Medical Physics II

2nd semester

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Lectures 1

Introduction
and
Electricity Potential of Nerves

Introduction to Medical Physics

What is medical physics?

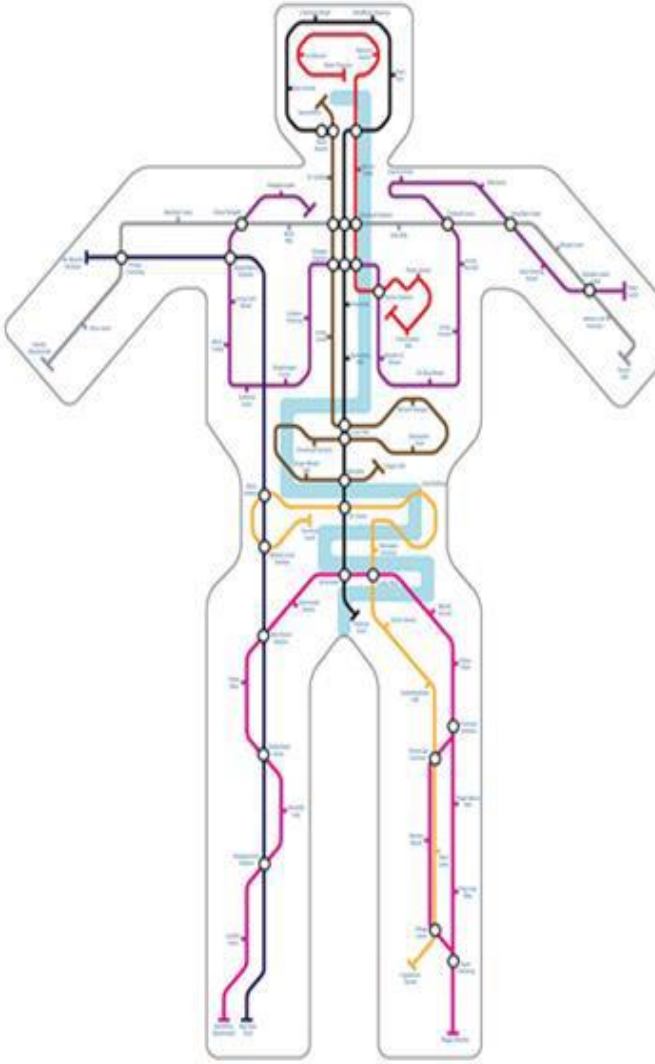
Medical physics is the **application** of physics to medicine.

All areas of physics can be applied to medicine (Mechanics, electromagnetism, thermodynamics, nuclear physics, optics, fluids,…..)

Medical physics is mainly involved in developing **new instrumentation** and **technology** used for diagnosis and treatments.

The human body is a very complex system. **Concepts of modelling in physics** can by applied to simulate different **activities** of the human body systems:

