

Modern Biology
(Nerve Impulse and Muscle Contraction)

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Nerve Impulse (Action Potential)

**Schematic picture
of Neurons**

Resting Potential

**Graded/Action
Potential**

Structure of Neuron

- Neurons are a special type of cell for information transfer around the body.
- ❖ *Dendrites*: Receive signals from neighboring neurons (like radio antenna).
- ❖ *Axon*: Transmit Signals over a distance (like telephone wire)
- ❖ *Axon Terminal*: Transmit Signals to other neuron dendrites (like a radio transmitter).
- ❖ *Myelin Sheath*: Speeds up signal transmission along axon.

Structure of Neuron

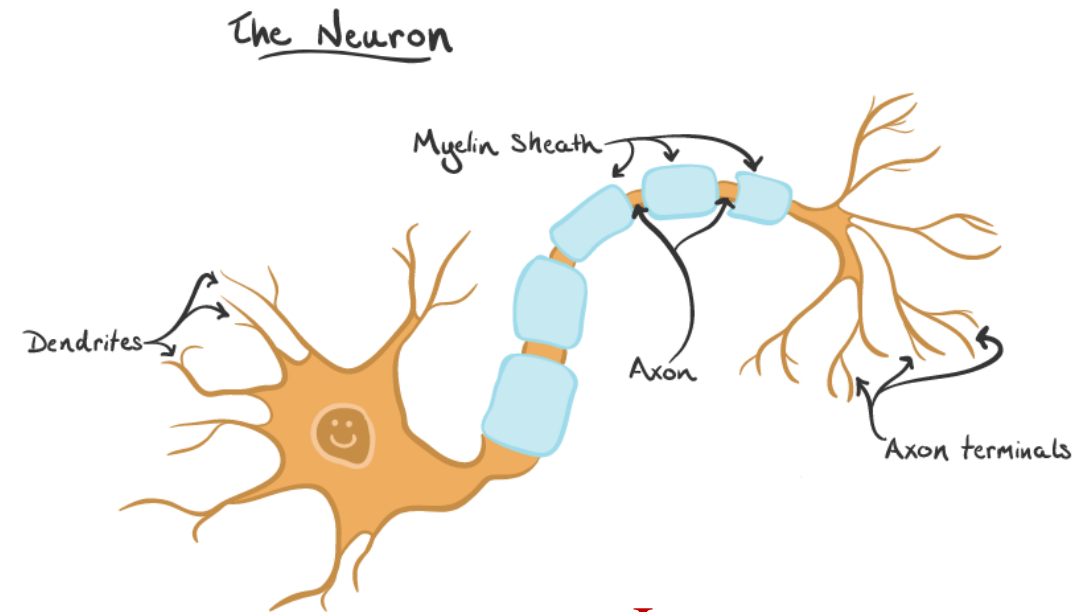
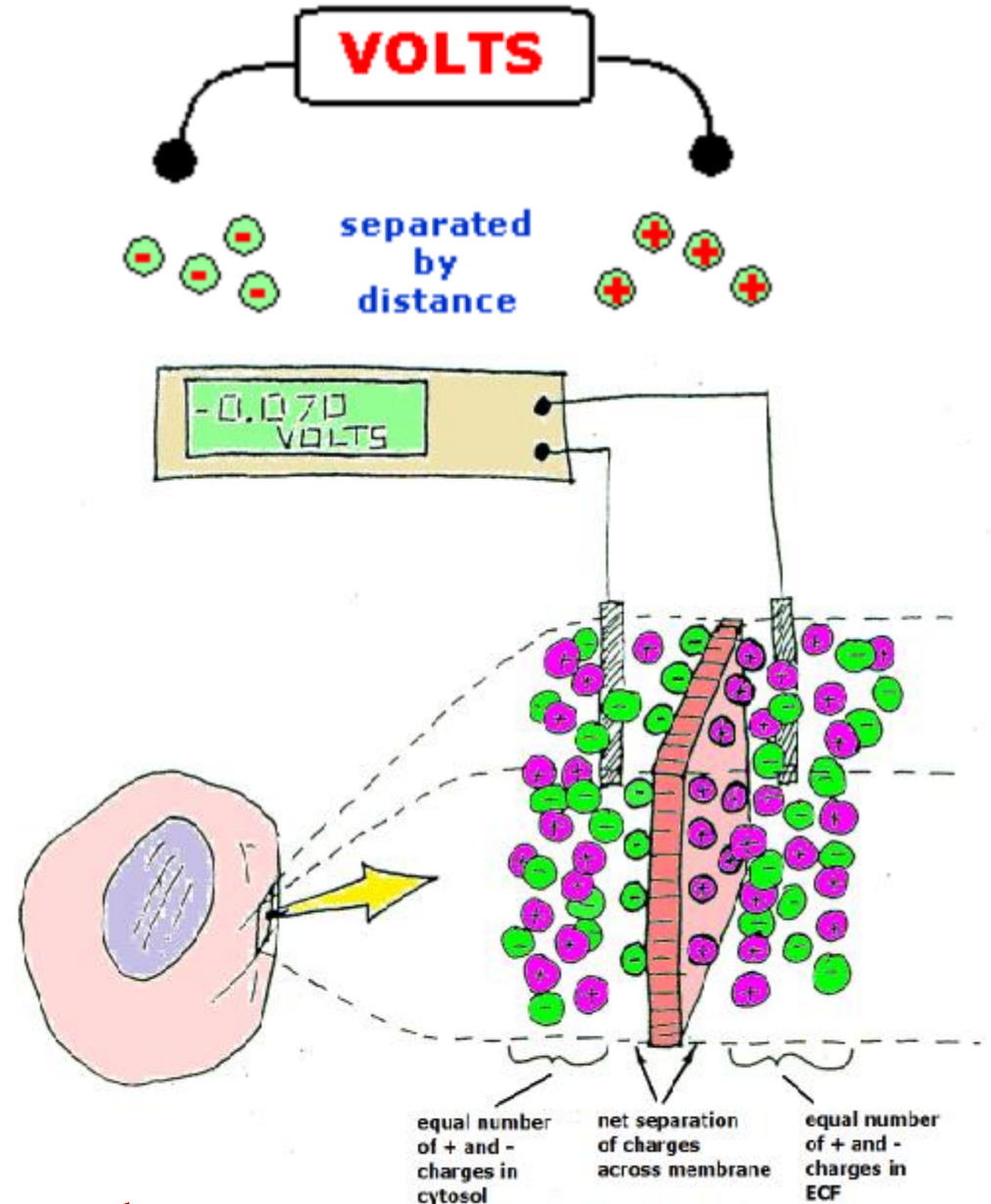


Image: cnx.org

Need to Study Resting Membrane Potential??

