Neuro 80 Section 2 Sept 20, 2019

Section 2 (week 09/16 - 09/20) MCB/Neuro 80, Fall 2019

Resting Potential of the Squid Giant Axon

Most cephalopods, including **squid**, travel using water jet propulsion. In squid, the sequence of muscle contractions involved in jet propulsion is partly controlled by a pair of neurons, one on each side of their body. These neurons have a very **thick axon (diameter up to 1mm)** running down the mantles called "**giant axon**". In the 1940's and 50's Alan Hodgkin and Andrew Huxley performed experiments on the squid giant axon. They established the mechanism of action potential propagation and predicted the existence of ion channels, which was only confirmed decades later. They shared the Nobel Prize in Physiology with John Eccles in 1963.

In this activity, we'll explore **some properties of the resting potential of the squid giant axon**. The table below gives the permeability and concentration of different ions inside and outside the axon.

Ion	Na+	K+	Cl-	Proteins
Permeability	0.04	1	0.45	0
[ion] inside the axon	40mM	400mM	55mM	385mM
[ion] outside the axon	450mM	20mM	560mM	0mM

1. Calculate the equilibrium potential of Na^+, K^+, and Cl^-. How do these values compare to mammalian neurons? Na^+: $\frac{60}{1}\log(45/4) = 60 \times 1.05 = 63.069$

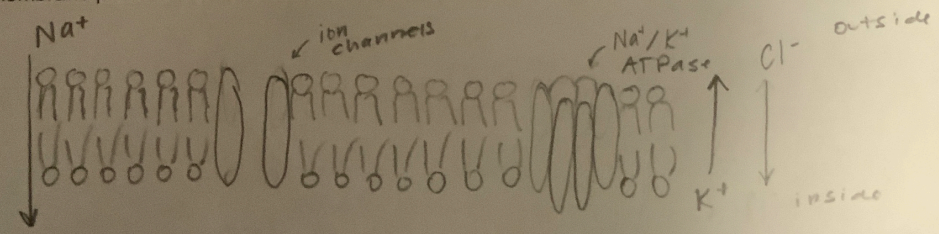
K^+: $\frac{60}{1}\log(20/400) = 60\log(1/20) = -78.062$ Cl^-: $\frac{60}{-1}\log(560/55) = -60.47$

2. Calculate the resting potential of the squid giant axon. How does this value compare to mammalian neurons?

$$= 60\log\left(\frac{0.04\times450 + 1\times20 + 0.45\times\frac{55}{560} + 0\times0}{0.04\times40 + 1\times400 + 0.45\times\frac{55}{560} + 0\times385}\right) = -61$$

same as mammalian neurons

3a. Draw a section of neuronal membrane. Your drawing should show the lipid bilayer, as well as the membrane proteins that contribute to the resting potential.

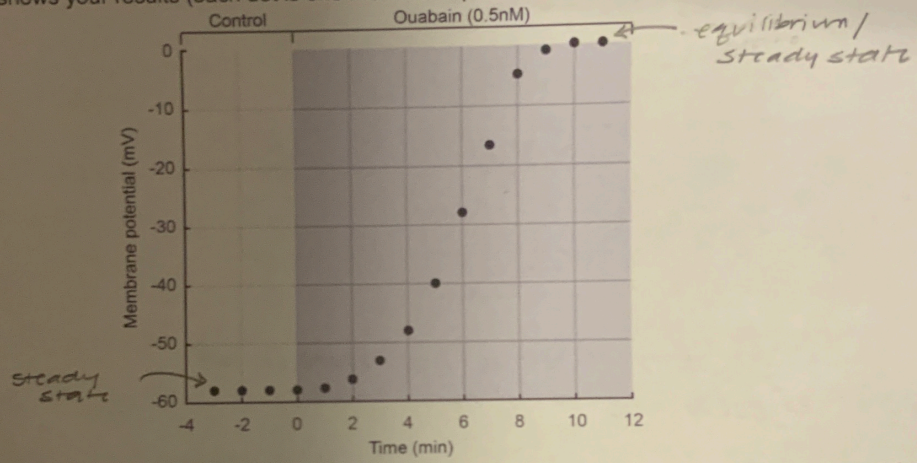


b. On the same drawing, indicate the direction of Na+, K+, and Cl- net currents across the membrane, given the membrane is permeable to those ions (hint: compare the values you just calculated)

Ouabain

Ouabain is a neurotoxic substance found in some plants of Eastern Africa, where it is traditionally used as an arrow poison. You want to investigate the **effects of ouabain on the electrical properties of neurons** in culture.

You periodically measure the membrane potential of neurons in culture, then wash on the ouabain. The graph below shows your results (each dot is one membrane potential measurement).



1. Describe and interpret the graph.

Ouabain induces massive depolarization of membrane potential until the membrane potential is 0 (no net electropotential gradient.

The graph

2. On the graph, show when the neuron is at steady state and/or at equilibrium. Explain your reasoning.

3. Formulate at least two hypotheses regarding the mechanism of action of ouabain.

1. It penetrates the cell membrane of neurons so ions can freely flow
2. Affects ATP-ase's ability to maintain potential
3. Increases ion permeability