



REDOX POTENTIAL :

From its routine measurement to its energetic meaning

ADSA[®] – ASAS MEETING (7th to 11th July 2008)

INDIANAPOLIS

Presented by Jean-Philippe MARDEN (PhD.)

Redox measurements in ...



Soil



Wine



Cheese

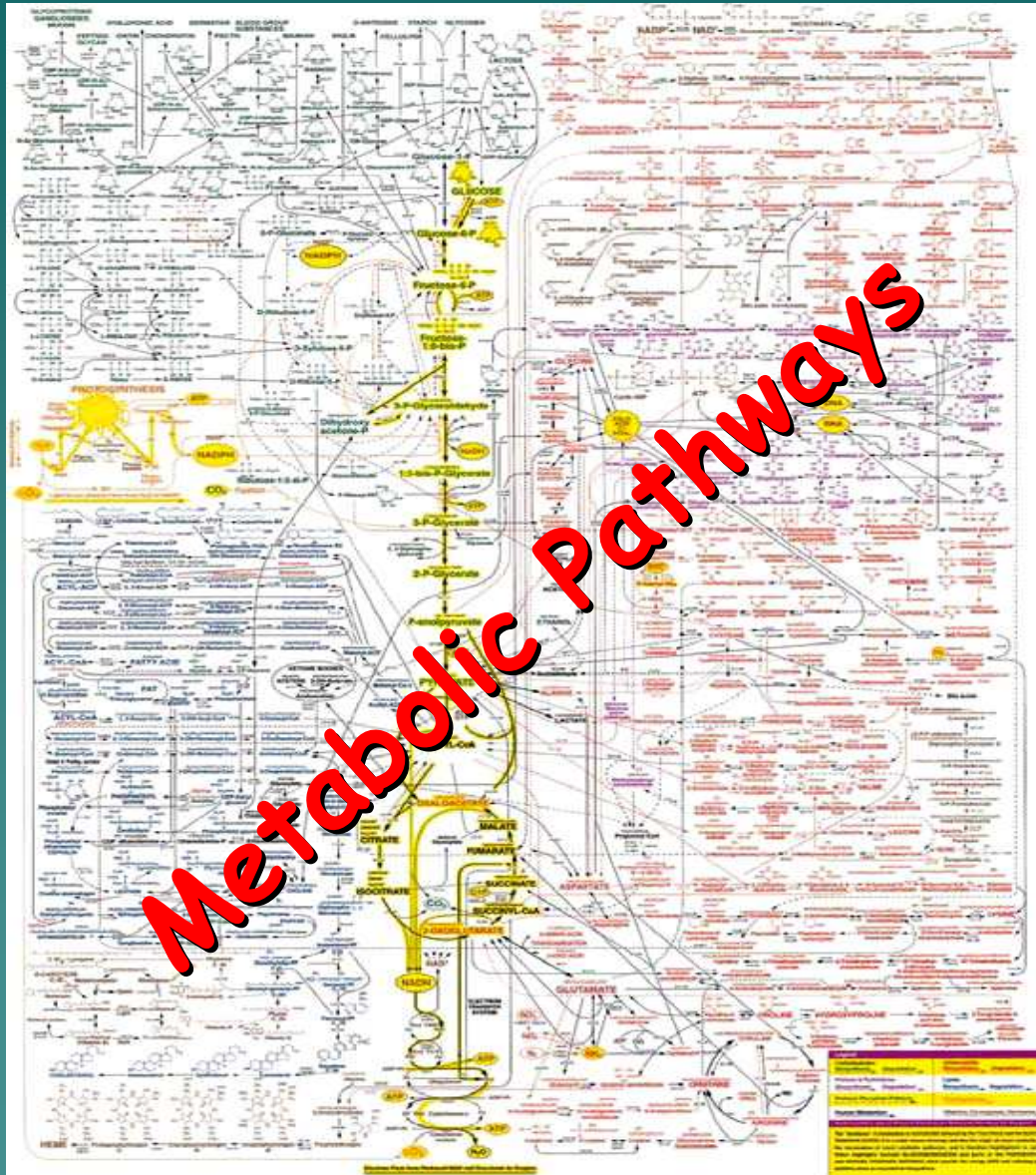


Lakes, rivers, etc...



Deep oceans

No life without energy...



Life can be summarized in some thousands of chemical reactions.