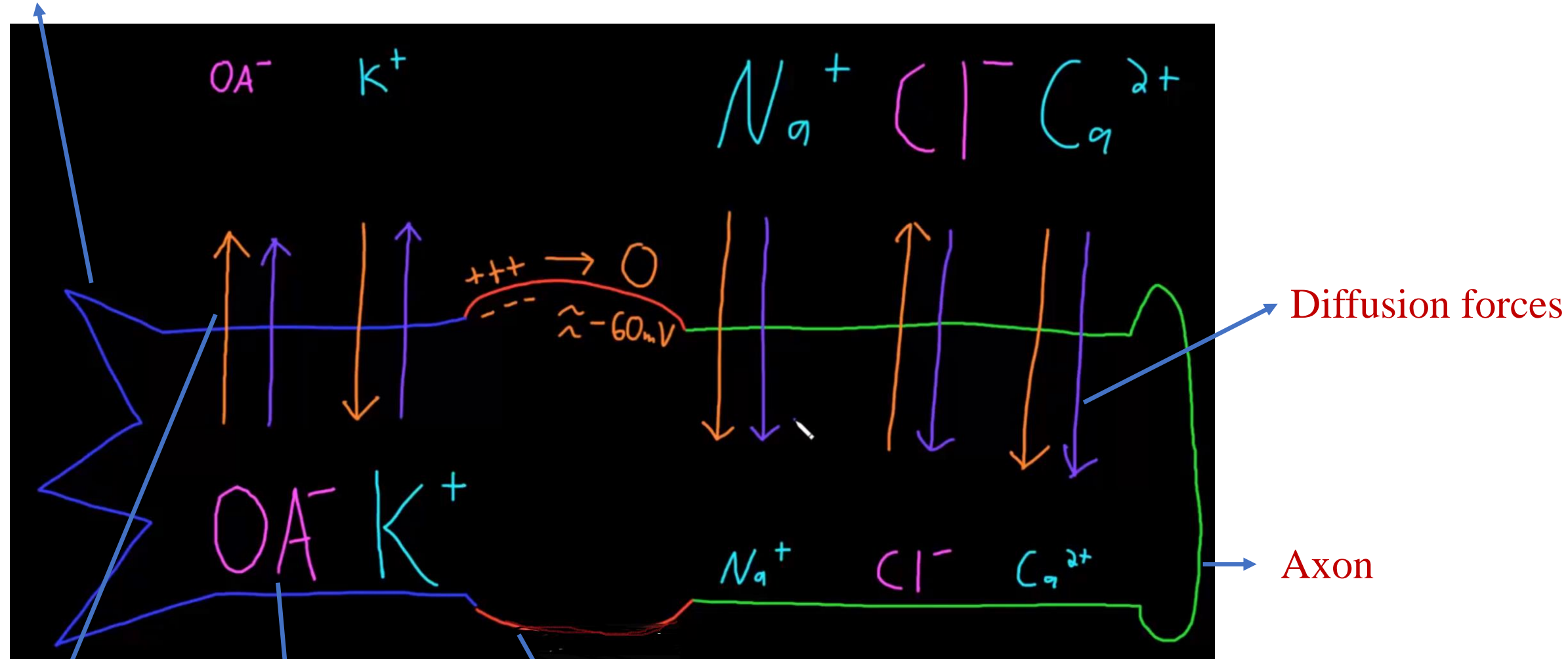
Potential Difference/Resting Potential

- **Electrical potential difference** between the inside and the surrounding extracellular fluid of cell is termed the membrane potential.
- When a nerve or muscle cell is at "rest", its membrane potential is called the **Resting membrane potential**



Ions in Action for Resting Membrane Potential??

Resting Potential Ions



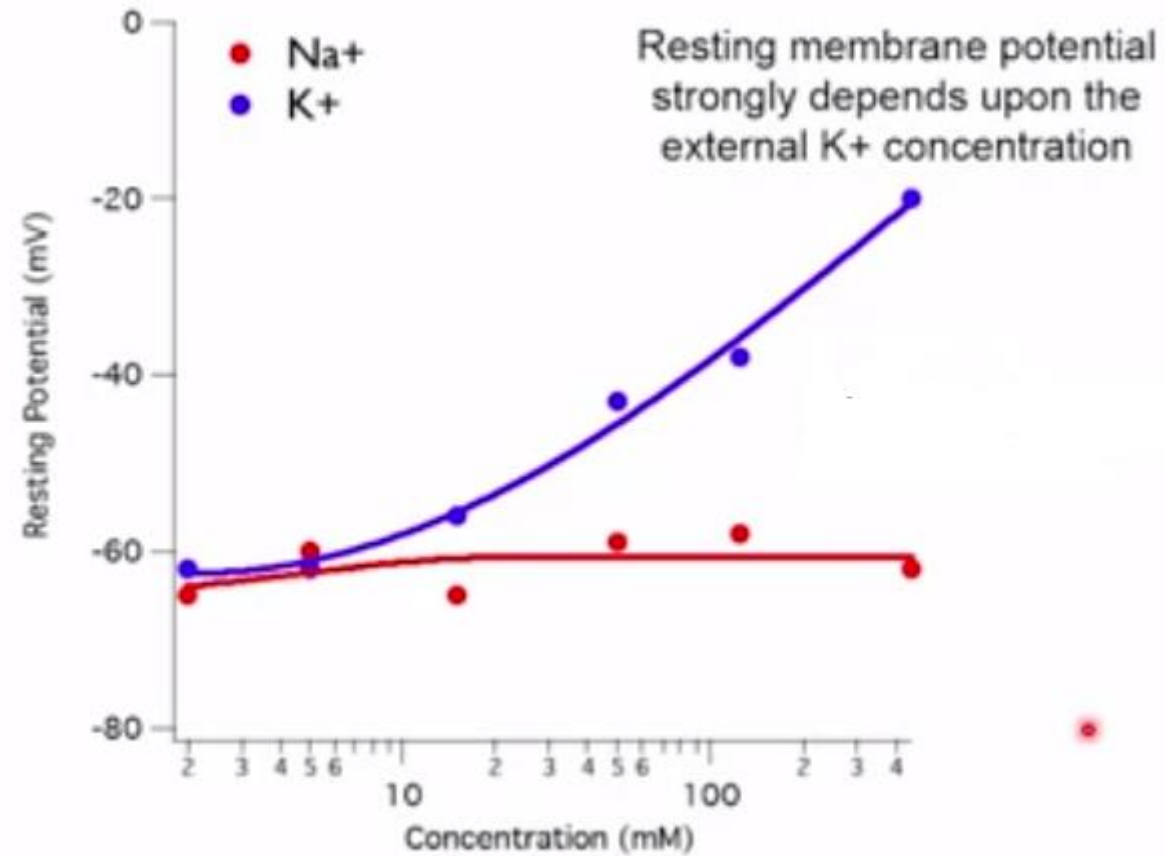
Electrical force

Organic Anions

Soma

Leak channels allows ions to pass through membrane with different permeability

Resting Potential (Important Ions)



Resting Potential Expression

- *Electrical force* :Each ion will be attracted to the side of membrane with opposite charge.

$$M'_s = -u_s c_s \frac{d\psi}{dx}$$

Diagram illustrating the components of the electrical force equation:

- M'_s is the net force.
- $-u_s$ is the Mobility of charge particle.
- c_s is the Total number of charges.
- $\frac{d\psi}{dx}$ is the Elec field gradient.

- *Chemical Diffusion force* related to concentration gradients across neuron membrane (Particles move from higher to lower concentration).

$$M'_s = -D_s \frac{dc_s}{dx}$$

Diagram illustrating the components of the chemical diffusion force equation:

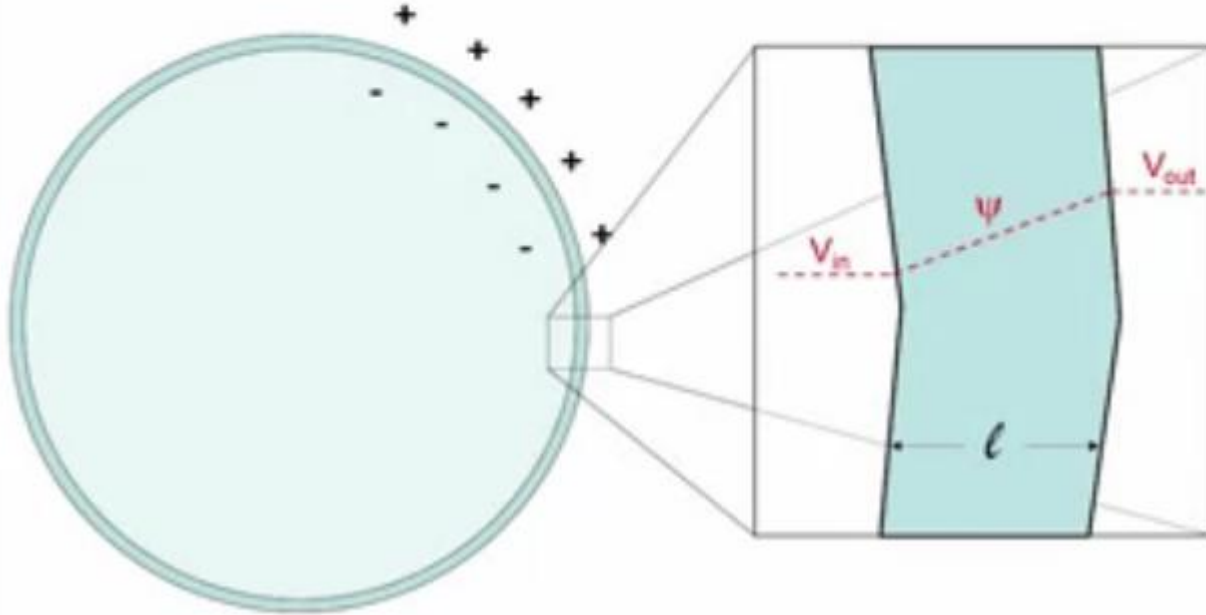
- M'_s is the net force.
- $-D_s$ is the Diffusion constant.
- $\frac{dc_s}{dx}$ is the Concentration gradient.

- Each of ions are acted by two forces combinedly called *Electrochemical forces* which enable performing various functions.

