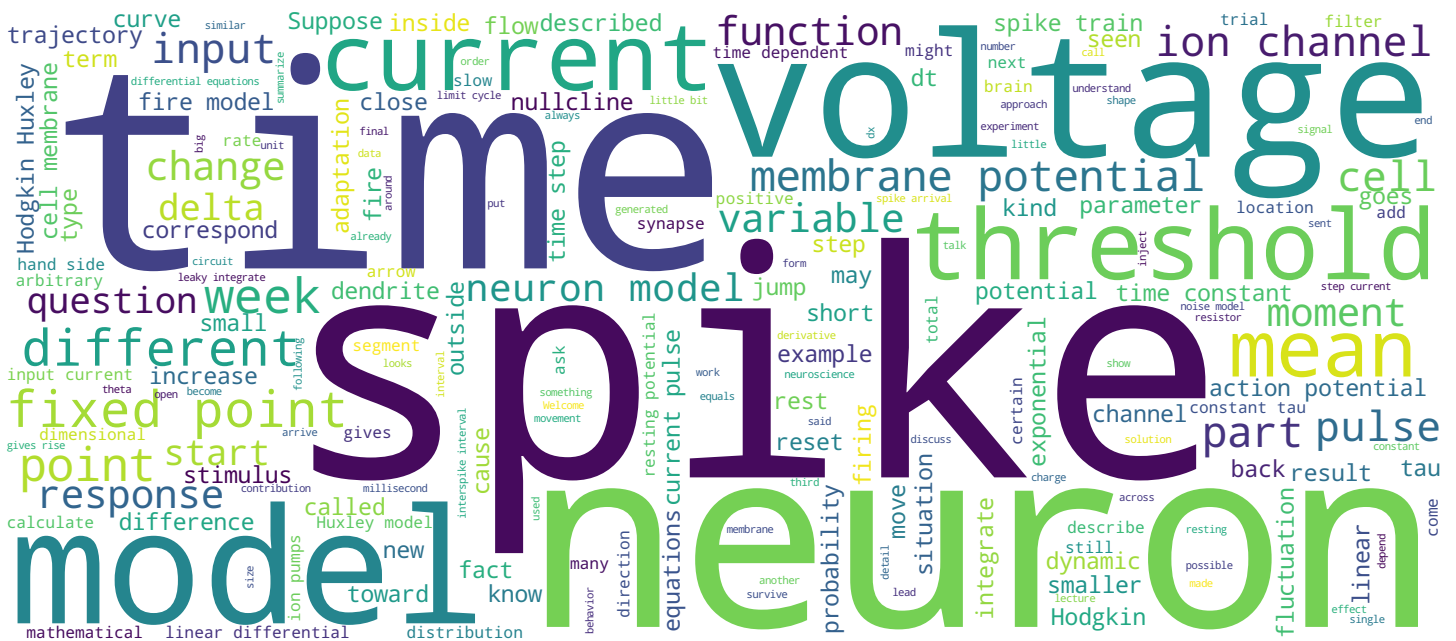


ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

EPFL, Lausanne, Switzerland

- the zoo of ion channels



EPFL



Week 2 – part 1: Biophysics of neurons



2.1 Biophysics of neurons

- Overview

2.2 Reversal potential

- Nernst equation

2.3 Hodgkin-Huxley Model

2.4 Threshold in the

Hodgkin-Huxley Model

- where is the firing threshold?

2.5. Detailed biophysical models

- the zoo of ion channels

Welcome to the second week of the class Neural Dynamics. This week, we will discuss biophysical models of neurons, models of the Hodgkin-Huxley type.

Notes

Summary

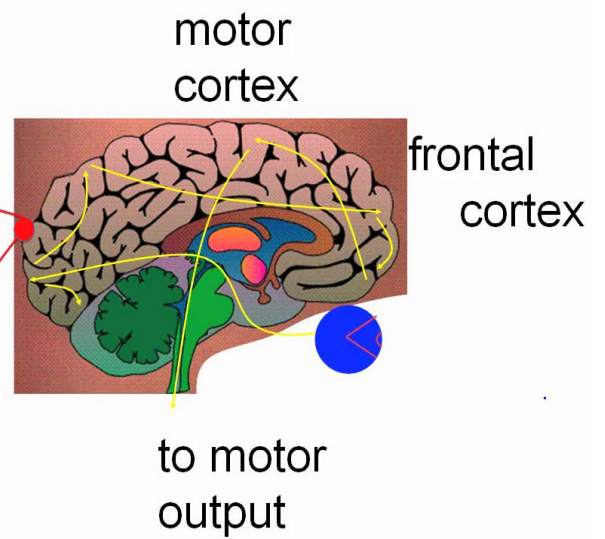


0m 05s

Neuronal Dynamics – 2.1. Introduction



10 000 neurons
3 km wires



Just like in the previous week, we will describe neurons that are part of the brain.