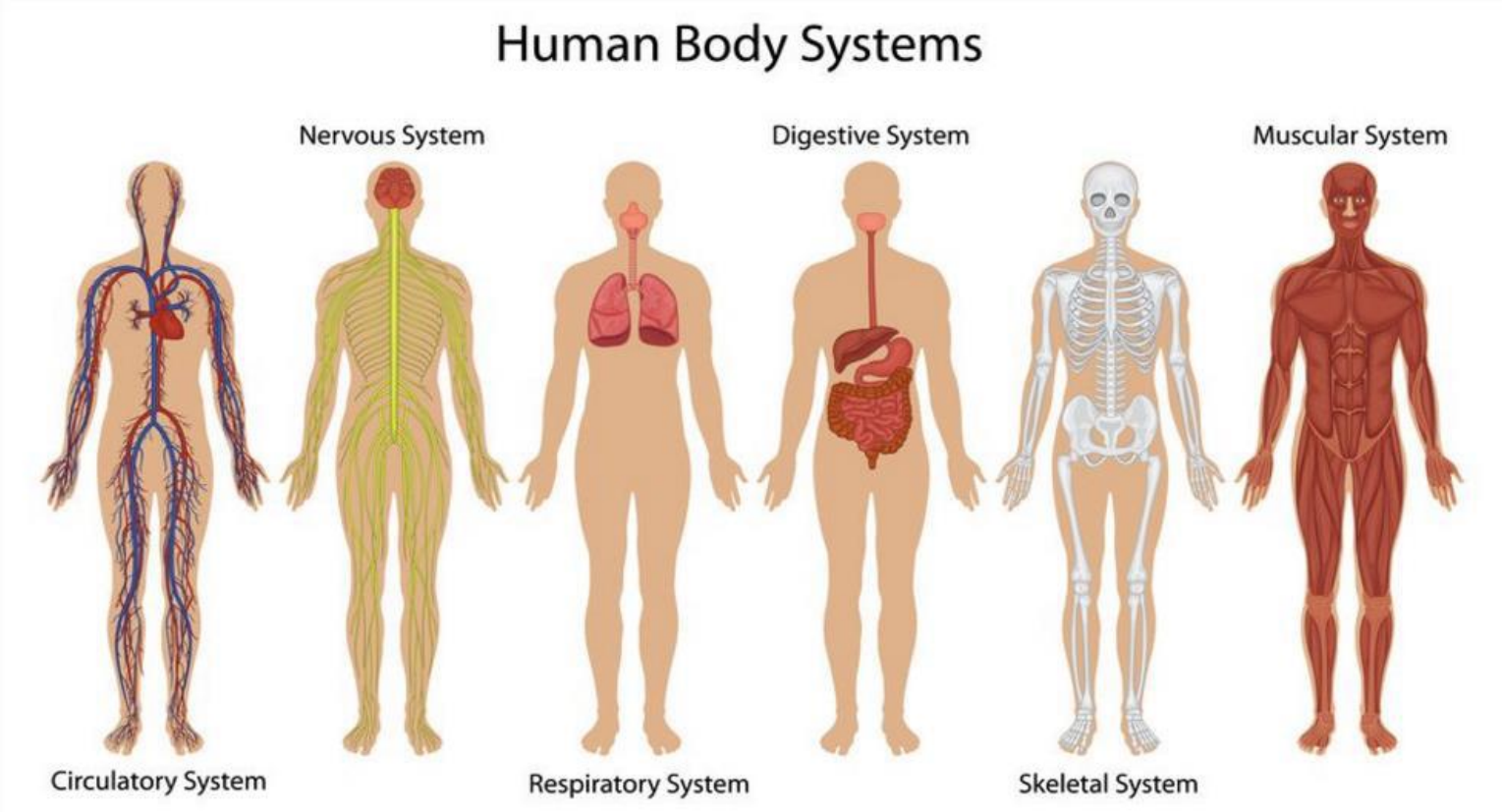
For example, modelling the **blood flows** in studying the body's circulatory system.



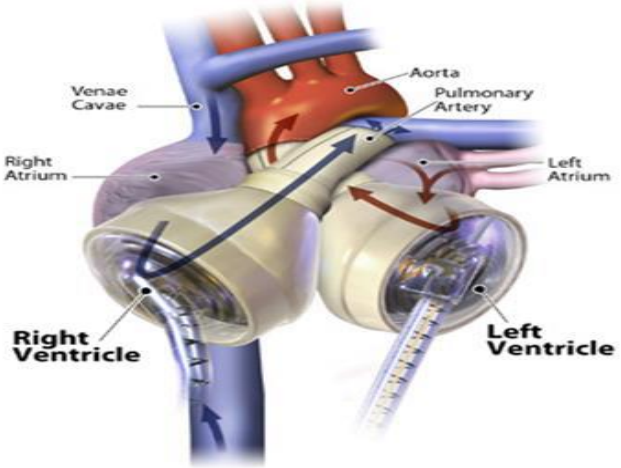
Introduction to Medical Physics

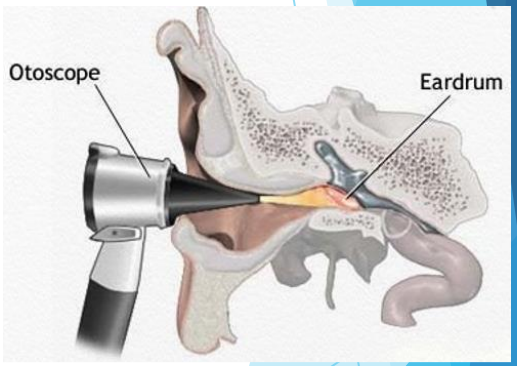
The human body comprises different systems working together to keep the body healthy.

