# Troubles acidobasiques : l'approche de Stewart

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# Nomenclature

ACIDOSE

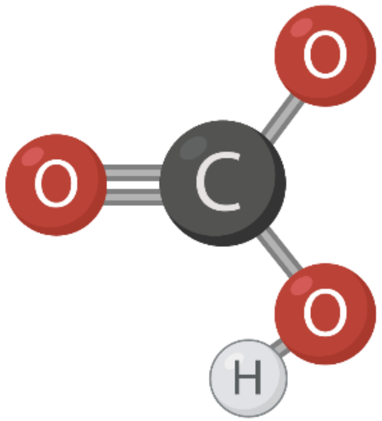
ALCALOSE

ACIDÉMIE

ALCALÉMIE

# Déterminants du pH

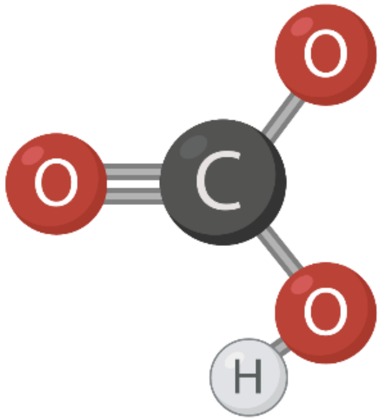

Dioxyde de carbone




Bicarbonate

# Déterminants du pH


Dioxyde de carbone




Bicarbonate

# OBJECTIFS

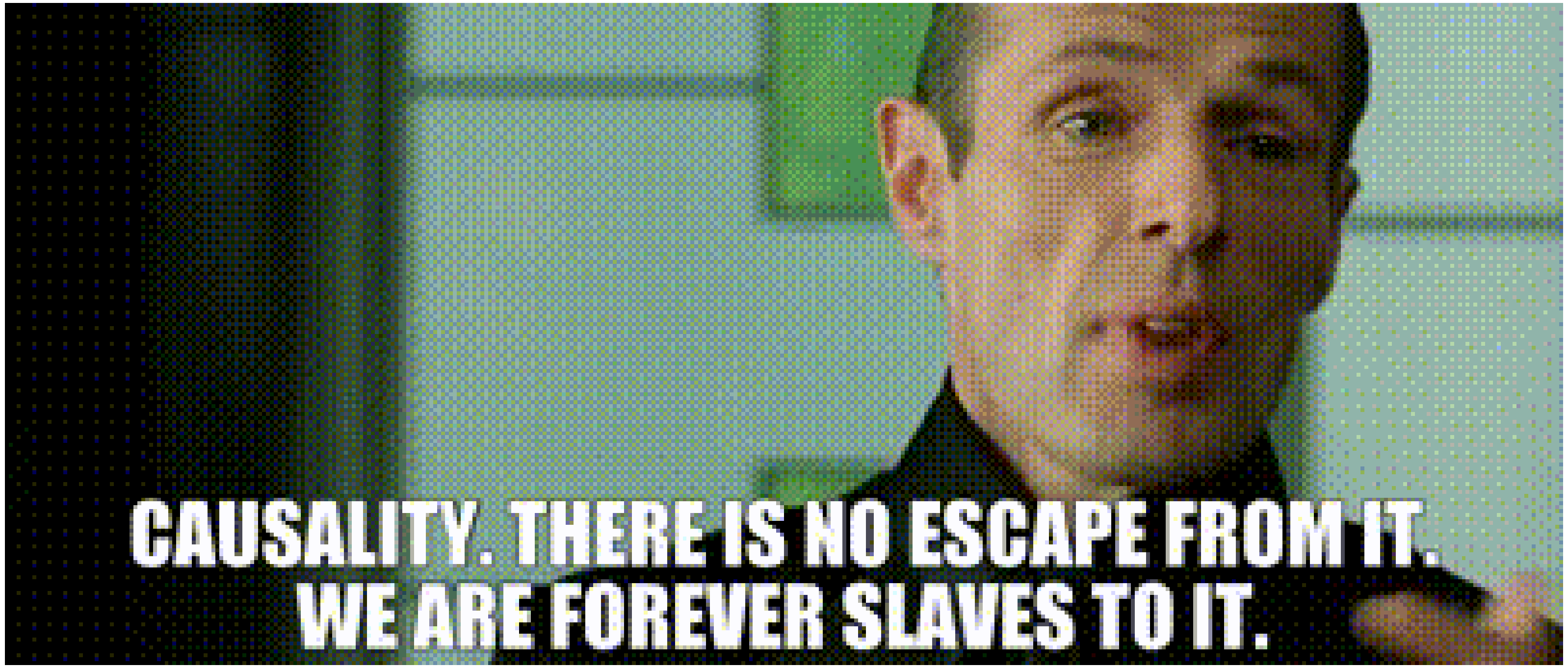
Identifier les limites du modèle classique

Comprendre pourquoi il faut changer de modèle

Comprendre un modèle alternatif

Appliquer le modèle

# Observation vs. causalité



# Relation vs. causalité

Mes patients neurolésés ont plus de séquelles lorsqu'ils maintiennent une pression artérielle basse.

Je dois maintenir une pression artérielle normale suite à une neurolésion.

Lorsque le ciel est nuageux, il pleut plus souvent.

Lorsque le ciel est nuageux, je dois m'abriter.

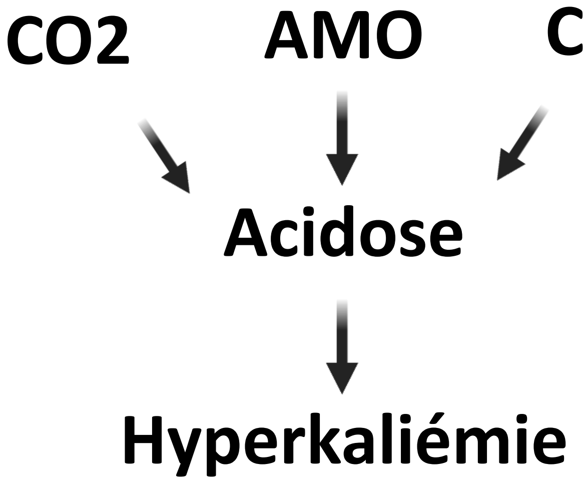
Suite à un traumatisme, les patients tachycardes meurent plus souvent.

