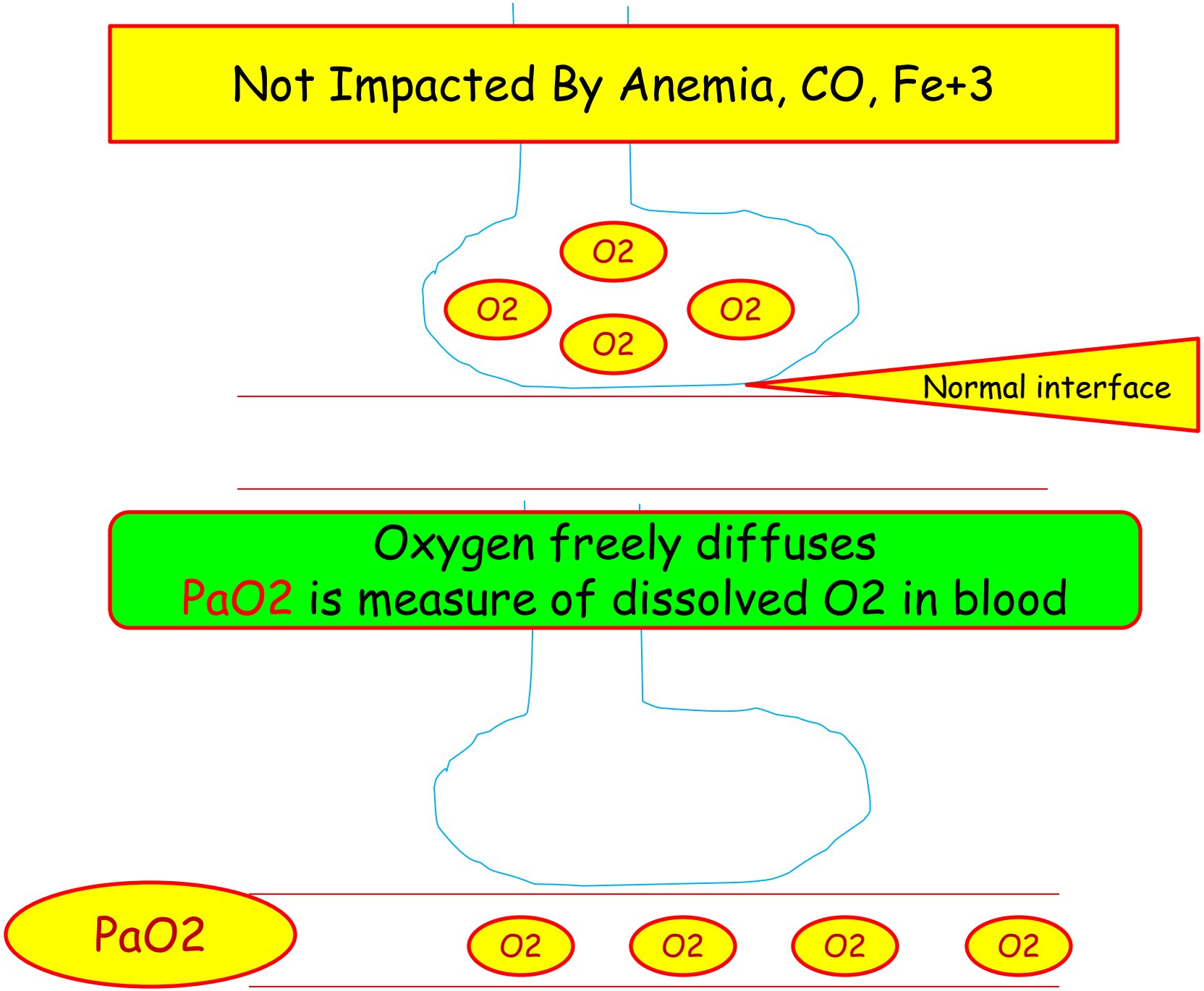
Oxygen Pressure (dissolved oxygen)

+ **PaO_2** x (.003 ml O_2/mm Hg/dl)

Definitions: Gas Transport & Measure

- PaO2 (ABG), Arterial Oxygen Pressure (Tension): measures dissolved gas in plasma ('normal' >80 mm Hg)
  - Not impacted by disorders of hemoglobin (i.e. anemia, CO, Fe+3)
  - Determined by PAO2 and the alveolar-capillary interface


