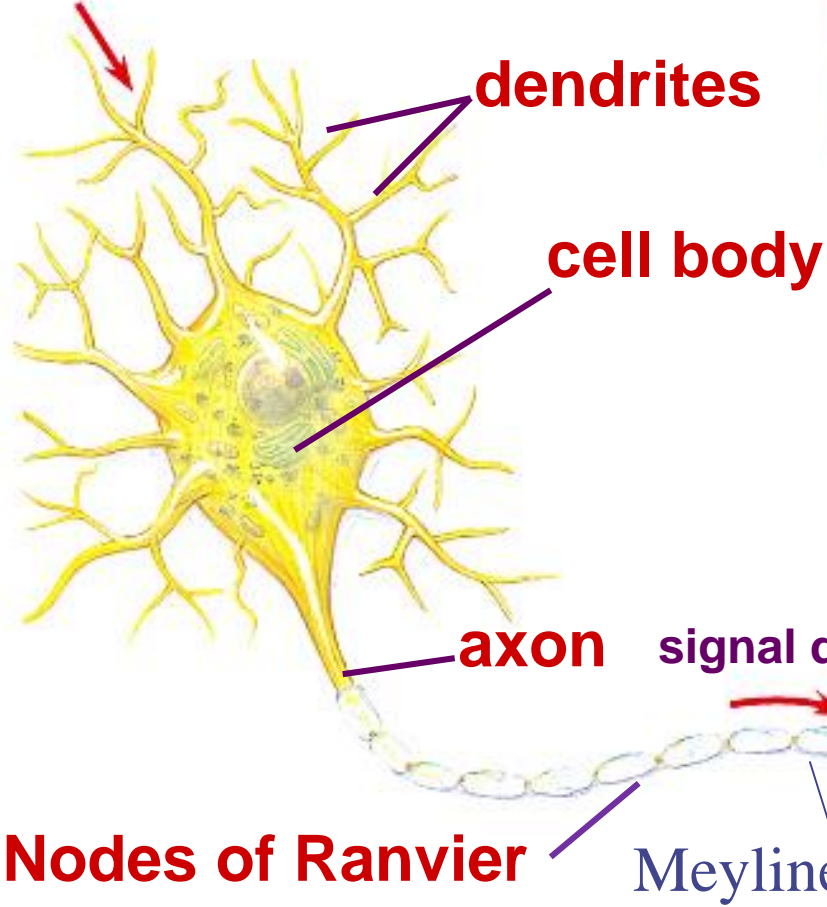
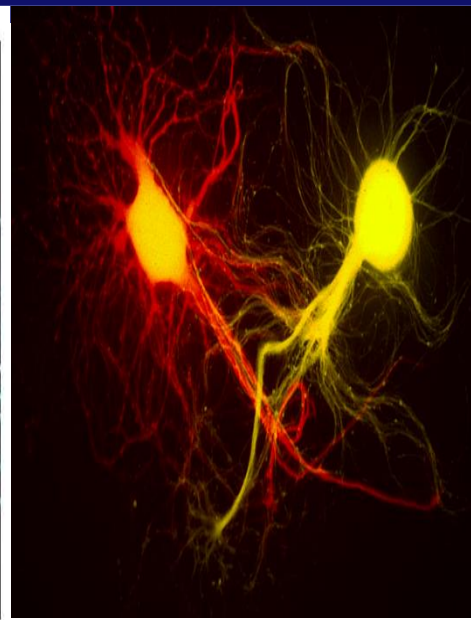
A detailed microscopic image of a neuron, showing its cell body (soma) with a prominent purple nucleus and surrounding blue cytoplasm. Numerous branching processes, including dendrites and an axon, extend from the cell body. The background is a dark, textured purple.

# The Nervous System



# Neuron (nerve cell)



Structure fits function, it have many entry points for signal one path out transmits signal