Je dois ralentir la fréquence cardiaque des patients traumatisés.

Devant une hyperkaliémie, j'observe souvent une acidose.

L'acidose est une cause d'hyperkaliémie.

# L'exemple du chlore



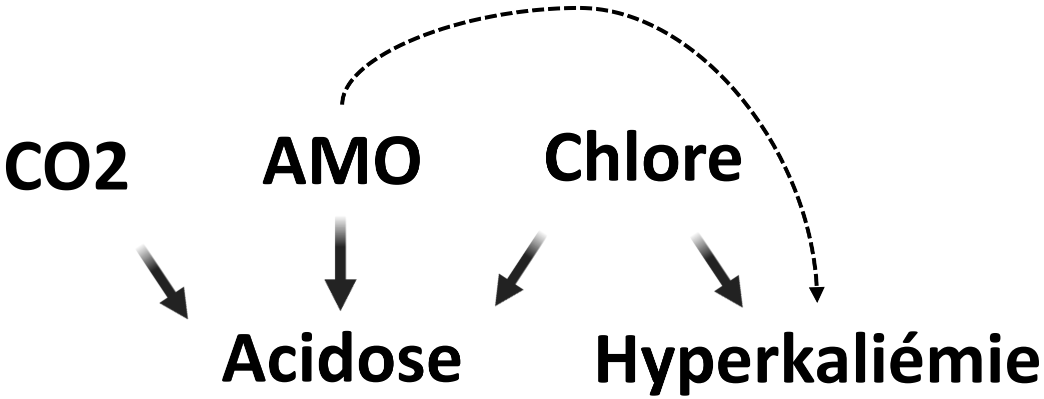
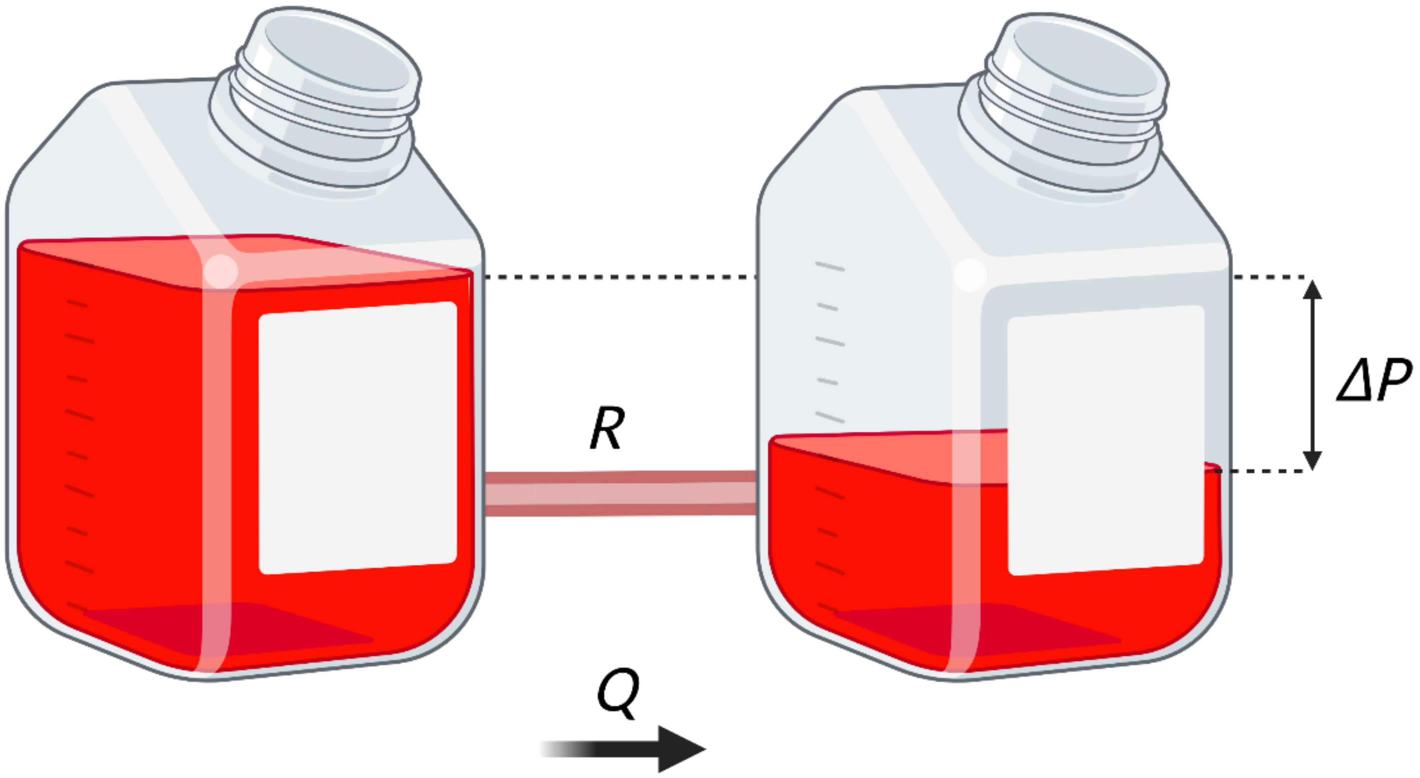



*Table 2.* Ranges of volume and electrolyte composition in vomitus, diarrhea fluid, and ileostomy drainage[a]

