



# Computational Neuroscience

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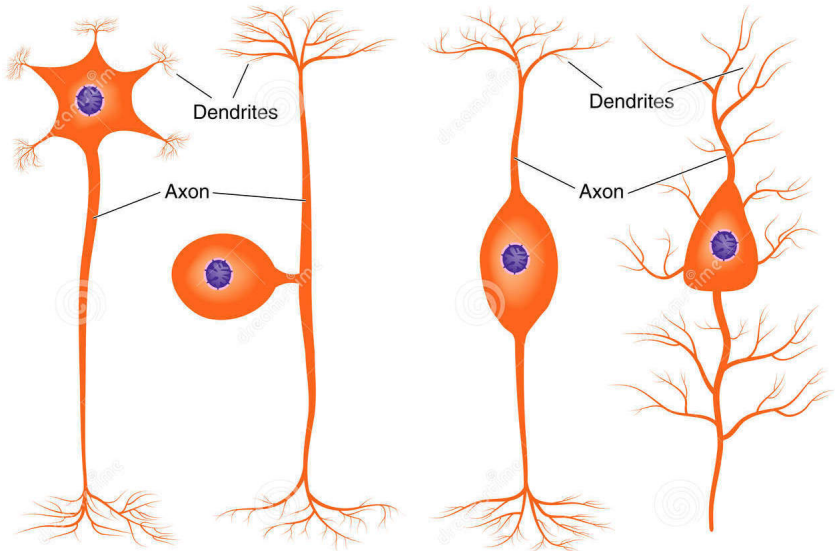
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# Neurons and Synapses

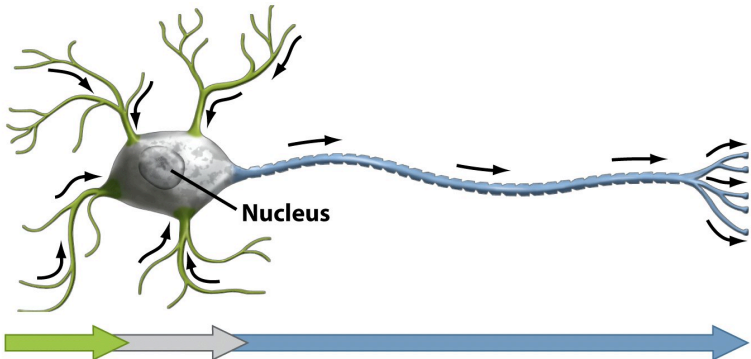
## Brain and Neurons



# Neurons Structural Diversity



# Neurons Basic Structure



## **Dendrites**

Collect  
electrical  
signals

## **Cell body**

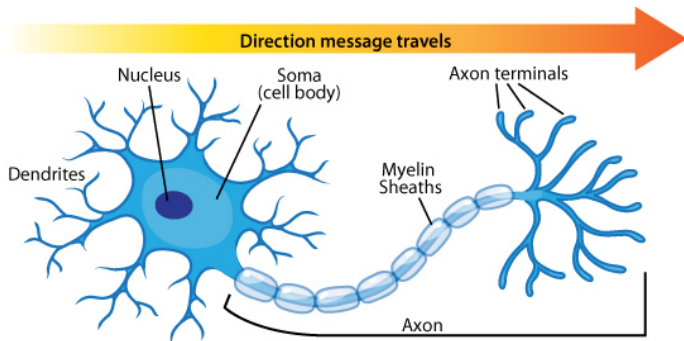
Integrates incoming  
signals and generates  
outgoing signal to  
axon

## **Axon**

Passes electrical signals  
to dendrites of another  
cell or to an effector cell