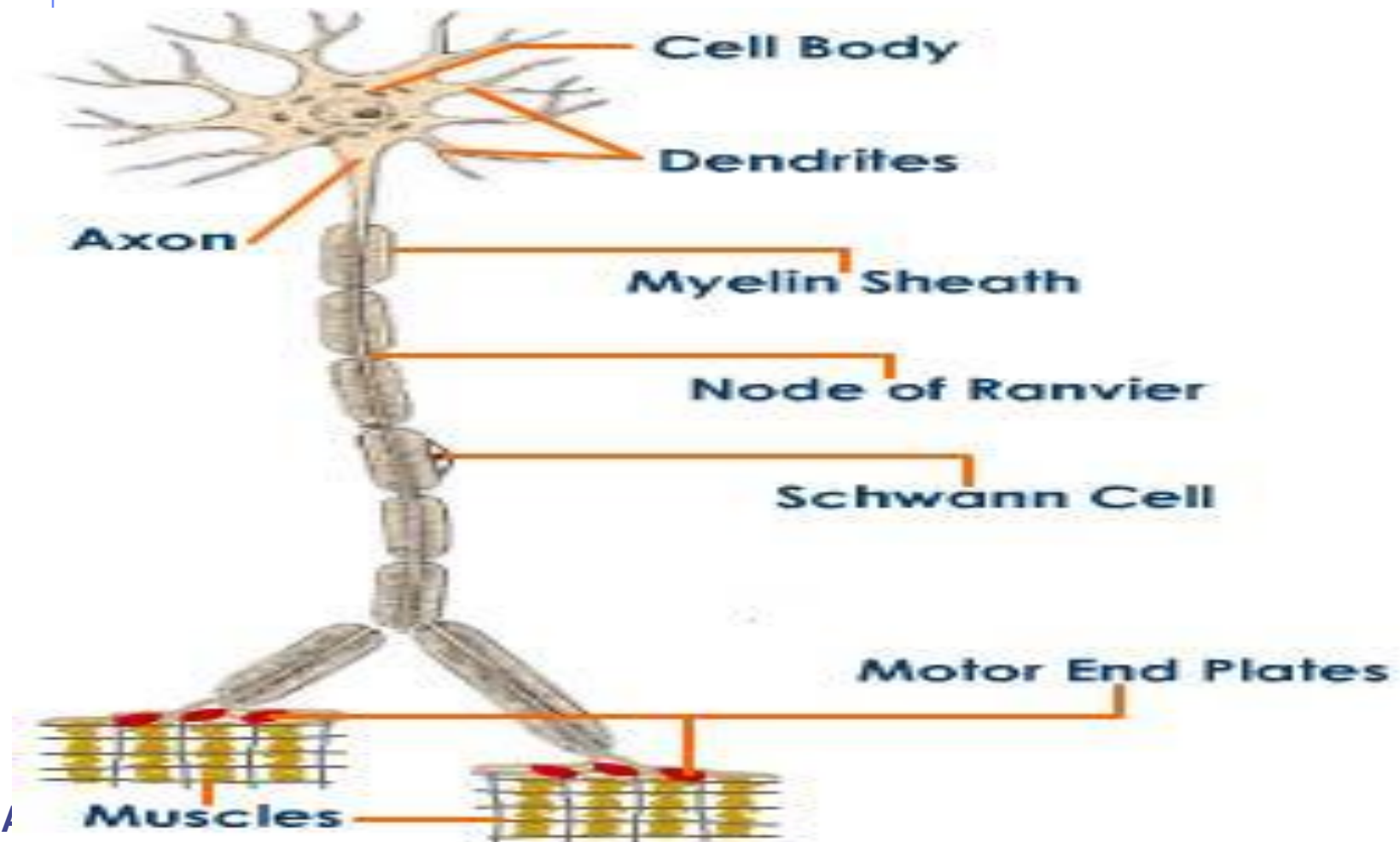
Nodes of Ranvier

Meyline sheath

Telodendria

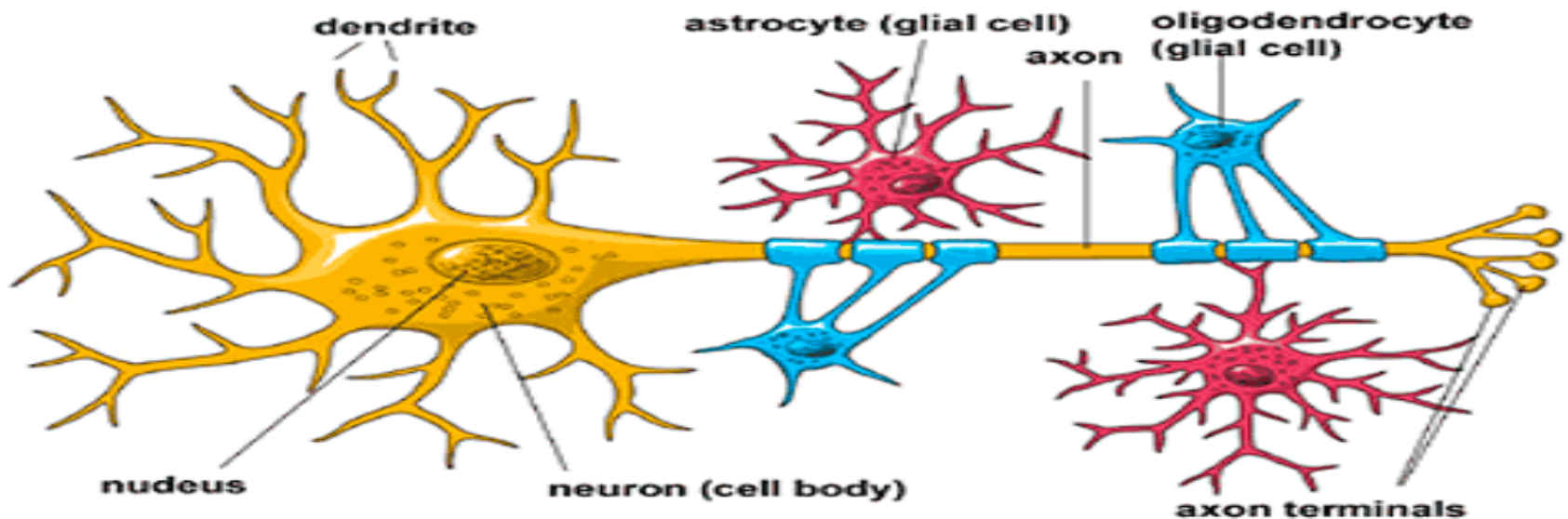


# Neuron (nerve cell)



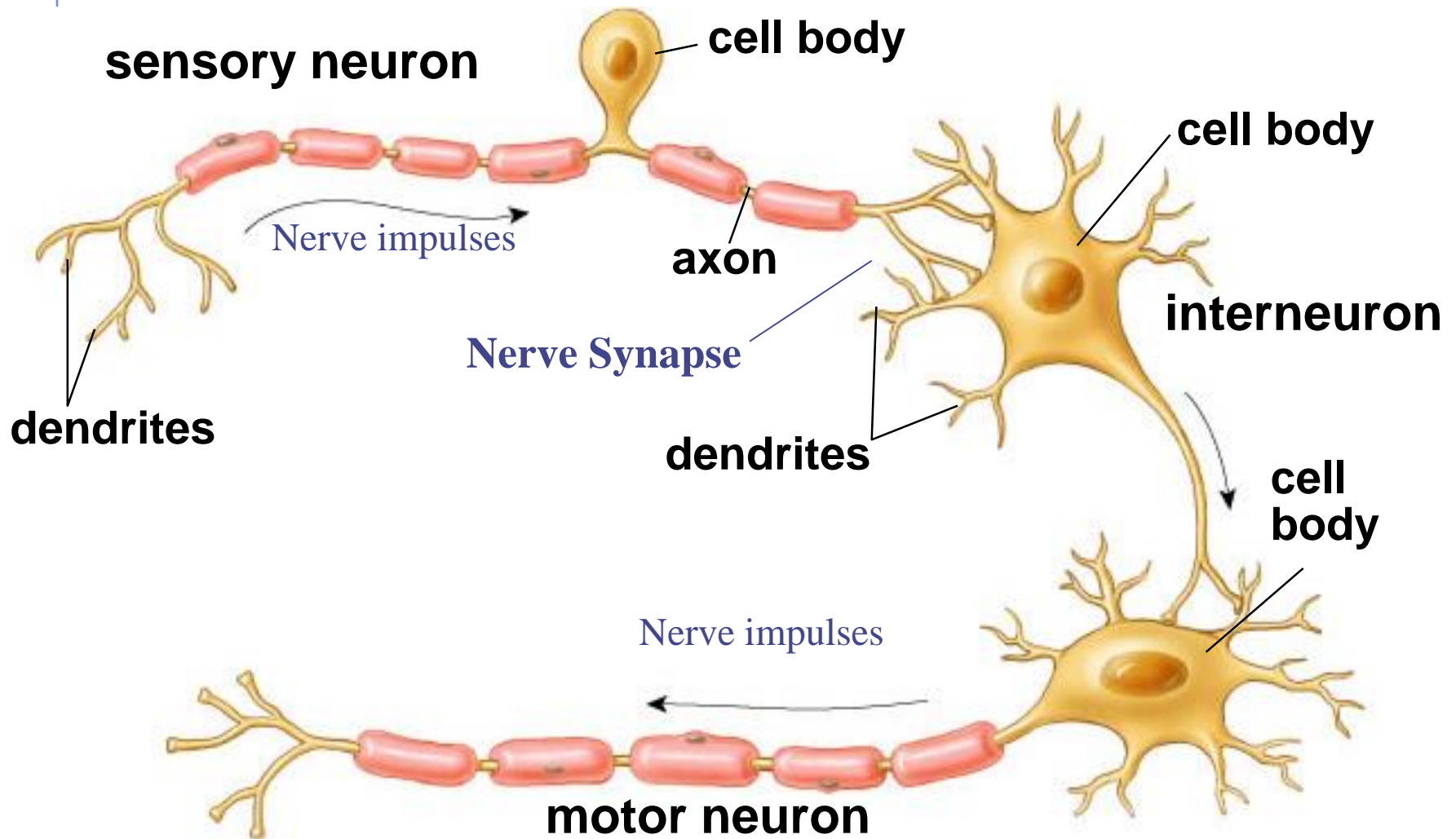
# Neurons support

- Structurally and functionally by: Schwann cells, oligodendrocytes, and neuroglial cells
  - ◆ Supply nutrients
  - ◆ Remove wastes
  - ◆ Guide axon migration
  - ◆ Immune function



