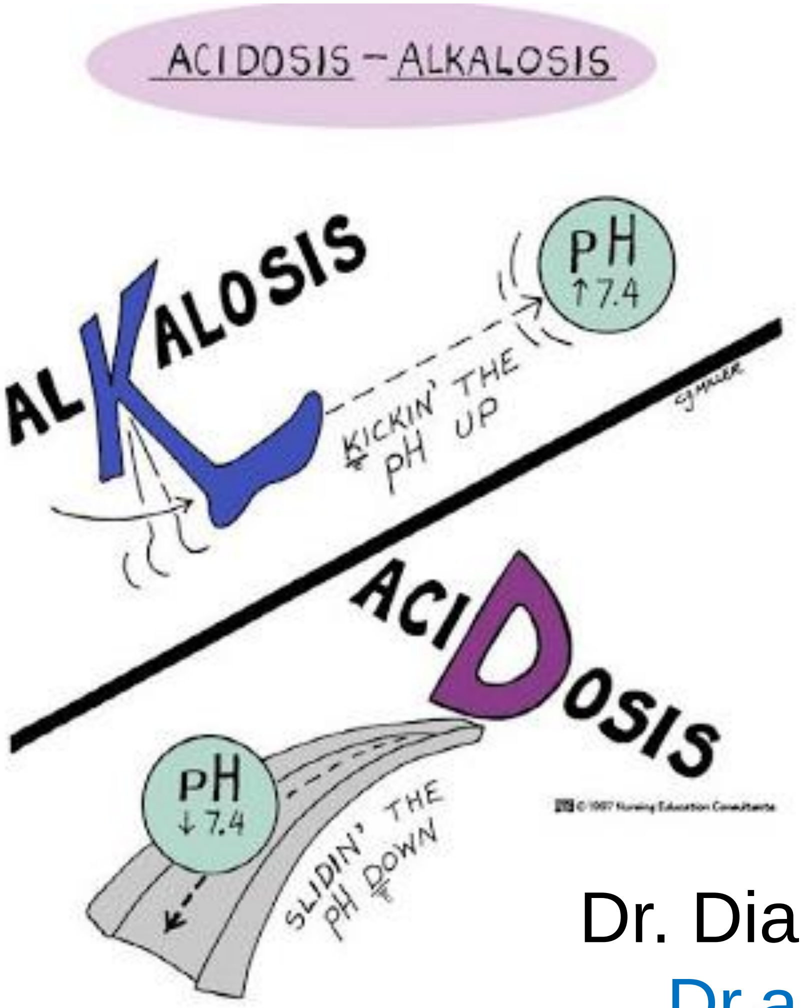

Buffers II

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Lecture 5
MD summer

Buffer systems in the body:

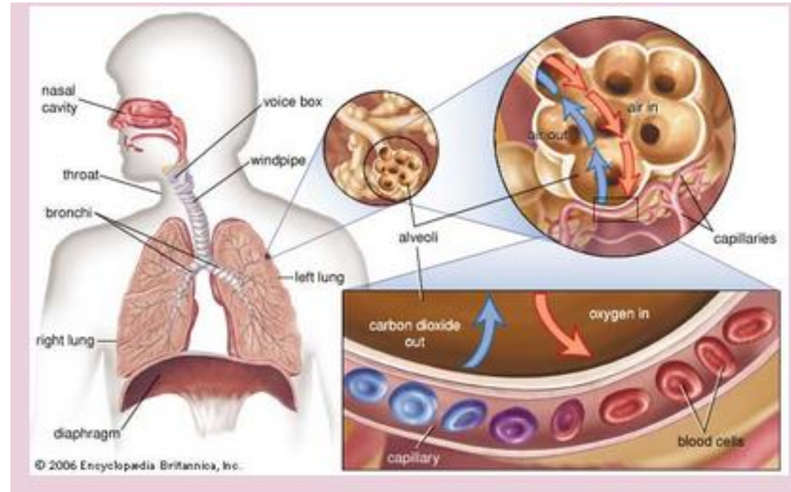
1. The bicarbonate–carbonic acid buffer system (ECF)