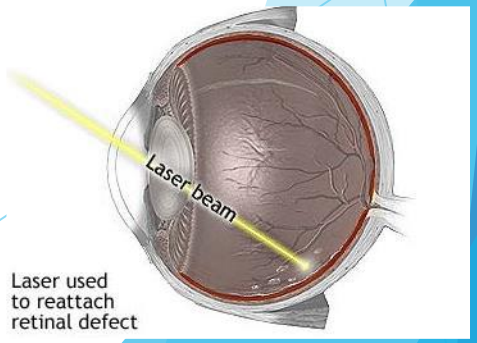
We can use analogies with physics to simulate the function of these systems and to understand the connections between them.



Application to medical diagnosis





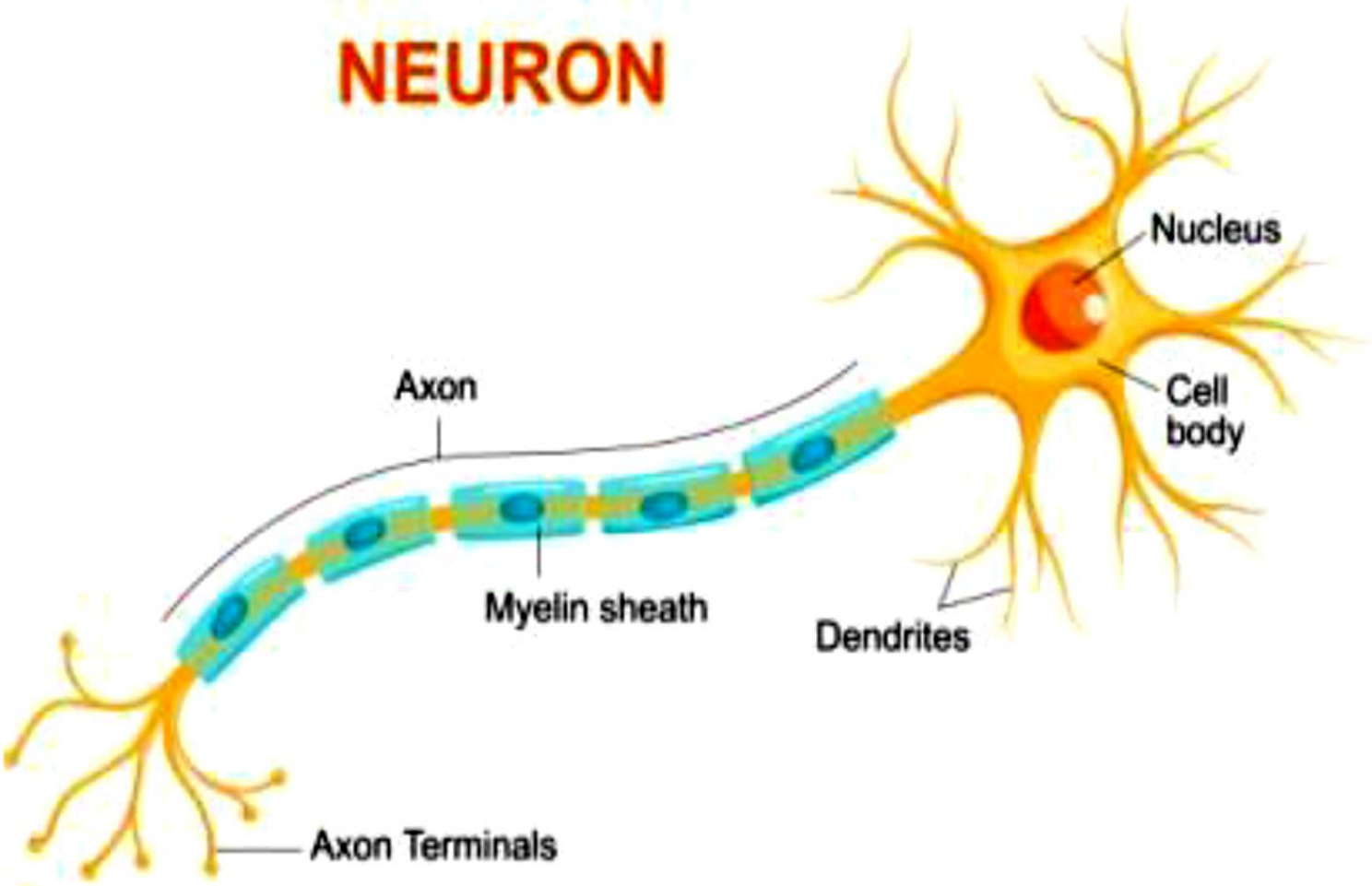


Electricity Potential of Nerves

- **Neurons** are the **information processing units** of the **brain** that have a **responsibility** for