***Hodgkin-Huxley model***

The **Hodgkin–Huxley model**, or **conductance-based model**, is a mathematical model that describes how action potentials in neurons are initiated and propagated. It is a set of nonlinear differential equations that approximates the electrical characteristics of excitable cells such as neurons and cardiac myocytes. It is a continuous-time dynamical system.

Alan Hodgkin and Andrew Huxley described the model in 1952 to explain the ionic mechanisms underlying the initiation and propagation of action potentials in the squid giant axon.[1] They received the 1963 Nobel Prize in Physiology or Medicine for this work.

The typical Hodgkin–Huxley model treats each component of an excitable cell as an electrical element. The lipid bilayer is represented as a capacitance (Cm). Voltage-gated ion channels are represented by electrical conductances (*gn*, where *n* is the specific ion channel) that depend on both voltage and time. Leak channels are represented by linear conductances (*gL*). The electrochemical gradients driving the flow of ions are represented by voltage sources (*En*) whose voltages are determined by the ratio of the intra- and extracellular concentrations of the ionic species of interest. Finally, the membrane potential is denoted by *Vm*.

Channel kinetics are described with the usual Hodgkin-Huxley channel equation and constants with, α, β being the forward and backwards rate, respectively.

One other technical note is that certain function forms can become indeterminate at certain voltage values. Given a specific voltage, an(V) may evaluate to the indeterminate form 0/0. The solution to this problem is to apply L’Hospital’s rule, which states that if f(x) and g(x) approach 0 as x approaches a, and f ‘(x)/ g’(x) approaches L as x approaches a, then the ratio f (x)/ g(x) approaches L as well. Using this rule, it can be shown that an (10) = 0.1. Hence, the limits for every case are hardcoded for simplicity and efficiency.

All of the constants listed in Table 1, are defined in Python. These numbers fall into the range of experimental values provided in the original Hodgkin and Huxley model.

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| ***Constant*** | ***Chosen Value*** |
| Cm (μF/cm2) | 1.0 |
| GNa (mmhos/cm­­2) | 120.0 |
| GK (mmhos/cm­­2) | 36.0 |
| Gl (mmhos/cm­­2) | 0.3 |
| Vm (mV) | 0.0 |
| VNa (mV) | 115.0 |
| VK (mV) | -12.0 |
| Vl (mV) | 10.613 |
| VThresh (mV) | 55.0 |
| Iinj (μA/cm2) | 10.0 |
| Tmin (ms) | 0.0 |
| Tmax (ms) | 35.0 |

Table : Constants defined in Python based on range of values defined in the Hodgkin-Huxley mode

***References***

1. Hodgkin AL, Huxley AF (August 1952). [*"A quantitative description of membrane current and its application to conduction and excitation in nerve"*](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1392413). The Journal of Physiology. **117** (4): 500–44. [*doi*](https://en.wikipedia.org/wiki/Doi_(identifier)):[*10.1113/physio. 1952.sp004764*](https://doi.org/10.1113%2Fjphysiol.1952.sp004764). [*PMC*](https://en.wikipedia.org/wiki/PMC_(identifier)) [*1392413*](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1392413). [*PMID*](https://en.wikipedia.org/wiki/PMID_(identifier)) [*12991237*](https://pubmed.ncbi.nlm.nih.gov/12991237).