KING'S College LONDON

INSTITUTE OF PSYCHIATRY,
PSYCHOLOGY & NEUROSCIENCE

Module:
Techniques in Neuroscience

Week 2:
Electrophysiology: Looking at live neurons in action

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Topic 1:
An introduction to electrophysiology
Part 1 of 3

Topic list

This week, we will be looking at the following topics:

- ***Topic 1: An introduction to electrophysiology***
- Topic 2: Video of procedures
- Topic 3: Focused journal club

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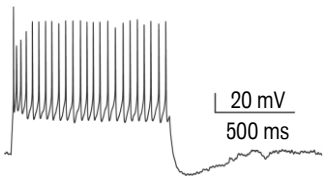
Part 1

Introduction

Galvani discovered that the nervous system uses electrical activity to perform its functions.



Biological activity is studied and recorded by electrophysiology.

Electrophysiology uses a range of techniques that can be invasive or non-invasive.

This topic is on invasive techniques.

Part 1
Types of biological electrical activity

Part 2
Extracellular recording of electrical activity

Part 3
Intracellular recording of electrical activity

Part 4
Single channel recording

Wellcome Library (2014)

Definitions to aid understanding

Definitions:

Resting membrane potential: the voltage difference across the membrane of a neuron when it is at rest (non-signalling). In a neuron, the inside of the cell is about 70 mVs (millivolts) less than the outside, so the resting membrane potential is said to be -70 mVs.

Concentration gradient: this occurs when the concentration of positive or negative ions is higher in one area than another.

Depolarisation: a change in a neurons membrane potential that make it more positive (less negative).

Hyperplarisation: a change in a neurons membrane potential that makes it more negative. It is the opposite of depolarization.

Ionotropic receptors: transmembrane proteins that form a channel allowing ions to travel in or out of a cell. These channels are opened when the receptor binds a ligand, like a neurotransmitter. Glutamate receptors and GABAA receptors are examples of ionotropic receptors.

Voltage-gated ion channels: transmembrane proteins that form ion channels whose opening and closing is regulated by the membrane potential near the channel.

Action potential: The process by which a neuron sends information down its axon.

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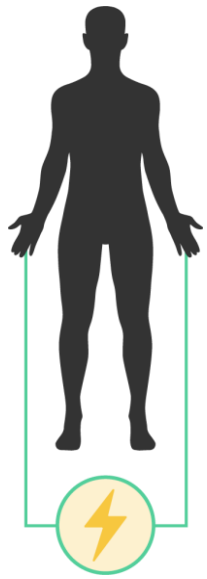
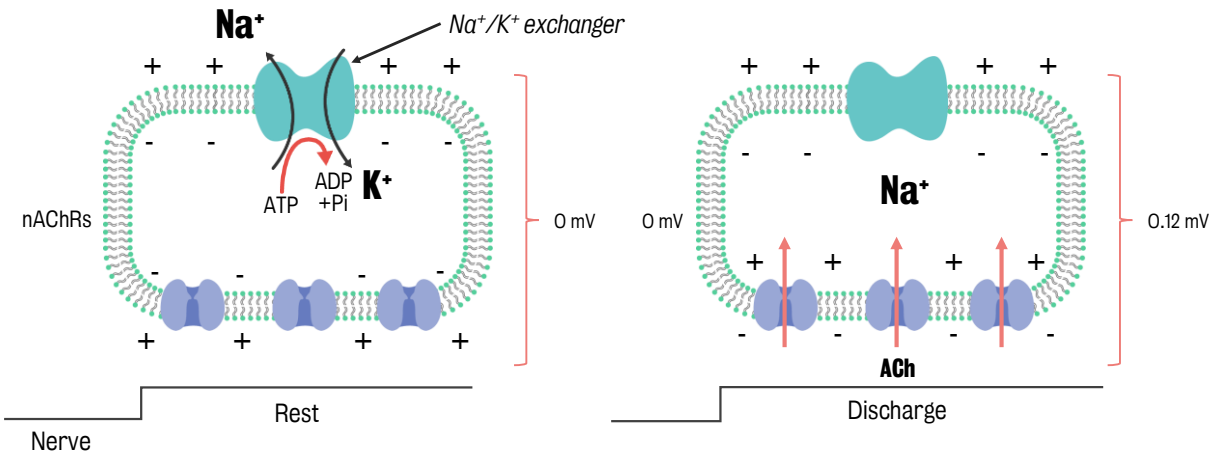
Types of biological electrical activity