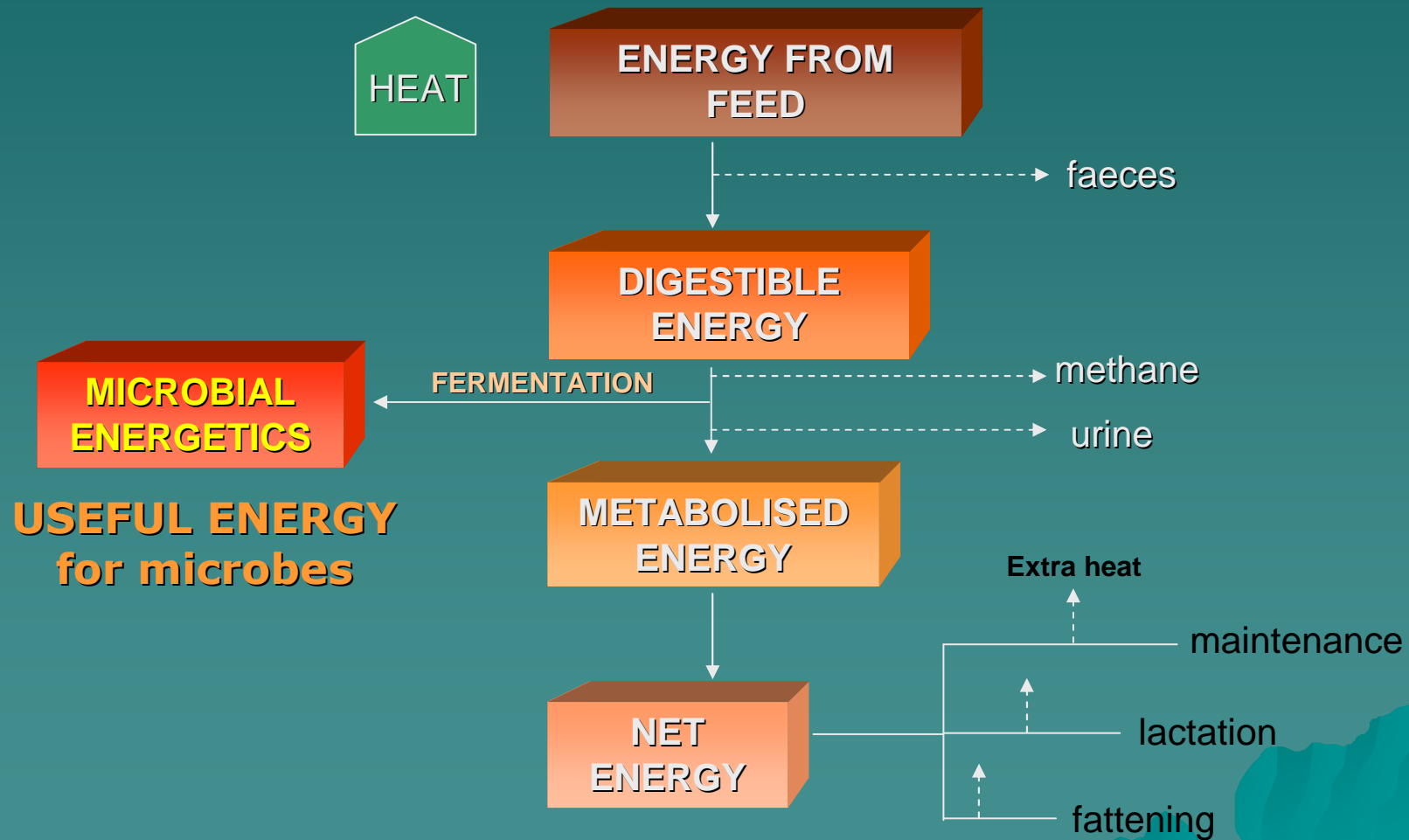
They are involved in metabolic pathways which ensure both a transfer and a utilization of energy.

*... like you I like fresh air, I breath and I release CO₂
and H₂O in the atmosphere !*

*... but I have in my stomach , an efficient microbiota
which is responsible for my energetic supply*



Energy transfer (at the animal level)



How this energy is measured ?

The Gibbs Free Energy (ΔG) is defined as the energy available to accomplish a “useful” work (reaction)

$$\Delta G = \Delta G^\circ + RT \ln [\text{Products} / \text{Reactants}]$$



$$\Delta G = -nF \Delta E$$

Oxido-reduction (redox) reactions

Most of the energy-transferring reactions involve an electron flux

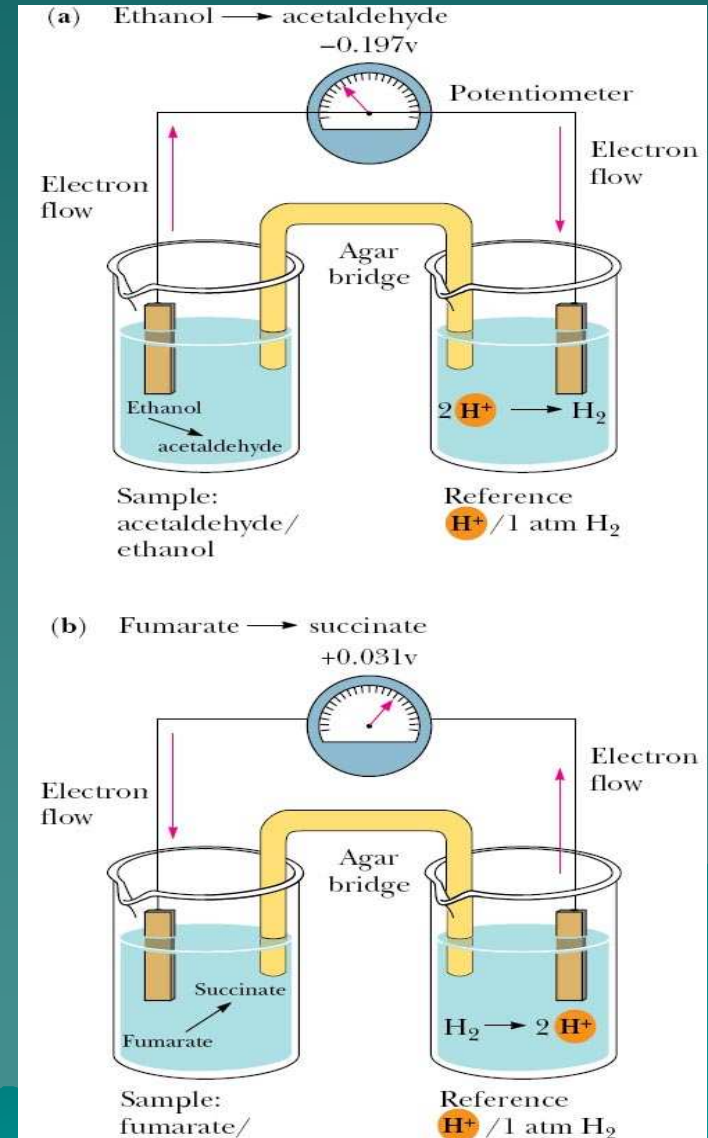
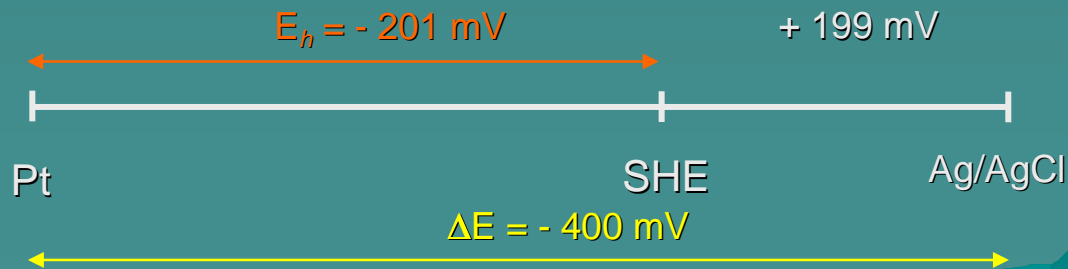
Nernst
Equation

$$\Delta E = \Delta E^\circ + RT/nF \ln [\text{Oxidised sp.}/\text{Reduced sp.}]$$

What is Redox Potential (E_h) ?