sending, **receiving**, and **transmitting electrochemical signals** throughout the body.

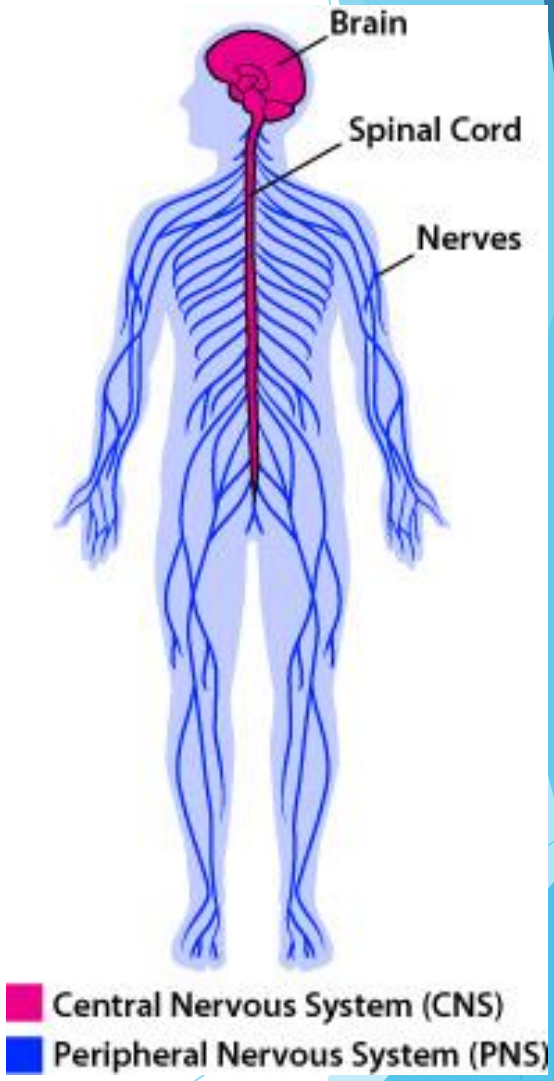
- **Neurons,** also known as **nerve cells**, are essentially the cells that make up the **brain** and the **nervous system**.
- **Neurons** do not touch each other, but where one neuron comes close to another neuron, a synapse is formed between the two.