1	**Large voltages generated by animals** such as electric eels or rays	**< 700V**
2	**Negative resting membrane potential** most neurons	**-70 mV**
3	**Postsynaptic potentials** small variable changes in membrane potential	**1-40 mV**
4	**Action potentials** large, fast, all or none fashion	**< 100mV**



Electroplaques

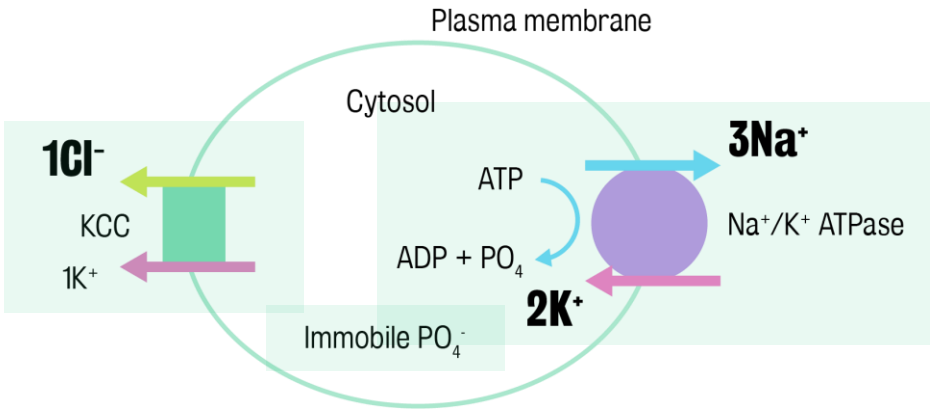


Na+: sodium ions
K+: potassium ions
Ach: acetylcholine

nAChRs: Nicotinic acetylcholine receptors
ATP: Adenosine triphosphate

5,000 stacked up in an eel or ray gives 0.12 V x 5,000 = 600 V

Neurons and electroplaques



KCC: Potassium & Chloride Co-transporter
Na+/K+ ATPase: Sodium /Potassium exchanger

Overall, these all generate a resting membrane potential of between -60 and -80 mV inside the neuron.

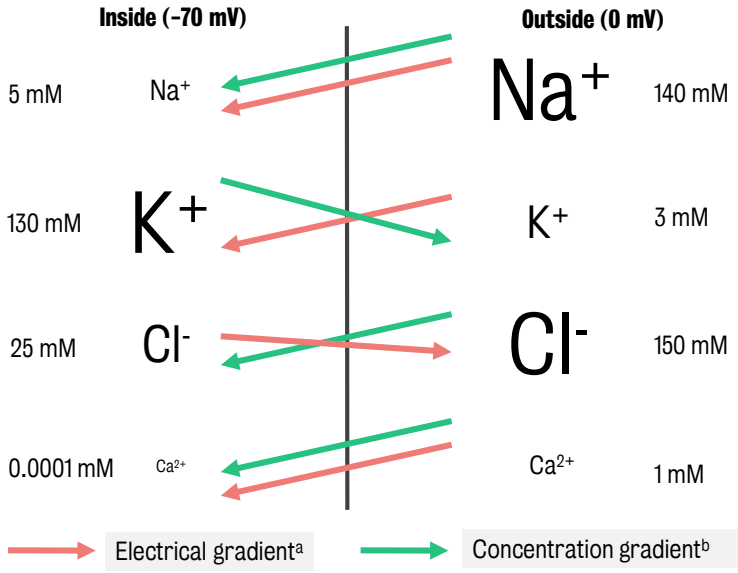
Resting membrane potential (Vm_{rest})

Concentration and electrical gradients direct ions inwards.

