

Neuroscience BIO-311  
Exercise questions for  
**Unit 2: Action Potentials**

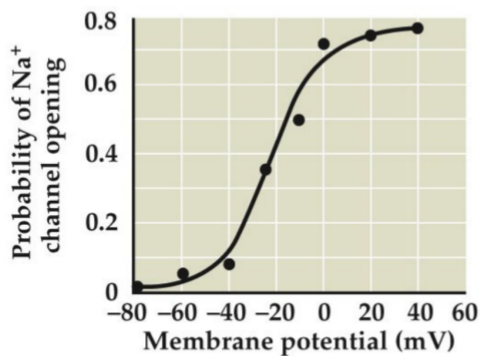
1) Explain what a “voltage clamp” is and what a “current clamp” measurement is.

Which electrical quantities are controlled and measured in each type of measurement?

What are the advantages and disadvantages of using each of them?

2) In this question, the aim is to construct an I-V relation for Na<sup>+</sup> currents, and to understand the difference between the I-V relation of ion currents, and the p<sub>open</sub> versus V<sub>m</sub> (abbreviated: p<sub>open</sub> - V) relation of an ion channel. - Consider the p<sub>open</sub> - V relationship for Na<sup>+</sup> channels.

At different V<sub>m</sub> steps, single Na<sup>+</sup> channels have different **open probability**



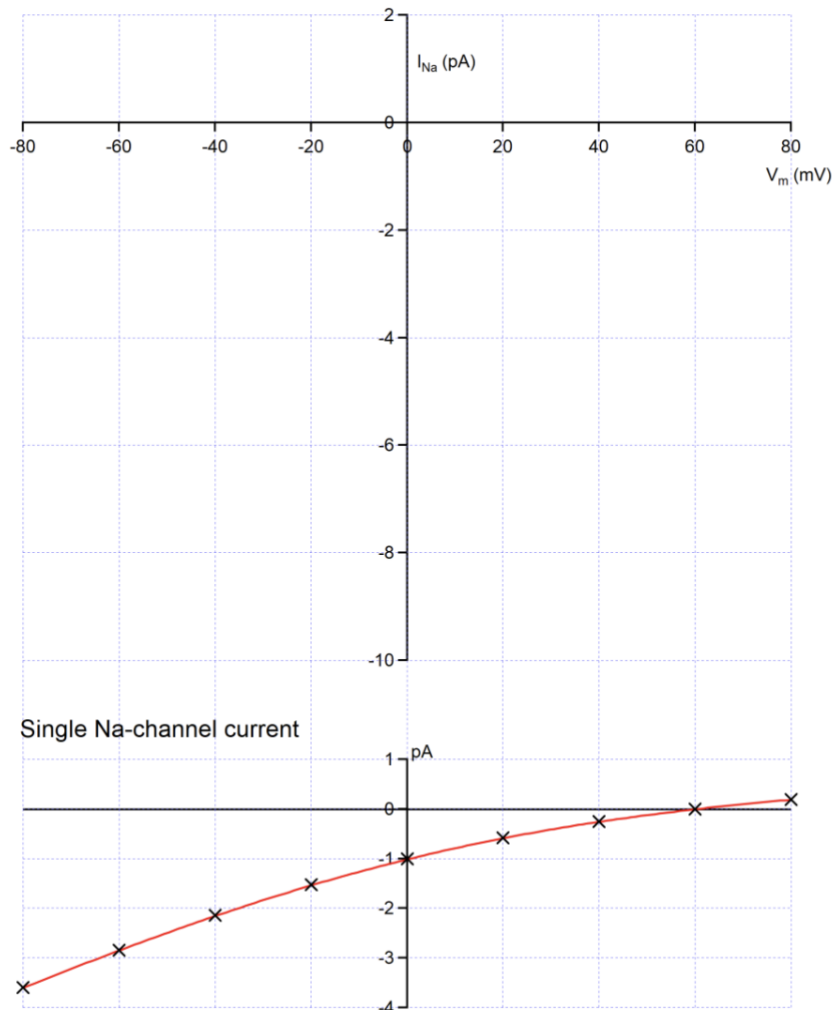
=> **open probability** is low at -80 mV, ~ 10% at -60 mV, and saturates at ~ +20 mV

=> concept of voltage-dependent ion channel

**p<sub>open</sub> vs V<sub>m</sub> relation**

- With the information above, construct an I-V relation for a simple thought-experiment: Assume you have voltage-clamped a small cell containing N = 10 Na<sup>+</sup> channels which have the same open probability as shown above (maximal p<sub>open</sub> = 0.8). Assume that ... i) N = 10 channels exist in your whole-cell recording, ii)

that the maximal open probability is 0.8 (see slide 35) iii) that the single-channel current  $i_{Na} = 1$  pA at 0mV, iv) that the reversal potential for  $Na^+$  channels is ( $E_{rev}$ ) is +60 mV Enter the approximate peak whole-cell  $Na^+$  current values ( $I_{Na}$ , in units of [pA]) for the indicated membrane potentials ( $V_m$ ; -60, -40, -20, 0, +20, +40, +60, +80 mV). - In the resulting relationship, which  $I_{Na}$  current do you expect at 0 mV? - Which  $I_{Na}$  current do you expect at +60 mV? - Then enter approximately all other  $I_{Na}$  current values, using the single-channel current amplitudes given in the bottom part of the graph. - Please discuss the differences between the I-V relationship you have just drawn, and the relationship  $p_{open} - V$ .



(Note: the single-channel current, bottom graph, was calculated according to the Goldman-Hodgkin-Katz current equation (see slide 31 and 33 of Unit 1), arbitrarily normalized to 1 pA at 0 mV).

3) Explain what is "saltatory conduction" of an action potential (AP). Why does the myelin sheath increase the speed of AP propagation along the axon?

4) Explain how to do a cell-attached, whole-cell and outside-out "patch-clamp" recording.