Resting Potential (Nernst Equation)

Combining diffusion and electrophoresis we get:

$$M_s = -D_s \frac{dc_s}{dx} - u_s c_s \frac{d\psi}{dx}$$



- At equilibrium when chemical and electrical energy are balanced (Net movement)

$$M_s = 0$$

- Simplifying we arrive at the membrane potential (Nernst Equation)

$$E_x = \frac{RT}{zF} \ln \frac{[X]_o}{[X]_i}$$

T= room temperature, z=charge ,
F=Faraday constant

Study how 100 billion Neurons are firing of nearly 50
action potentials per second thereby controlling what
we do, how we think, move muscles, listen to lecture
classes 😊 😊

Signal Propagation Between Neurons

- The process of sending signals takes place in two steps: **along the cell (action potential)** and **between cells (neurotransmitters)**
- Action potentials travel in neurons cell as an **electrochemical cascade**, allowing a net inward flow of positively charged ions into the axon.

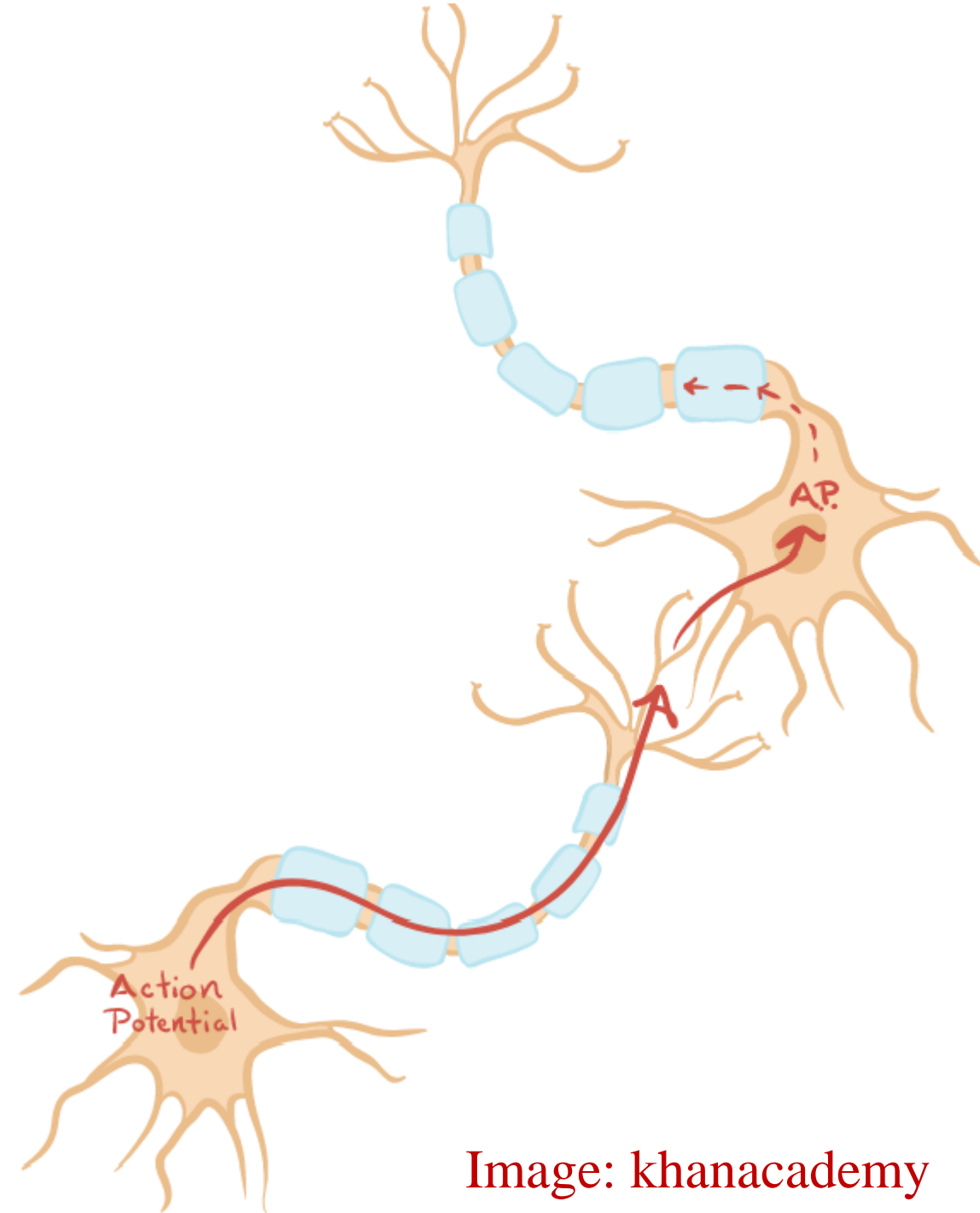
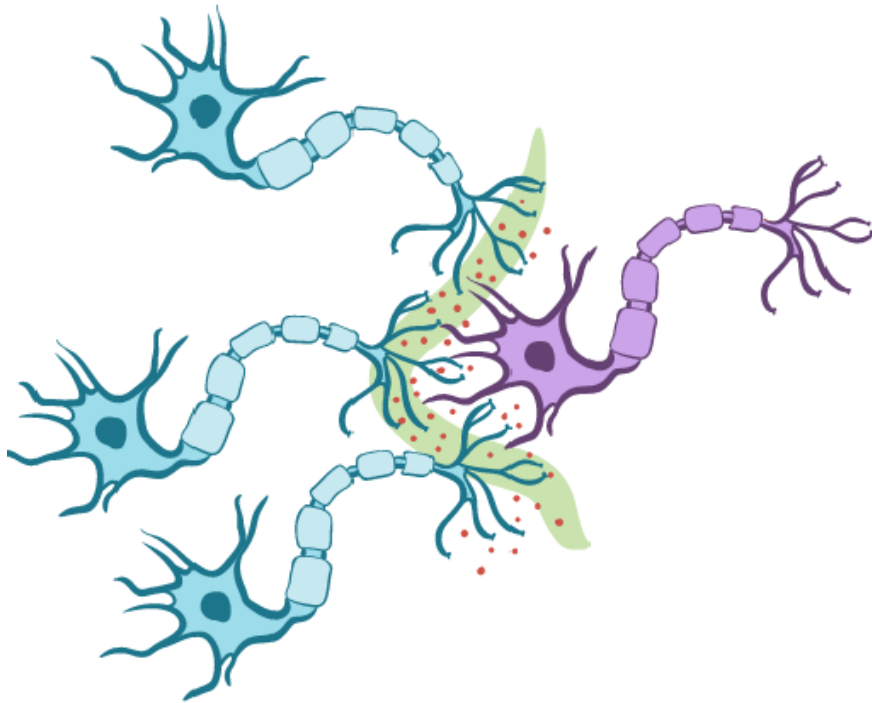
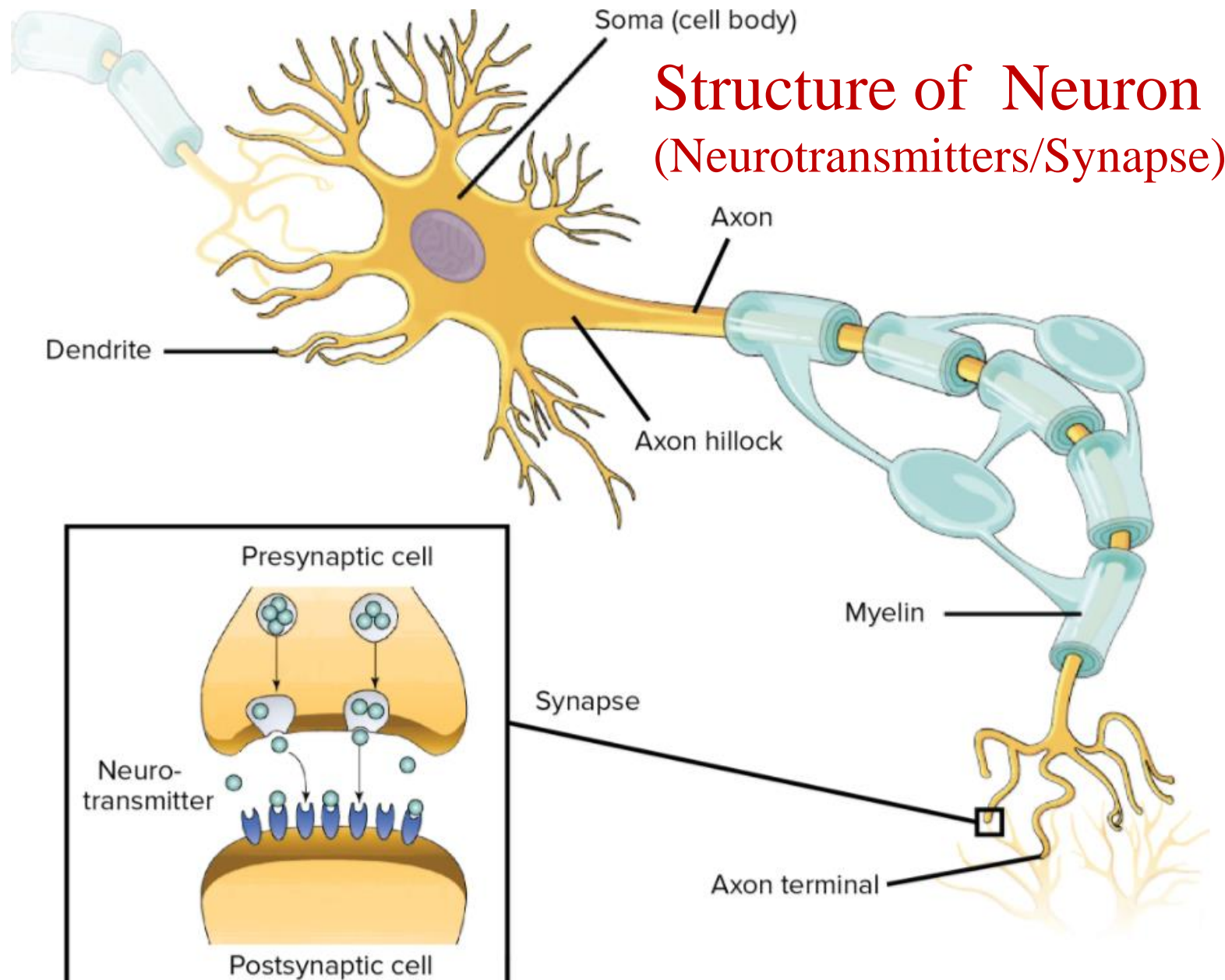
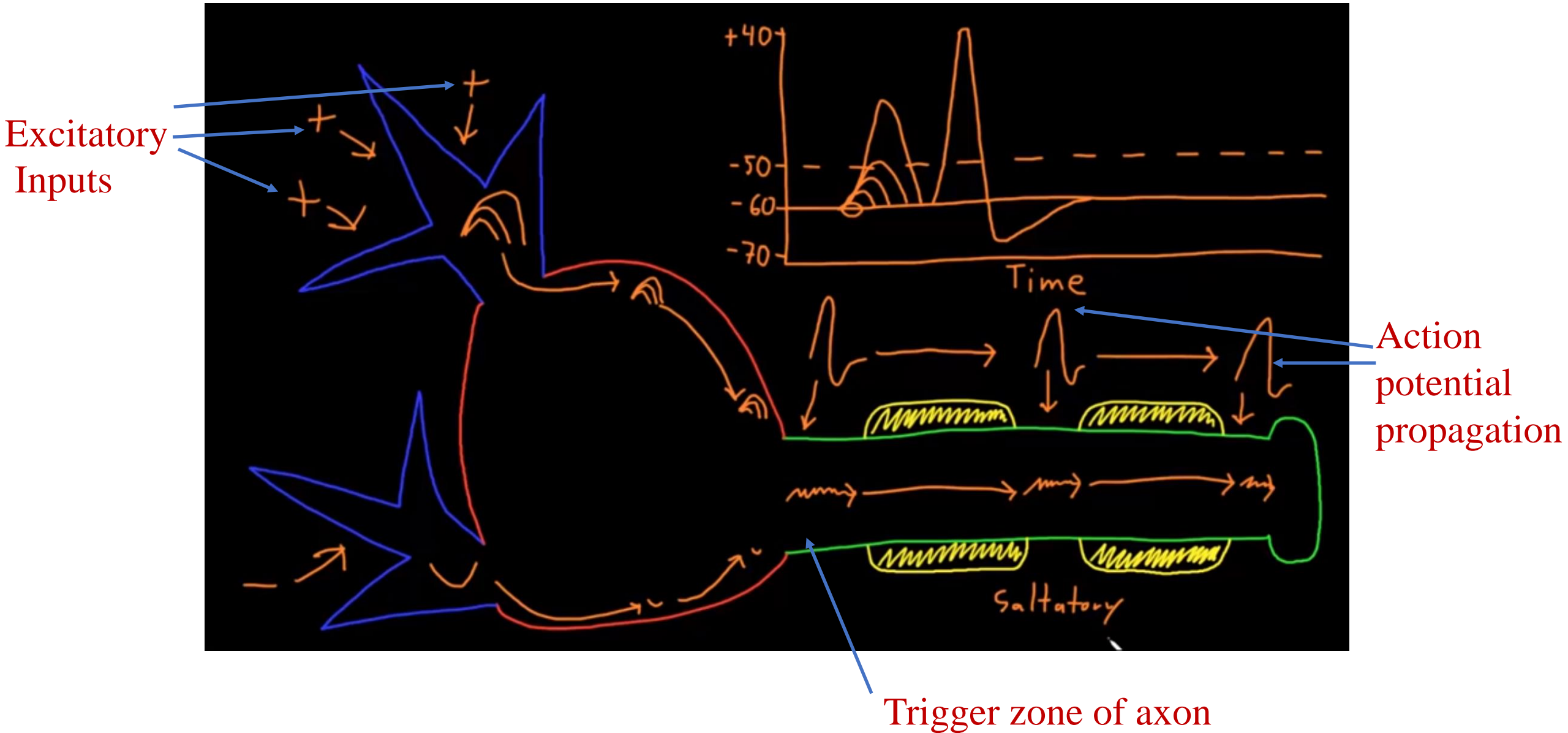