NEURON


Nucleus
Cell body
Axon
Myelin sheath
Dendrites
Axon Terminals

Components of The Central Nervous System

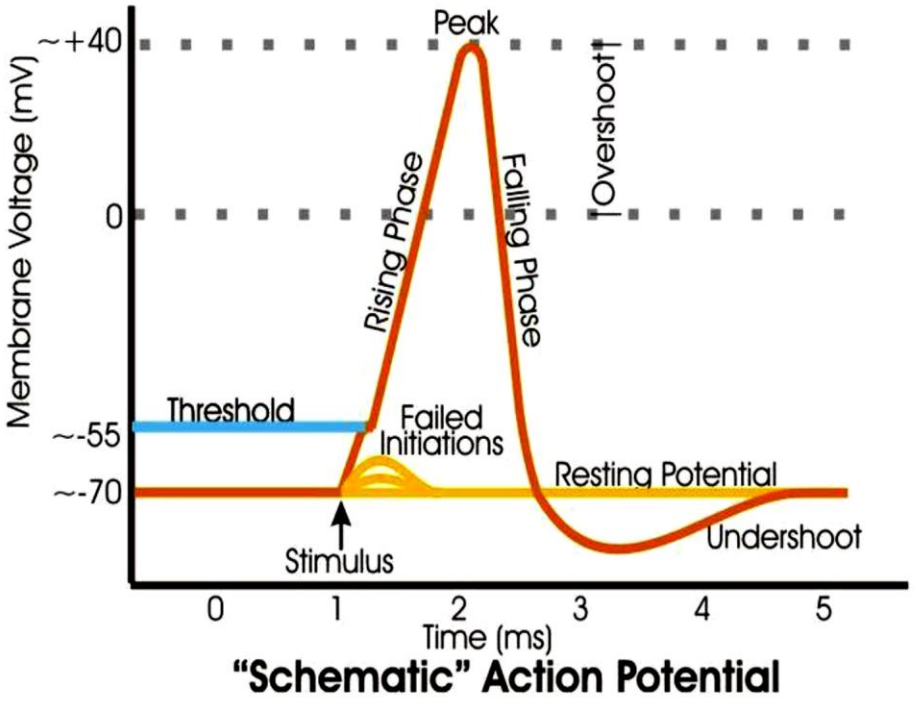
1. **The Brain.**
2. **Spinal Cord.**
3. **The peripheral nervous system,** which consists of sensory and motor nerves cells that contain these information-processing neurons.



Electricity Potential of Nerves

Because electrical signals are the basis of information transfer in the nervous system, it is essential to **understand** how these signals arise.

The **use** of electrical signals, as in sending electricity over wires to **provide** power or information, presents a series of problems in electrical engineering.



"Schematic" Action Potential

A Fundamental Problem for Neurons

1-Their **axons** can be quite long (remember that a spinal motor neuron can extend for a meter or more).

2-Neuron are not good electrical conductors**.**

3-Although **neurons** and **wires** are both capable of passively conducting electricity, the electrical properties of neurons compare poorly to even the most ordinary wire.

To compensate for this deficiency

Neurons have devolved a "Booster System" that allows them to conduct electrical signals over great distances despite their intrinsically poor electrical characteristics.

The electrical signals **produced** by this **booster system** are **called action potentials** (which are also referred to as **"spikes" or "impulses**).

Action Potential

An action potential is a **rapid rise** and **subsequent fall in voltage** or **membrane potential** across a **cellular membrane with a characteristic pattern.**

Sufficient current is **required** to initiate a voltage response in a cell membrane;

If the current cannot depolarize the membrane to the threshold level, an action potential will not fire.

Examples of cells that signal via action potentials are neurons and muscle cells.

