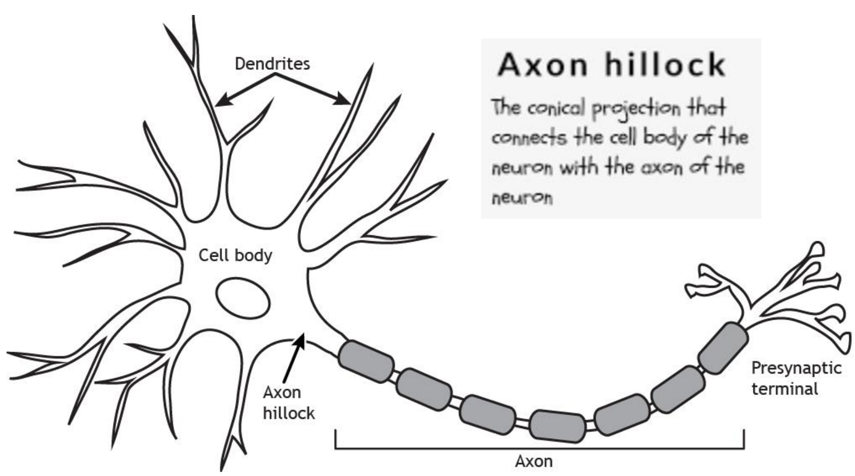
Clase 5 Potencial de acción

Contenido

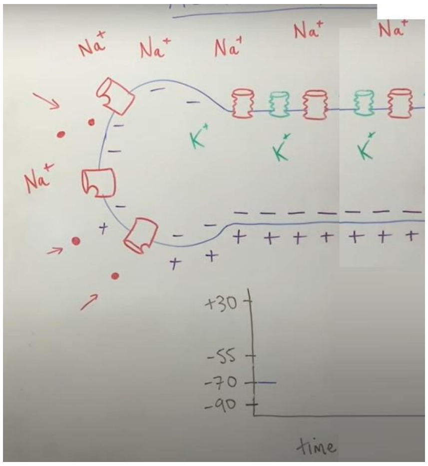
1. Definir potencial de acción
2. Desarrollar un modelo
3. Simular el comportamiento

- Temas repasar:
  - Elementos de acople capacitivo
- Temas Futuros

Neurona[1]



Potencial²



https://www.youtube.com/watch?v=BB0qVcp7FOQ

- En reposo mayor numero de iones de Na+ en el exterior de la célula que en el interior
- Mayor numero de iones de potasio K+ en el interior que en exterior.
- El interior de la célula esta a un potencial negativo respecto al exterior: cerca a -70 mV

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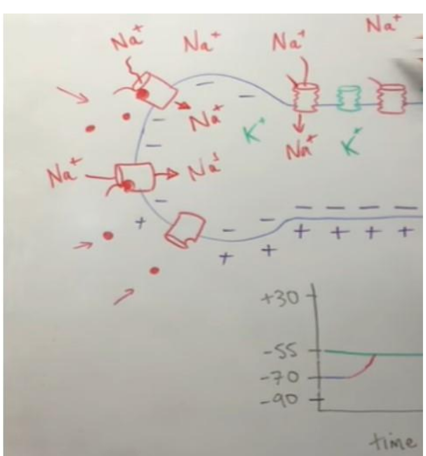
Potencial²



- Por difusión, iones de Na+ fluyen hacia adentro. (En la región llamada Axon Hillock)
- Como son positivos el voltaje interno va aumentando respecto al externo (se hace menos negativo).
- Al alcanzar -55mV las compuertas de sodio activadas por voltaje, ubicadas a lo largo del axón se van abriendo. Mas iones Na+ entran. El voltaje aumenta

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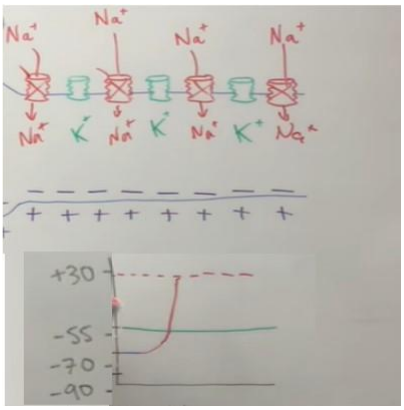
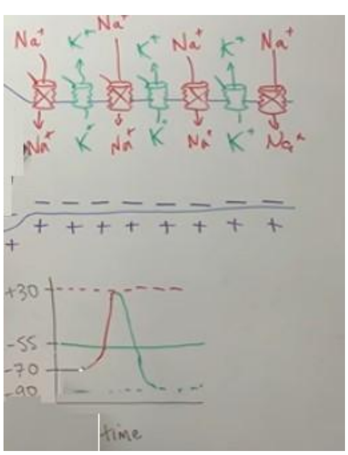
Depolarización: ingreso de Na+[2]



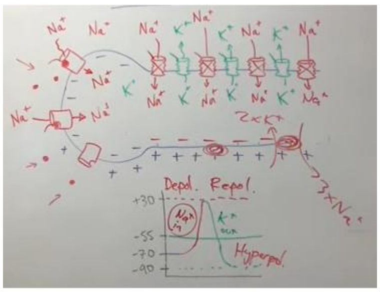
- La propagación sigue a lo largo del axón, mas compuertas se abren y el voltaje sigue aumentando, hasta + 30 mV.
- En este voltaje las compuertas de sodio empiezan a cerrarse.
- El potencial interior subió desde -70 mV hasta +30 mV: fase de Depolarización.
- Hay mas iones Na+ en el interior que en exterior

