Readings in Neuroinformatics

[redacted]

Hodgkin AL, Huxley AF. A quantitative description of membrane current and its application to conduction and excitation in nerve. Journal of Physiology. 117(4): 500–544, 1952.

Abstract

1) 1 1 Nerve cells transmit changes in membrane potentials (named 'action potentials') in an all-or-none process along the length of the nerve cell axon. The exact nature and the

2) 0.5 mechanism of the action potential are unclear. Evidence suggests that the axon membrane Too specific (here)

3) 1 2 becomes permeable to sodium ions specifically, carrying positive charge into the cell. There

4) 0.5 may also be voltage-dependent changes in potassium permeability. The rapid all-or-none nature of the change renders the problem difficult to observe. It is thus of interest to study the changes Avoid

5) 1 in permeability of the membrane to changes in the concentration of these ions and the

6) 1 3 membrane potential. ~~In~~ We propose voltage clamp experiments, ~~the authors~~ to show that the permeability changes with respect to the membrane potential, not to the current, and solved the resulting non-linear differential equations that were fitted to the time course of the action potential. ~~Their~~ Our quantitative model assume~~d~~s no feedback from the membrane potential changes and the

4 resulting equations corroborated past experimental results. Althoug The results ~~greatly constrain, but~~ do not explain, the precise mechanism of the propagation of the action potential in squid giant axons. ~~Their~~ Our description is expected to provide insight on the nervous electrical properties of

5 other species and may eventually contribute to the better understanding of the human nervous system.

they greatly constrain it...

5

1) Intro + background
2) Problem definition
3) Proposed solution
4) Methods + Results
5) Impact
6) Style + understanding
Words

Readings in Neuroinformatics

[redacted]

Reference: *Hodgkin, Alan L., and Andrew F. Huxley. "A quantitative description of membrane current and its application to conduction and excitation in nerve." The Journal of physiology 117.4 (1952): 500-544.*

1) 0.5
2) 0.5
3) 0.5
4) 1
5) -
6) 0.5

3

1 2 3 4?

Abstract: The following article deals with a mathematical model for the electric current flow through the surface membrane of a nerve fibre via a set of non linear differential equation. The paper is structured in three different sections. The first one illustrates the experimental results and how the electrical properties of the membrane can be described by an electrical circuit with three parallel conductances (one for each ion Na, K and Cl) a voltage source associated and a capacitor representing the capacitance of the membrane due to the phospholipid bilayer. The critical point of this model is the value of the conductances; indeed it is possible to consider them to be constant only in the stationary case and not with the development of an action potential. At this purpose, the second section illustrates a dynamical model describing the behavior of the conductance, for every single ion, in time and depending on the membrane potential. The third part, using the equations and the model fitted so far illustrates the reconstruction of the generation and propagation of the action potential in a nerve fibre.

Readings in Neuroinformatics

[redacted]

September 28, 2018

A.L. Hodgkin and A. F. Huxley, A Quantitative Description of Membrane Current and its Application to Conduction and Excitation in Nerve, J.Physiol. (1952) 117, 500-544

Abstract

1) 0.5
2) 1
3) 0.5
4) 0.5
5) 0.5
6) 1

The information flow in the nervous system is achieved by action potentials, which are signals that propagate along the connecting fibres between neurons (axons). In the axon's natural state, there is a potential difference across its membrane. Voltage gated ion channels allow the depolarization and signal transfer during the process of an action potential. The time evolution of the ion-gate conductance's as well as their dependence on the membrane voltage are still to be determined. In this paper, ~~the~~ current flowing through the membrane ~~is explained~~ by treating the membrane as an electrical circuit that is composed of capacitors and resistors. Starting at the physical laws for the electric components of the model, differential equations are derived that describe the time dependence of the particle and ion configuration inside and outside of the axon. The remaining parameters of the model are evaluated for the cases of potassium and sodium ion gates using data from voltage clamp experiments on squid giant axons. Further phenomena and details of the axons electrical properties could be explained by the model described in this paper, such as the two types of currents that are observed in the squid giant axon. During the action potential, an initial inward current is followed by a slowly increasing outward current.

we explain

(4)

Readings in Neuroinformatics

[redacted]

Hodgkin, A. L., & Huxley, A. F. (1952). A quantitative description of membrane current and its application to conduction and excitation in nerve. *The Journal of Physiology*, *117*(4), 500–544.

