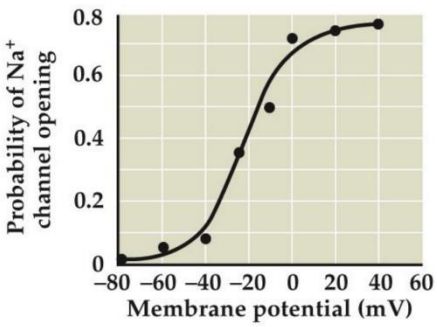
Neuroscience BIO-311 Ramdya
Exercise questions for
**Unit 2: Action Potentials**

**Question 1:**
a) Explain what is a “voltage clamp” and what is a “current clamp” measurement.
b) Which electrical quantities are controlled, and measured in each type of measurement?
c) What are the advantages and disadvantages of using each of them?

**Question 2**: In this question, the aim is to construct an I-V relation for $Na^+$ currents, and to understand the difference between the I-V relation of ion currents, and the $P_{open}$ versus Vm (abbreviated: $P_{open}$ - V) relation of an ion channel. (Consider the $P_{open}$ - V relationship for $Na^+$ channels depicted in the graph below).

*Opening probability ($P_{open}$) for single $Na^+$ channels at different membrane potentials ($V_m$)*

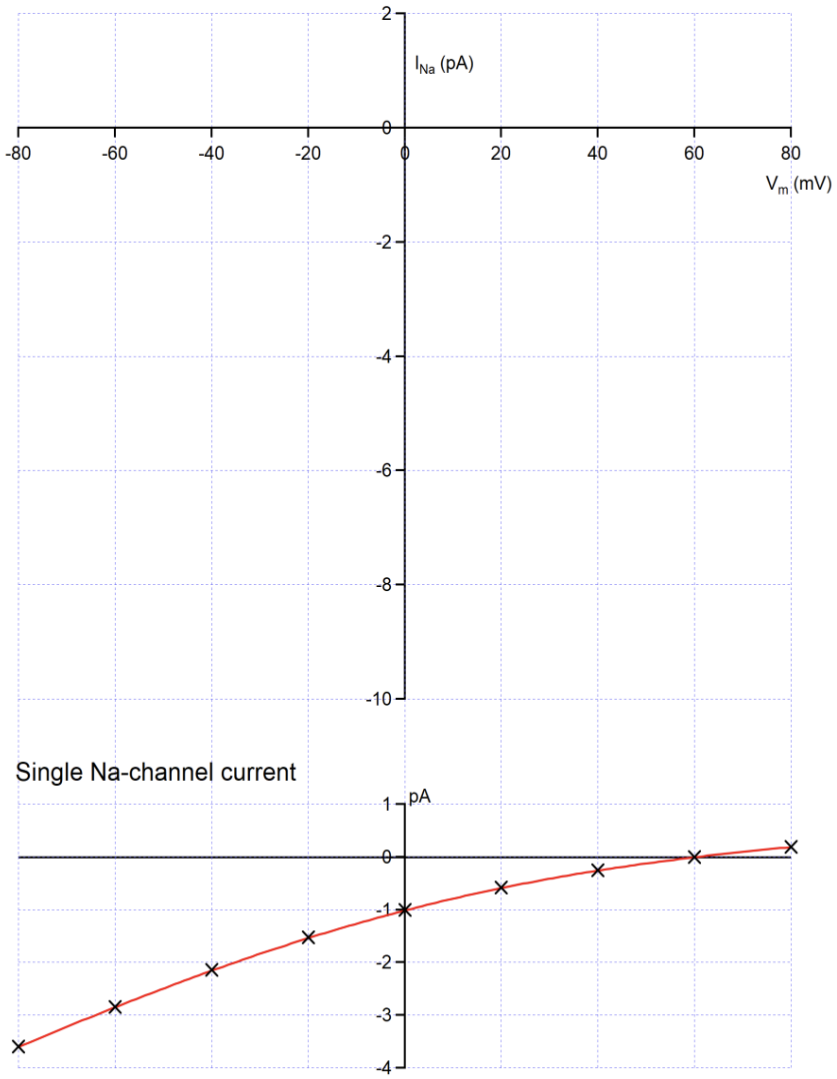



=> **open probability** is low at -80 mV, ~ 10% at -60 mV, and saturates at ~ +20 mV

=> concept of voltage-dependent ion channel
$p_{open}$ vs $V_m$ relation

With the information in the graph above, **construct an I-V relation** for a simple thought-experiment: Assume you have *voltage-clamped* a small cell containing N = 10 $Na^+$ channels which have the same open probability as shown above (maximal $P_{open}$= 0.8). Also assume that the single Na-channel current is $i_{single\text{-}channel}$ = 1 pA at 0mV and that the reversal potential for $Na^+$ channels is ($E_{rev}$) is +60 mV.

a) Enter the approximate peak whole-cell $Na^+$ current values ($I_{Na}$, in units of [pA]) for the indicated membrane potentials (Vm; -60, -40, -20, 0, +20, +40, +60, +80 mV), using the single-channel current amplitudes given in the bottom part of the graph.
b) Please discuss the differences between the I-V relationship you have just drawn, and the relationship $P_{open}$ – V (bottom part of the graph).




(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).

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

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