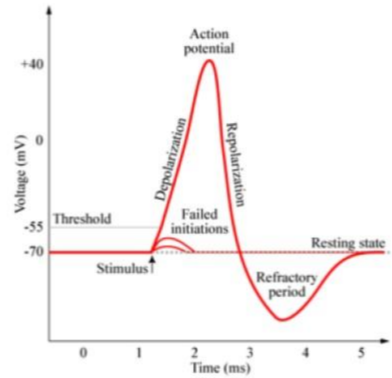
Repolarización: salida de K+[2]



- En este voltaje de + 30 mV las compuertas de K+ empiezan a abrirse.
- A medida que van saliendo iones de K+ el voltaje del interior va cayendo.
- El voltaje del interior baja hasta -90 mV

Potencial de acción[2]





Dinámica de la conductancia del potasio K[3]

Potassium conductivity $g_K(t)$ is simulated as proportional to the forth power of a gating variable, n(t):

$$g_K = n^4 \overline{g_K}$$

where $\overline{g_K}$ is the maximum conductance of potassium in the cell, occurring when n = 1. The dynamics of potass conductivity are simulated to respond to changes in membrane potential via a first-order process

$$\frac{dn}{dt} = \alpha_n(1-n) - \beta_n n$$

where α_n and β_n are the rates of opening and closing of the channel. The dependency of the opening and clos on voltage are modeled by functions that match the observed data:

$$\alpha_n = 0.01 \frac{10 - v}{\exp\left(\frac{10 - v}{10}\right) - 1}$$

$$\beta_n = 0.125 \exp\left(\frac{-v}{80}\right)$$

where v is the membrane voltage (inside cell minus outside cell) and measured relative to the resting potential of around -60 mV. The units in the above expression are in mV.

Dinámica de la conductancia del sodio Na[3]

<u>Step 2: Simulating the dynamics of the sodium conductance</u>

Sodium conductivity $g_{Na}(t)$ is simulated as governed by two gating variables, m(t) and h(t):

$$g_{Na} = m^3 h \overline{g_{Na}}$$

where $\overline{g_{Na}}$ is the maximum conductance of sodium in the cell, occurring when m = 1 and h = 1. As for potassium conductivity, the dynamics of sodium conductivity are simulated to respond to changes in membrane potential via first-order processes

$$\frac{dm}{dt} = \alpha_m(1-m) - \beta_m m$$

$$\frac{dh}{dt} = \alpha_h(1-h) - \beta_h h$$

The difference is that since there are two gating variables there are two opening rates α_m and α_h and two closing rates β_m and β_h. The equations that capture the voltage dependency of these variables are

$$\alpha_m = 0.1\frac{25-v}{\exp\left(\frac{25-v}{10}\right)-1}$$

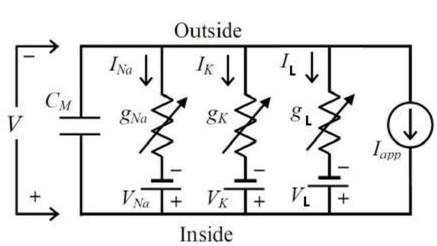
$$\beta_m = 4\exp\left(\frac{-v}{18}\right)$$

$$\alpha_h = 0.07\exp\left(\frac{-v}{20}\right)$$

$$\beta_h = \frac{1}{\exp\left(\frac{30-v}{10}\right)+1}$$

Again, v is the membrane voltage (inside cell minus outside cell) and measured relative to the resting potential of around -60 mV. The units in the above expression are in mV.

Circuito equivalente[3]



- Capacitancia C corresponde a las capas de las membranas de las células.
- IK, Ina e Il son las corrientes iónicas asociadas a K, Na y a fugas indefinidas respectivamente.
- Las conductancias de los canales Na y K son dependientes de voltaje

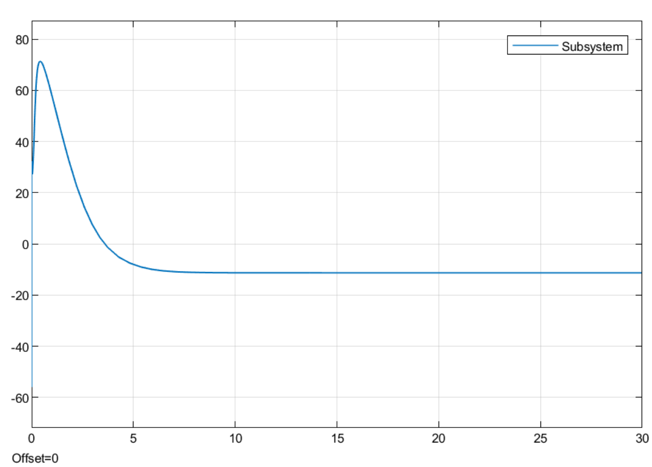
Circuito equivalente[3]

- Ley de Kirchoff de corriente:

$$C\frac{dV}{dt} = I_{ion} + I_{app}$$

$$C\frac{dV}{dt} = -(v - v_{Na})g_{Na} - (v - v_K)g_K - (v - L)g_L + I_{app}$$

- La capacitancia de la membrana tiene un valor de $C_m = 1\frac{\mu F}{cm^2}$
- $v_{Na} = 115mV;\ v_K = -12mV; v_L = 10.6mV$
- https://virtualrat.org/hodgkin-huxley-model-action-potential-squid-giant-axon



Referencias

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