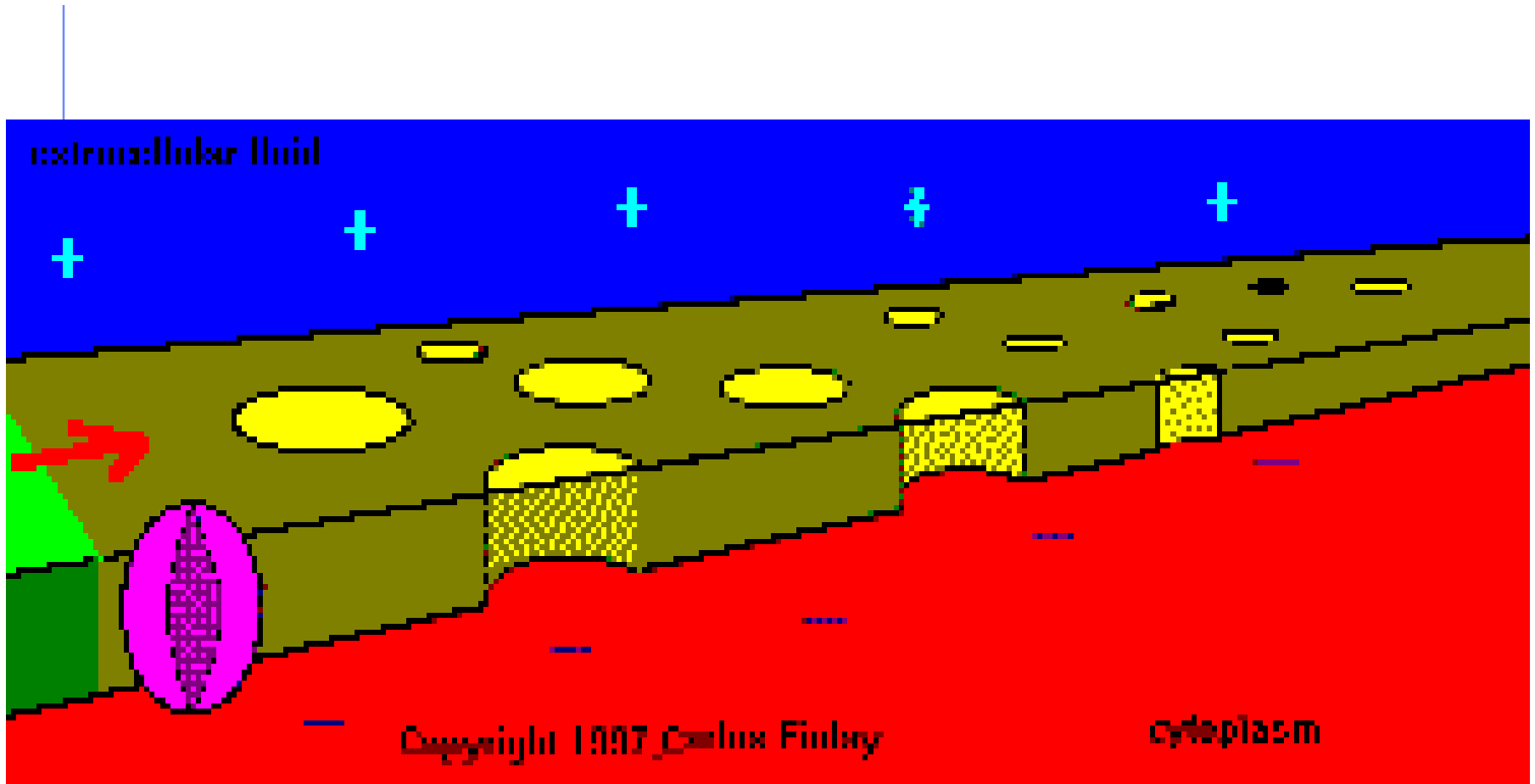
# Types of neurons:-

1- Sensory neuron 2- Motor neuron



# Excitability (Electric potential)

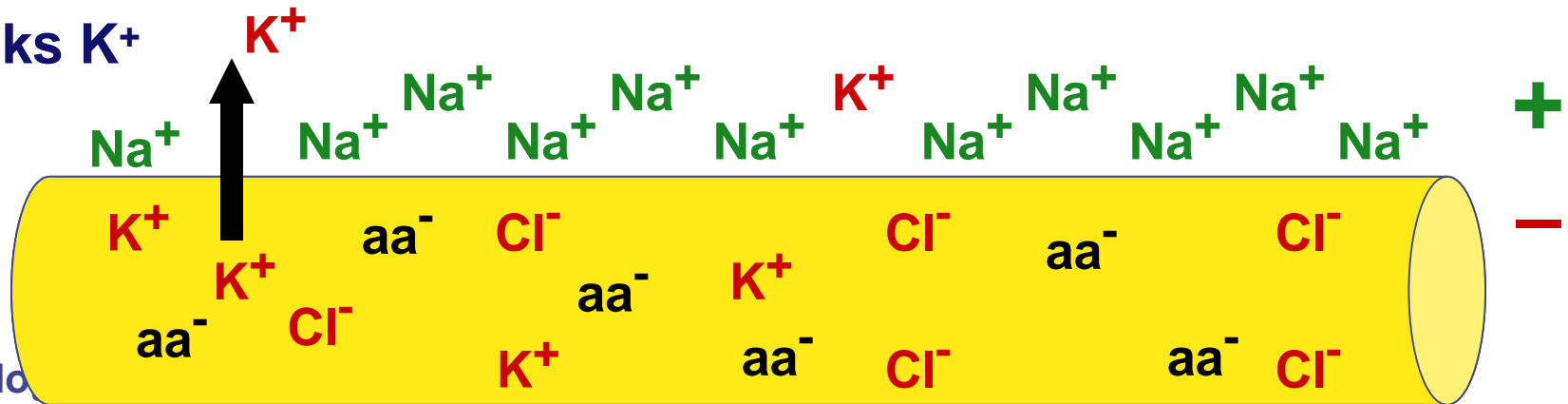
- 1- Resting potential
- 2- Threshold potential
- 3- Action potential