2. The hemoglobin buffer system in RBCs

3. The phosphate buffer system in all types of cells

4. The protein buffer system of cells and plasma.

The bicarbonate–carbonic acid buffer system in blood



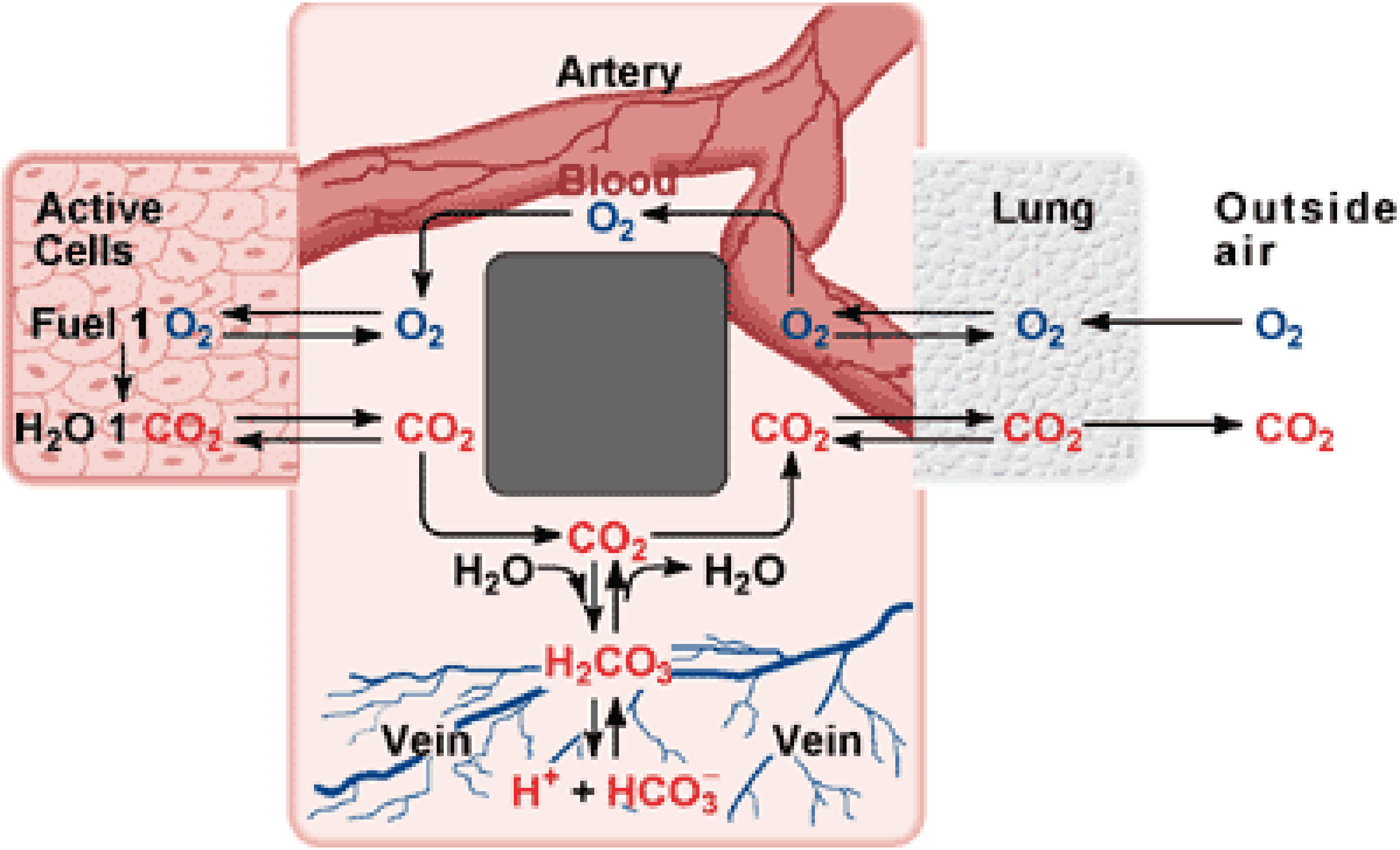
$$CO_{2(g)} \rightleftharpoons CO_{2(aq)}$$

$$CO_{2(aq)} + H_2O_{(l)} \rightleftharpoons H_2CO_{3(aq)}$$

$$H_2CO_{3(aq)} \rightleftharpoons H^+_{(aq)} + HCO_3^-{}_{(aq)}$$

Net: $$CO_{2(g)} + H_2O_{(l)} \rightleftharpoons H^+_{(aq)} + HCO_3^-{}_{(aq)}$$

Bicarbonate buffer system



The bicarbonate–carbonic acid buffer system in blood

$$CO_{2(g)} + H_2O_{(l)} \rightleftharpoons H^+_{(aq)} + HCO_3^-{}_{(aq)}$$

pKa of H_2CO_3 is 6.1, while the pH of human blood is 7.4

$7.4 = 6.1 + \log [HCO_3^-] / [CO_2]$
$1.3 = \log [HCO_3^-] / [CO_2]$
$[HCO_3^-] / [CO_2] = 20$