Image: khanacademy

- Chemicals known as neurotransmitters (glutamate, dopamine) are stored in membrane-bound vesicles at the axon terminal of neurons.
- Get released when Ca^{2+} enters the axon terminal and act by binding to receptors on the membrane of the postsynaptic cell.
- Neurotransmitters are “**excitatory**” firing a target neuron (Glutamate)
“**inhibitory**” making a target neuron less likely to fire (GABA).



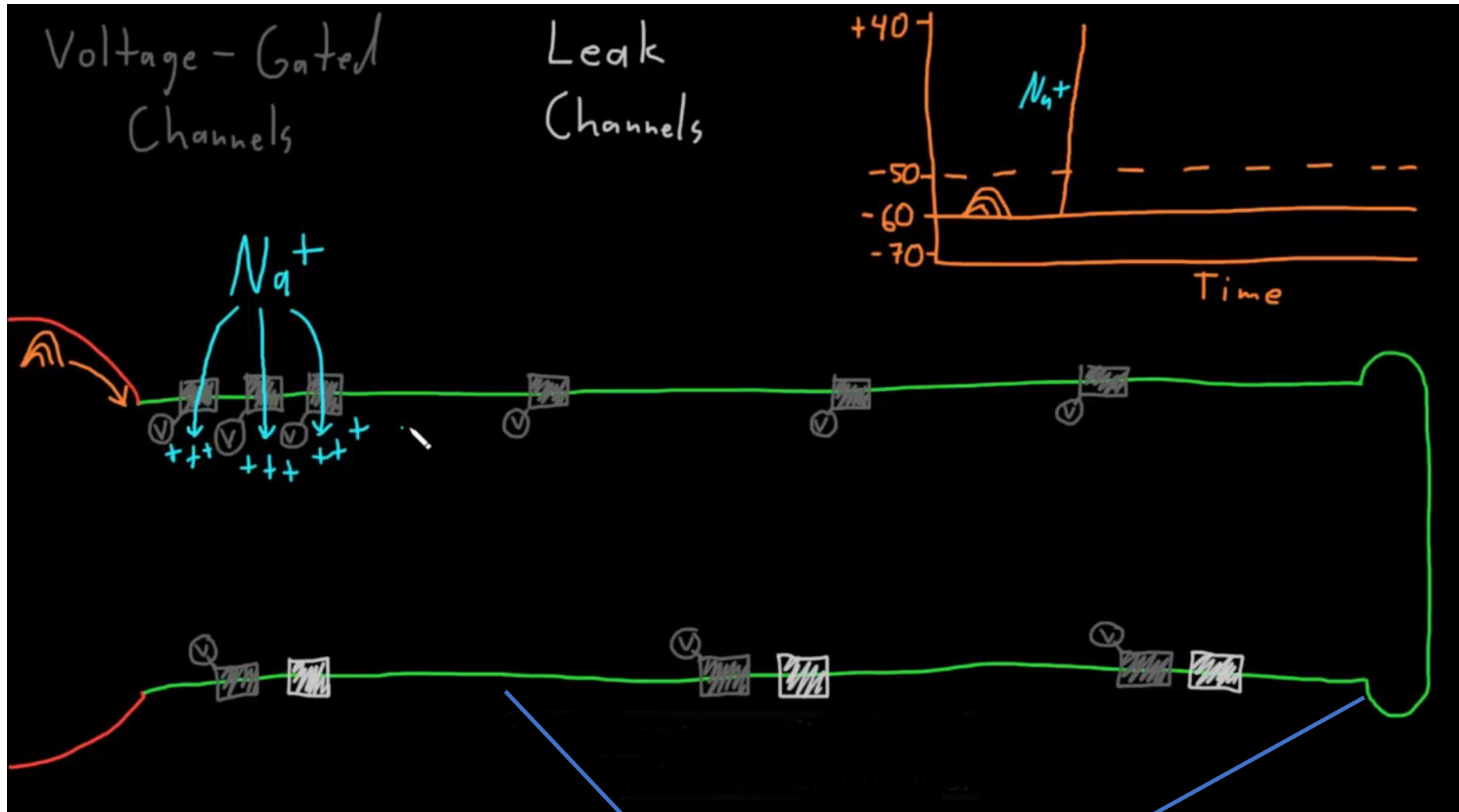
Action Potentials/Nerve Impulse



Action Potential/Nerve Impulse

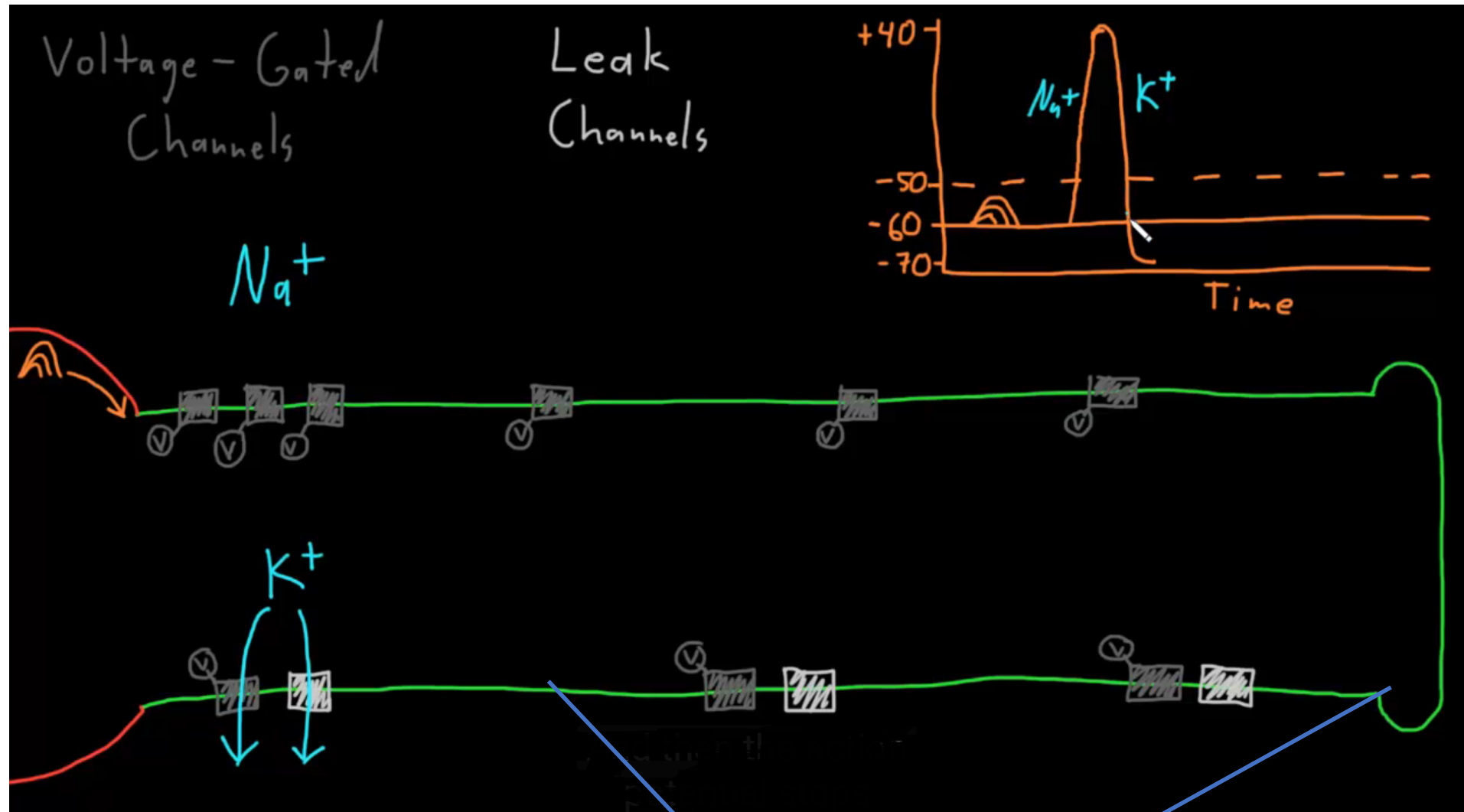
- *Action potential (AP)* occur when the combined effect of graded potentials in time brings the membrane of trigger zone over threshold potential (-50mv)
- They occur in *axons* of neuron.
- AP do not decay with time and distance and remain constant in duration.
- Myelinated axons conduct action potentials pass faster.
- AP speed in axons is around 1 to 100 metre/sec
- Size of AP varies from neuron to neuron

Action Potentials(Raising- Na^+)



Axon Enlarged

Action Potentials (Falling-K⁺)

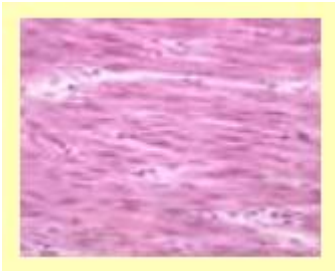
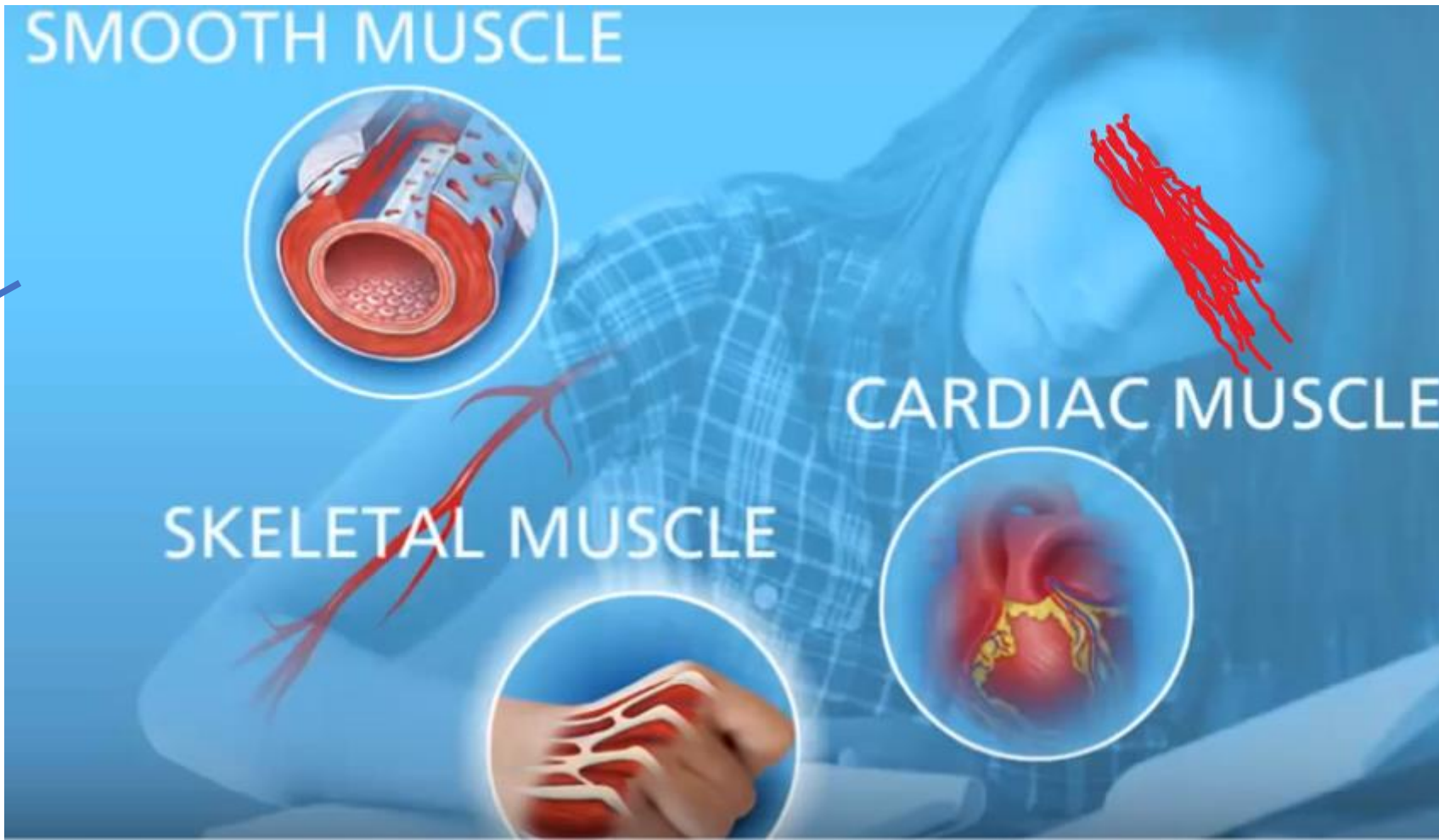