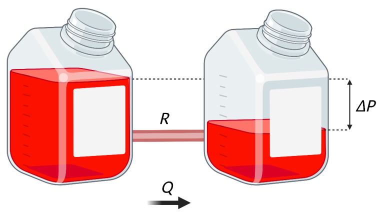
| State | Volume (L/d) | [$Na^+$] (mmol/L) | [$K^+$] (mmol/L) | [$Cl^-$] (mmol/L) | [$HCO_3^-$] (mmol/L) |
|---|---|---|---|---|---|
| Normal stool | <0.15 | 20 to 30 | 55 to 75 | 15 to 25 | 0[b] |
| Vomitus/NG drainage | 0.00 to 3.00 | 20 to 100 | 10 to 15 | 120 to 160 | 0 |
| Inflammatory diarrhea | 1.00 to 3.00 | 50 to 100 | 15 to 20 | 50 to 100 | 10 |
| Secretory diarrhea | 1.00 to 20.00 | 40 to 140 | 15 to 40 | 25 to 105 | 20 to 75 |
| Congenital chloridorrhea | 1.00 to 5.00 | 30 to 80 | 15 to 60 | 120 to 150 | <5 |
| Villous adenoma | 1.00 to 3.00 | 70 to 150 | 15 to 80 | 50 to 150 | Unknown[c] |
| Ileostomy drainage | | | | | |
| new | 1.00 to 1.50 | 115 to 140 | 5 to 15 | 95 to 125 | 30 |
| adapted | 0.50 to 1.00 | 40 to 90 | 5 | 20 | 15 to 30 |

# Equation : relation ou causalité ?




$$Q = \frac{\Delta P}{R}$$

# Equation : relation ou causalité ?




$$Q = \frac{\Delta P}{R}$$

**Lorsque la pression augmente, le débit augmente (à résistance constante)**

**Si j'augmente la pression, alors j'augmente le débit**

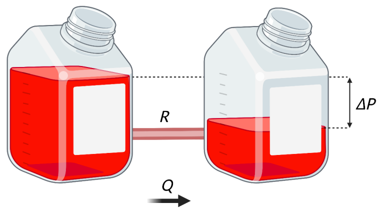
**Lorsque la résistance augmente, le débit diminue (à pression constante)**

**Si j'augmente la résistance, alors je diminue le débit**

**Lorsque la pression augmente, la résistance diminue (à débit constant)**

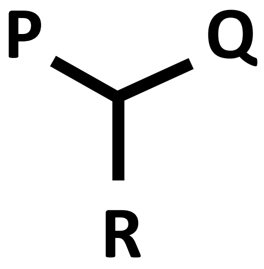
**Si j'augmente la pression, alors je diminue la résistance**

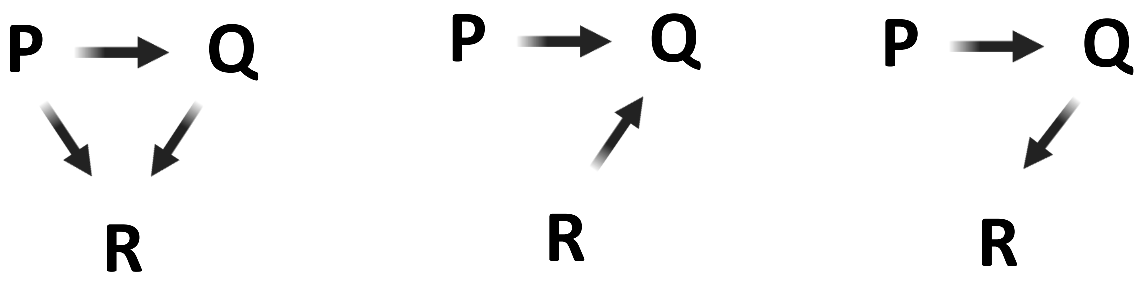
# Equation : relation ou causalité ?




$$Q = \frac{\Delta P}{R}$$

**Chaque paramètre peut être déterminé par les deux autres**



# Equation de Henderson-Hasselbach

$$pH = pKa + log_{10}\frac{[A^-]}{[AH]}$$

$$AH \leftrightarrow A^- + H^+$$

$$pH = 6.10 + log_{10}\frac{[HCO_3^-]}{[CO_2]}$$

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

**HCO3** **CO2**

**pH**

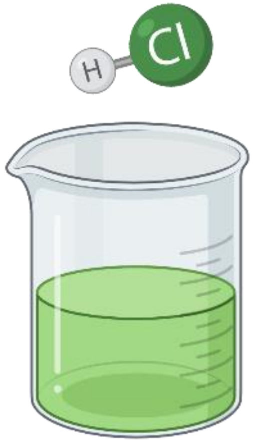
**pH** **CO2**

**HCO3**

**HCO3** **pH**

**CO2**

# Validation par l’observation



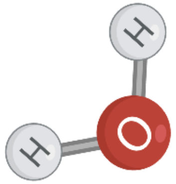
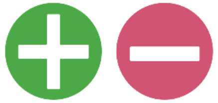