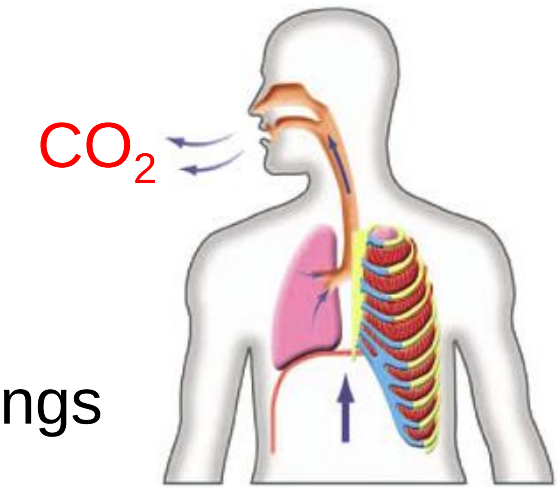
$\longrightarrow$ most of the dissolved CO_2 is present as HCO_3^-

Normal values:
pH = 7.4
pCO_2 = 40 mm Hg (~ 1.2 mM)
$[HCO_3^-]$ = 25 mM

What happens when the pH of the blood drops?

- Low pH means more H^+

$$H^+_{(aq)} + HCO_3^-{}_{(aq)} \rightleftharpoons H_2CO_{3(aq)}$$



$$H_2CO_{3(aq)} \rightleftharpoons CO_{2(aq)} + H_2O_{(l)}$$

$$CO_{2(aq)} \rightleftharpoons CO_{2(g)}$$ exhaled by the lungs

-Aspirin

-High altitudes - rate of respiration increases.

-Athelete example

What happens when the pH of the blood increases?

- Higher pH means more OH^-

$NaOH + H_2CO_3 \longrightarrow NaHCO_3 + H_2O$

$CO_2 + H_2O \longrightarrow H_2CO_3$ to replace the consumed acid

$[CO_2]$ decrease and respiration decrease to reduce the rate of CO_2 consumption.

$[HCO_3^-] / [CO_2]$ = 25 mM/ 1.25 m M = 20

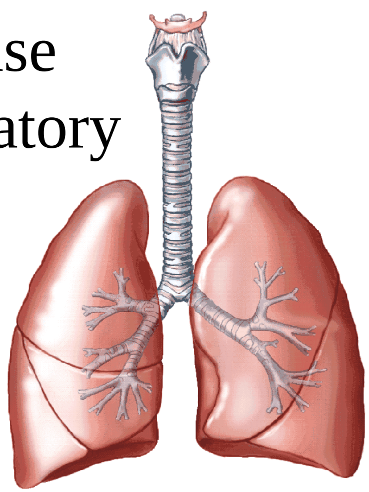
Buffer range = 6.1 $\pm$ 1 = 5.1-7.1

Breathing and the bicarbonate buffer system

$$H_2O + CO_2 \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^- \leftrightarrow HCO_3^-$$

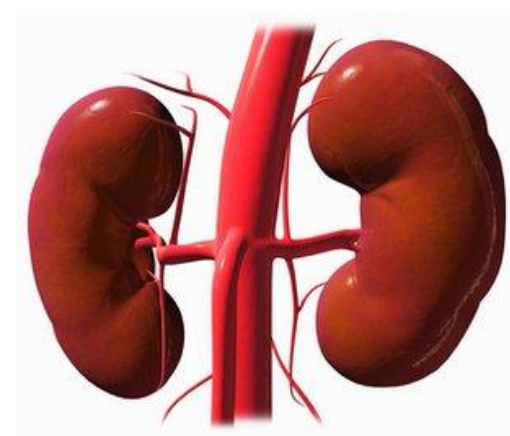
Reserve

Increase respiratory rate



Decrease respiratory rate

Other buffer systems



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Protein Buffers

-Because of the presence of the dissociable acidic (-COOH) and basic (-NH2) groups, proteins act as buffers.