Muscle Contraction

Structure of
Skeletal Muscle

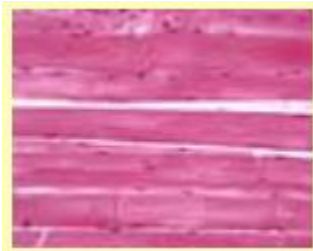
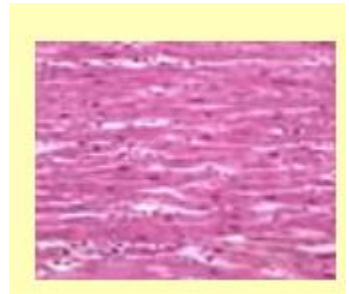
Mechanism of
Muscular contraction

STRUCTURE OF MUSCLES



**Involuntary
Control
(Stomach)**

**Involuntary
Control**

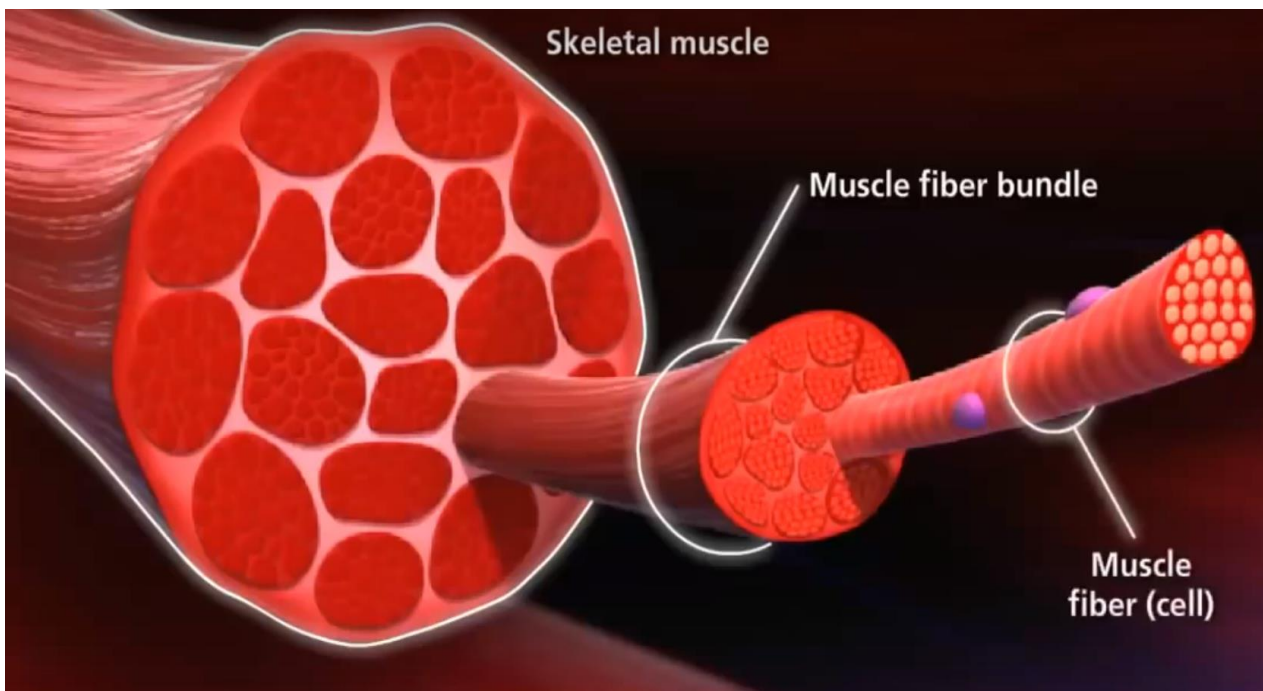


**Voluntary
control**

Skeletal muscle does not consist of individual cells. Rather it is formed from huge, multinucleate **muscle fibers**

Tough Question

What is the fundamental unit of Skeletal Muscle fiber



SARCOMERE

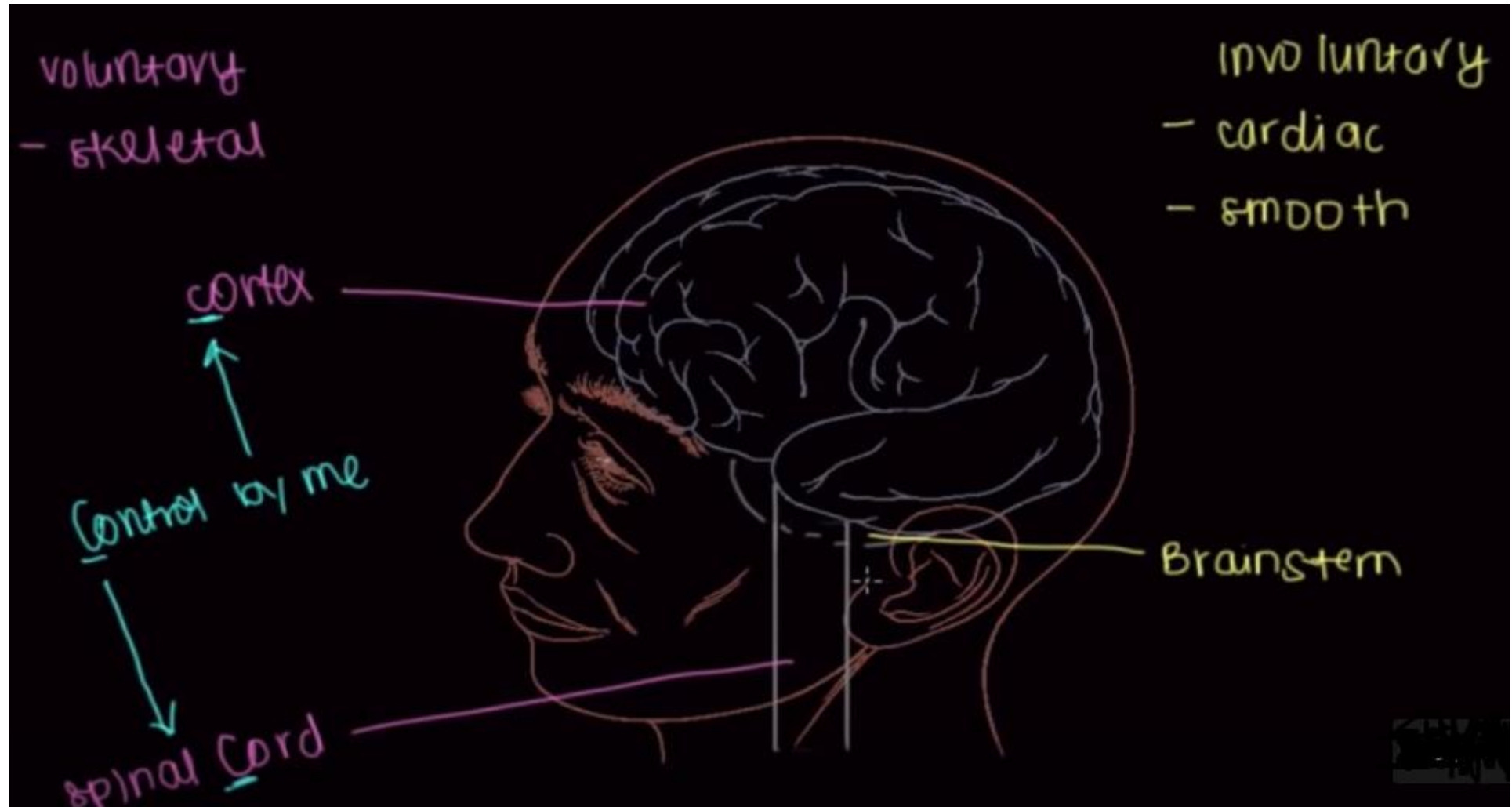
Thick and thin protein filaments in myofibril or muscle cell.