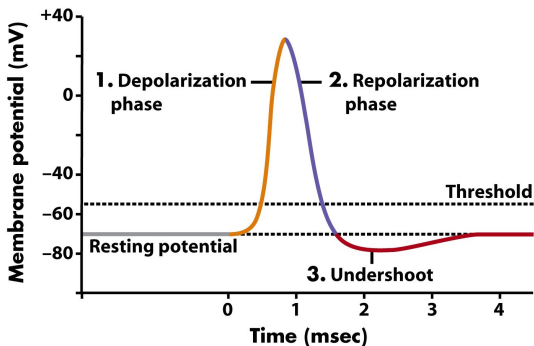
## Functions of the Neuron

- Transmit information from one point in the body to another.
- Process the information in various ways.
- The neuron has a specialized structure for carrying out these functions:
  - Cell Body (soma): Input, process
  - Dendrites: Input, process
  - Axon: Transmit
  - Terminal Buttons: Output



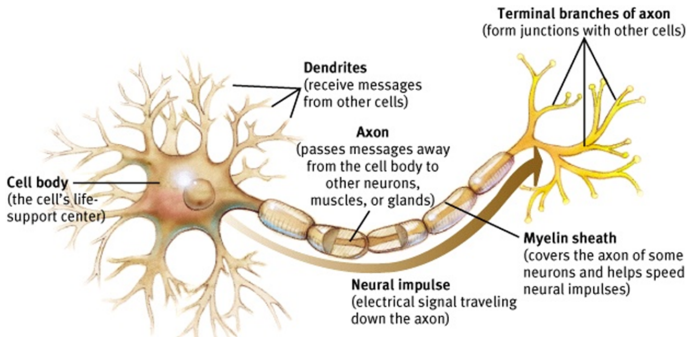
## Neural Potentials (voltages)

- **Resting Potential:**
  - A steady charge maintained between action potentials.
  - Value about  $-70$  to  $-90$  mV.
- **Action Potential:**
  - A rapid change in potential that moves from the base of the axon to its terminals.
  - Also called the neural impulse or spike.



## How Neurons Work?

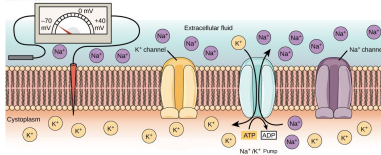
- Activity at the neurons dendrites or cell body initiates an action potential at the base of the axon.
- Action potential races down the axon to the terminal buttons.
- Terminal buttons release a neurotransmitter substance into the synapses.



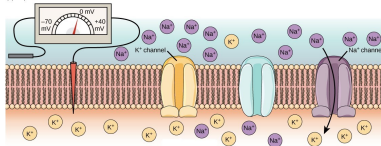


# Neurons Membrane Structure

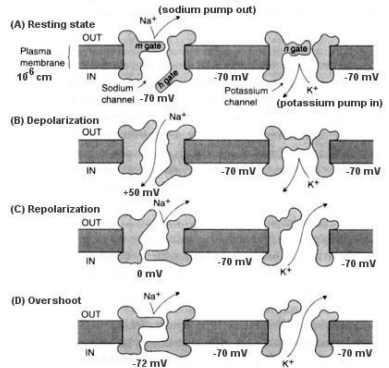
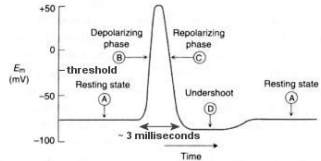
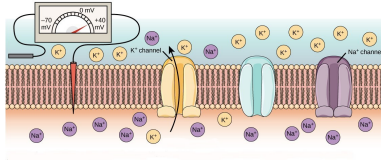
(a) Resting potential



