BMT-72106, EXERCISE 5

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1. EXERCISE 1

Compare MEA and patch clamp measurements. How they work and what can you measure with them? What are their advantages and disadvantages? The patch clamp is a laboratory technique in electrophysiology used to study Ionic currents in individual isolated living cells, tissue sections, or patches of cell membrane. Patch clamping can be performed using the voltage clamp technique. In this case the current passing across the membrane is controlled by the experimenter and the resulting changes in voltage are recorded, generally in the form of action potentials. It usually involves cell-attach patch, inside-out patch, whole-cell recording or whole-cell patch, outside-out patch,perforated patch, loose patch. Microelectrode arrays(MEAs) also referred to as multielectrode arrays are devices that contain multiple microelectrodes through which neural signals are obtained or delivered, essentially serving as neural interfaces that connect neurons to electronic circuitry. There are two general classes of MEAs: implantable MEAs, used in vivo, and non-implantable MEAs, used in vitro. The fundamental unit of communication of neurons is, electrically, at least, the action potential. This all-or-nothing phenomenon originates at the axon hillock, resulting in a depolarization of the intracellular environment which propagates down the axon. This ion flux through the cellular membrane generates a sharp change in voltage in the extracellular environment, which is what the MEA electrodes ultimately detect. Thus, voltage spike counting and sorting is often used in research to characterize network activity. The major strengths of in vitro arrays when compared to more traditional methods such as patch clamping include: 1)Allowing the placement of multiple electrodes at once rather than individually.
2)The ability to set up controls within the same experimental setup (by using one electrode as a control and others as experimental.) This is of particular interest in stimulation experiments.
3) The ability to select different recordings sites within the array.
4) The ability to simultaneously receive data from multiple sites.
5) Recordings from intact retinate are of great interest because of the possibility of delivering real-time optical stimulation and, for instance, the possibility of reconstructing receptive fields.
Disadvantages, in vitro MEAs are less suited for recording and stimulating single cells due to their low spatial resolution compared to patch clamp and dynamic clamp systems. The complexity of signals an MEA electrode could effectively transmit to other cells is limited compared to the capabilities of dynamic clamps.There are also several biological responses to implantation of a micro-electrode array, particularly in regards to chronic implantation.

2. EXERCISE 2

Consider the following circuit representing the cell membrane: a) Write the dierential equation to describe Vm. $c_M dV_M/dt = -(V_M - E_M)/r_M + I_M(t)/A$

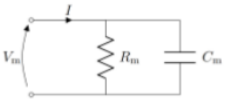
membrane.PNG 

Fig. 1. cell membrane

In response to a current step: $c_M dV_M/dt = -(V_M - E_M)/r_M + I_M(t)/A$,when $I_M(t) = I_0$, 0, when $I_0 = 0$;

Fig. 2. Vm-response

b)without $V_m(t) has the following shape$:I = C*dV/dt, $c) without b) without the resistor$I = C*dV/dt$c) without the capacitor$I = dV/dR

3. EXERCISE 3

Consider the equivalent circuit of the cell membrane shown on the next page. (It is the one from the Hodgkin-Huxley model, but this piece of information is not actually needed here.) Write the equation for the current through membrane I as a function of membrane potential Vm, capacitance Cm, conductivities , and reversal potentials Ei. a)The ion channels in the circuit depend on so-called gating variables.How are these gating variables included in the model? $I = C_m * dV_m/d + g_k(V_m - V_k) + g_{Na}(V_m - V_{Na} + g_l * (V_m - V_l))$ b)The ion channels in the circuit depend on so-called gating variables.How are these gating variables included in the model The properties of a excitable cell are described by a set of four ordinary differential equation together with the equation for the total current mention above. Other three are about the n, m, h which are the dimensionless quantities between inactivation. For p = (n, m, h) , p_{inf} and $(1 - p_{inf})$ are the steady state values for activation and inactivation, respectively, and are usually represented by Boltzmann equations as functions of Vm. In order to characterize voltage-gated channels, the equations are fit to voltage clamp data. For a derivation of e Hodgkin-Huxley equations under voltage-clamp. For each value of the the membrane potential the nonlinear gating equations reduce to equations.Thus, for every value of membrane potential Vm the sodium and potassium currents can be described: $I_{Na}(t) = g_{NA} * m * (V_m)^3 h(V_m)(V_m - ENa), I_K(t) = g_K * n$ c)What is the direction of the electrochemical gradient of the ions and how is this presented in the circuit below? The electrochemical gradient is from higher concentration to

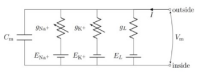


Fig. 4. hodgkin

lower concentration and because of the charge flow across the membrane it generates the potential difference in accordance to the concentration change direction because of the diffusion. In the picture, the electrochemical gradient of the Na^+ is from outside to inside and theK^+ is from inside to outside and the L is also from inside to outside.

4. EXERCISE 4

Course feedback on Moodle.

5. SUMMARY

To summarize, we study the Vm of the ion channels from the relation to capacity and resistance. Through the Hodgkin and Huxley model,we also explore the ion channels in the circuit. In gating variables, K, Na and L, their electrochemical gradient s also studied.

REFERENCES

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[2] Pine J. A History of MEA Development. In: Baudry M, Taketani M, eds 'Advances in Network Electrophysiology Using Multi-Electrode Arrays'.[3] 'A quantitative description of membrane current and its application to conduction and excitation in nerve' The Journal of Physiology. 117 (4): 50044. doi:10.1113/jphysiol.1952.sp004764. PMC 1392413. PMID 12991237