Hyperchlorémie

Albumine

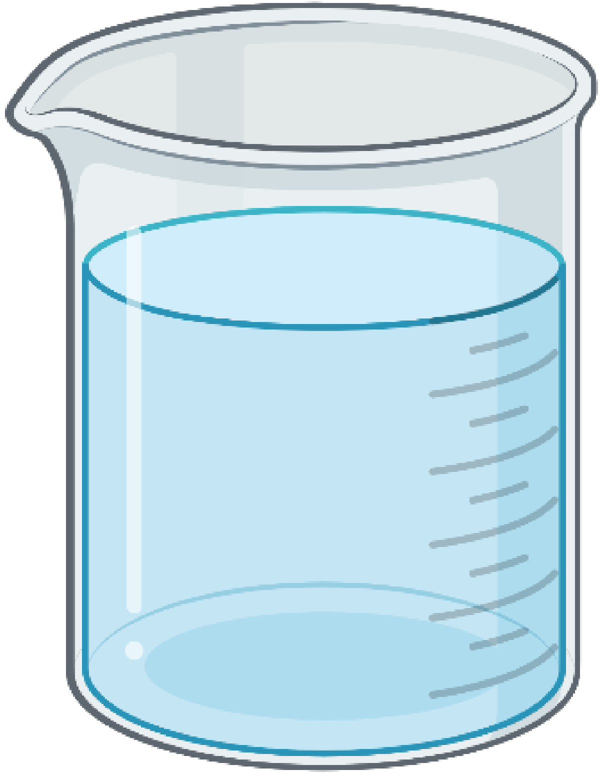
Dilution - contraction

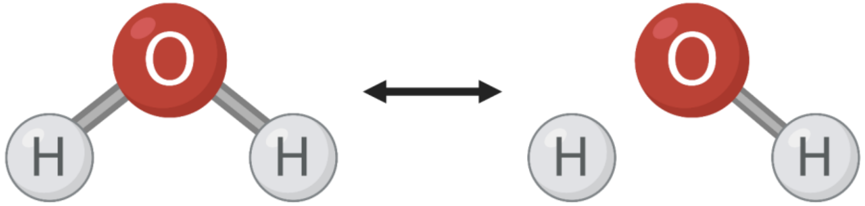
# Le modèle de Stewart

# Le modèle de Stewart

| | | |
|---|---|---|
| Dissociation de l'eau |  | $K'_w = [H^+] \times [OH^-]$ |
| Conservation de la masse |  | $A \leftrightarrow B \Rightarrow [A] = [B]$ |
| Electroneutralité |  | $Cations = Anions$ |