# Cells: surrounded by charged ions

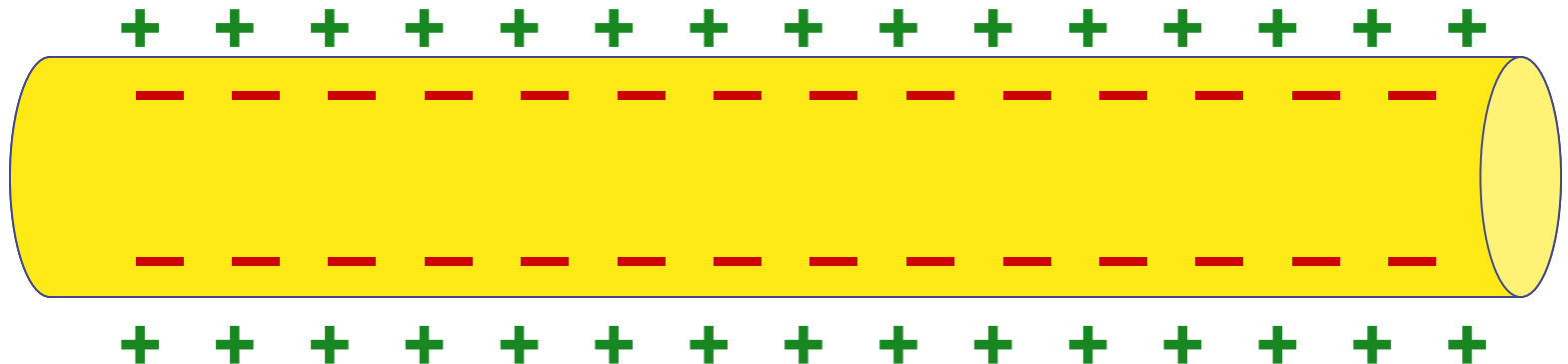
- Cells live in a sea of charged ions
  - negative ions : more concentrated within the cell
    - Cl<sup>-</sup>, charged amino acids
  - positive ions :
    - more concentrated in the extracellular fluid
    - K<sup>+</sup>, Na<sup>+</sup>

channel  
leaks K<sup>+</sup>



# Cells have voltage!

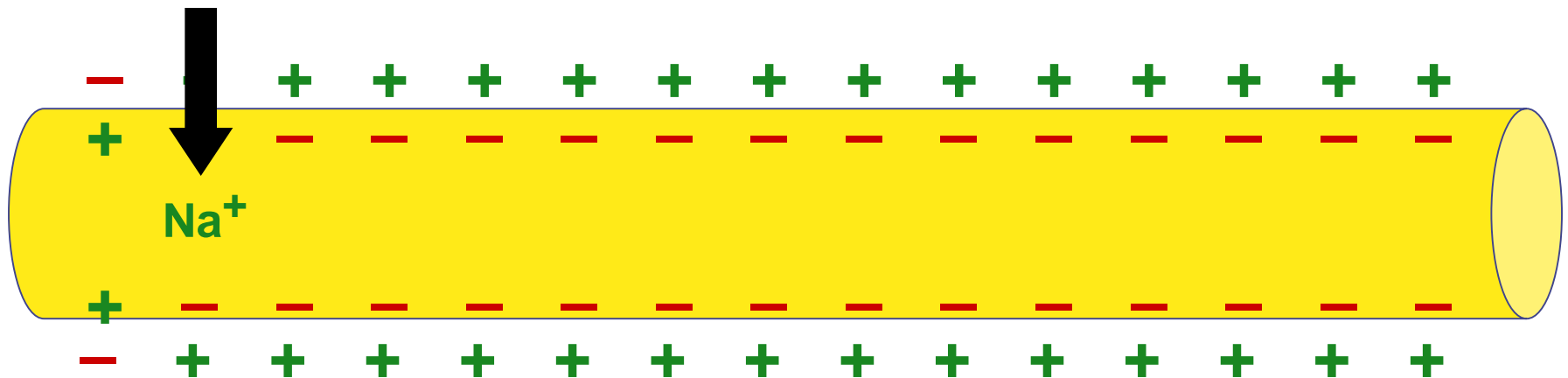
- Opposite charges on opposite sides of cell membrane
  - ◆ membrane is polarized
    - negative inside; positive outside
    - charge gradient
    - stored energy (like a battery)





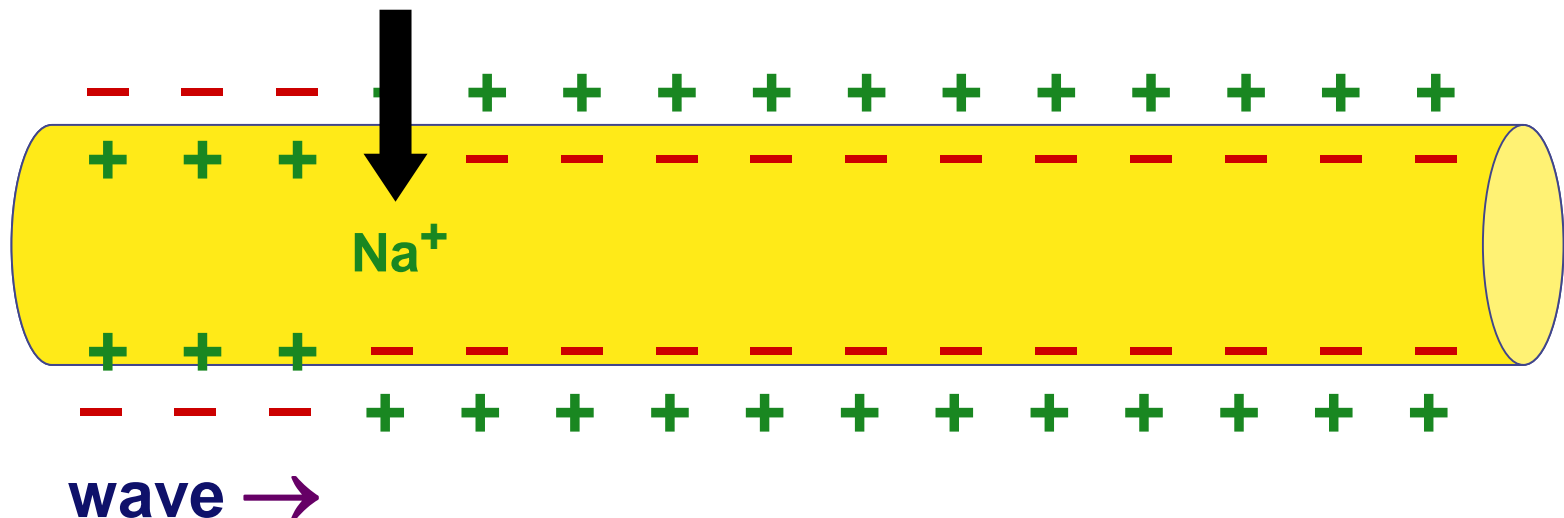
# How does a nerve impulse travel?

