ELECTRO PHYSIOGY 101

BIE 2009

Units: m μ n p f a z

10^{-3} −6 −9 −12 −15 −18 −21 ----.

eg: mV μA nA pA pS pF fF aF zJ

typical units for many cell data

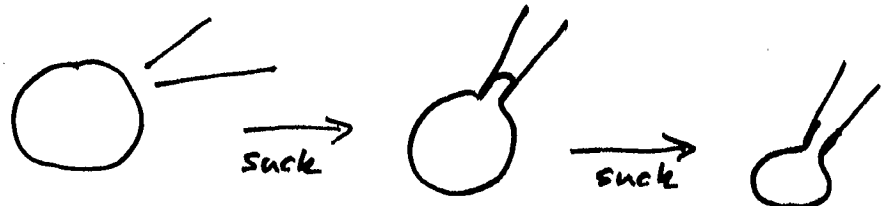
(capacitance of 1 vesicle ~ 40 aF)

energy change to open MET 4zJ

Basic $V = iR$ or equivalently $i = gV$ OHM

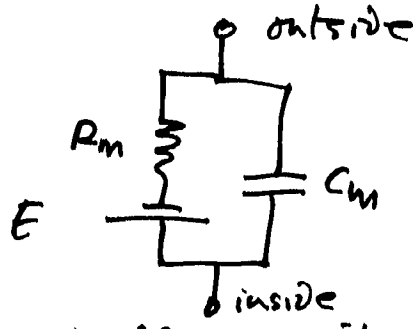
R – resistance in ohms(Ω) g – conductance in $ohms^{-1}$ = Siemens.

Patch clamping :

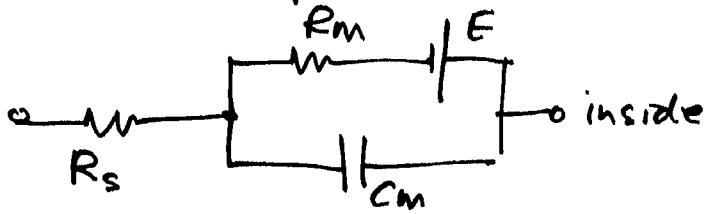


Advantages of patch pipettes:
Low noise; better response time; high resolution

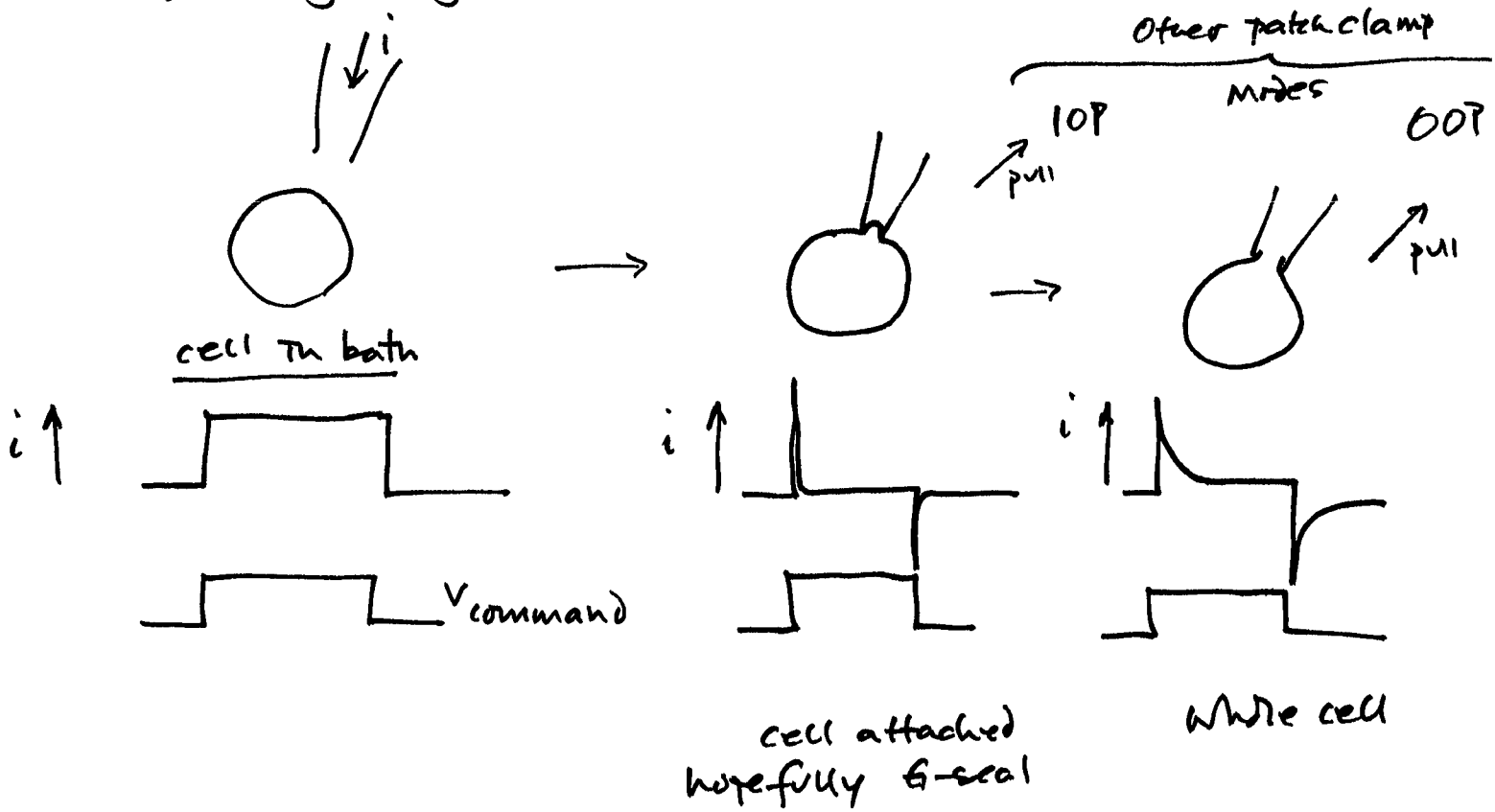
Equivalent Circuit of a cell Membrane:



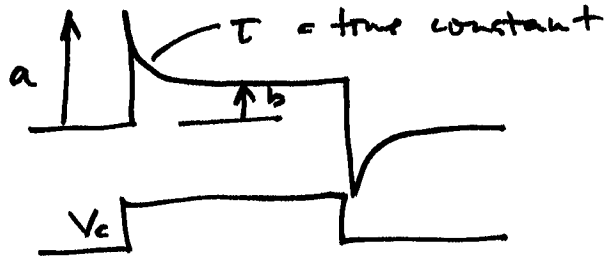
When recorded with a patch pipette circuit looks like



3 Steps to getting a whole cell recording



Various features of WC current trace tell you about params.

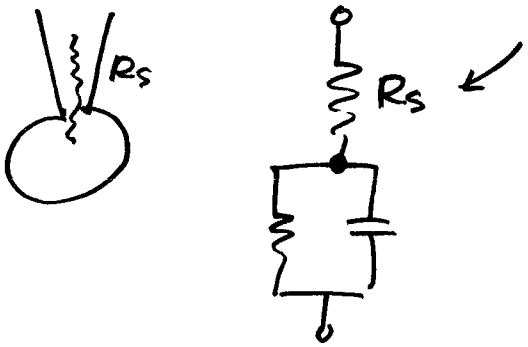


$$a = \frac{V_c}{R_s} \quad ; \quad b = \frac{V_c}{R_s + R_m} \quad ; \quad \tau = \frac{R_s R_m}{R_s + R_m} \cdot C_m \simeq R_s C_m$$

Items to think about:

Intracellular solution in pipette ; Extracellular solns.
Stability and positioning of pipette ;
Recording protocols ;
Other simultaneous tasks eg imaging.
eg deflecting hair bundle

Series resistance (or 'access' resistance)



Current flowing through Rs leads to a voltage drop

⇒ potential at cell not what is dialled up

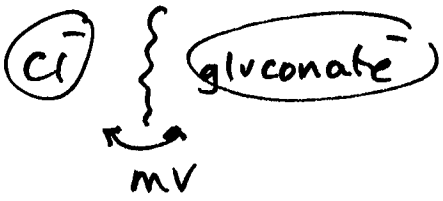
⇒ C_M not charged quickly enough

⇒ errors in current kinetics.

* Correct during expt + in analysis

Junction potential.