Notes

Summary



0m 16s

Neuronal Dynamics – 2.1 Introduction



10 000 neurons

1mm

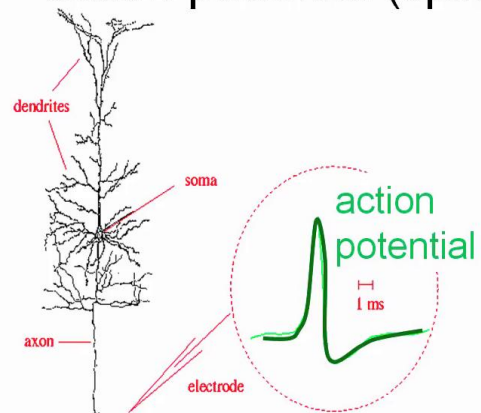
3 km wires



Ramon y Cajal

Signal:

action potential (spike)



How is a spike generated?

And these neurons, as we have seen, communicate with each other by sending out short electrical pulses called action potentials, or spikes. The question I would like to ask this week is how are these spikes generated? What is the biophysical mechanism that causes a spike to be sent out to other neurons?

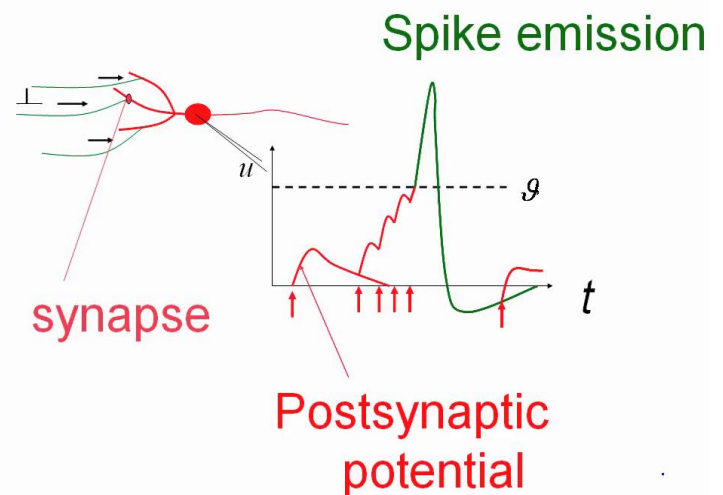
Notes

Summary



0m 22s

Review of week 1: Integrate-and-Fire models



- spikes are events
- triggered at threshold
- spike/reset/refractoriness

In the previous week, we talked about a simple neuron model-- a neuron model where spikes are represented as pulses. If a pulse comes in, it causes a response. If several pulses come in, these responses are added until a threshold is reached and a spike is sent out. Now in this description, spikes are formal events that are generated at the moment of threshold crossing. And we don't worry about the biophysical mechanisms or the exact shape of the spike. In fact, we just paste in a spike whenever the variable called the membrane potential reaches the threshold. Now this week, we will talk about how a spike can be generated based on the biophysics of cell membranes.

Notes

Summary

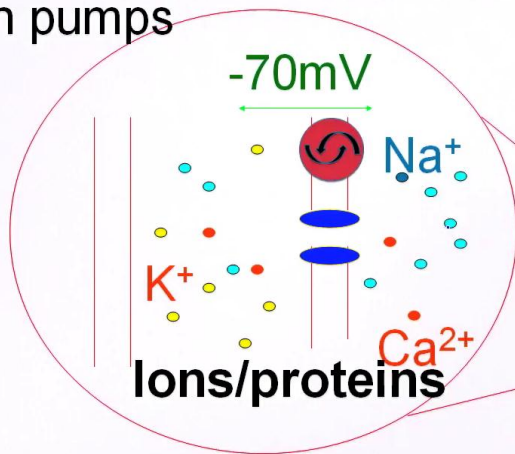


Neuronal Dynamics – week 2: Biophysics of neurons

Cell surrounded by membrane

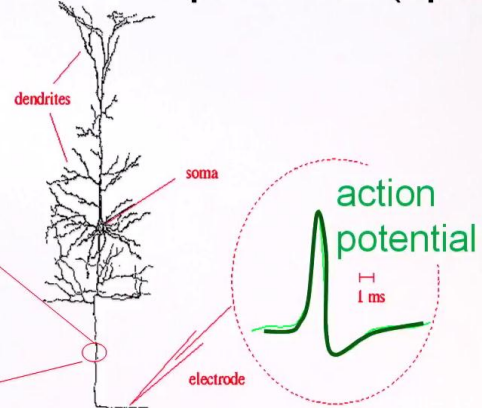
Membrane contains

- ion channels
- ion pumps



Signal:

action potential (spike)



Like any other cell, a neuron-- with all its complicated structure-- is surrounded by a cell membrane that separates the inside of the cell from the outside of the cell. Embedded in the cell membrane are ion channels and ion pumps. Ion pumps use energy to push sodium ions from inside the cell towards the outside. And with the same time, they transport potassium ions inside the cell. Ion channels are very specific proteins embedded in the cell membrane. And these proteins can change their shape, and thereby open or close a gate-- a pore. And if the gate is open, ions can flow inside and outside the cell.