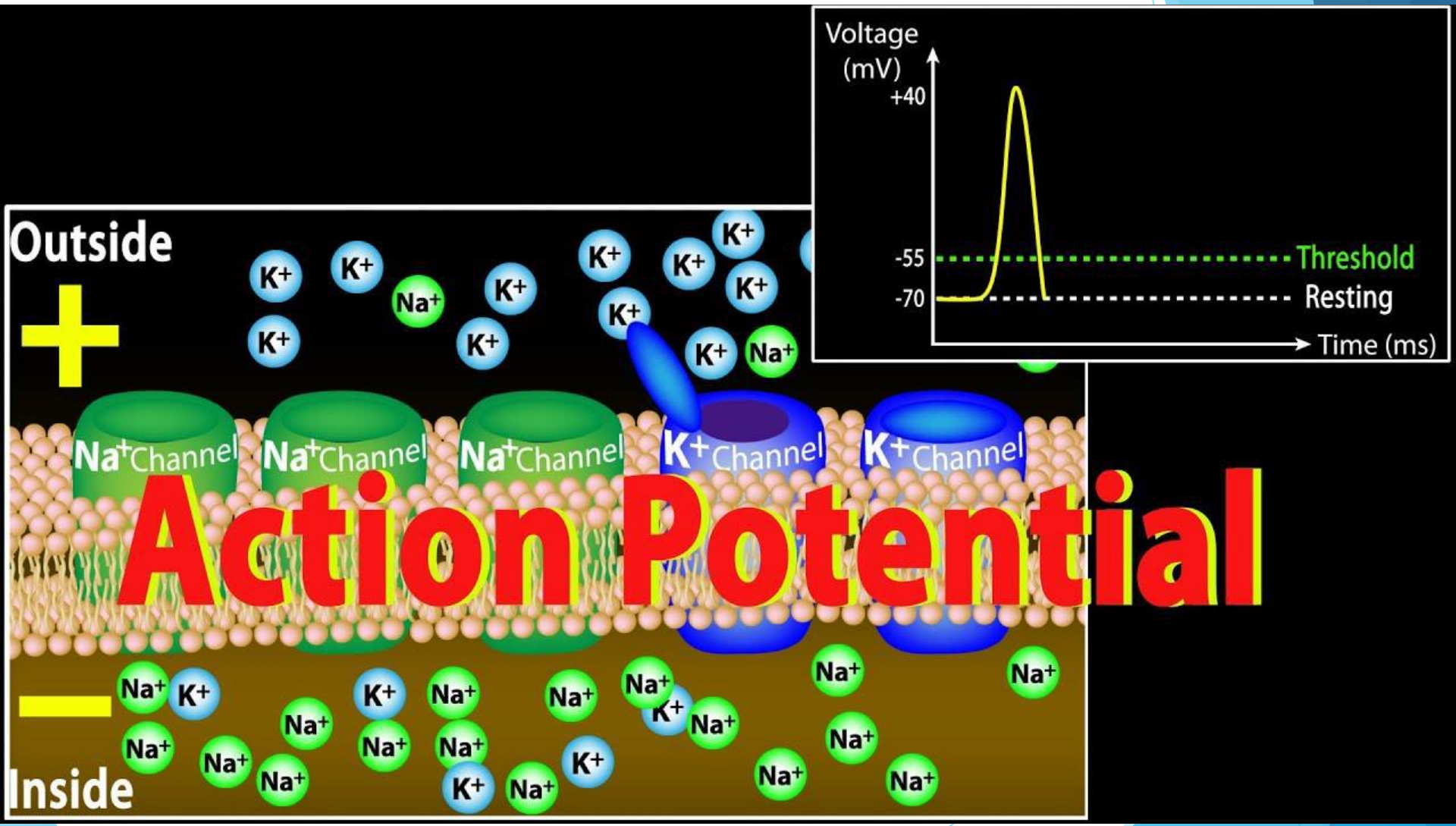
For a long time, the communication process between the nerves and their target tissues was a big **unknown** for physiologists.

With the **development** of electrophysiology and the **discovery** of the electrical activity of neurons, it was **discovered** that the **transmission of signals from neurons to their target tissues is mediated by action potentials.**