-Particularly the imidazole group of the side chain of histidine residue (pKa = 7.3)

Proteins, specifically Albumin, account for 95% of non-carbonate buffering action in plasma (has 16 His/mole)

Histidine

Phosphate Buffer systems

-Phosphate anions and proteins are important buffers that maintain a constant pH of ICF.

-Intracellular and tubular fluids of kidney

- $H_2PO_4^-$ dissociates to H^+ and HPO_4^{-2}

-pKa is 7.1-7.2

- In RBCs 2,3 BPG is 4.5 mM contributing to ~16% Non carbonate buffer function.

- Glu-6P, ATP act as buffers

$H^+ + Na_2HPO_4$

$OH^- + NaH_2PO_4$

Hemoglobin (Hb) Buffer

-Major intracellular buffer of the blood

-Hb has a high number of His (38 molecules/mole of Hb)

-Works cooperatively with the bicarbonate buffer system

-It buffers CO_2 and H_2CO_3

More details in the 3rd year

Buffer systems of the body

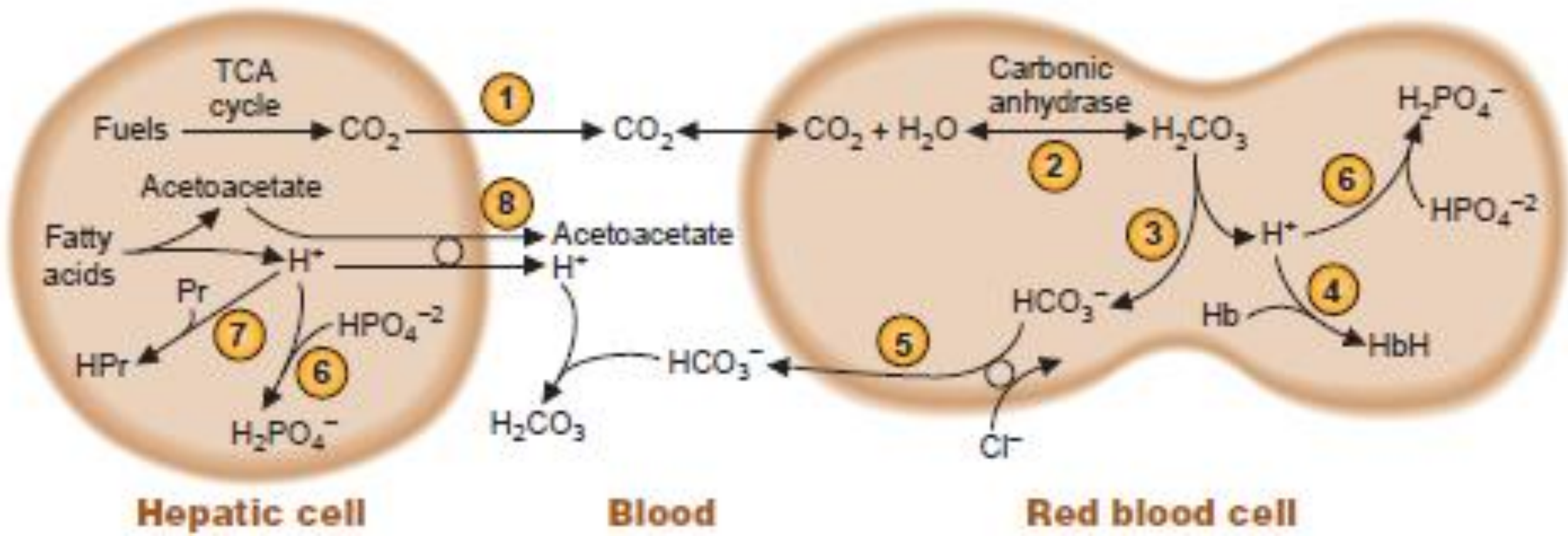

FIG. 4.9. Buffering systems of the body. CO_2 produced from cellular metabolism is converted to bicarbonate and H^+ in the red blood cells. Within the red blood cells, the H^+ is buffered by hemoglobin (Hb) and phosphate (HPO_4^{2-}) (*circles 4 and 6*). The bicarbonate is transported into the blood to buffer H^+ generated by the production of other metabolic acids, such as the ketone body acetoacetic acid (*circle 5*). Other proteins (Pr) also serve as intracellular buffers. See the text for more details.

Questions

Done or not yet?!