Notes

Summary



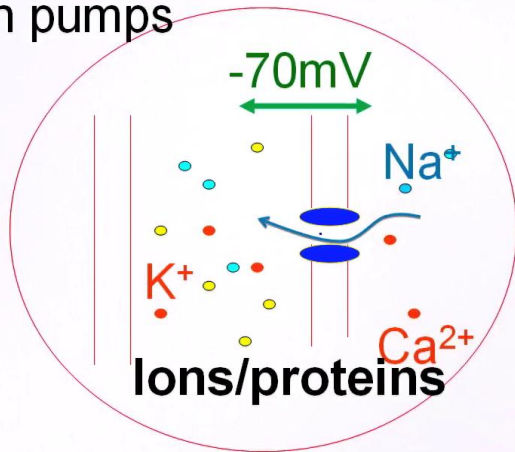
1m 41s

Neuronal Dynamics – week 2: **Biophysics of neurons**

Cell surrounded by membrane

Membrane contains

- ion channels
- ion pumps



Resting potential -70mV

→ how does it arise?

Ions flow through channel

→ in which direction?

Neuron emits action potentials

→ why?

So the question we will ask, then, is why is it that experimentalists measure a difference in potential between the inside and outside of the cell? How does this difference in potential of a neuron at rest-- how does this resting potential arise? I mentioned that if the ion channel is open, ions can flow inside or outside the cell. Well, which direction are the ions going to flow? And finally, how do ion channels and ion pumps interact so as to cause the generation of a spike? What's the biophysics that allows neurons to emit an action potential?

Notes

Summary



2m 42s

Neuronal Dynamics – 2. 1. Biophysics of neurons

Resting potential -70mV

→ how does it arise?

Ions flow through channel

→ in which direction?

Neuron emits action potentials

→ why?

→ **Hodgkin-Huxley model**

Hodgkin&Huxley (1952)

Nobel Prize 1963

Now these are questions that have puzzled the community of neuroscientists for decades, until Hodgkin and Huxley published their model-- a set of equations known nowadays as the Hodgkin-Huxley model, probably the most famous model in the whole field of neuroscience, a model that's discussed basically in any textbook on neuroscience, a model that really can be considered a breakthrough and lead to a Nobel Prize awarded to Hodgkin and Huxley.

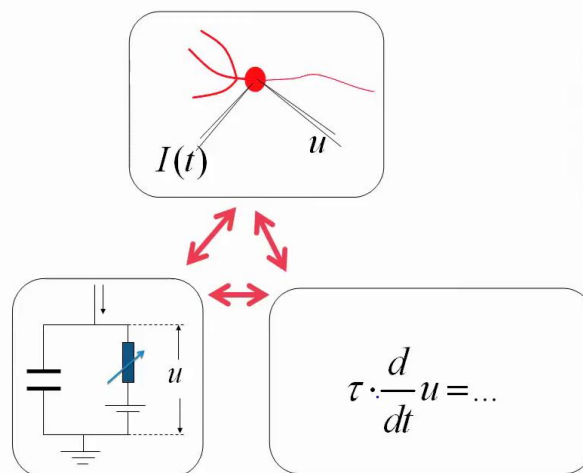
Notes

Summary



3m 37s

Neuronal Dynamics – 2. 1. Biophysics of neurons



→ Hodgkin-Huxley model

Hodgkin & Huxley (1952)

Nobel Prize 1963

So in this week, I will walk you through a model of Hodgkin and Huxley. Now this is a model that's not just described by equations. It's a model that also corresponds to an equivalent circuit. And the circuit itself is abstraction of observations that are made by Hodgkin and Huxley. Hodgkin and Huxley run a careful set of experiments on the giant axon of a squid-- of a special animal. And they abstracted away some details to arrive at an equivalent and electrical description, which then led them to write down a set of mathematical equations. Before I discuss with you the details of the model, I would like you to take some time to answer the following set of questions. Take two minutes, and then we are back for part two of week two.

Notes

Summary



4m 18s