- **Stimulus**: nerve is stimulated
  - ◆ open  $\text{Na}^+$  channels in cell membrane
    - reached threshold potential
    - membrane becomes very permeable to  $\text{Na}^+$
    - $\text{Na}^+$  ions diffuse into cell
  - ◆ charges reverse at that point on neuron
    - positive inside; negative outside
    - cell becomes depolarized



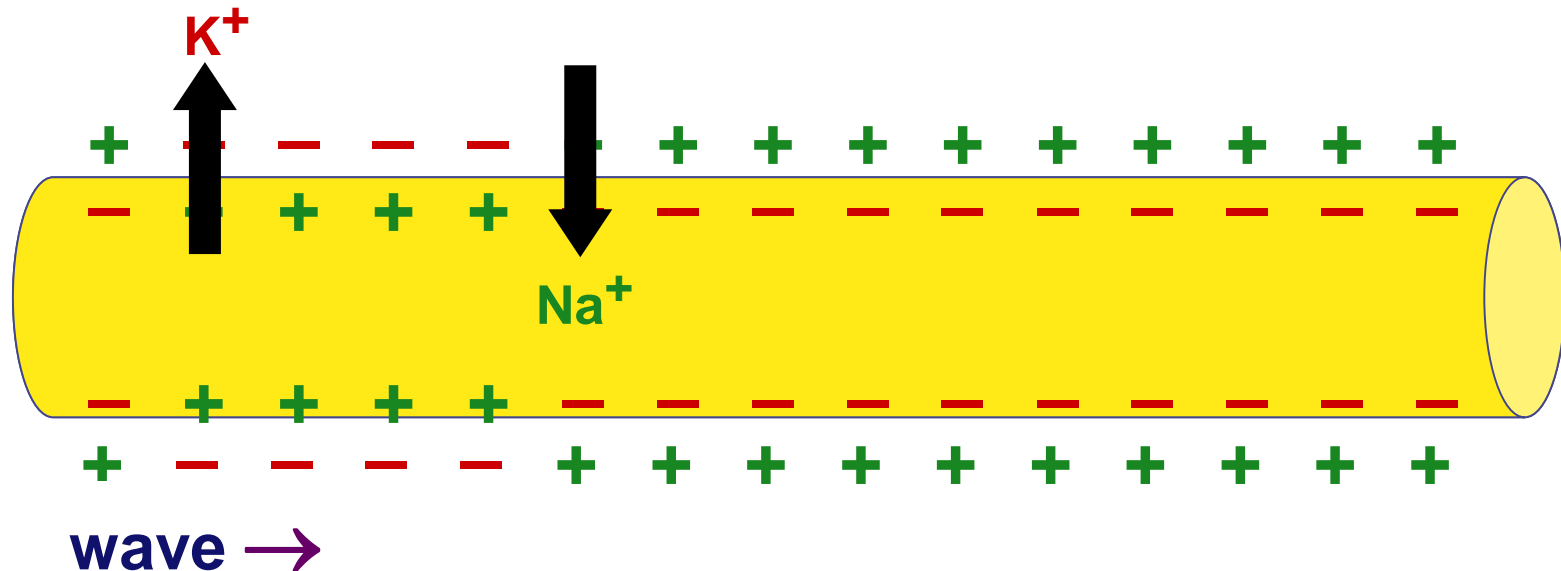
# How does a nerve impulse travel?

- **Wave**: nerve impulse travels down neuron
  - ◆ change in charge opens other  $\text{Na}^+$  gates in next section of cell
  - ◆  $\text{Na}^+$  ions continue to move into cell
  - ◆ “wave” moves down neuron = **action potential**



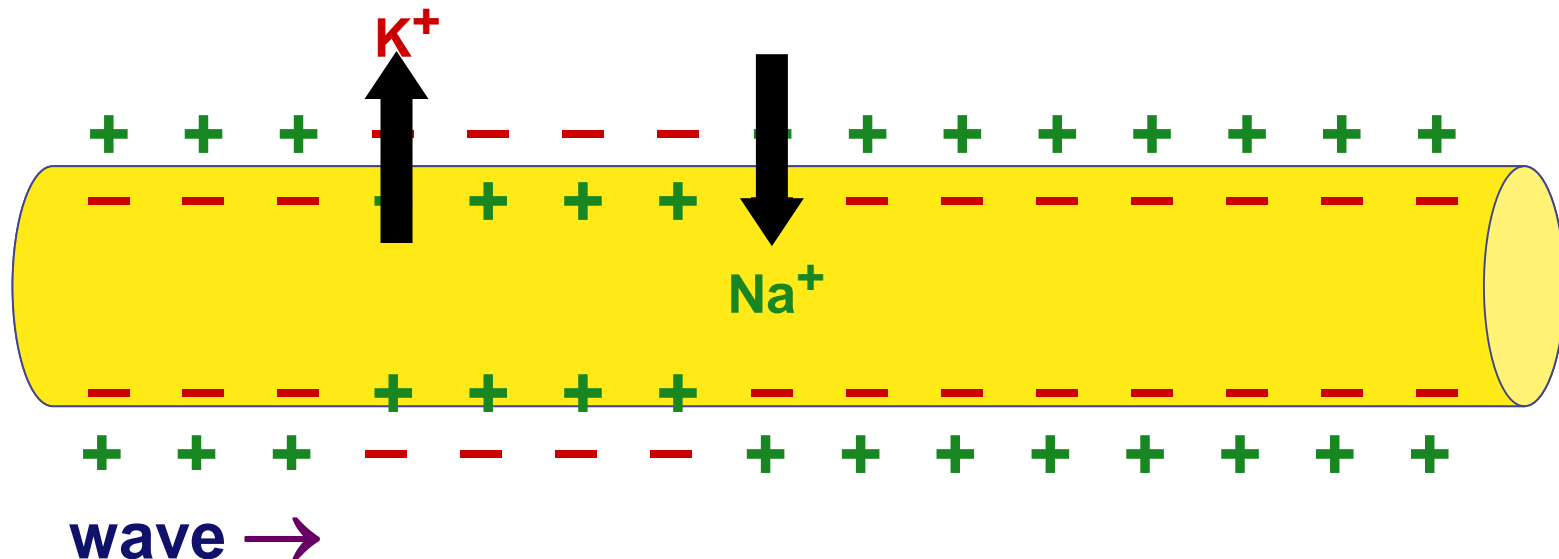
# How does a nerve impulse travel?