O2
O2
O2
O2
Normal interface


Not Impacted By Anemia, CO, Fe+3
O2
O2
O2
O2
Normal interface
Oxygen freely diffuses
PaO2 is measure of dissolved O2 in blood
PaO2
O2
O2
O2
O2

PaO2 determined by ABG

Oxygen freely diffuses
PaO2 is measure of dissolved O2 in blood

PaO2

O2 O2 O2 O2

Anemia does NOT impact the ability of oxygen to dissolve in plasma

Patient with Hgb 10 (12-15) and HCT of 30% (40-45)

PaO2

A. ⇩

B. ⇧

C. ⇔

Definitions: Gas Transport & Measure

- SaO2: Arterial Oxygen Saturation: percentage of heme binding sites occupied by oxygen (>95%)
  - Unaffected by anemia; fewer cells, but they are still saturated.

Next slide is FYI…

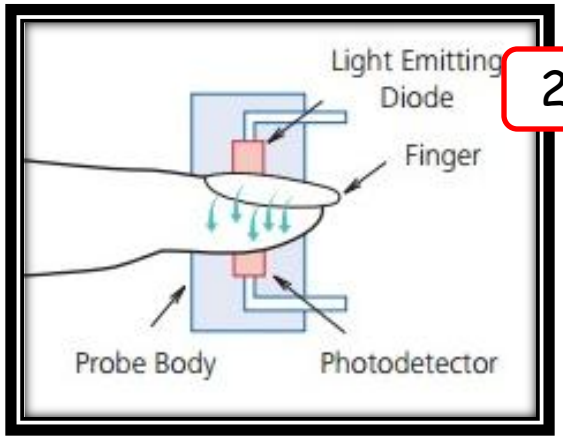
Definitions: Gas Transport & Measure

FYI…

- SaO2: Arterial Oxygen Saturation: percentage of heme binding sites occupied by oxygen (>95%)
  - Unaffected by anemia; fewer cells, but they are still saturated.
  - SaO2 (ABG) might vary from SpO2 (pulse oximeter)