# DIY plasma ! – Eau pure

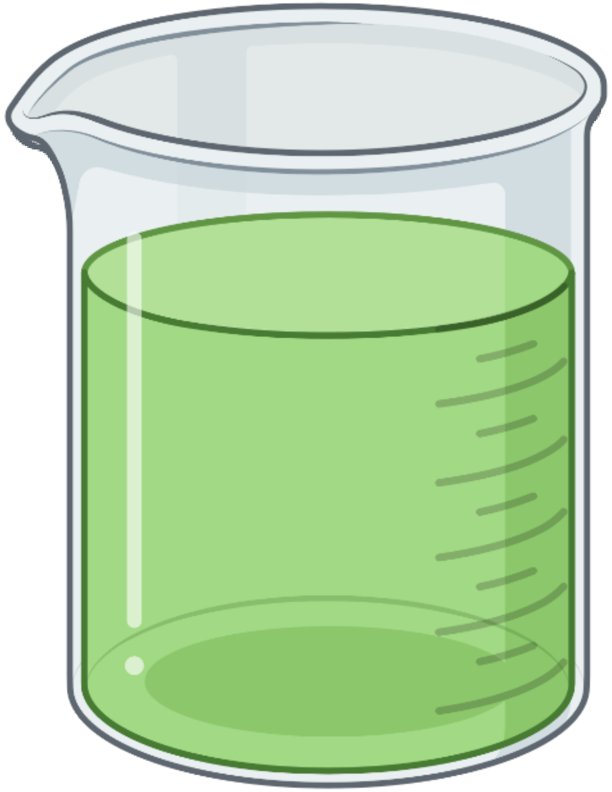





$$H_2O \leftrightarrow H^+ + OH^-$$

$$K'_w = [H^+][OH^-] = 10^{-14}$$

# DIY plasma ! – Eau pure + ions forts



$$HCl \rightarrow H^{+} + Cl^{-}$$

$$NaOH \rightarrow Na^{+} + OH^{-}$$

$$\boxed{Na + K - Cl} + H^{+} - OH^{-} = 0$$

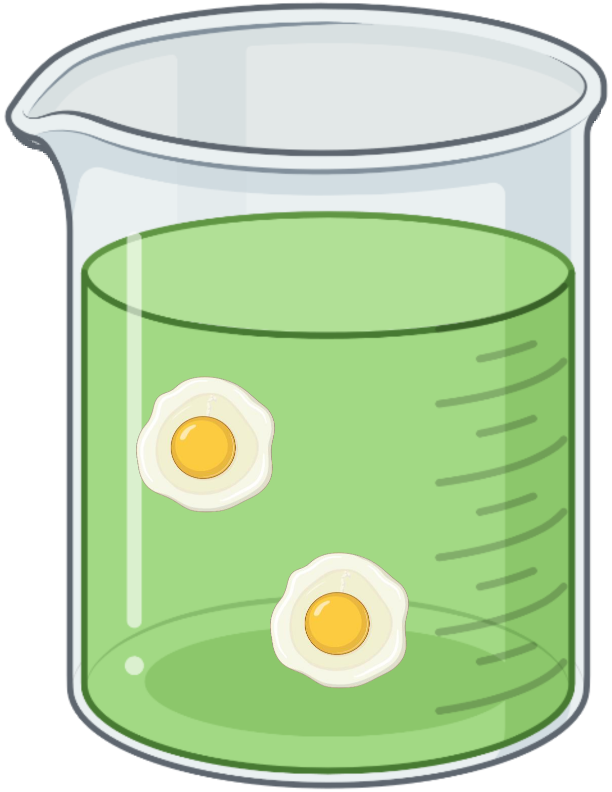
$$\boxed{SID = Na + K - Cl \sim 42}$$

**SID** **Indosés**

**Acides – bases forts**

# pH

# DIY plasma ! – Eau pure + ions forts + amino-acides



$$AH \leftrightarrow H^+ + A^-$$

$$pH = pKa + log_{10} \frac{[A^-]}{[AH]}$$

$$\boxed{A_{tot} = AH + A^- \text{(albumine, phosphate)}}$$

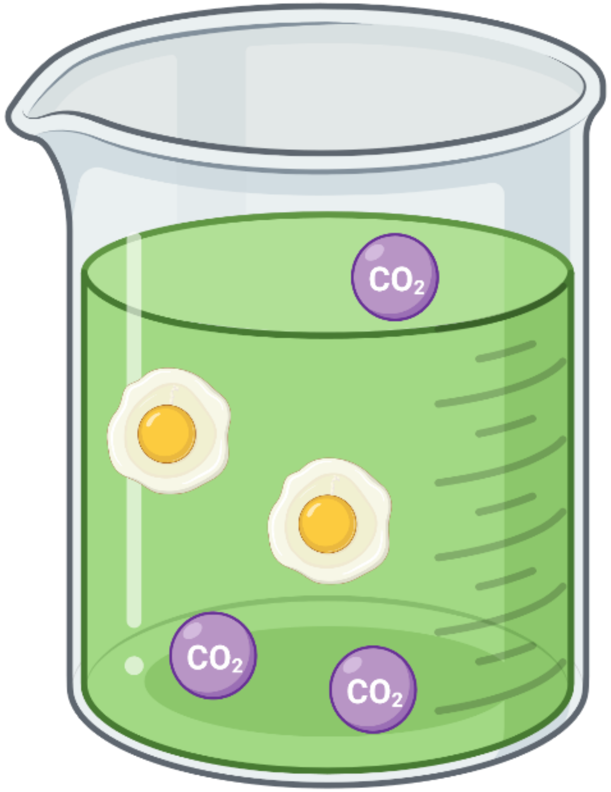
$$\boxed{SID} - \boxed{A^-} + H^+ - OH^- = 0$$

**SID** **Indosés** **Albumine** **Phosphate**

**Acides – bases forts** **Acides – bases faibles**

# pH

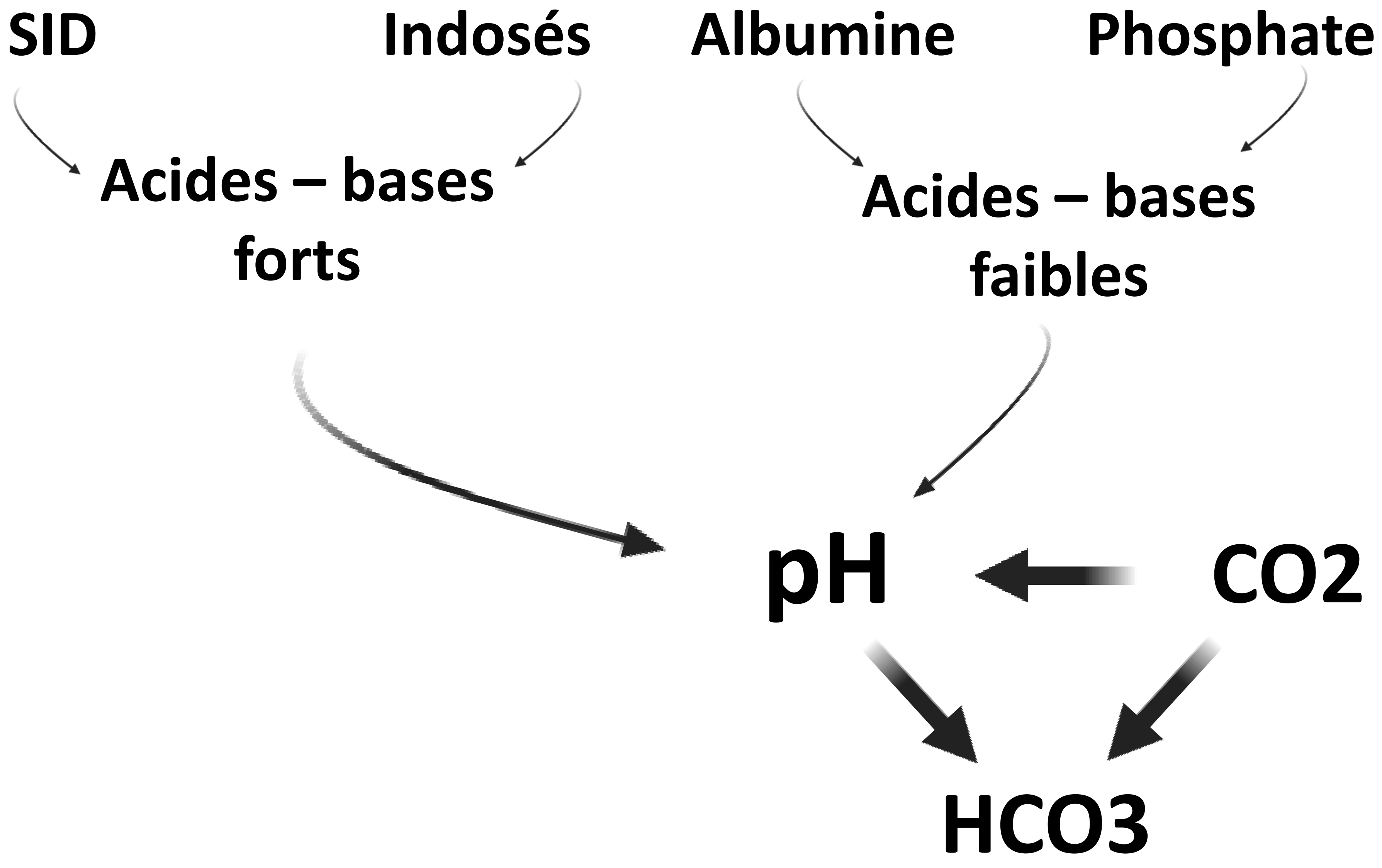
# DIY Plasma - Eau + ions forts + amino-acides + CO2




$$pH = 6.10 + log_{10} \frac{[HCO_3^-]}{[CO_2]}$$

$$\boxed{SID} - \boxed{A^-} - \boxed{HCO_3^-} + H^+ - OH^- = 0$$

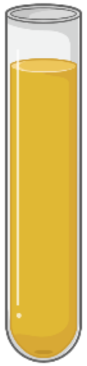
Bonus : $TA_c = TA_m + 0.25\,(40 - Alb)$