Arises from eg interface between two different anionic solutions



eg between solution and electrical connector wire

* Correct by using software estimates (eg in PClamp) by correctly zero-ing current before giga seal

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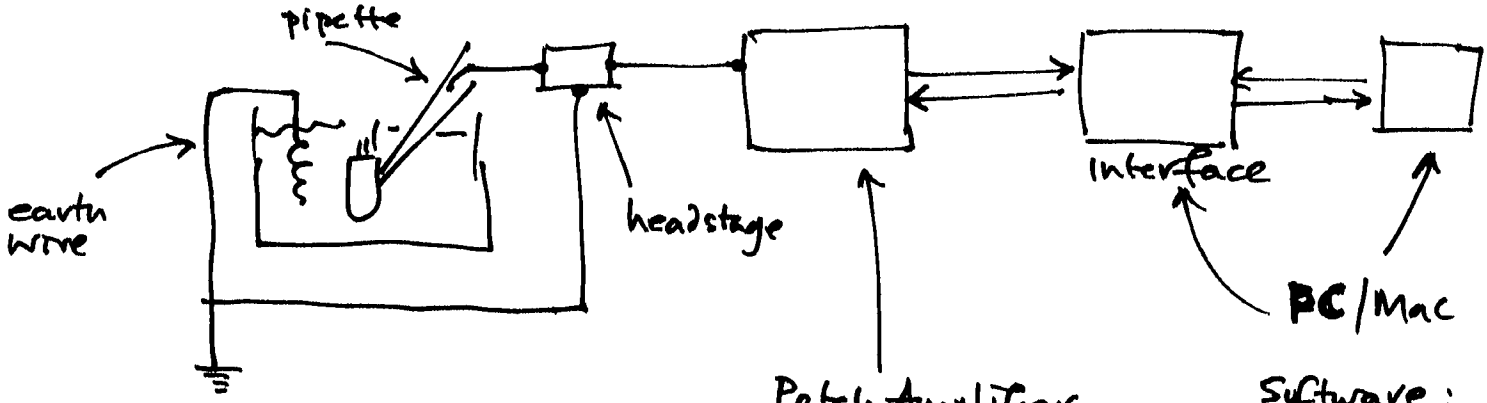
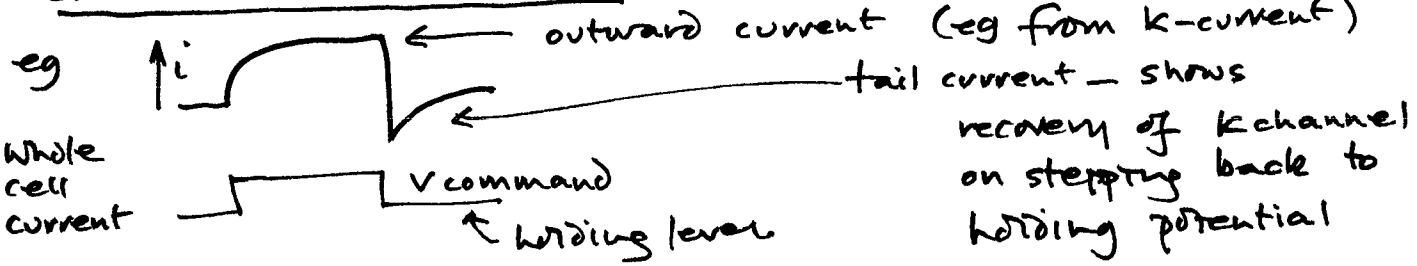


Patch Amplifier
eg Axopatch 200B
HEKA 10
etc

Software:
eg PClamp
Patchmaster
Homebrew
etc

Some things you can learn from Eφ recordings:

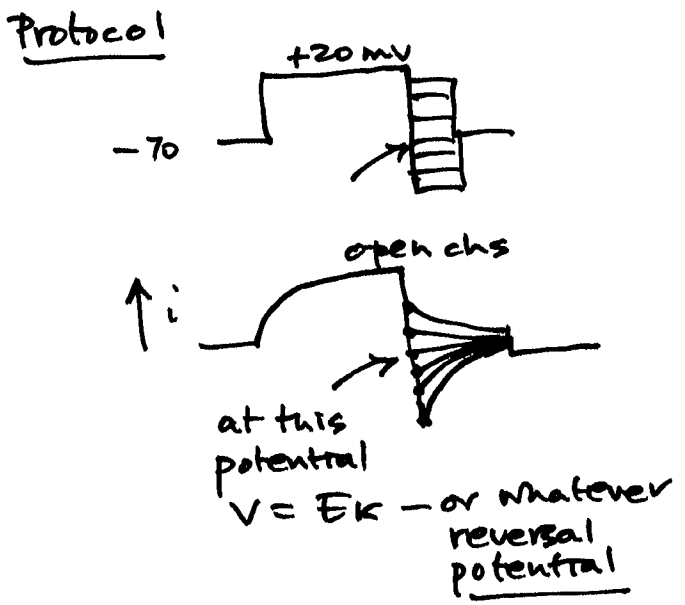
Characterise ionic currents

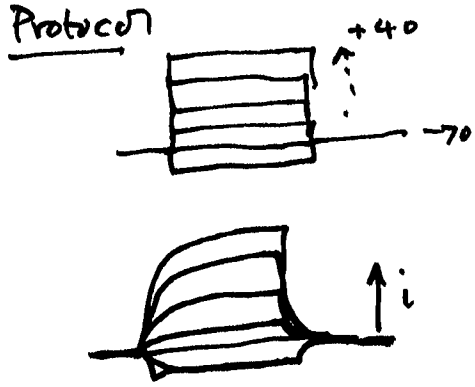


Tail current analysis

$$i_K = g_K(V) \cdot (V - E_K)$$

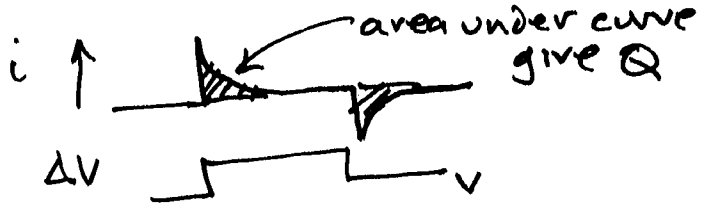
$g_K(V)$ – voltage activated conductance





→ measure i → $g_K(V)$ the "activation".

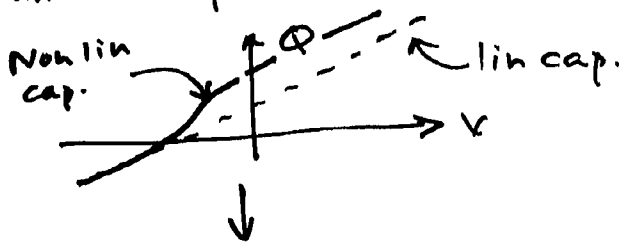
Characterise passive Eφ



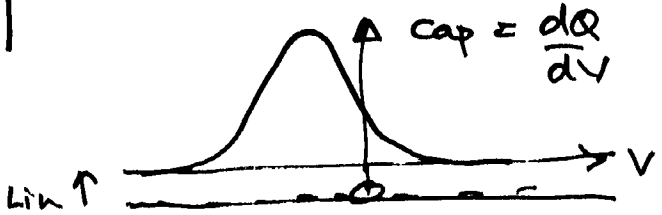
maths!

$$Q \doteq \frac{\Delta V}{R_s} \int_0^\infty e^{-t/R_s C_m} = \Delta V \cdot C_m$$

In an QHC plot Q vs V



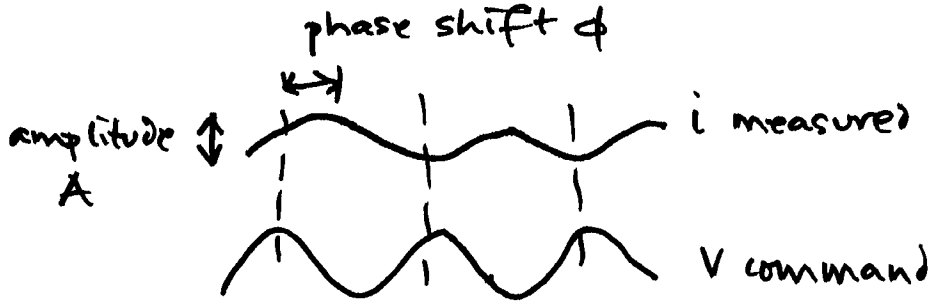
Non linear capacitance

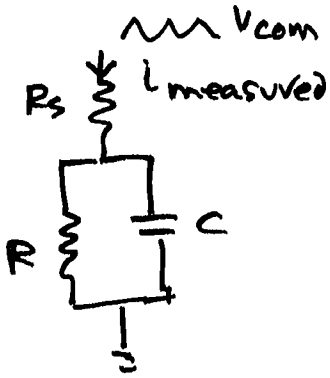


To measure OHC Motor function

1. Charge transients at different V
2. Use software to compute capacitance
3. Use a 'lock-in' amplifier to measure capacitance
4. Measure cell length

Principle of 3. Use sine wave commands not steps





Lock in amplifier gives A and ϕ — continuously
Arrange lock in amplifier so that it gives an output

$\propto C_m$ on one channel

$\propto$ mess $\sim R_s$ on 2nd channel.

Can also be used to measure exocytosis, resolution

$\sim 10fF \simeq 300$ synaptic vesicles