4 wavelengths

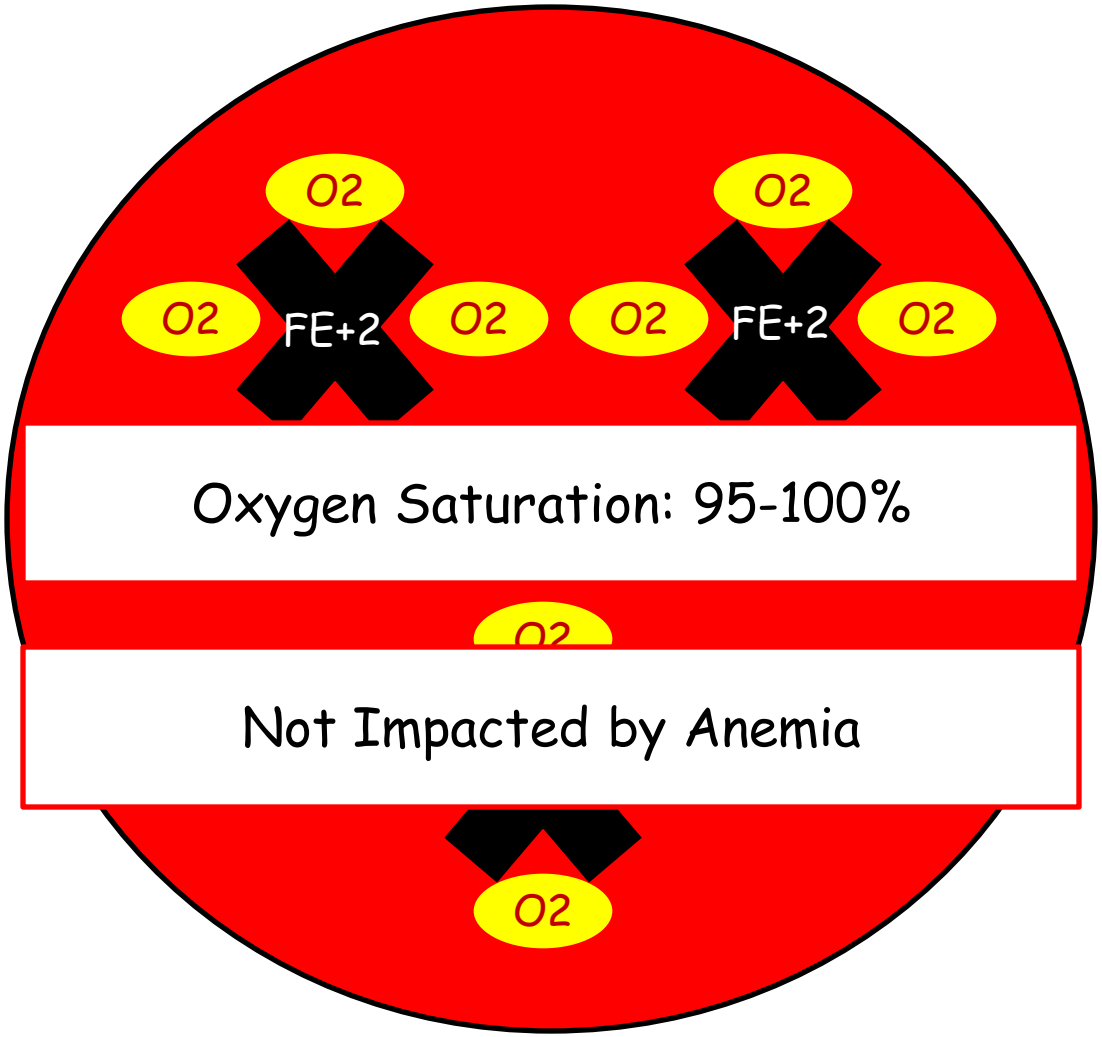
Co-oximeter



2 wavelengths

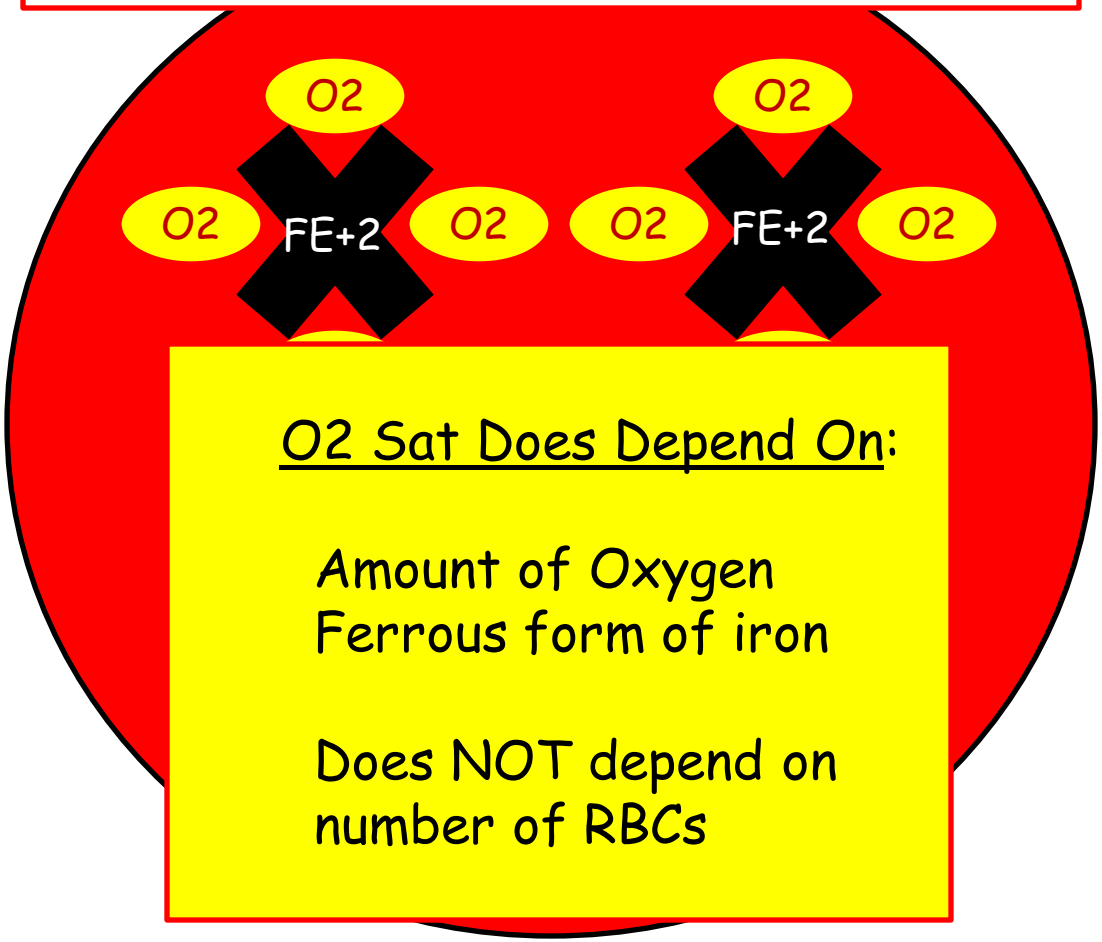
Pulse Oximetry

Oxygen freely diffuses into RBCs
SaO2 measures Hgb binding sites bound to oxygen



Oxygen Saturation (SaO2)

Oxygen Saturation: 95-100%



<u>O2 Sat Does Depend On</u>:

Amount of Oxygen
Ferrous form of iron

Does NOT depend on number of RBCs

Oxygen Saturation (SaO2)

Oxygen freely diffuses into RBCs
SaO2 measures Hgb binding sites bound to oxygen