- **Re-set**: 2nd wave travels down neuron
  - ◆  $K^+$  channels open up slowly
  - ◆  $K^+$  ions diffuse out of cell
  - ◆ charges reverse back at that point
    - negative inside; positive outside



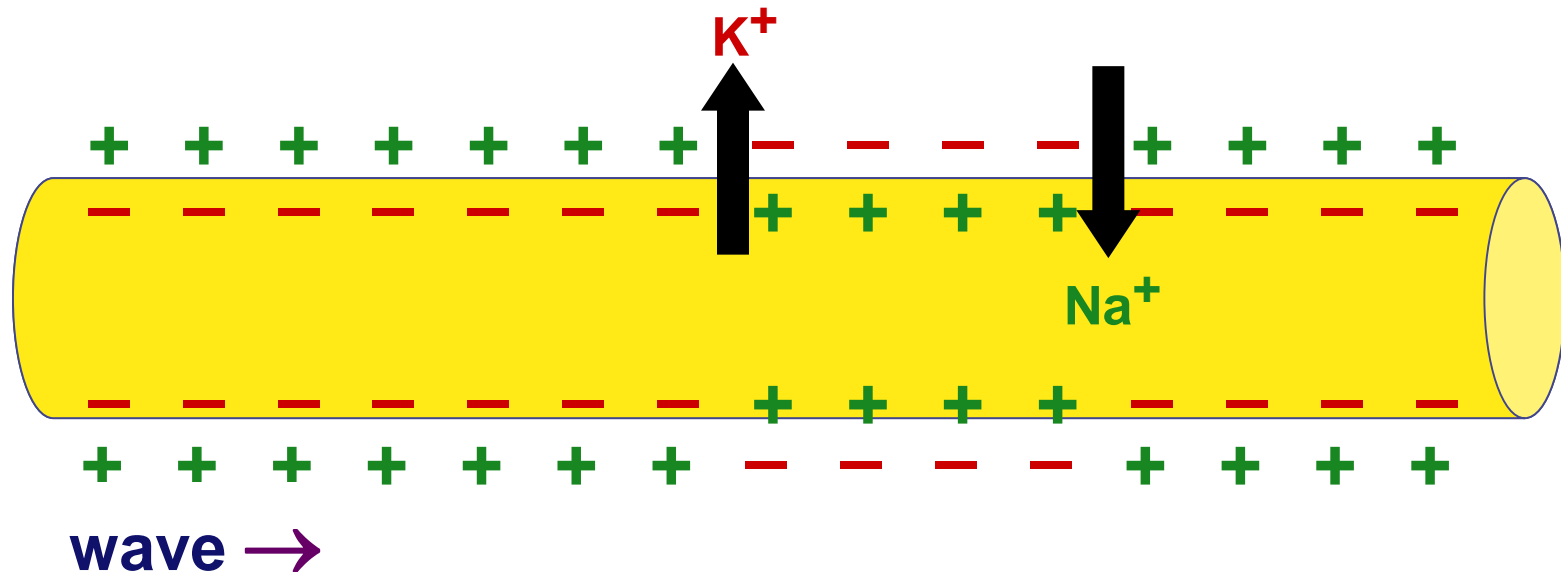
# How does a nerve impulse travel?

- Combined waves travel down neuron
  - ◆ wave of opening ion channels moves down neuron
  - ◆ signal moves in one direction → → →
    - flow of  $K^+$  out of cell stops activation of  $Na^+$  channels in wrong direction



# How does a nerve impulse travel?

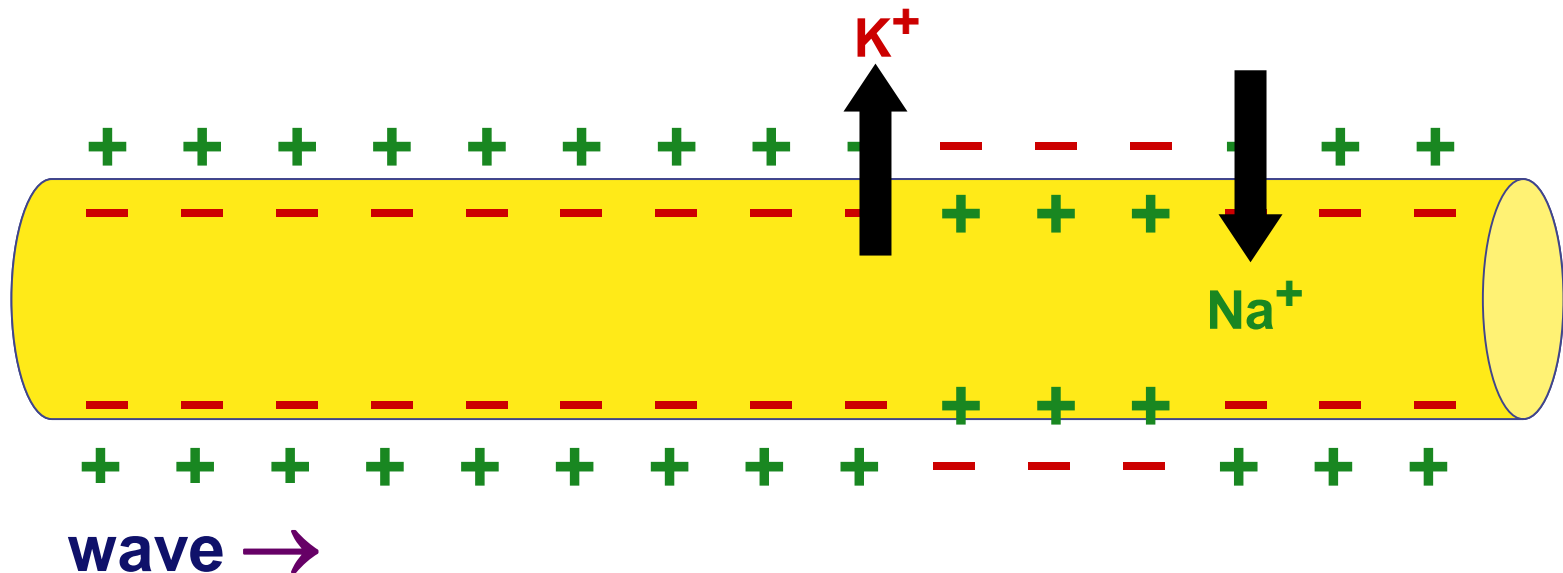
- Action potential propagates
  - ◆ wave = nerve impulse, or action potential
  - ◆ brain → finger tips in milliseconds!