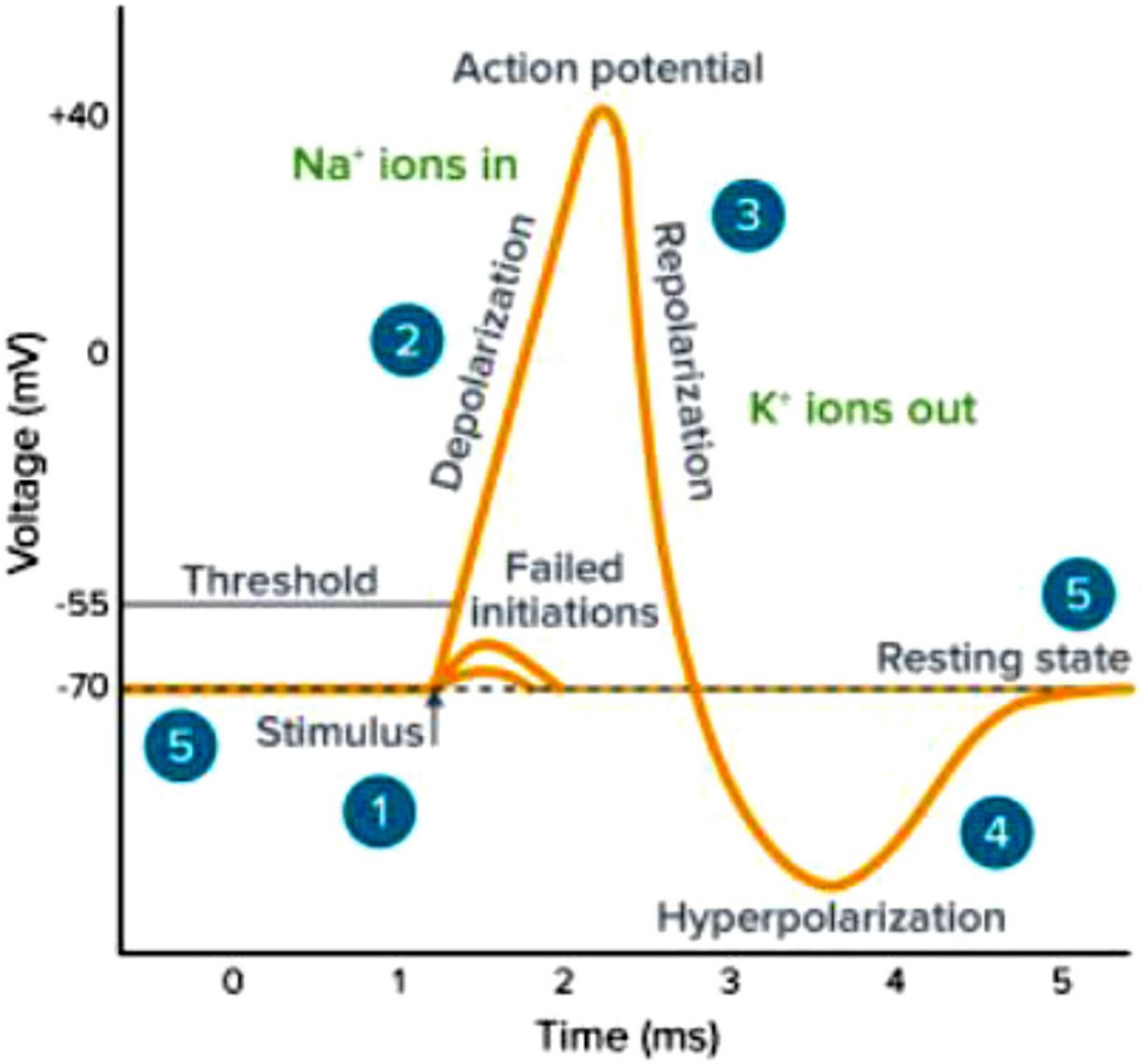
How Can Generate Action Potential

1. The **stimulus** starts the rapid change in **voltage** or **action potential**.
2. In **patch-clamp mode**, sufficient current must be administered to the cell to raise the voltage above the threshold voltage to start membrane depolarization.
3. **Depolarization** is caused by a rapid rise in membrane potential opening of **sodium channels** in the cellular membrane, resulting in a large influx of sodium ions.
4. Membrane **repolarization** **results** from rapid sodium channel inactivation and a **large efflux** of **potassium ions** resulting from activated potassium channels.
5. **Hyperpolarization** is a lowered membrane potential **caused** by the **efflux** of potassium ions and the **closing** of the potassium channels.
6. **Resting** state is when membrane potential **returns** to the resting voltage that **occurred** before the **stimulus occurred**.