SID
Indosés
Albumine
Phosphate
Acides – bases forts
Acides – bases faibles
pH
CO2
HCO3

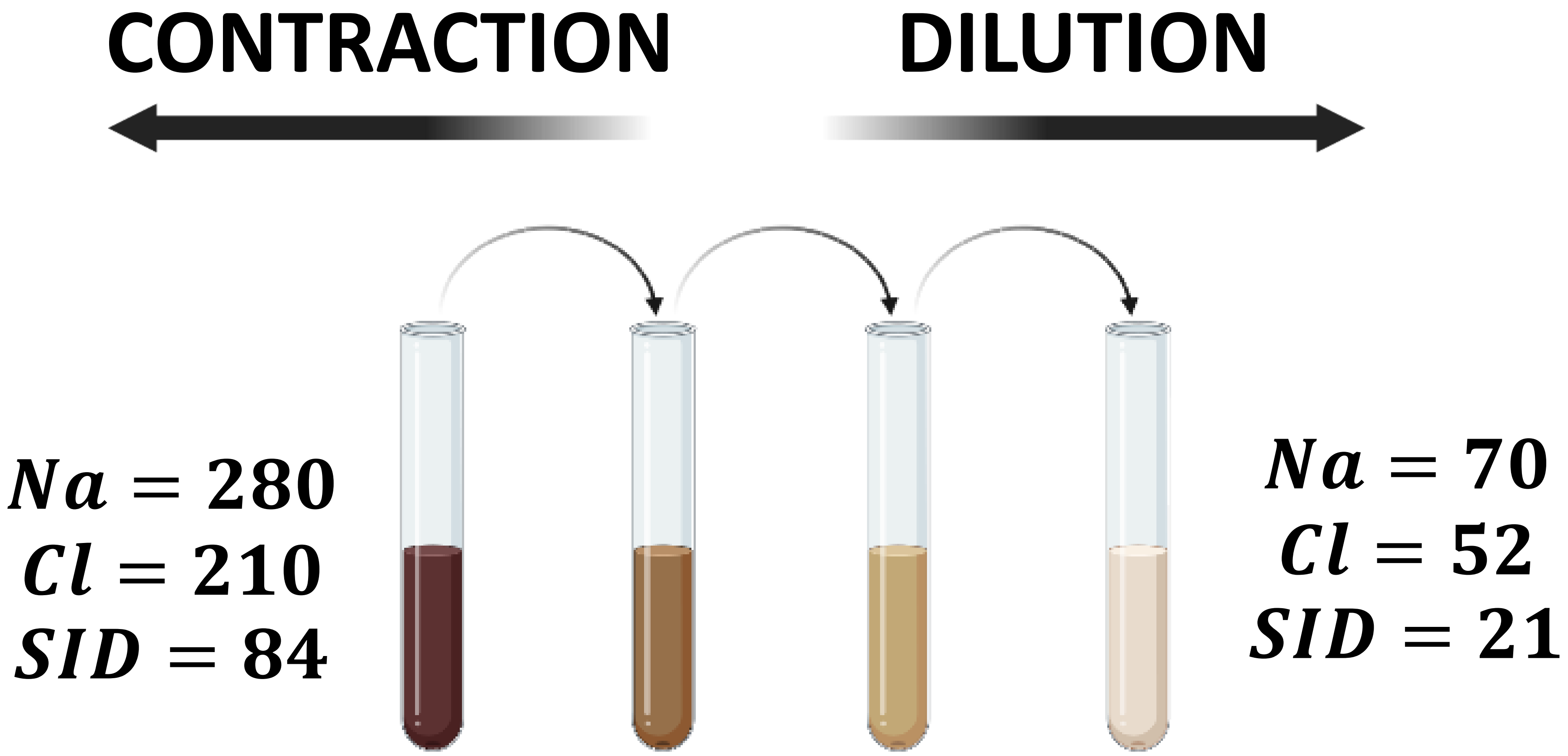
# Le modèle de Stewart, ça marche ?