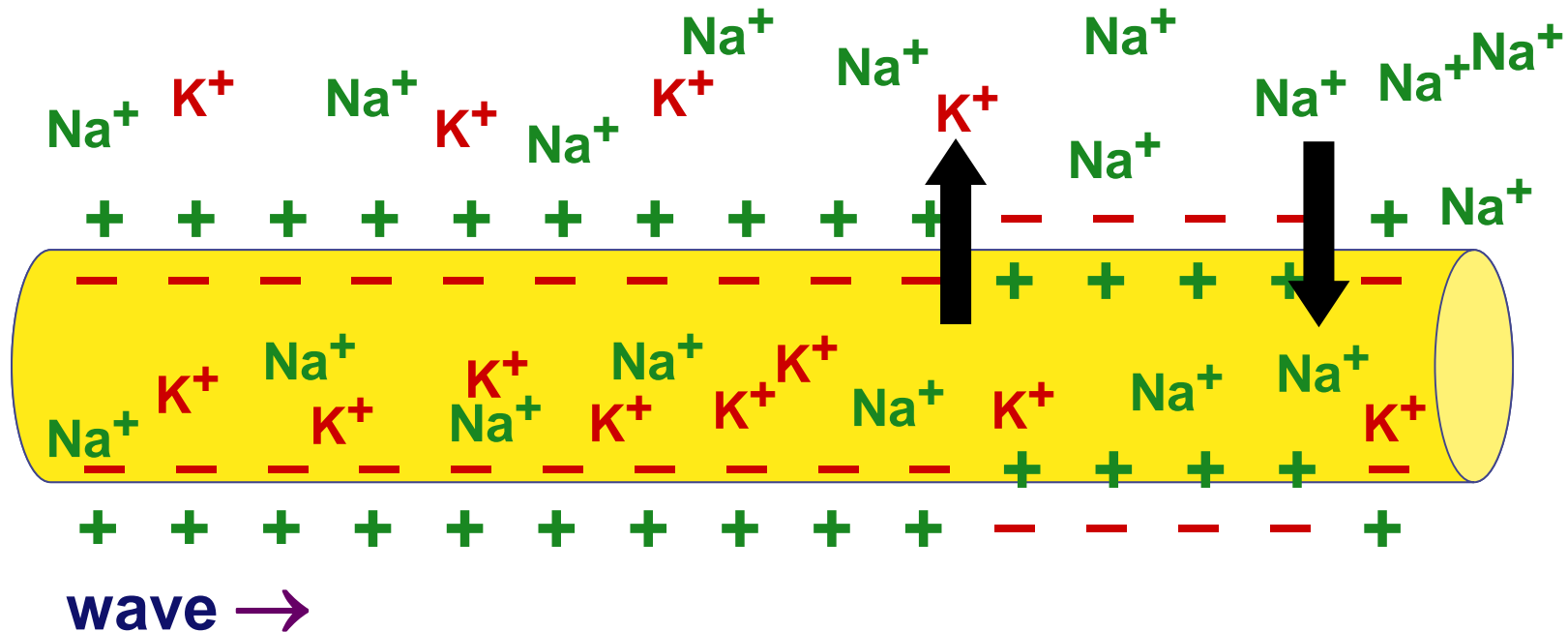
# Voltage-gated channels

- Ion channels open & close in response to changes in charge across membrane
  - ◆  $\text{Na}^+$  channels open quickly in response to depolarization & close slowly
  - ◆  $\text{K}^+$  channels open slowly in response to depolarization & close slowly



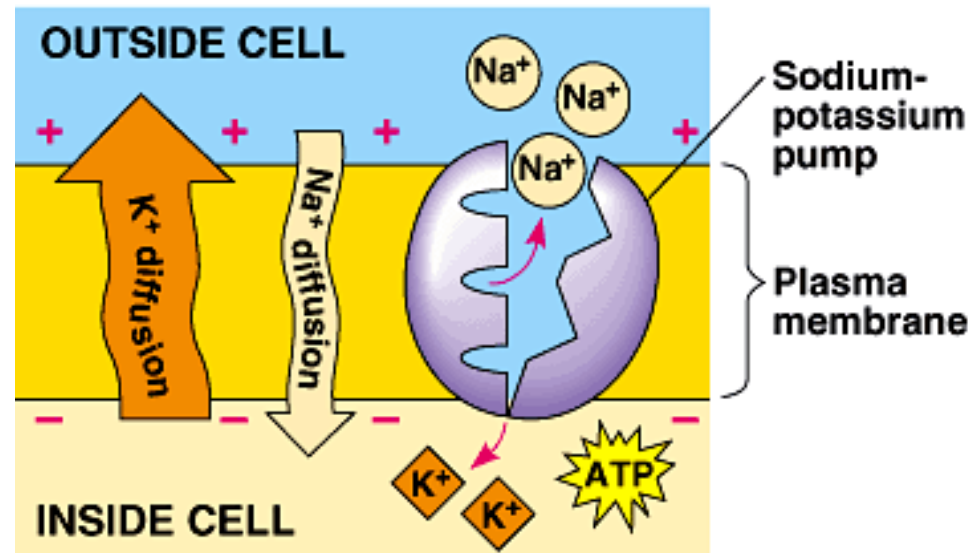
# How does the nerve re-set itself?

- After firing a neuron has to re-set itself
  - ◆  $\text{Na}^+$  needs to move back out
  - ◆  $\text{K}^+$  needs to move back in
  - ◆ both are moving against concentration gradients
    - need a pump!!