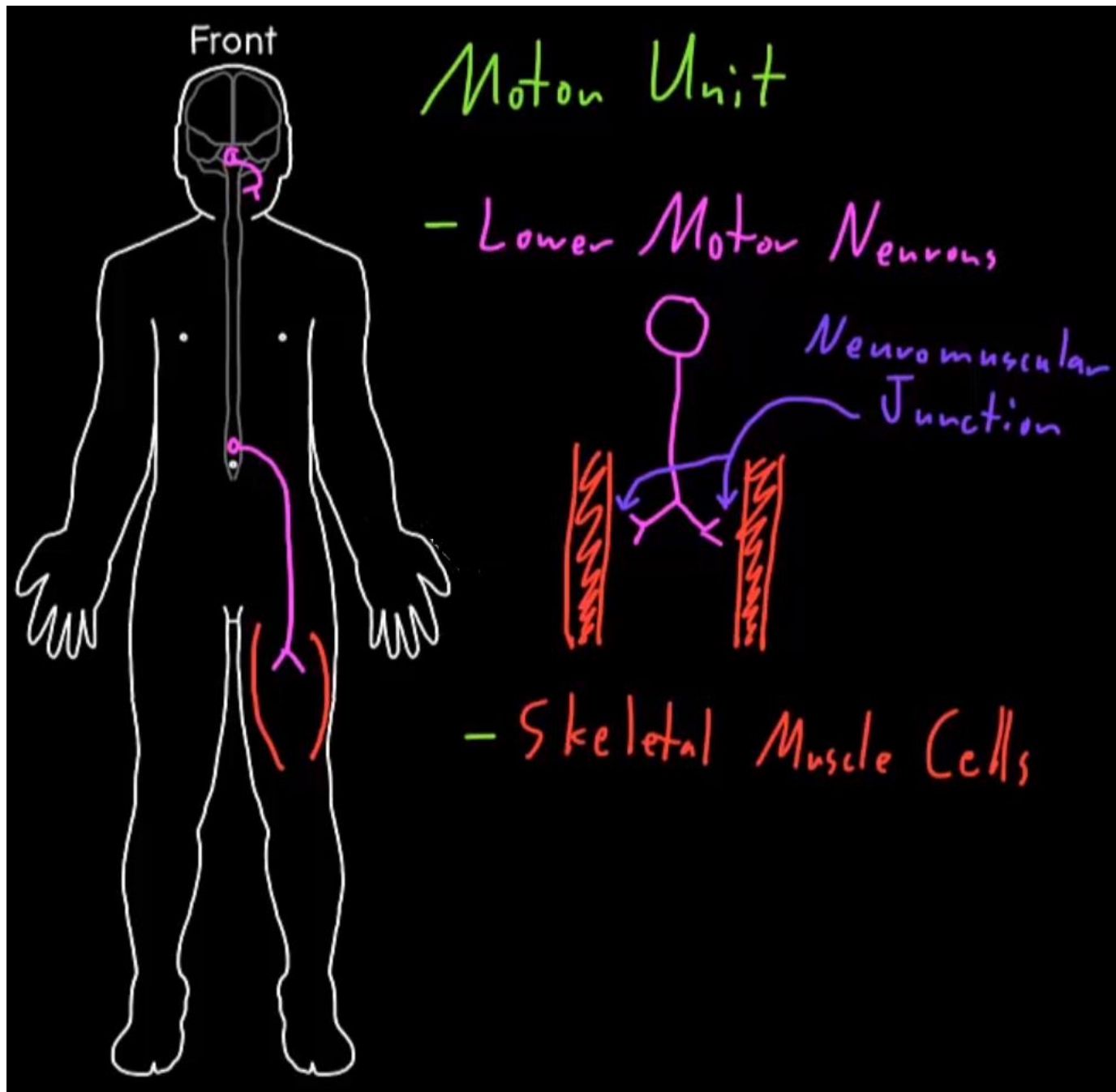
Myosin anchored at the M-line

Actin anchored to Z-line

Brain/Spinal Cord Connections with Muscles



What is Neuron connecting to Muscle called ??



Birds Eyeview

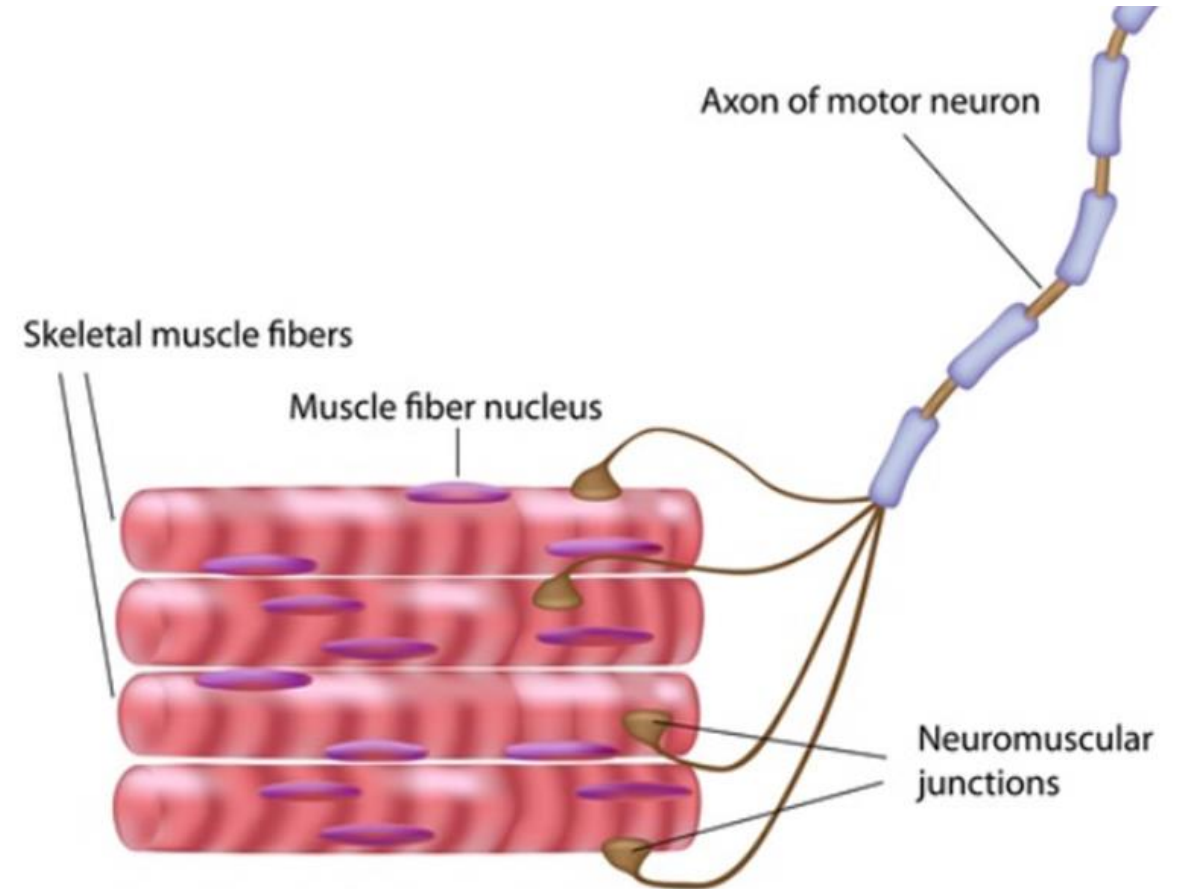
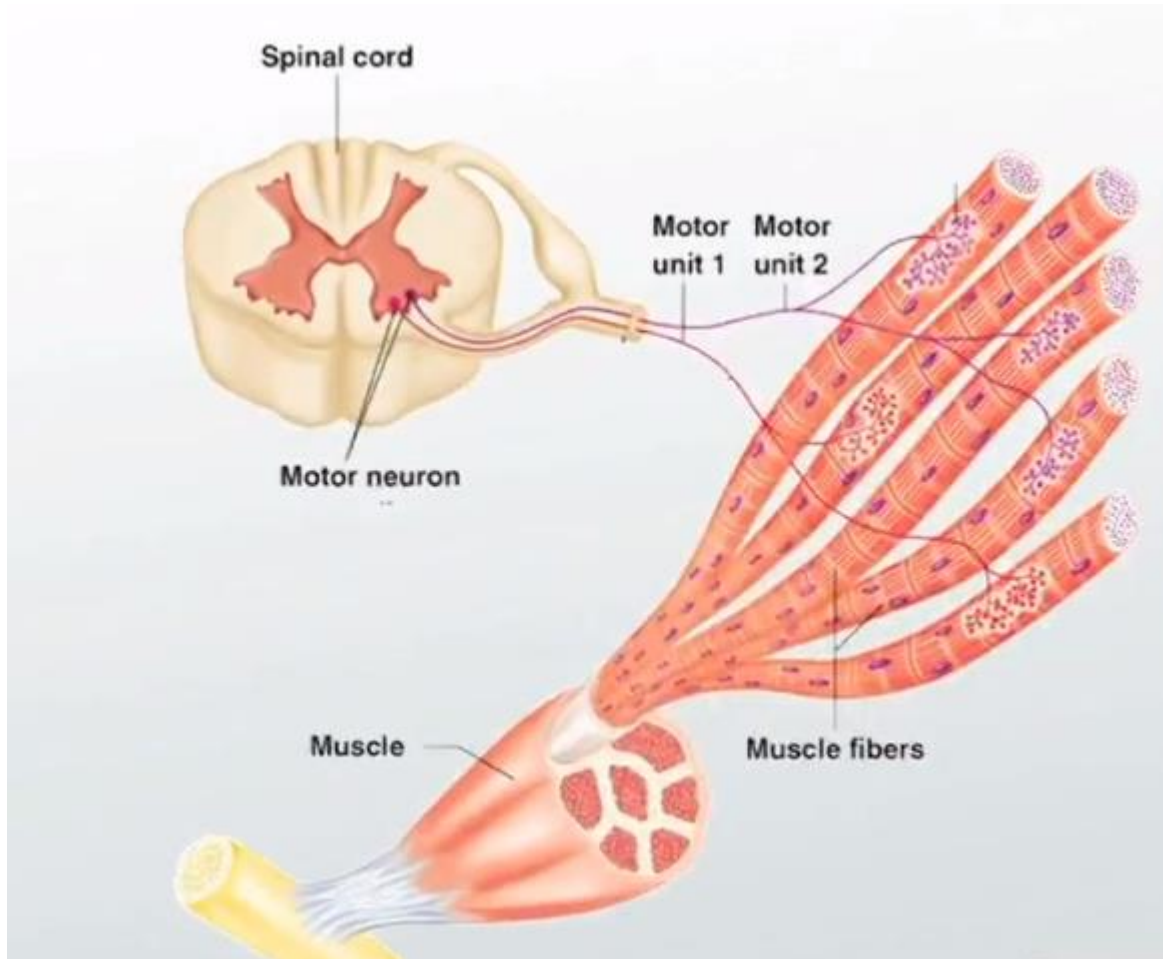
Lower Motor Neurons
(from brainstem or spinal
cord) control skeletal
muscles