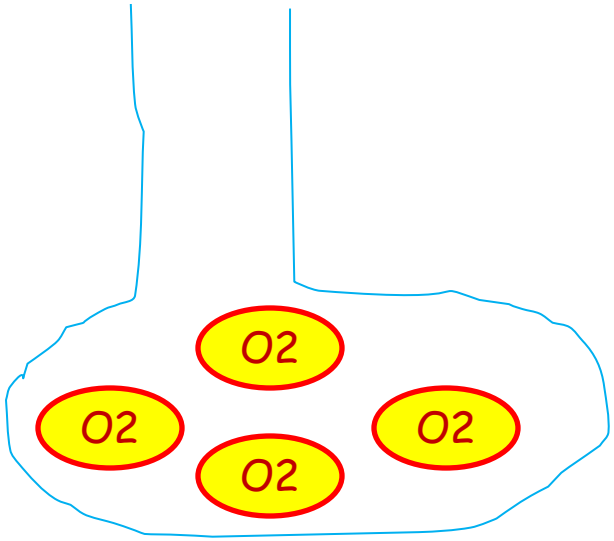
~ Not Impacted By Anemia ~
Is Impacted by CO, Fe+3, A-a variables

Patient with Hgb 10 (12-15) and HCT of 30% (40-45)

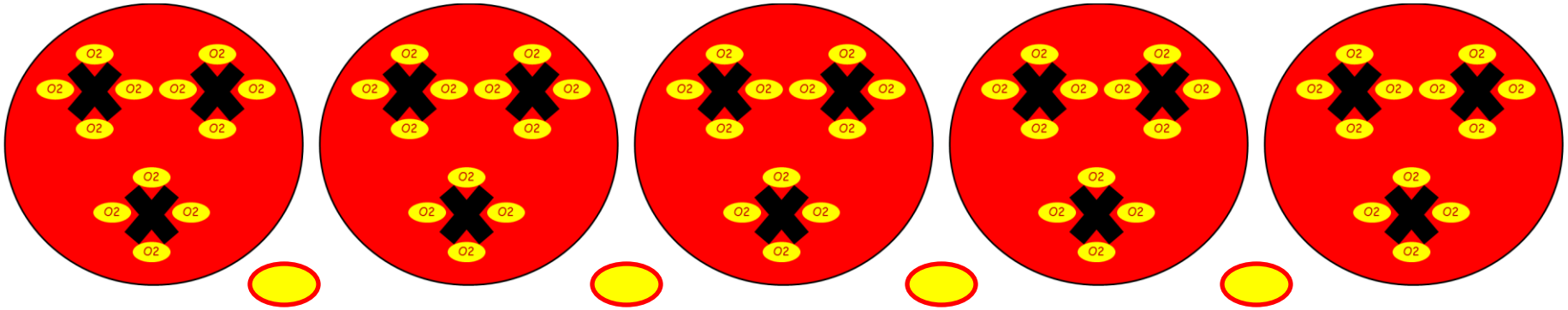
	PaO2	SaO2
A.	⇩	⇩
B.	⇧	⇧
C.	⇔	⇔

Definitions: Gas Transport & Measure

- Oxygen Content (~20 ml O2/dl): amount of oxygen bound to Hgb PLUS the Hgb content.
  - PaO2 (dissolved oxygen) contributes very minimally.
  - Hgb is the major player
    - Anemia will impact content
  - SaO2 is close to 100% (under normal circumstances)