Abstract

Too broad

1) 0.5
2) 1
3) 0.5
4) 0.5
5) —
6) 0.5

1 An animal's actions are coordinated by transmitting signals to and from different parts of its body throughout the nervous system. The nervous system consists of nerve cells, called neurons, which transmit information along their axons - or nerve fibers - to communicate with neighboring neurons. The information transmission is mediated by an electric current flow through the surface membrane of the neuron. Current can be carried through the membrane either by 2 charging the membrane capacity or by movement of ions through the resistances in parallel with the capacity. The dynamics of the system that gives rise to this electric signal have not yet been sufficiently mathematically formalized. 3 Here we discuss the results of the preceding papers (Part I), put the results of the p into mathematical form (Part II) and show that they will account for conduction and excitation in quantitative terms (Part III). 4 The voltage clamp data obtained previously are used to find equations which describe the changes in sodium and potassium conductance associated with an alteration of membrane potential.The equations, given on pp. 518-19, were used to predict the quantitative behaviour of a model nerve under a variety of conditions which corresponded to those in actual experiments. It is concluded that the responses of an isolated giant axon of Loligo to electrical stimuli are due to reversible alterations in sodium and potassium permeability arising from changes in membrane potential.

What is your contribution?

Our results show

3

Readings in Neuroinformatics

[redacted]

Hodgkin, A. L. & Huxley, A. F. A quantitative description of membrane current and its application to conduction and excitation in nerve. *The Journal of Physiology.* 117.4, 500–544 (1952).

Abstract

In nervous systems

not relevant

~~Human brain is made of billions of~~ neurons communicating together through electrical impulses referred to as action potentials. These electrical signals are caused by the movement of ions through the cell membrane creating currents. However, the exact mechanism by which these ions flow and interact remains unknown. In this paper we propose a mathematical model that partially describes the laws governing the creation of the membrane current for a squid axon. We validate our model's ability to explain the axon's electrical behavior under various conditions by comparing it to previously recorded data from a voltage clamp experiment. Results show that the proposed mathematical model can predict many of the observed electrical properties of the axon. This suggests that the model could serve as a basis for understanding neuronal activity.

1) 1
2) 1
3) 1
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6) 1

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NAME ?

PAPER ?

Activities in nerve such as conduction and excitation are associated with changes in membrane current.

1

The electrical behavior of the membrane may be represented by equivalent circuit containing constant capacitor in parallel with voltage sources whose inner conductance can be time-variable, standing for different ion channels, namely sodium, potassium and "leakage" made up by chloride and other ions.

1) 0.5

2) –

3) –

4) 0.5

5) 0.5

6) –

1.5

3 Here we show that the sodium and potassium conductance are functions of time and membrane potential, while other parameters may be taken as constant. ! Not true

Using voltage clamp method, the parameters can be determined by fitting solutions to experimental curves at various membrane potentials. The empirical model can predict many of the electrical properties of the squid giant axon with fair accuracy, including: the form, duration and amplitude of spike; the conduction velocity; the impedance changes during the spike; the refractory period; ionic exchanges; subthreshold responses; and oscillations.

4

It is concluded that the responses of an isolated giant axon of *Loligo* to electrical stimuli are due to reversible alterations in sodium and potassium permeability arising from changes in membrane potential.

The range of phenomena to which our equations are relevant is limited in short-term responses and isolated squid giant axons. The basic mechanism of conduction may be the same in many excitable tissues, but the great difference in the shape of action potentials show that at least some of the parameters in our equations must have very different values.

