Week 2 – part 3 : Hodgkin-Huxley Model

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Neuronal Dynamics:
Computational Neuroscience of Single Neurons

Week 2 – Biophysical modeling:
The Hodgkin-Huxley model

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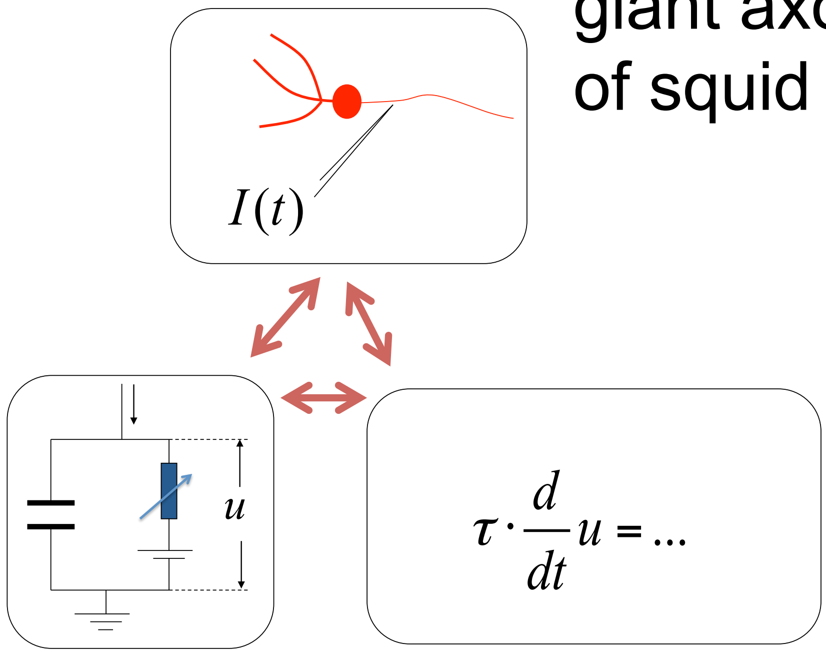
Neuronal Dynamics – 2. 3. Hodgkin-Huxley Model