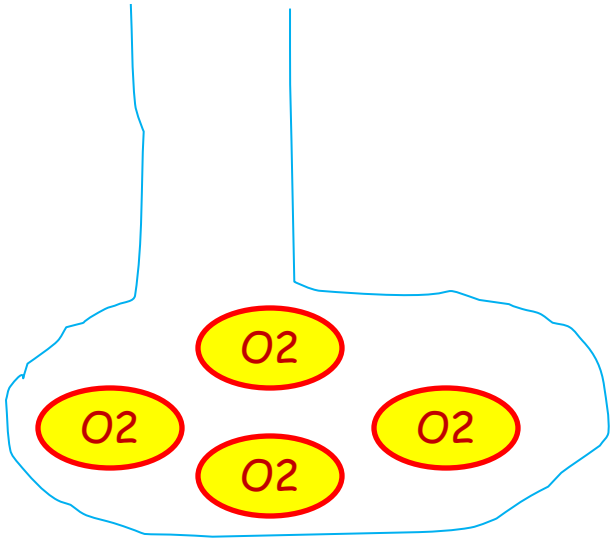


Oxygen Content (CaO2):
Measures number of RBCs and amount of oxygen bound to Hgb

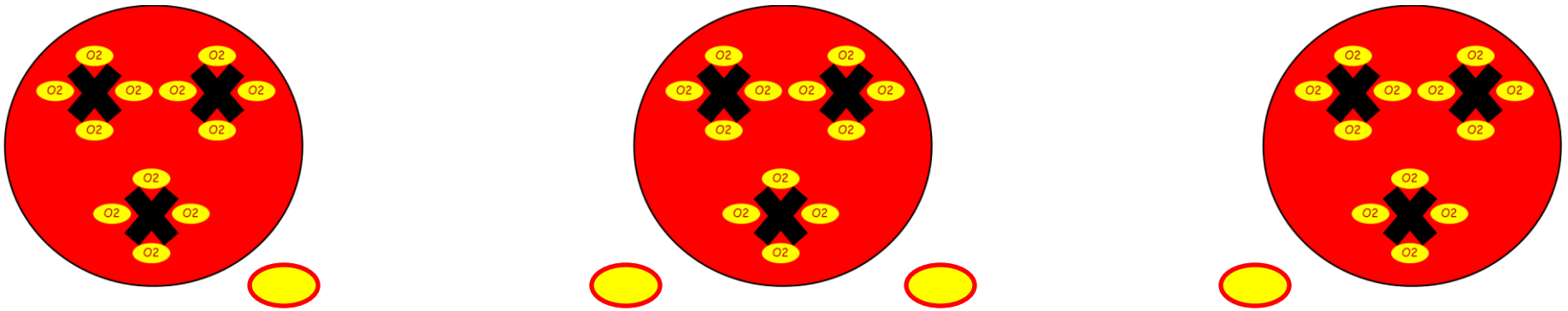


Oxygen Content
Hgb (gm/dl) x 1.34 ml O_2/gm Hb x SaO_2 + PaO_2 x (.003 ml O_2/mm Hg/dl)

Typical Values (normal)
Hgb ~15 x 1.34 (~20) x 95-100% SaO2 + 0.3 = 20 ml O2/dl



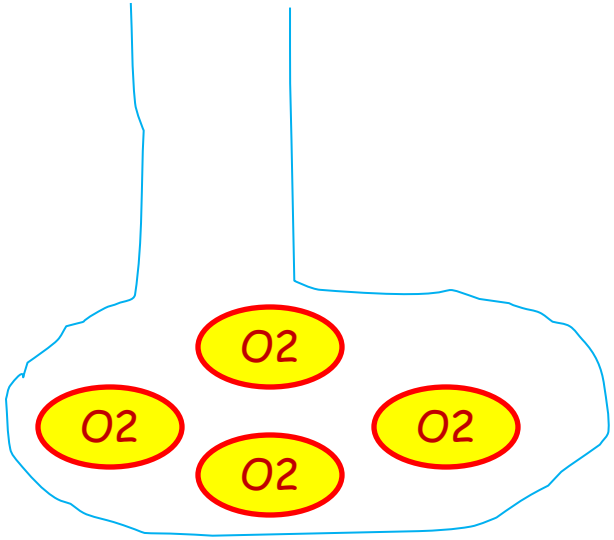
Anemia
(less RBC to carry O2)