The ability of a chemical species to give (reductant) or to capture electrons (oxidant)

The redox potential (E_h in volts) is measured as a potential difference (ΔE) with respect to the Standard Hydrogen Electrode (SHE)



According to the literature...

- ◆ In 1957 : Broberg G., one of the first to publish on ruminal E_h values (*in vitro*, *in vivo* on sick/healthy animals)
- ◆ Followed by Barry et al. (1977) ; Marounek et al. (1982 ; 1987)
- ◆ Regain interest in mid 90's : Mathieu et al. (1996) ; Broudiscou et al. (2001) ; Andrade et al. (2002) ; Giger-Reverdin et al. (2006)

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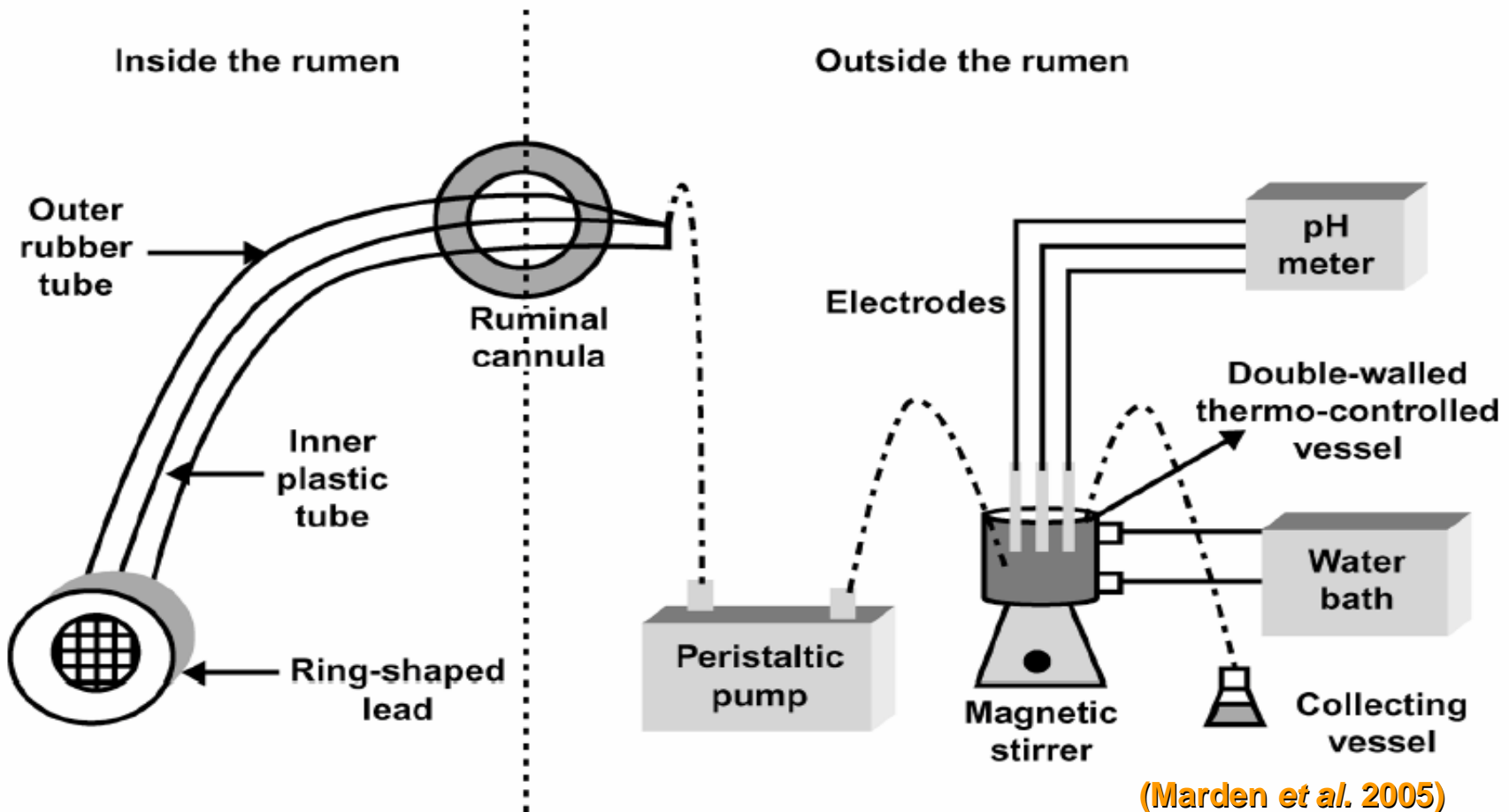
- ◆ Regain interest in E_h : Mathur et al. (1996) ; Broudis et al. (2001) ; Reverdin et al. (2002) ; Giger-Reverdin et al. (2002) ; Giger-Reverdin et al. (2002) ; Giger-Reverdin et al. (2002)