Action Potential



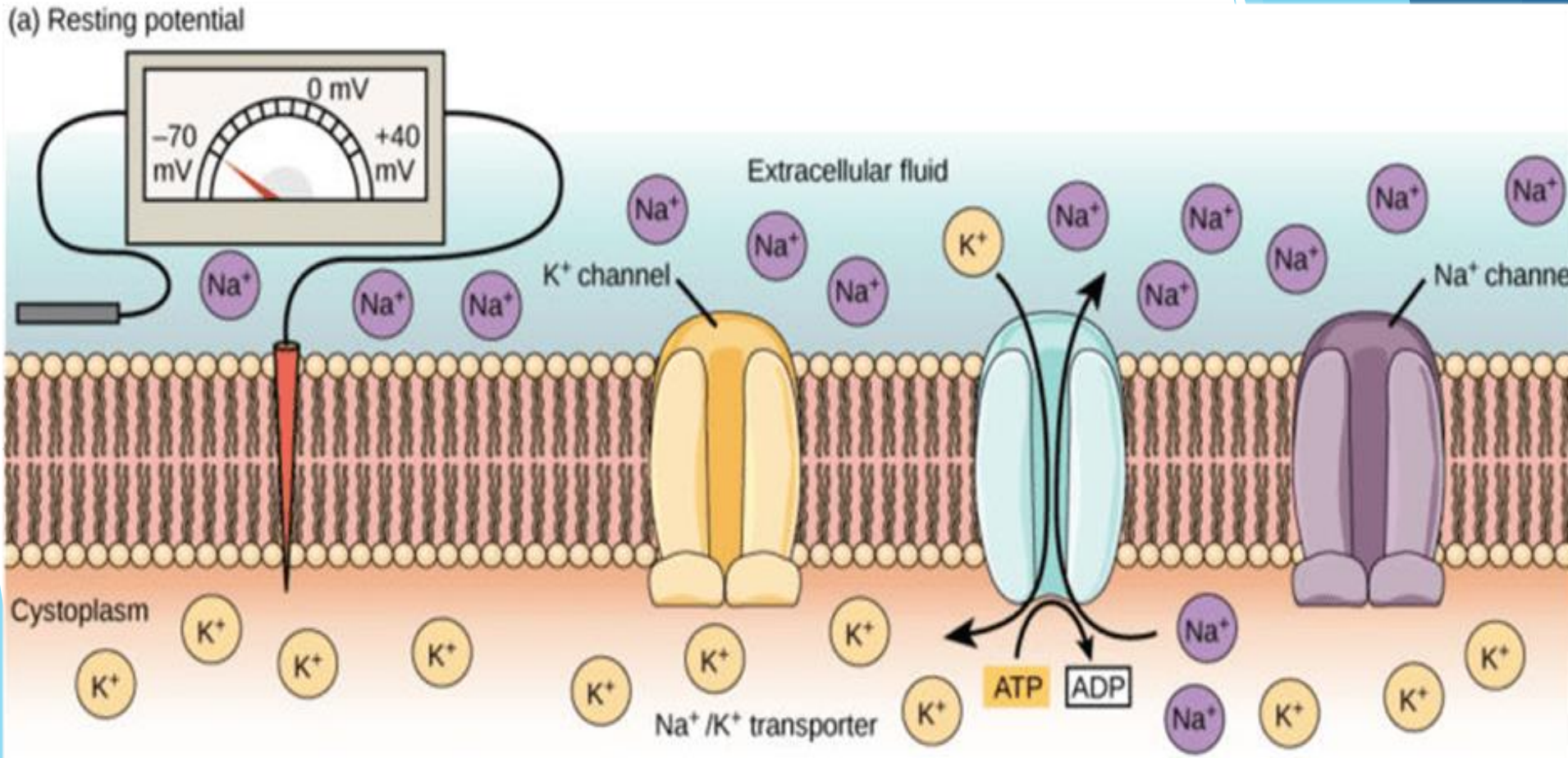
How Can Generated Action Potential



Electrical Nature of Nerves

1. **Neurons** use electrical signals to communicate with other **neurons**, **muscles**, and **glands**.
2. When **microelectrodes** are **placed** on **either side** of the membrane of an inactive neuron, measurements from a voltmeter indicate an electrical potential difference of **-70 mV** (millivolts).
3. The **charge** of the inside of the **neuron cell** is negative in relation to the outside. This charge separation across the membrane is **known** as **the membrane potential**.

Electrical Nature of Nerves



At the resting potential, all voltage-gated Na^+ channels and most voltage-gated K^+ channels are closed. The Na^+/K^+ transporter pumps K^+ ions into the cell and Na^+ ions out.