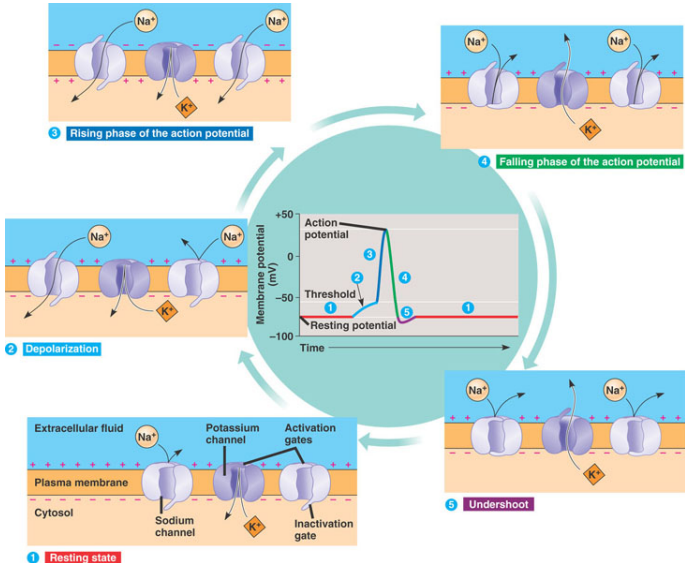
(b) Depolarization



(c) Peak

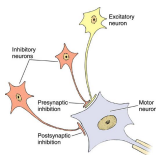


# Neurons in Action

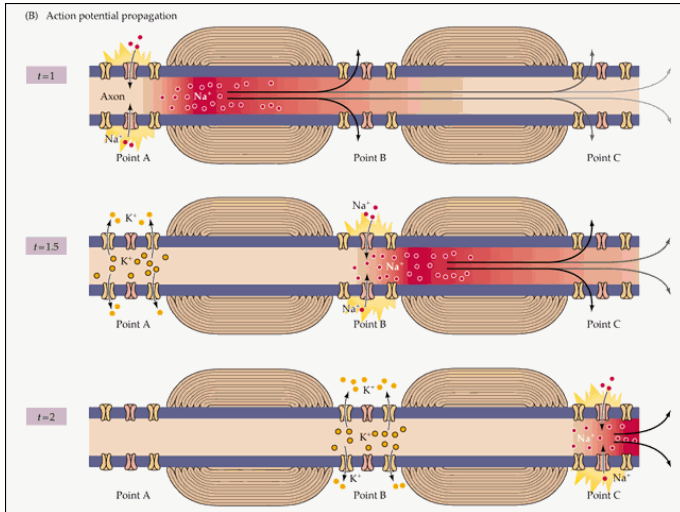


## Two Types of Neurons

- Excitatory:
  - Cause an excitatory electrical change in the postsynaptic potential (EPSP).
  - Release of neurotransmitter tends to depolarize the receiving neuron, making it more likely to fire an action potential.
  - Open the membrane channels for Sodium ( $Na^+$ ) and Calcium ( $Ca^{2+}$ ) ions.
- Inhibitory:
  - Cause an inhibitory postsynaptic potential (IPSP).
  - Release of neurotransmitter tends to hyperpolarize the receiving neuron, making it less likely to fire an action potential.
  - Open the membrane channels for Chloride ( $Cl^-$ ) and Potassium ( $K^+$ ) ions.



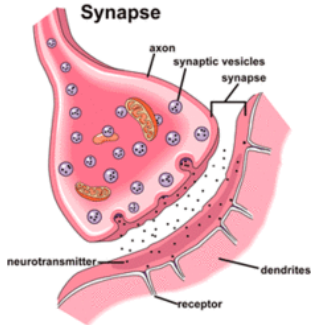
# How Axon Works?



# Synapse

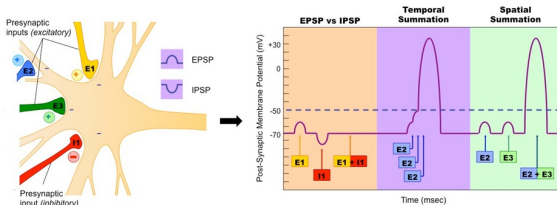
The synapse is a connection between a terminal button of one neuron (pre-synaptic neuron) and a dendrite (or the cell body) of another neuron (post-synaptic neuron).