Concentration gradient makes ions move out despite inward electrical gradient.

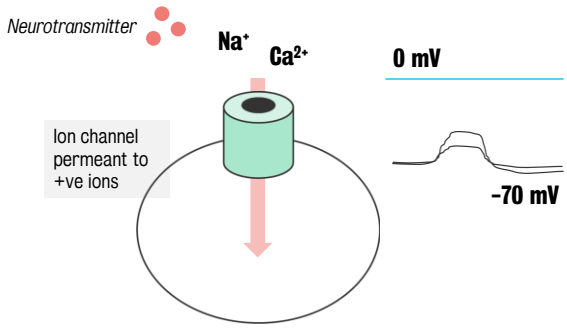
Ions move inward down concentration gradient, despite the electrical gradient.

Ions move inward down concentration and electrical gradient.



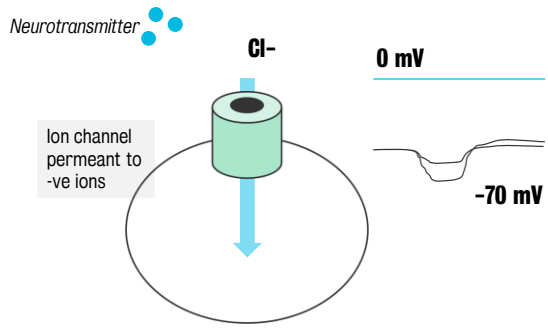
Post-synaptic potentials

Excitatory postsynaptic potentials (EPSP)



EPSPs are generated by activation of ion channels that depolarise neurons.

Inhibitory postsynaptic potentials (IPSP)

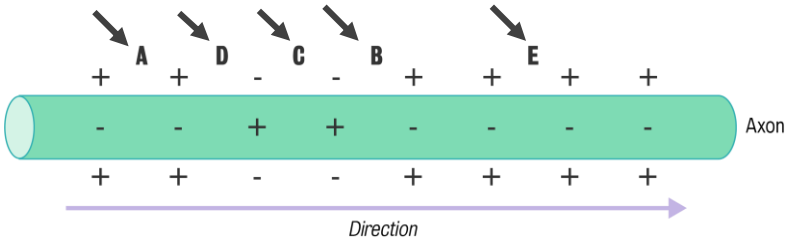


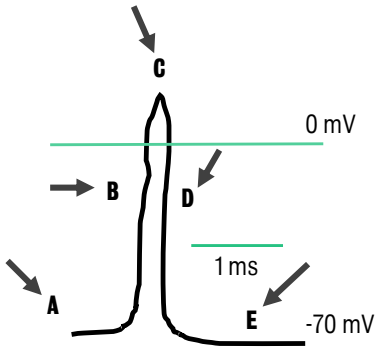
IPSPs are generated by activation of ion channels that hyperpolarise neurons.

EPSPs and IPSPs are:

- graded in amplitude due to the concentration of neurotransmitter and length of time the neurotransmitter is in the synaptic cleft
- additive, but decay in amplitude as they move around the neuron

Action potentials





	Nav	Kv
A) Resting Vm	Closed resting	Closed resting
B) Upstroke	Open	Closed resting
C) Peak	Closed inactivating	Start opening
D) Downstroke	Closed inactivated	Open
E) Resting Vm	Close resting	Closed resting

Summary of biological electrical activity

	Ep	Vm_{rest}	PSP	AP
Size	600 volts (120 mV)	-80 to -60 mV	1 to 40 mV	100 mV
Recorded from outside cell?	yes	no	no	yes
Generated by neurotransmitter ion channel receptors	yes	no	yes	no
Generated by voltage gated ion channels	no	no	no	yes
Duration	2 to 5 ms	continuous	1 to 40 ms	0.5 to 2 ms
Graded	yes	yes	yes	no

Click ***Next*** to continue

End of part 1