Electrophysiology neuron getting 5a instruction manual

Electrophysiology neuron.

In this chapter, basic concepts from neurophysiology are discussed. Membrane potential generation, voltage-gated channels' role and dynamics, and Hodgkin-Huxley equations are presented. Experimental techniques such as voltage-clamp and patch-clamp methods are also covered to explain neuronal dynamics processes. Clinical examples illustrate key points. By the end of this chapter, understanding the resting membrane potential's significance and action potentials' generation through ion concentration gradients and voltage-gated sodium and potassium channels is expected. Also, formulating the Hodgkin-Huxley equations and performing simulations using them to explore effects of ion homeostasis changes or abnormal channel gating is possible. The human brain has approximately 100 billion neurons, each connected to thousands others. This complexity makes it a challenging subject. We use conductance-based modeling by introducing an electrical equivalent circuit here. Another approach is the Goldman-Hodgkin-Katz voltage equation based on ion concentrations and permeabilities. Pumping also affects membrane potential as the net current isn't zero. Although small, this effect ranges from -2 to -5 mV. Here we focus on average properties. The behavior of individual ion channels will be discussed later. General aspects of differential equations are presented in Chapter 3. This is the standard form of activation and inactivation variables. Historically, Hodgkin and Huxley used different expressions for these variables. The equation describing channel states is given as $$\begin{aligned} \dot{n}=\alpha _n(V) (1-n)-\beta _n(V)n,\\ \dot{m}=\alpha _m(V) (1-m)-\beta _m(V)m,\\ \dot{h}=\alpha _h(V) (1-h)-\beta _h(V)h, \end{aligned}$$where the functions $$\begin{aligned} \begin{array}{l} \alpha _j(V) \text{ and } \beta _j(V), \\ j\in {n,m,h}, \end{array} \end{aligned}$$ describe transition rates between open and closed states of channels. For sodium, it holds that $$I_\mathrm{Na}=g_\mathrm{Na}(E_\mathrm{Na}-V_m)=g_\mathrm{Na}\times 0$$ as the Nernst potential of sodium is set experimentally. Depolarizations detected by EEG electrodes do not reflect the actual voltage changes within neurons. Instead, they are influenced by the arrangement of cortical neurons in columns perpendicular to the cortex surface. Surface-level depolarizations result in an extracellular space with a negative charge, while deep depolarizations lead to a positive charge in this region. Conversely, surface hyperpolarizations produce a positive EEG signal, whereas deep hyperpolarizations cause a negative scalp signal. This is because EEG electrodes detect the voltage changes at multiple levels of neural activity simultaneously. In the case of EPSPs and IPSPs, only the summed effects across many neurons contribute to the observed EEG signal, rather than individual signals from specific neurons. The polarity of these detected potentials – upgoing for negative, downgoing for positive – can be determined by considering the chosen montage. Deep neural activity, such as that below the scalp, would typically yield a negative EEG recording due to IPSPs promoting hyperpolarization and K+ movement out of the cell, causing an outward flow of current. The electric properties of neurons are influenced by the cell's interior becoming more negative, leading to the extracellular space becoming relatively positive. This phenomenon targets deeper regions of the neuron column, making the adjacent superficial area negatively charged. The scalp EEG electrode can detect this negative charge, resulting in an upward deflection on the tracing. The Model 4AD Stimulus Isolation Amplifier is a low-noise optical isolation amplifier that provides both analog and digital input modes. The device offers zero leakage current, high compliance, and zero power-on spikes, ensuring safe operation when the amplifier is off. It features a voltage or current output, good step response, biphasic functionality, and a low battery indicator. The amplifier's inputs are either analog or digital, with an analog input range of 0-10V. A negation switch allows for negative input voltages. The digital input is TTL and CMOS compatible, and both inputs are BNC connectors that can be selected via the front panel toggle switch or digital control. The output can be configured as either a current source or voltage source, allowing the unit to operate as a Voltage-Controlled Current Source (VCCS) or Voltage-Controlled Voltage Source (VCVS). The output polarity can be set to accommodate various applications. This device operates in both digital and analog modes, with adjustable settings for output range and polarity via a toggle switch on its front panel. In the digital mode, the output current can be precisely set using a 10-turn potentiometer, directly reflecting the pot's value when a digital signal is applied. The device accepts input signals ranging from 0 to 10V or -10V to 0 and outputs currents proportionally, with options for four different ranges: 0-0.01mA, 0-0.1mA, 0-1mA, or 0-10mA in digital mode, and a direct proportional output range of 0 to 10V (or -10V to 0) in analog mode. The device is powered by twenty 9-volt alkaline batteries.