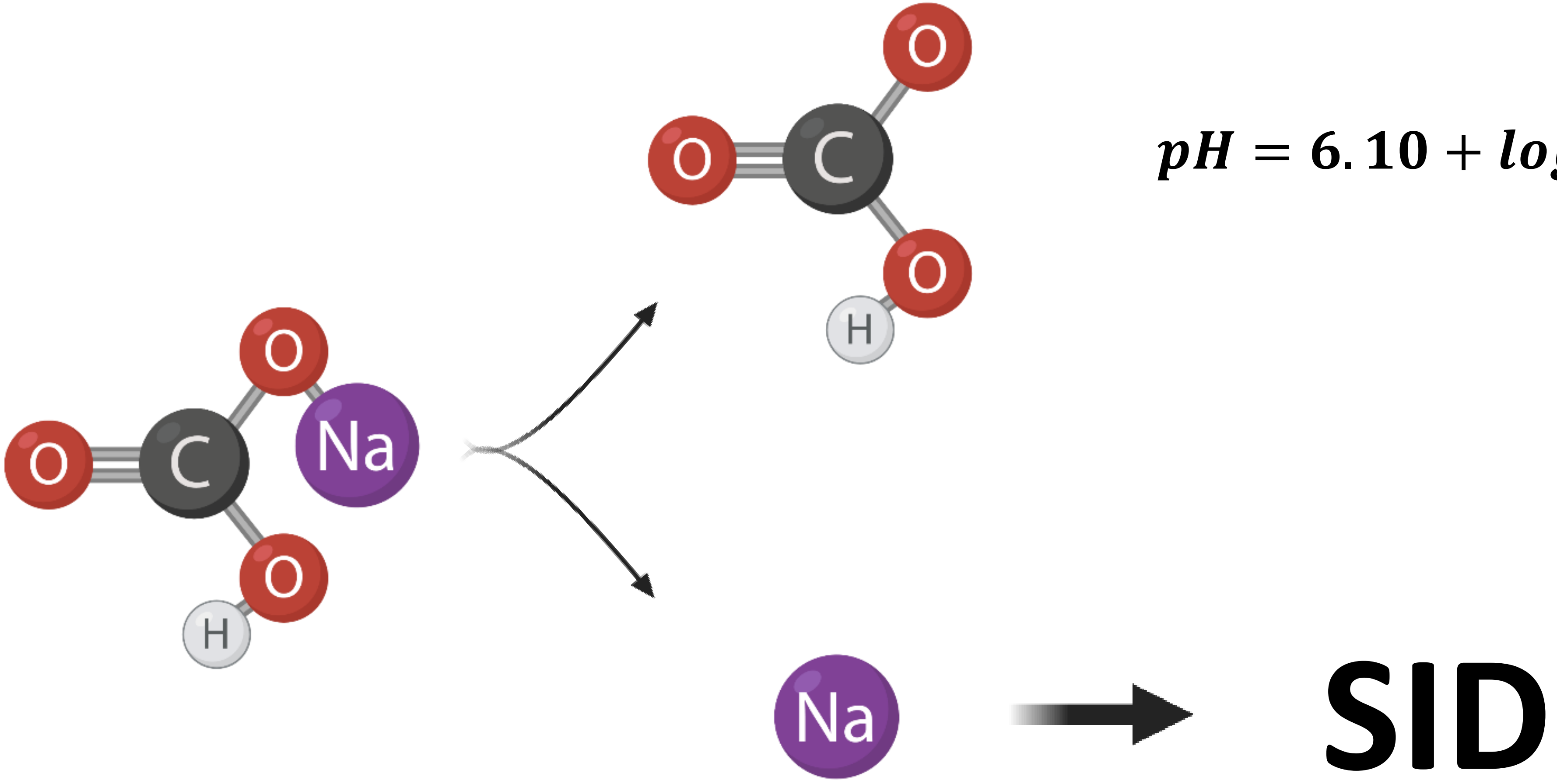
$$Na = 154$$
$$Cl = 154$$
$$SID = 0$$

$$SID \downarrow\downarrow$$



$$Na = 140$$
$$Cl = 105$$
$$SID = 42$$


CONTRACTION
DILUTION
$Na = 280$
$Cl = 210$
$SID = 84$
$Na = 70$
$Cl = 52$
$SID = 21$




$$pH = 6.10 + log_{10} \frac{[HCO_3^-]}{[CO_2]}$$

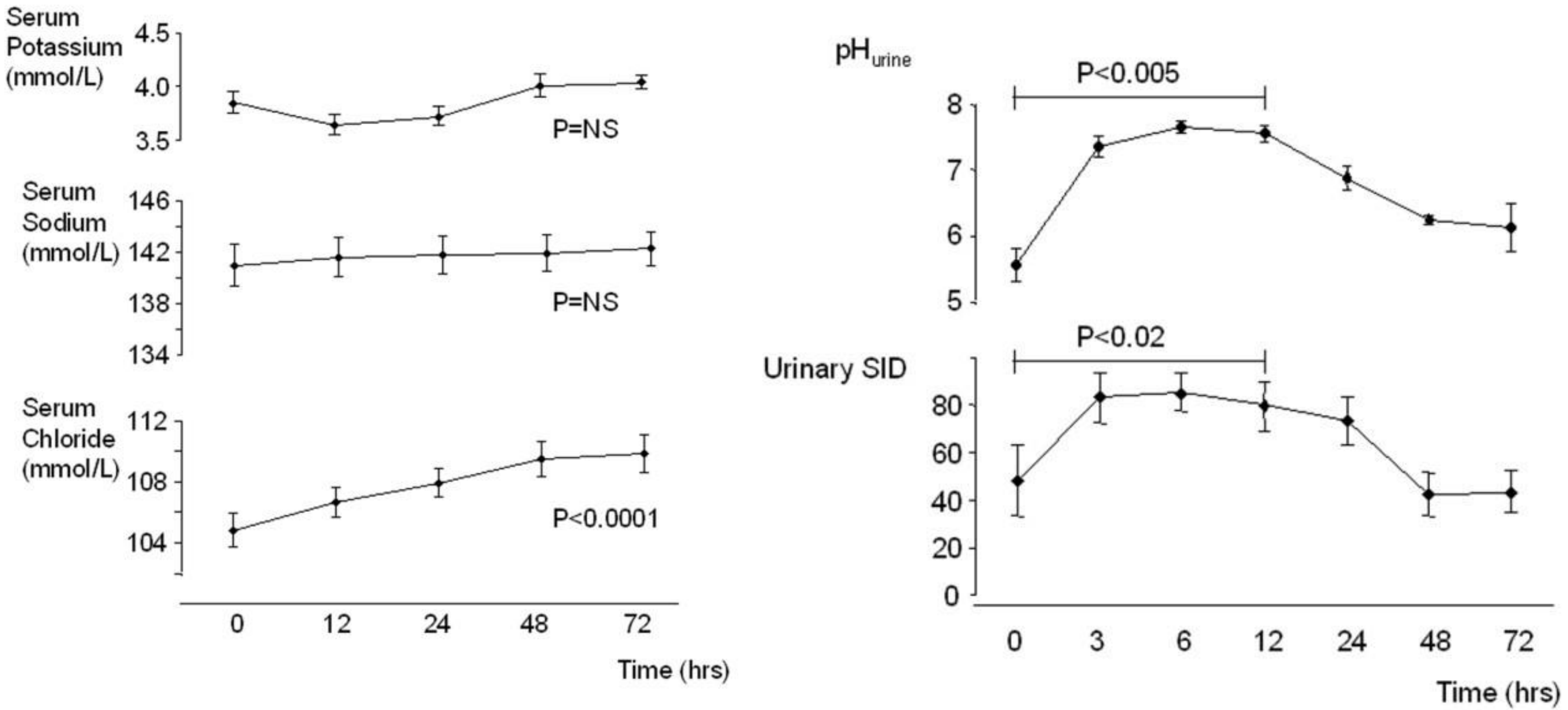
Crit Care. 2006; 10(1): R14.
PMCID: PMC1550864
Published online 2006 Jan 9. doi: 10.1186/cc3970
PMID: 16420662