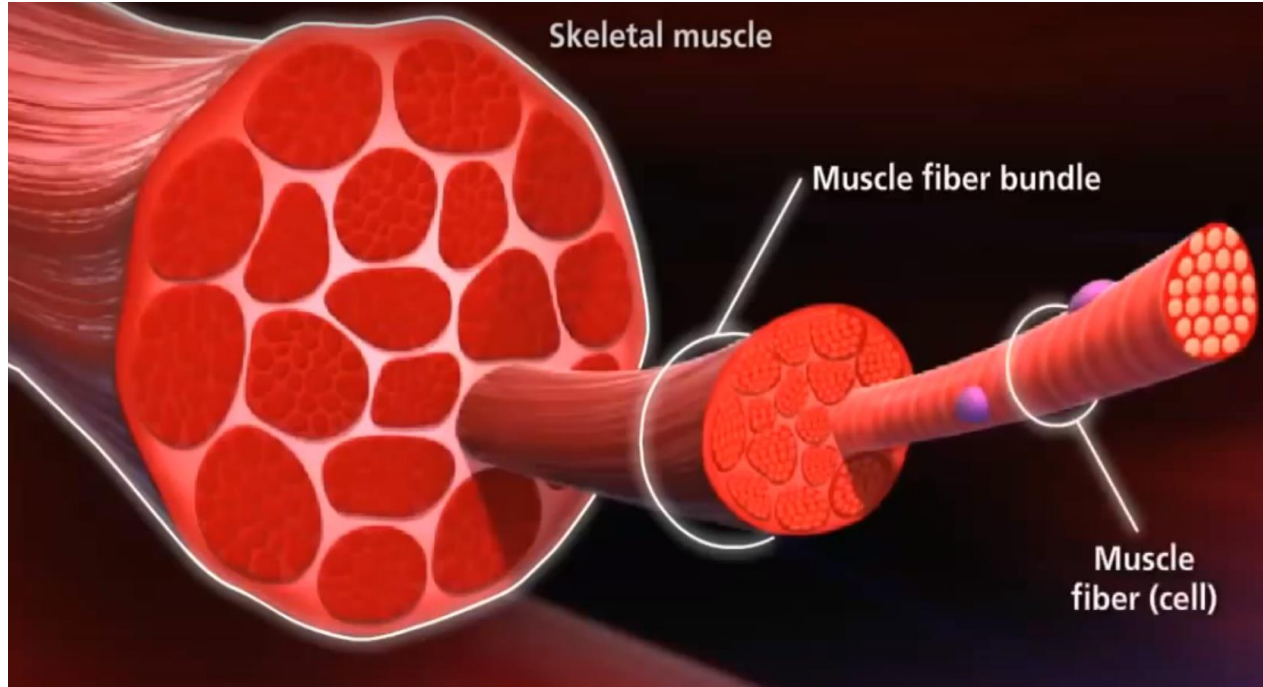
All fibers innervated by the
same neuron are called
motor unit

Tough Question. Give it a try 😊 😊

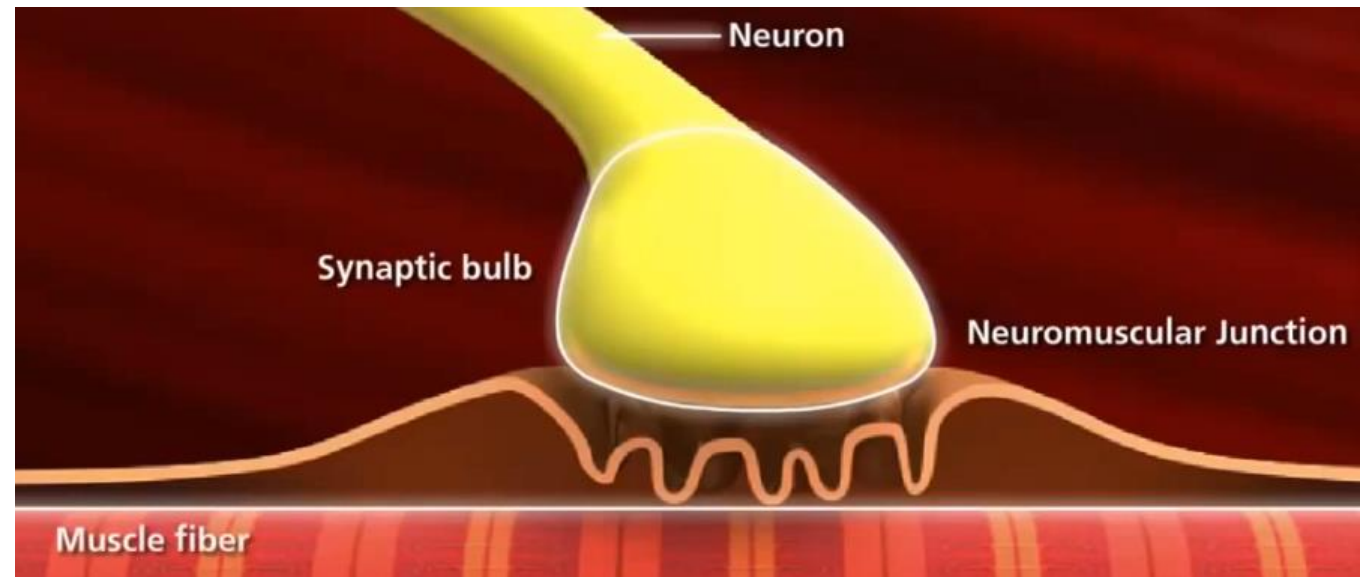
What is the site of signal exchange between Neuron
and Muscle

Closer Look: Neuron/Muscle connection





Neuromuscular junction is the site of signal exchange



Innervation of Skeletal Muscle

Muscles will contract/relax when they receive signals from the nervous system.

Muscle action begins at the motor end plate (**or neuromuscular junction**), which is analogous to a synapse between neurons

The neuromuscular junction is a site where a motor axon terminal releases neurotransmitters (**acetylcholine**)

Acetylcholine binds to receptors localized in the muscle membrane at the motor end plate.

Depolarizes the muscle fiber and electrical impulse travels down the T tubule and opens calcium stores

Thanks for coming 😊 😊