giant axon of squid

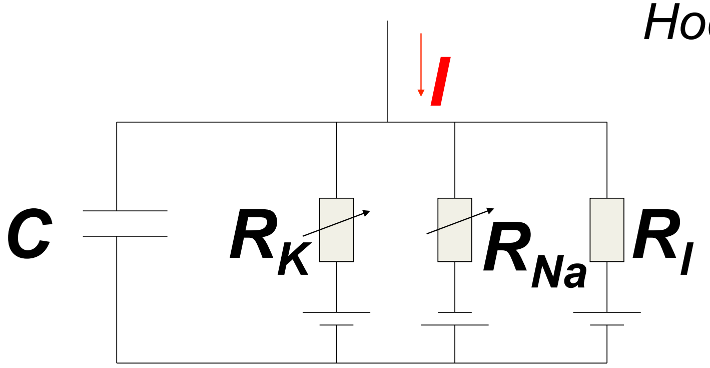


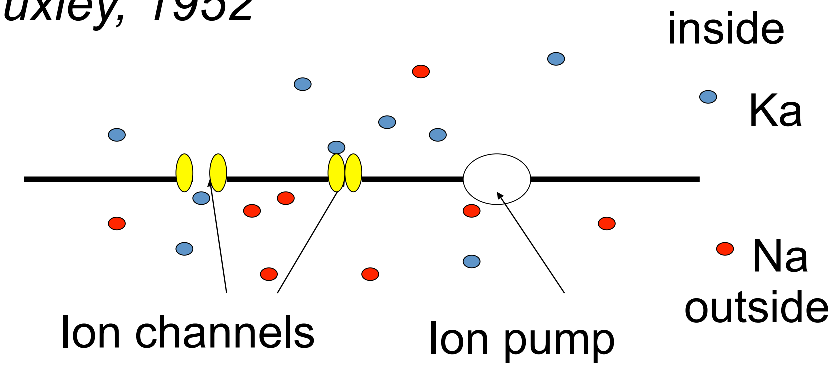
→Hodgkin-Huxley model

Hodgkin&Huxley (1952)
Nobel Prize 1963

Neuronal Dynamics – 2.3. Hodgkin-Huxley Model

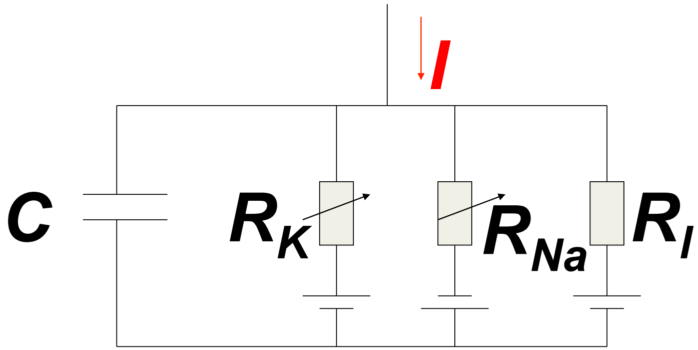
Hodgkin and Huxley, 1952





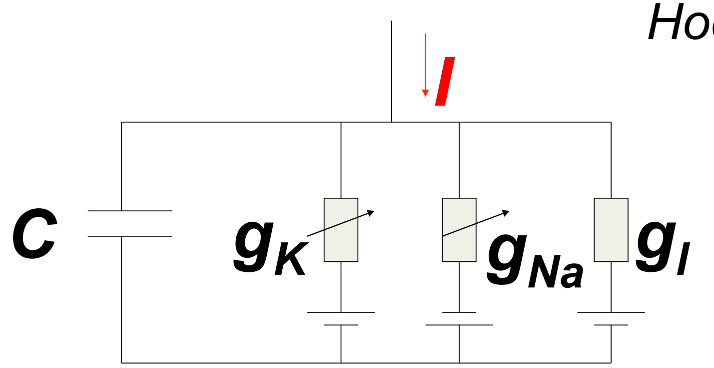
Mathematical derivation

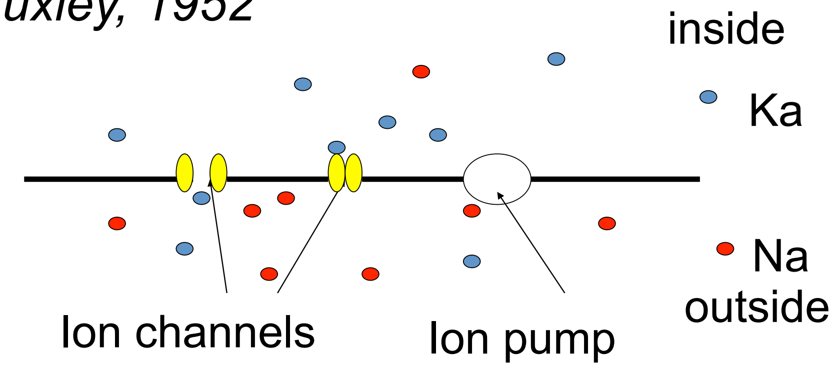
Neuronal Dynamics – 2.3. Hodgkin-Huxley Model



Neuronal Dynamics – 2.3. Hodgkin-Huxley Model

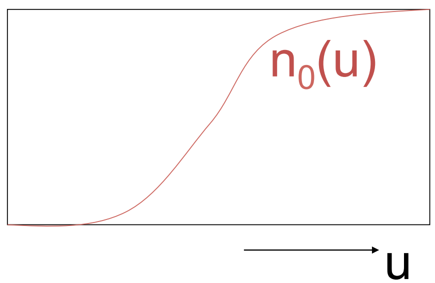
Hodgkin and Huxley, 1952

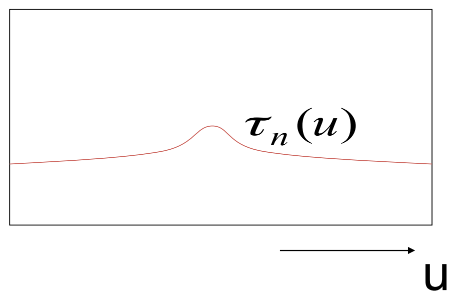




$$C\frac{du}{dt} = \overbrace{-g_{Na}m^3h(u-E_{Na})}^{I_{Na}} \overbrace{-g_K n^4(u-E_K)}^{I_K} \overbrace{-g_l(u-E_l)}^{I_{leak}} + \overbrace{I(t)}^{\text{stimulus}}$$

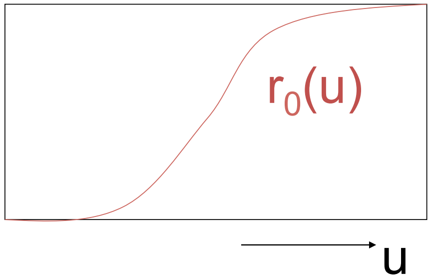
$$\frac{dm}{dt} = -\frac{m - m_0(u)}{\tau_m(u)} \qquad \frac{dh}{dt} = -\frac{h - h_0(u)}{\tau_h(u)}$$

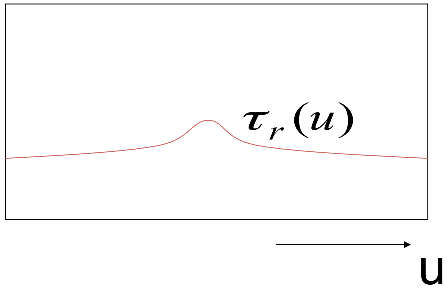




Neuronal Dynamics – 2.3. Ion channel

$$C\frac{du}{dt} = -\sum_k I_{ion,k} + I(t)$$

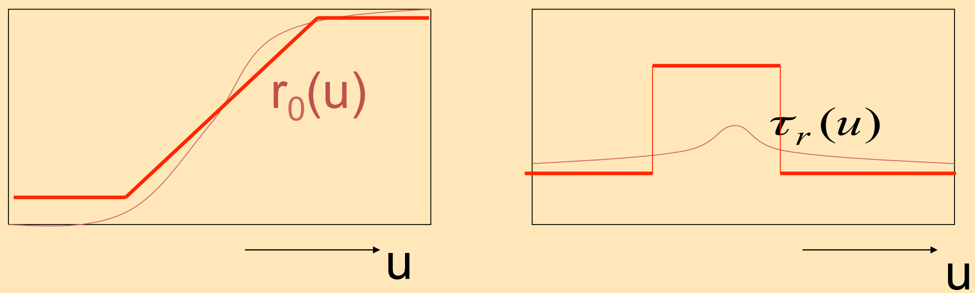




$$I_{ion} = -g_{ion} r^{n_1} s^{n_2}$$

$$\frac{dr}{dt} = -\frac{r - r_0(u)}{\tau_r(u)} \qquad \frac{ds}{dt} = -\frac{s - s_0(u)}{\tau_r(u)}$$

Neuronal Dynamics – Exercise 2.3. Ion channel



$$C\frac{du}{dt} = -g_{ion} r^{n_1} s^{n_2} (u - E_{Na}) + I(t)$$

$$\frac{dr}{dt} = -\frac{r - r_0(u)}{\tau_r(u)}$$