# Acetazolamide-mediated decrease in strong ion difference accounts for the correction of metabolic alkalosis in critically ill patients

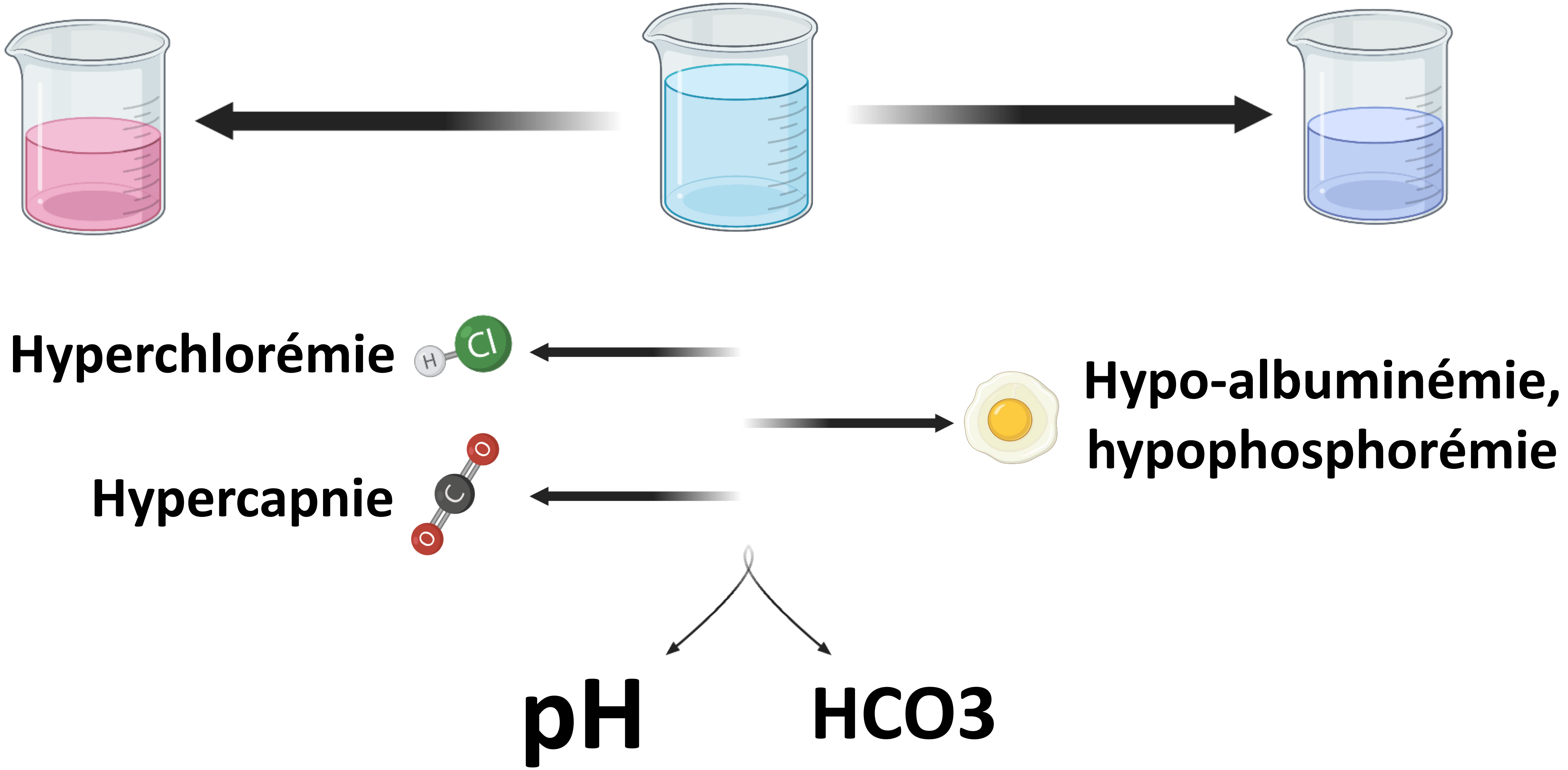
Miriam Moviat,[1] Peter Pickkers,[✉1] Peter HJ van der Voort,[2] and Johannes G van der Hoeven[1]

## Conclusion

A single dose of acetazolamide effectively corrects metabolic alkalosis in critically ill patients by decreasing the serum SID. This effect is completely explained by the increased renal excretion ratio of sodium to chloride, resulting in an increase in serum chloride.



Serum Potassium (mmol/L)
4.5
4.0
3.5
P=NS
Serum Sodium (mmol/L)
146
142
138
134
P=NS
Serum Chloride (mmol/L)
112
108
104
P<0.0001
0
12
24
48
72
Time (hrs)
pH urine
P<0.005
8
7
6
5
Urinary SID
P<0.02
80
60
40
20
0
0
3
6
12
24
48
72
Time (hrs)


Hyperchlorémie
H
Cl
Hypercapnie
O
C
O
Hypo-albuminémie,
hypophosphorémie
pH
HCO3

*D’après SFAR*

# THX !

Slides