E_h situated between -150 & -260 mV

ΔE situated between -302 & -380 mV

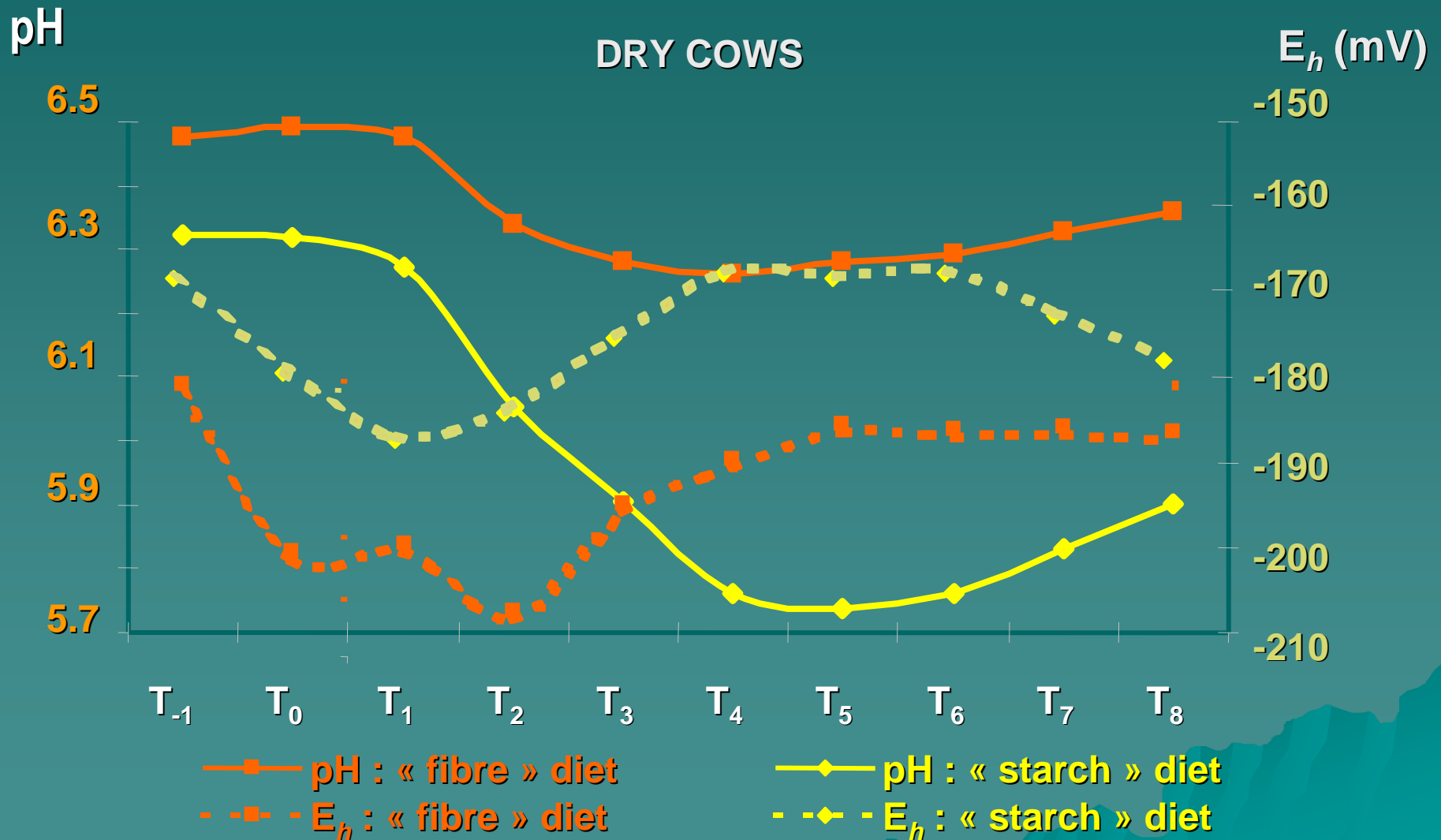
E_h situated between -103 & -181 mV

An “ex vivo” device to measure pH and E_h

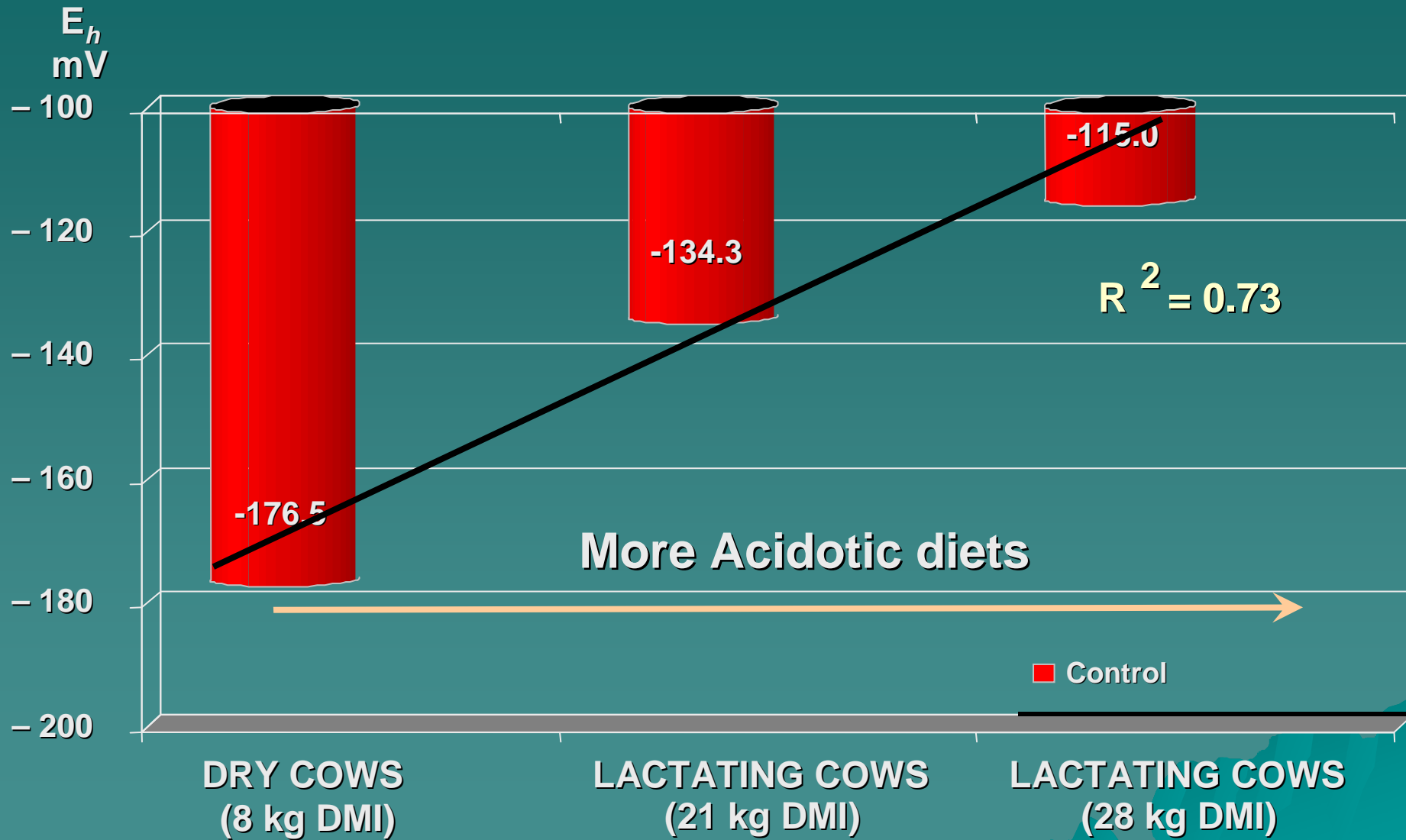


No atmospheric contamination
Simultaneous sampling

Some results ...