PaO2 not changed
SaO2 not changed

Hgb = 9

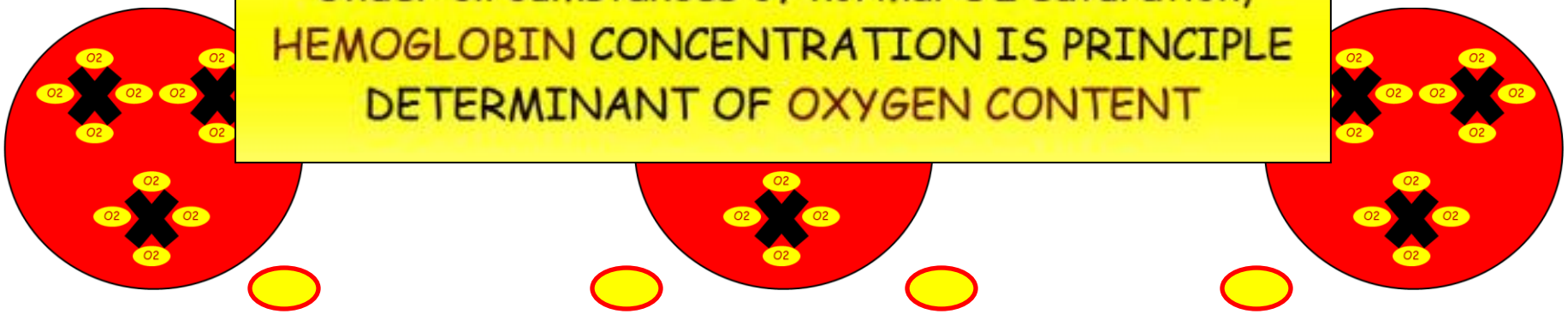
(Hgb 9 x 1.34) x 95-100% SaO2 + 0.3 = 12 ml O2/dl



O2 content is ~ 30% more than the Hgb

Anemia
(less RBC to carry O2)

Under circumstances of normal O2 saturation, HEMOGLOBIN CONCENTRATION IS PRINCIPLE DETERMINANT OF OXYGEN CONTENT



PaO2 not changed
SaO2 not changed

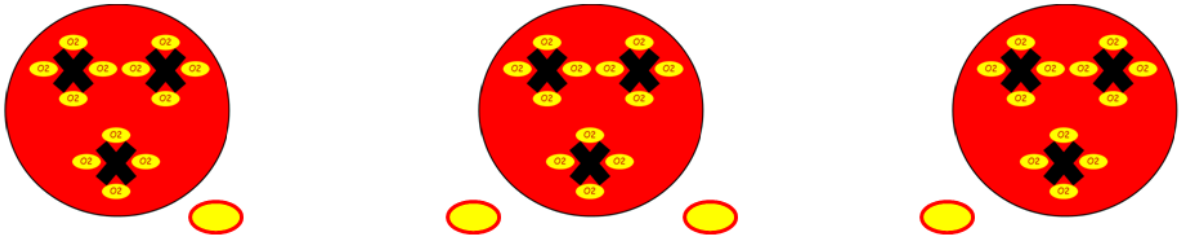
Hgb = 9

(Hgb 9 x 1.34) x 95-100% SaO2 + 0.3 = 12 ml O2/dl

Oxygen Content: (Hb 10 x 1.34) x 95-100% SaO2 + 0.3 = 13 ml O2/dl

Patient with Hgb 10 (12-15) and HCT of 30% (40-45)

	PaO2	SaO2	CaO2
A.	⇩	⇩	⇔
B.	⇧	⇧	⇧
C.	⇔	⇔	⇩



Cardiovascular Response to Hypoxia?