- Terminal button
- Vesicles containing neurotransmitter
- Synaptic gap
- Receptor proteins (in membrane of receiving neuron)

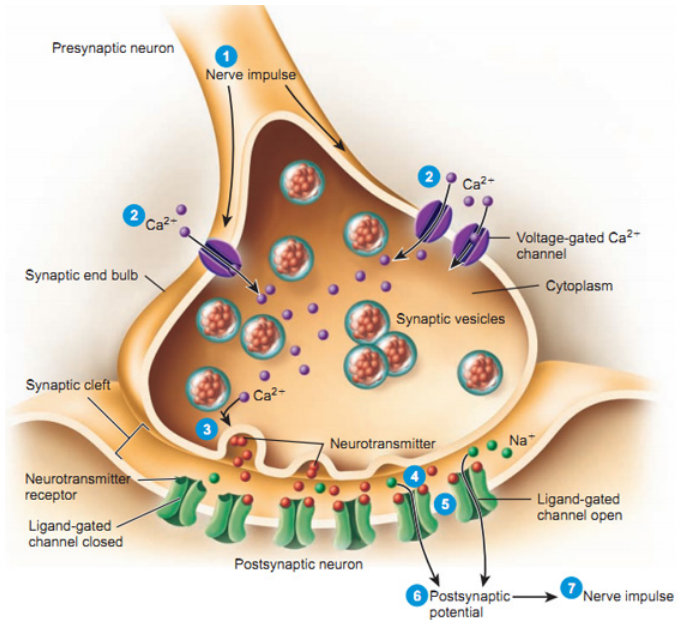


# Action at the Synapse

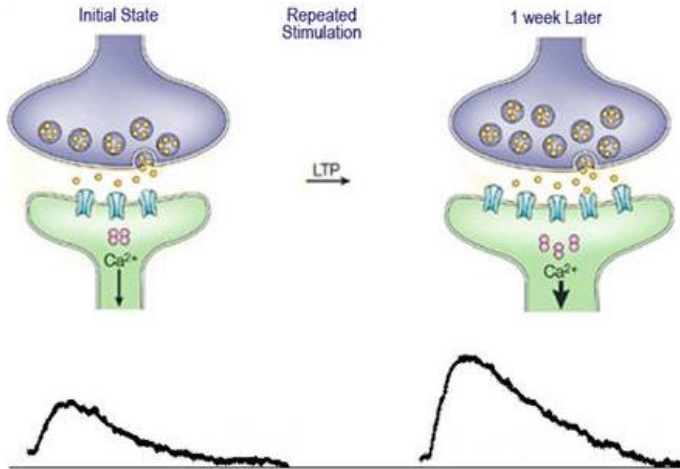
- Arrival of action potential at the terminal button causes vesicles to move toward synaptic gap.
- Those reaching the cleft burst open, dumping neurotransmitter into the cleft.
- Neurotransmitter locks onto receptor proteins, activating them.
- Resting potential of receiving neuron changes temporarily.
- Neurotransmitter is removed from receptor proteins, terminating the action.



# Action at the Synapse

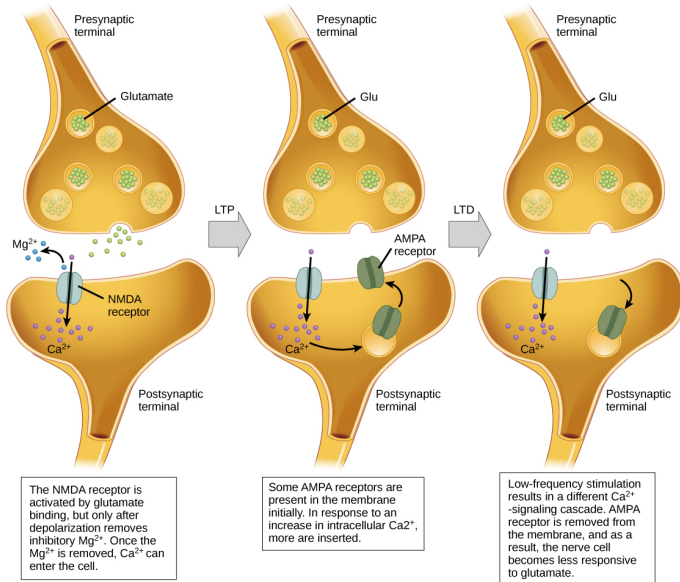


# Synaptic Plasticity





# Synaptic Plasticity



# Neurons and Synapses in Action