Some results ...



DASCOR pH loggers with immersed sensors



Figure 2, Original Logger



Figure 4, Removing logger case (left: original model, right: new design)

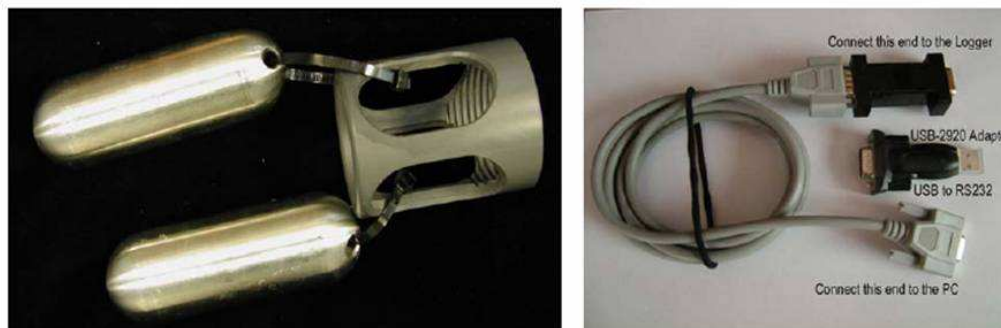
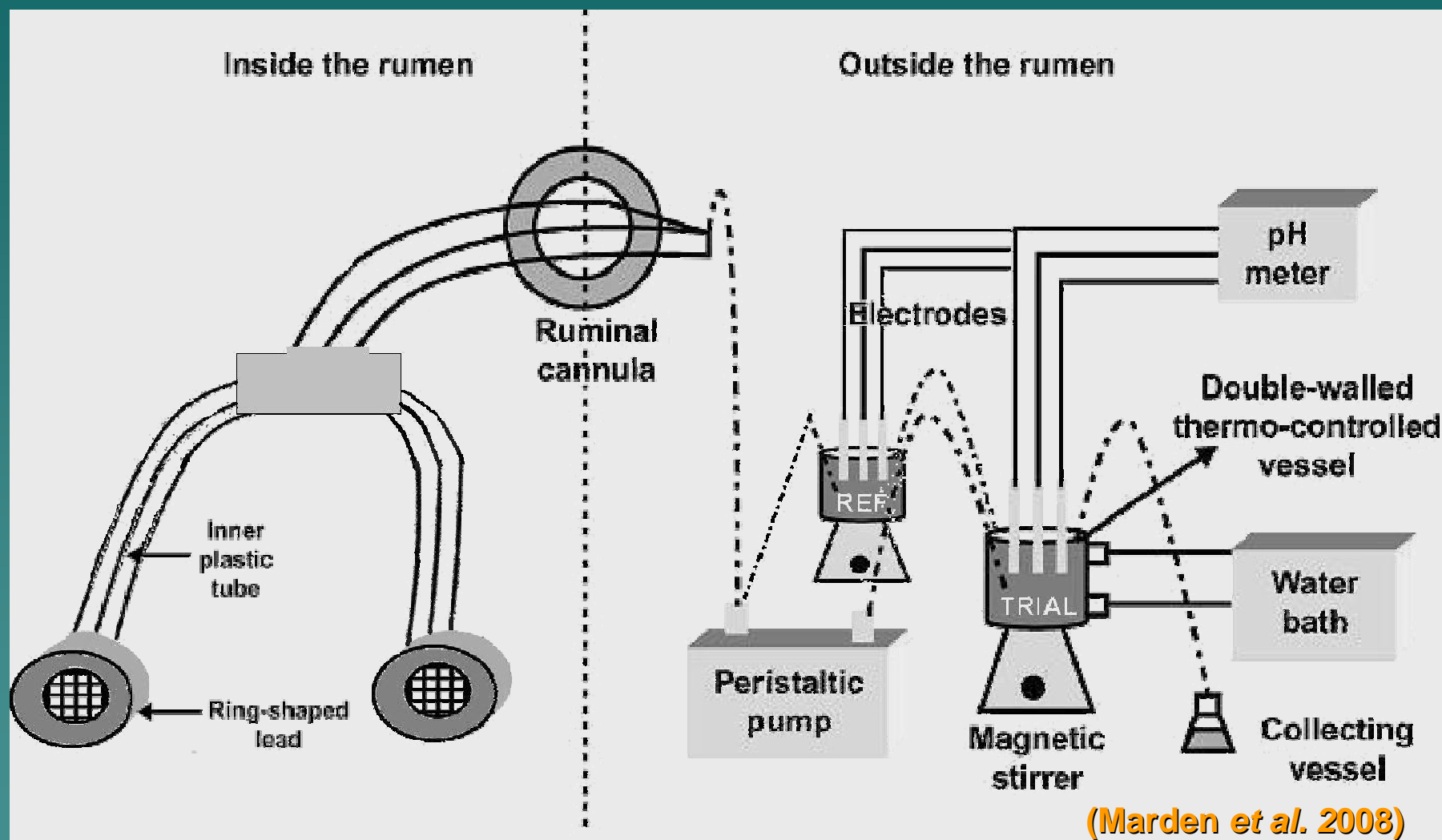


Figure 7, Electrode shroud with attached weights, SIA Cable & Dongles

(Penner *et al.* 2006)

