Due 10 October 2014 by 5:00 PM at FS229

QUESTION ONE:

Part One. Propose a mechanism and/or structures that modify the properties of lipids to resist the effect of high pressure. Recall that organisms can survive the remarkable pressures of the oceanic depths (and even survive the 'nil' pressure of outer space).

Part Two. Compare your mechanism to known pressure resistant organisms. These can be from any biological clade (it is not just Archaea, but also plants and animals that survive high pressures). I am especially interested in the physical/chemical mechanisms.

Hint: Make sure you approach the question from a physico-chemical perspective. You should be able to find many papers on the effect of hydrostatic pressure on membranes, but probably very little on the lipid structures that are most resistant to the effects of pressure. Focus on mechanisms and provide explanations that can be understood by your professor and fellow students.

QUESTION TWO:

How long will it take for you to die of dehydration if increasing extracellular $[K^+]$ is the causal agent?

Assumptions.

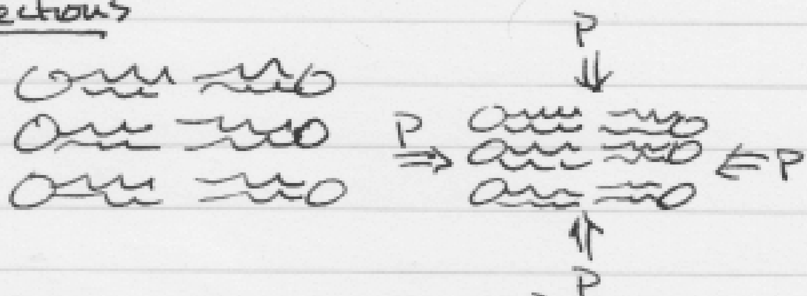
1) Your excitable cells have a potential of –80 mV, and the AP trains that would result in fibrillation are triggered at a threshold potential of –30 mV.
2) Cellular volume is unchanged (and that there is no osmotic water flow)
3) Do not considered kidneys or other regulatory mechanisms that would allow you to survive for at least a bit longer….

Hint: Show your units (points off if you don't)! Any additional assumptions you need to make (for example, your volume, your extracellular water volume and the rate at which you lose water) should be reasonable assumptions (Wikipedia may provide useful values).

Ground Rules: I expect that students may (or may not) wish to work with each other on the assignment (depending on personal preference), and may certainly come to me for help. But, please ensure that the work you hand in is in your own words (it's your voice I want to hear). I strongly prefer handwritten assignments. Excessive length is not encouraged.

KEY (high pressure - membrane effects and adaptations)

At high pressure, the "squeezing" is in
<u>both directions</u>



10
(5 for one direction)

The lipid is compressible: 5.6×10^{-7} kPa^{-1}
slightly more so than water 4.5×10^{-7} kPa^{-1}

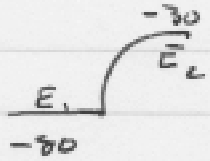
Physico-chemical aspects: Either from the chemical potential term $\bar{V}p$ where $\bar{V}$ is the partial molal volume, or Clausius-Clapeyron 20

$$\frac{dT_m}{dP} = \frac{T_m \Delta V}{\Delta H}$$ (~~Berkeley~~ UC-Davis PhysWiki)
(pressure raises T_m, exponentially)

Counter strategies?
- more unsaturated acyl chains?
- longer acyl chains?
- bulkier head groups? 70
- less sterol?

Most common amongst barophiles is greater unsaturation &, longer length
For example, C22:6 has lots (6!) of unsaturated bonds
Possibly, even fatty acids (single acyl chain)

KEY (could elevated $[K^+]_o$ be a cause of death due to dehydration?)



$E_1 - E_2 = -50\text{ mV}$

$$\underbrace{\frac{RT}{zF}\ln\frac{c_o}{c_i}}_{-80\text{ mV}} - \underbrace{\frac{RT}{zF}}_{25\text{ mV}}\ln\frac{c_o'}{c_i} = -50$$

for $c_o = 5$ mM, $c_i = 123$ mM, and c_o' is 37mM

solve for... solve for...

$$\frac{5 \text{ mmoles}}{x\,l} = \frac{37 \text{ mMoles}}{l}$$

$\rightarrow$ 0.135 l

Must lose 86.5% of extracellular fluid ($1 - 0.135 = 0.865$)

If ECF is 15 l, must lose 13 l

At 2 liters/day $\rightarrow$ 6.5 days

Student Answers (stem & leaf)

3	23
2	
2	
1	6
1	13
0	56666666677777789999 ← 6.469 days
0	0344

(multiply stem by 10 for days)