5 Furthermore, the discovery of molecular basis can be a direct proof of the equations.

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September 28, 2018

Hodgkin A.L. & Huxley A.F., *A Quantitative Description of Membrane Current and its Application to Conduction and Excitation in Nerve*, J.Physiol. 117, 500-544, 1952

Abstract

1) 0.5 The electrical behaviour of a nerve fibre depends on the current carried through its mem-
2) 1 brane. By charging the membrane capacity or by the transmenbranous movement of ions like
sodium and potassium, the current is affected. The permeability of these ions is influenced
3) 0.5 1 by the membrane potential. So, the depolarisation induces a transient increase in sodium
conductance and a slower increase in potassium conductance. Due to these graded changes,
4) 1 the membrane potential reaches a certain threshold causing an action potential. By repo-
larisation these phenomena are reversed and followed by a refractory period. Within this
5) 0.5 inactivation phase, depolarisation only lead to a reduced and delayed response. However,
2 there is no quantitative term to clearly decide whether the individual effects are able to
6) 0.5 induce an action potential. Here we show expressions for the relation between sodium and
3 potassium conductance to time and membrane potential. We derived equations from voltage
4 clamp records of a model nerve, thereby accurately predicting many electrical properties of
the axon. Even though we covered only short-term responses and presented them in an
5 isolated giant axon, our equations are an empirical description of the quantitative behaviour
of the axonal membrane under various conditions.

4

NAME?
PAPER?

1) —
2) —
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6) 0.5

2.0

The purpose of the study was to consider voltage clamp recordings of neurons that have been found in previous papers, and use it to derive a set of mathematical equations to model the behavior of the neurons. Specifically, the conductance of potassium and sodium ions through the membrane are described. The parameters of the equations are tuned so that the behavior fits previous experimental data. From this, the shape, excitation and propagation of action potentials in a squid's isolated giant axon can be predicted with a fair amount of accuracy. However, the model is limited in that they only describe short term behavior of the neurons. It is concluded that responses in the giant squid's axon to electrical stimuli are due to changes in the permeability of sodium and potassium due to changes in membrane potential. This is significant, because it is expected that this is true for axons in general, even in the human brain

Avoid
8

Readings in Neuroinformatics 2018

[redacted]

A. L. Hodgkin and A. F. Huxley, *A Quantitative Description of Membrane Current and its Application to Conduction and Excitation in Nerve*, J. Physiol., Vol. 117, p. 500-544, 1952

Abstract

1) 1 1 The cell membrane, which separates the cell body from the outside environment, is selectively permeable to ions and organic molecules and thus controls the in-and-out movement of substances. Through the representation of its electrical behavior by circuitry networks, insights about its
2) 1 2 properties and functionalities can be obtained. A precise model describing the existing experimental data is still unknown. Here we propose a circuit which describes the responses of an isolated giant
3) 1 3 axon of *Loligo* to electrical stimuli with the reversible alterations in sodium and potassium permeability arising from changes in membrane potential. We found equations and the
4) 0.5 4 corresponding parameters that describe the dependency of sodium and potassium conductance on the membrane potentials by using previously obtained voltage clamp data. Those equations were
5) 0.5 used to predict the quantitative behavior of a model nerve under a variety of conditions corresponding to the actual experiments. Good agreement were obtained in various cases, such as the action potential form, amplitude and threshold under zero membrane current, the propagation
6) 1 5 form, amplitude and velocity of the action potential and the total in-and-outward movement of sodium and potassium ions respectively. The theory also predicts that a direct current will not excite if it rises sufficiently slowly.

199 words

5

Readings in Neuroinformatics

[redacted]

Hodgkin, A. L., & Huxley, A. F. (1952). A quantitative description of membrane current and its application to conduction and excitation in nerve. *The Journal of physiology*, *117*(4), 500-544.

Neorons ?

Abstract:

1 The permeability and conductance of membrane can be measured through behaviors of ionic current in an excitable cell. Membrane potential would undergo significant changes upon an electric stimulation. Nevertheless, the ionic
2 mechanism of such phenomena remained unknown. Here we show that in the squid
3 giant axon, the membrane permeability of sodium and potassium ions is sufficient to ~~be~~ account for the alteration of membrane potential. The general goal of this paper is to put forth a simple representation based on the results found in preceding literature to quantitatively describe the ionic mechanism for
4 the initiation and propagation of action potential in excitatory cells. We took the voltage clamp data for sodium and potassium conductance to find the equations and further apply them to calculations of the membrane action potentials. Our predictions calculated from the equations showed fair accuracy corresponding to
5 the actual experimental data. These ~~simple~~ equations may provide a solid ground for mathematical description of behaviors of other ion channels and for building models to describe neuronal activities.

Don't diminish your work

1) 0.5
2) 1
3) 0.5
4) 0.5
5) 1
6) 0.5

4