Adapted “ex vivo” method for screening



Real-Time monitoring of rumen gases



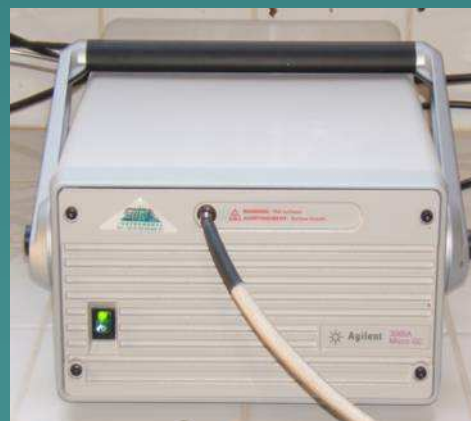
View of whole system



Hermetic cannula & security flasks



Data collection via software

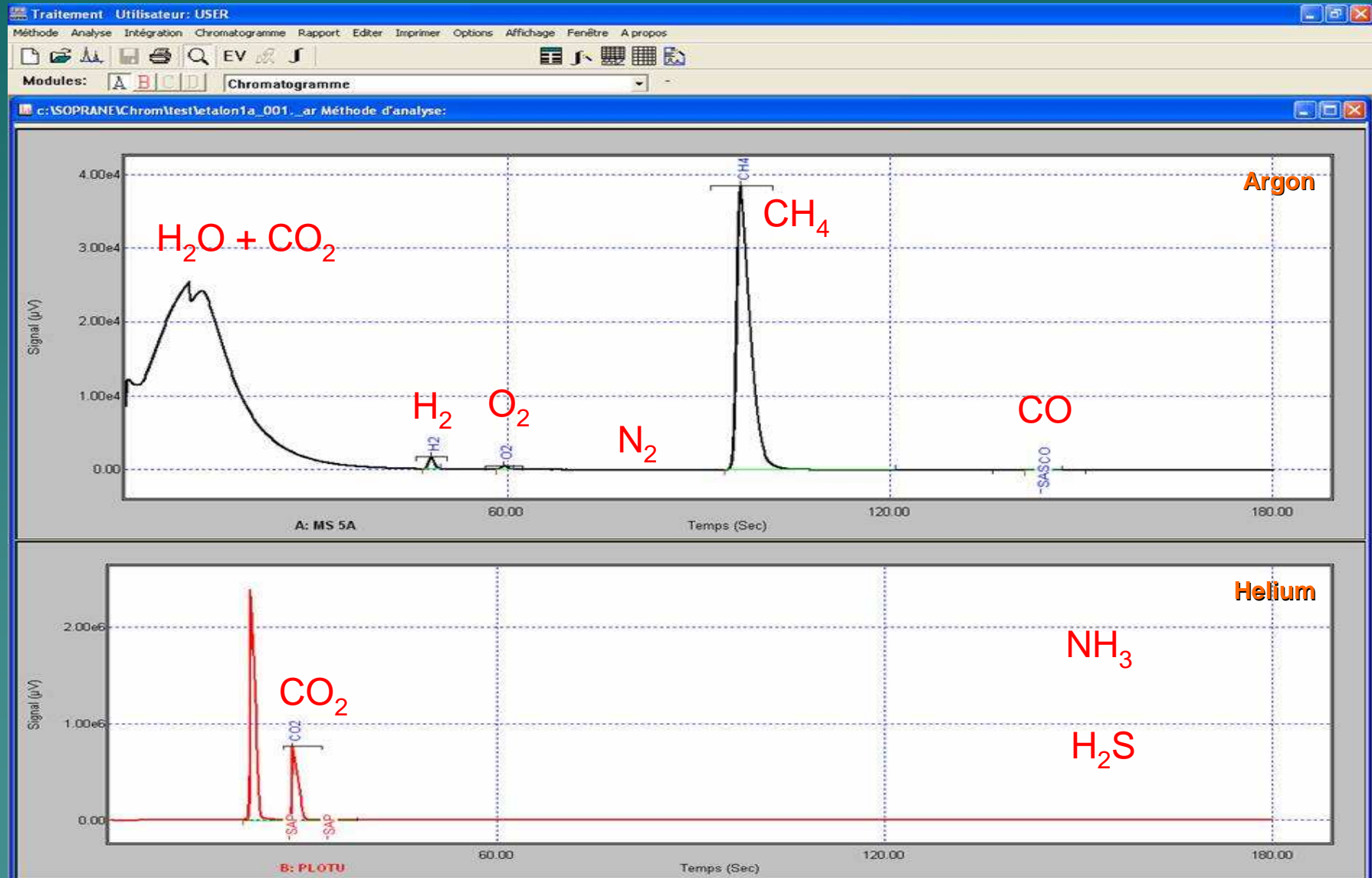


Gas chromatograph

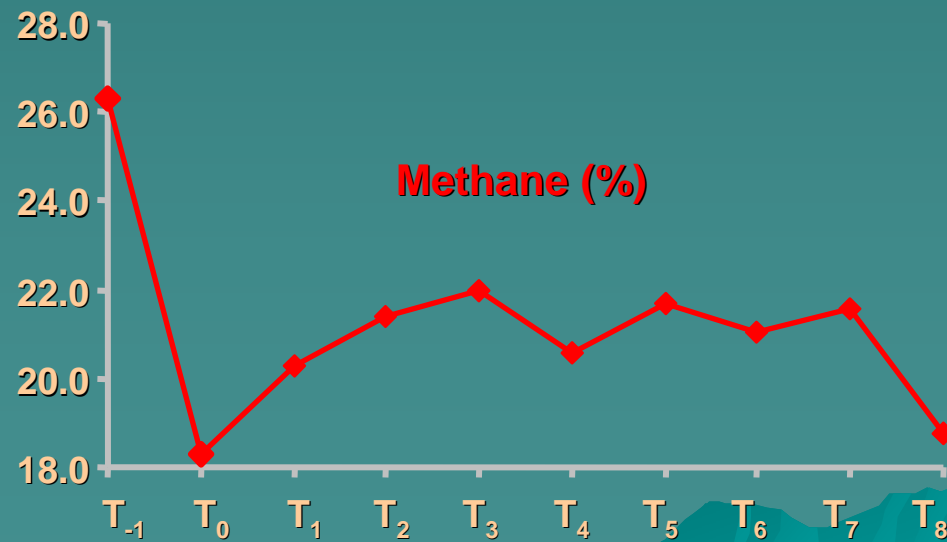
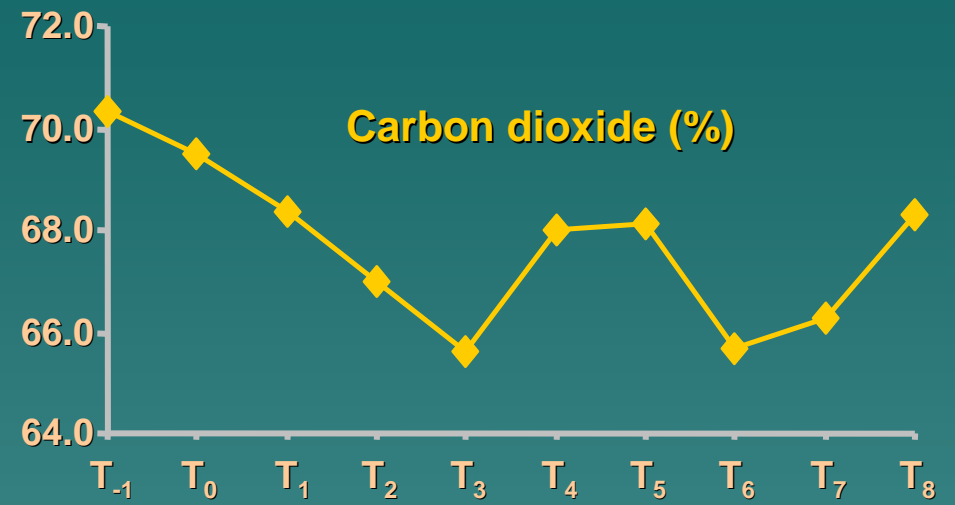
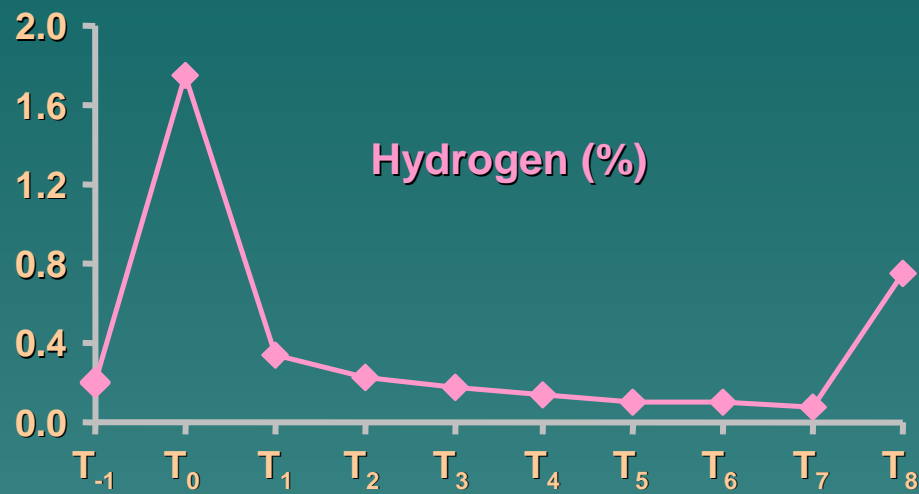


Gas sampler

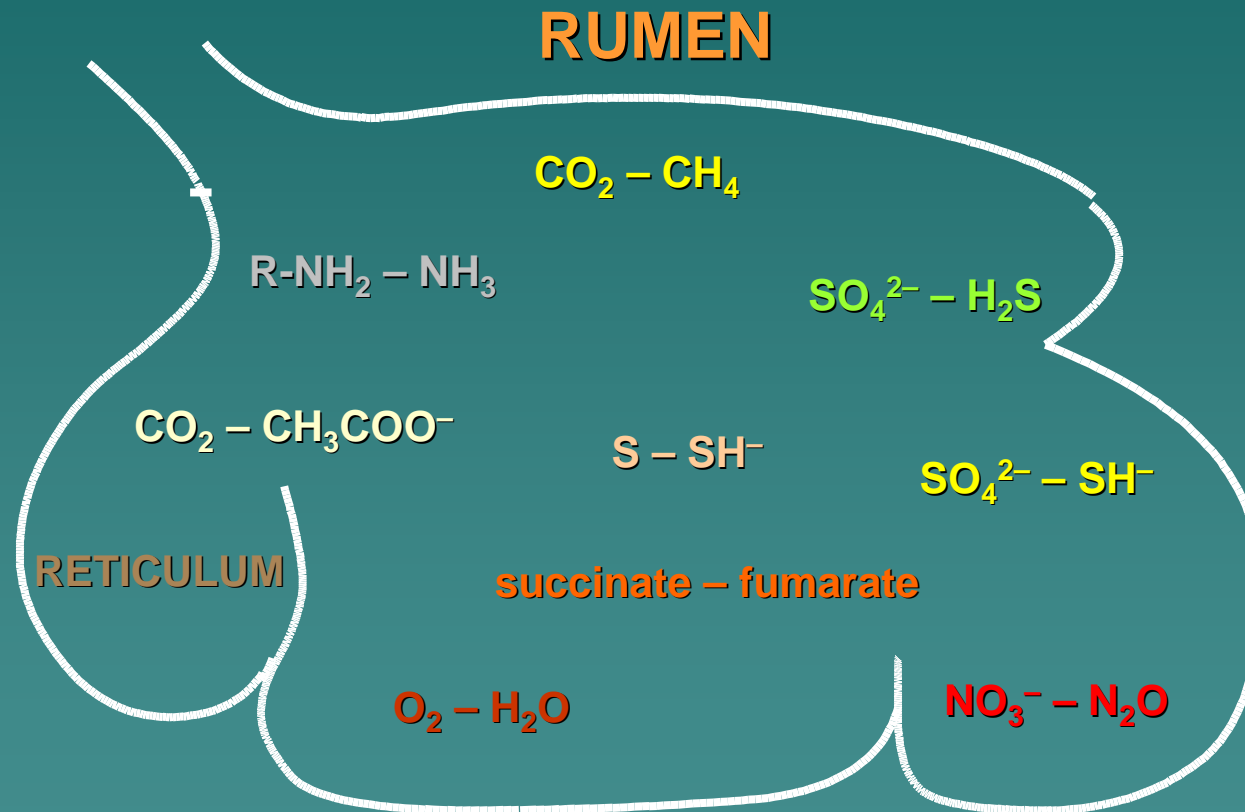
Real-Time monitoring of rumen gases



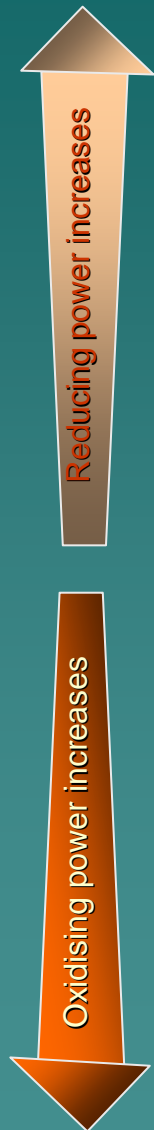
Some results ...



Gathering more redox couples...



Biological significance of E_h



E_h (volts)

- 0.30



acetogens

(strictly anaerobic)



- 0.27



Anaerobic respiration



- 0.25



methanogens
(strictly anaerobic)



0.0



Facultative aerobic



+ 0.40



Aerobic respiration

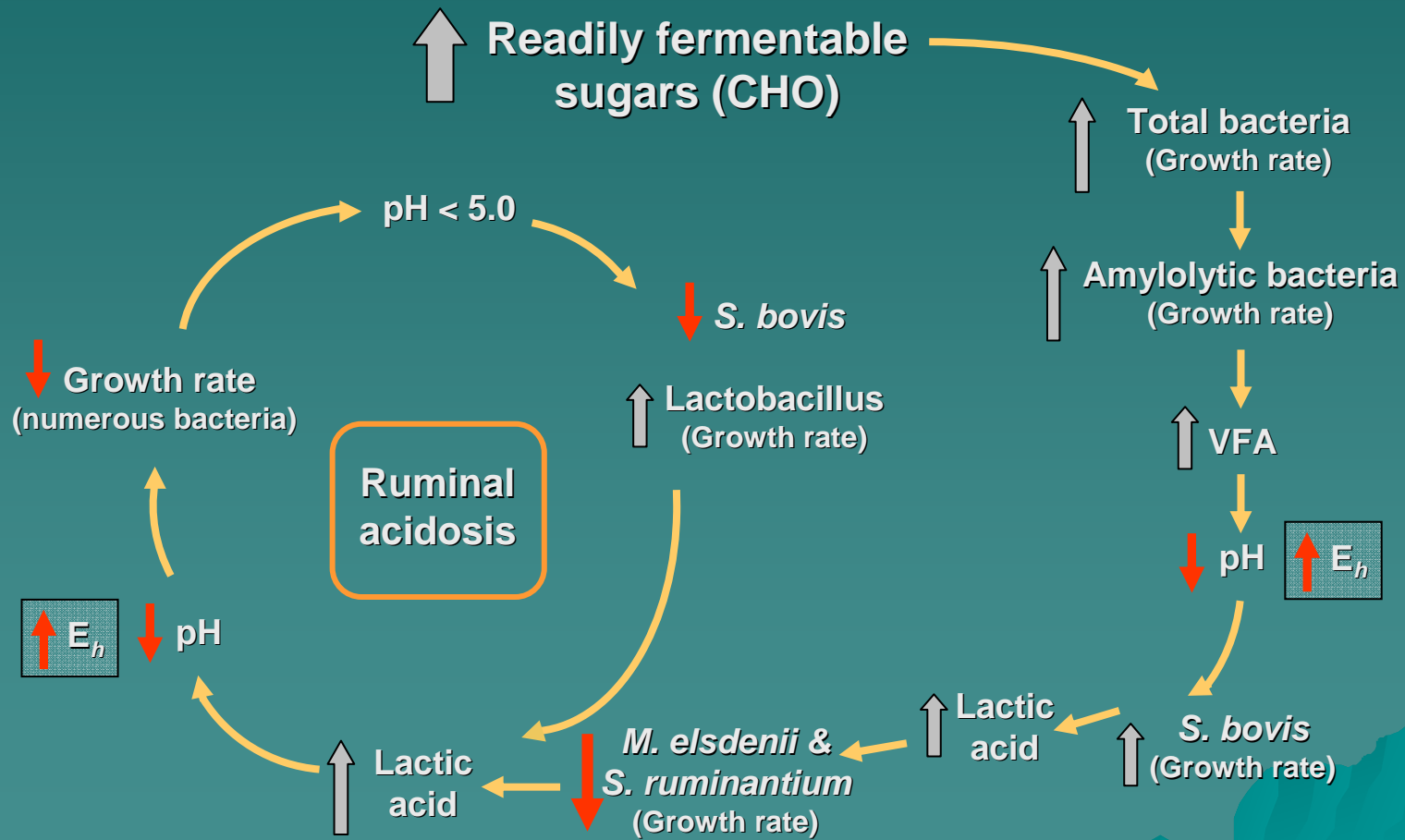


+ 0.82



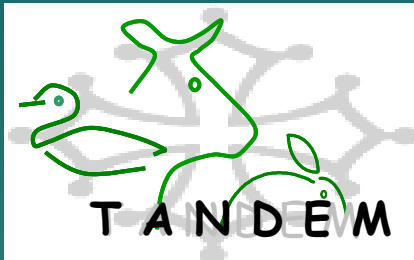
E_h complementary to pH

Sequential events during acidosis : pH & E_h Concept



(Nocek, 1997)

Acknowledgements



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(Director LFA)

Life is induced by electrons...
the movement of an electron is like a little current...
thus, life is just a little electric current...
All complex intermediates around this basic fact,
are purely ornamental.

(A. S. GYORGYI)

**Thanking you for
your attention ...**