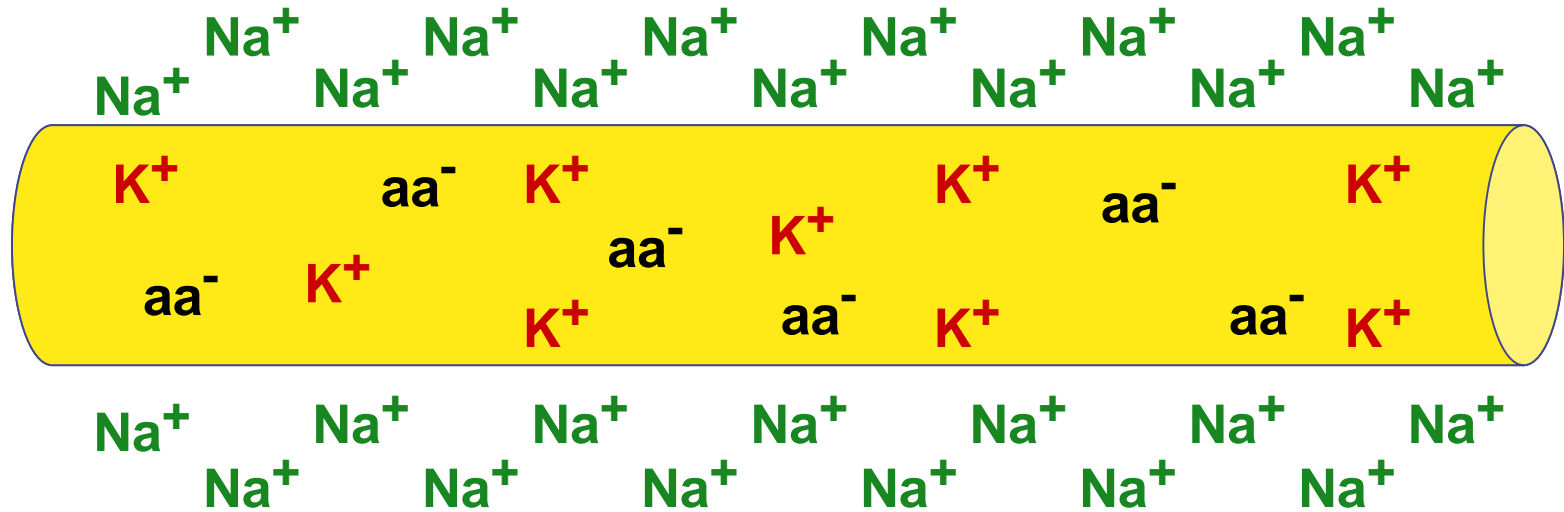


# How does the nerve re-set itself?

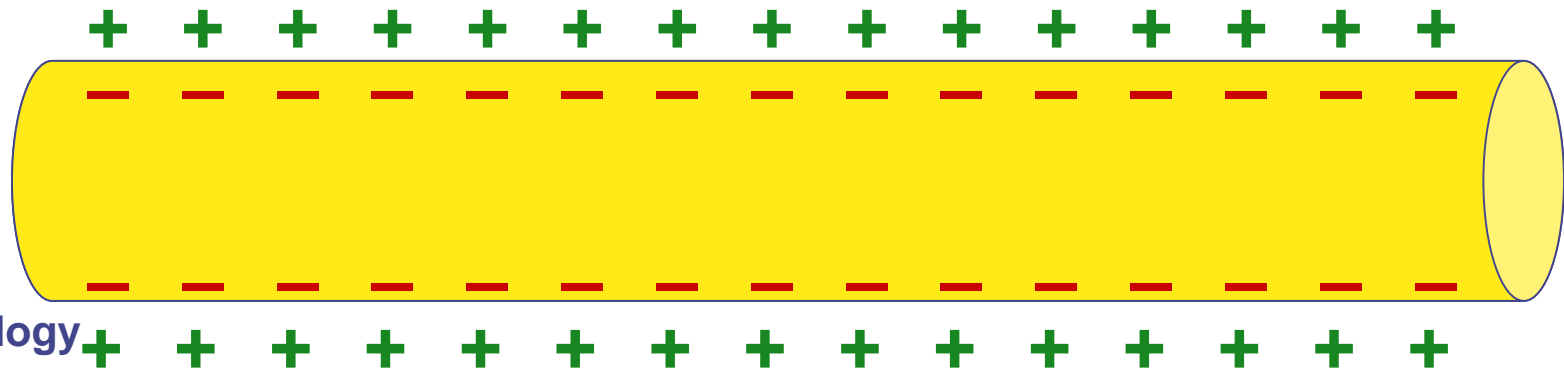
- **Na<sup>+</sup> / K<sup>+</sup> pump**
  - ◆ active transport protein in membrane
    - requires ATP
  - ◆ **3 Na<sup>+</sup> pumped out**
  - ◆ **2 K<sup>+</sup> pumped in**
  - ◆ re-sets charge across membrane



# Neuron is ready to fire again [\(link\)](#)

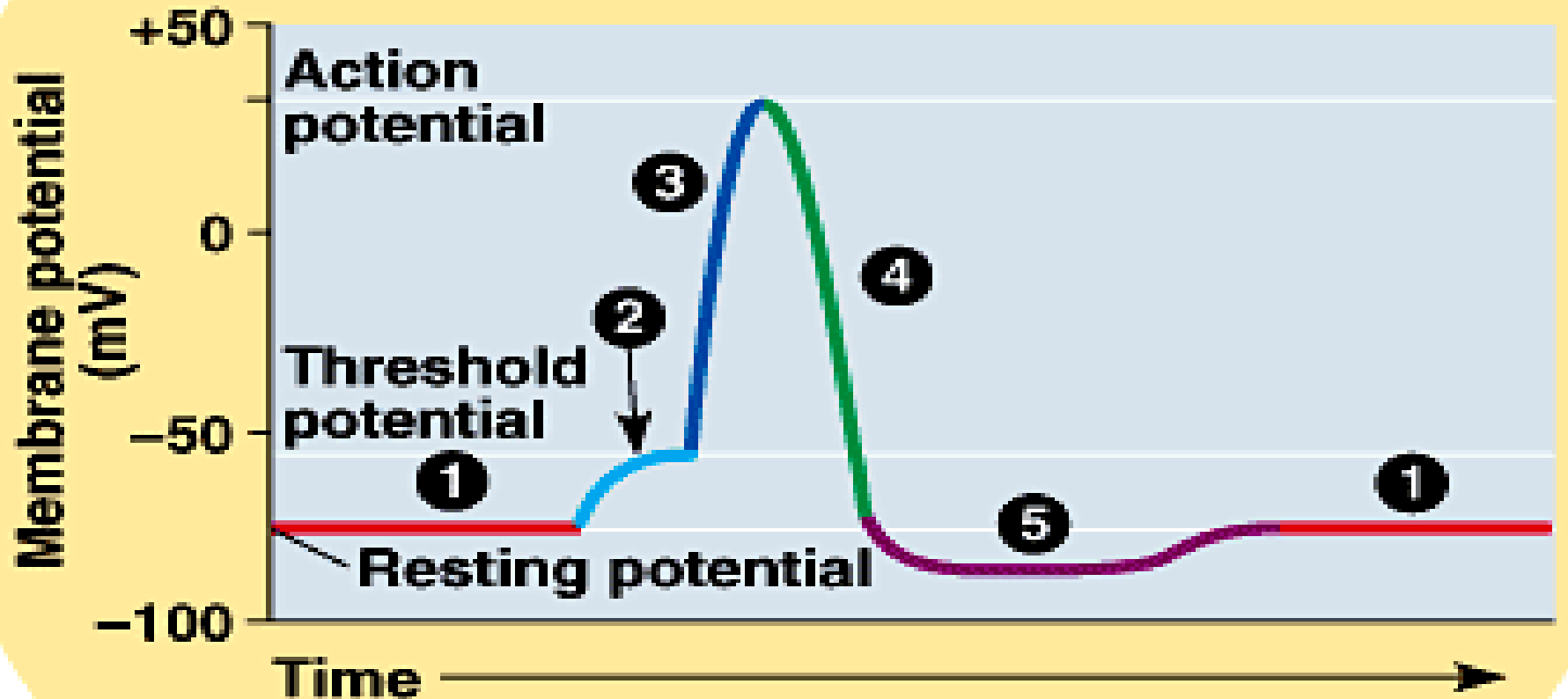


resting potential

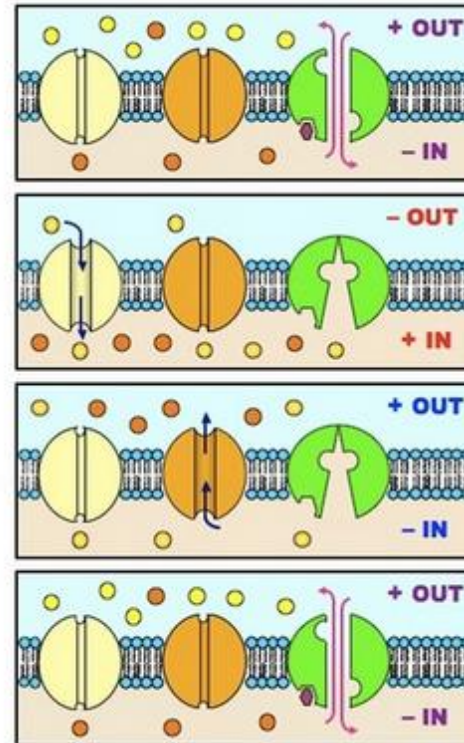
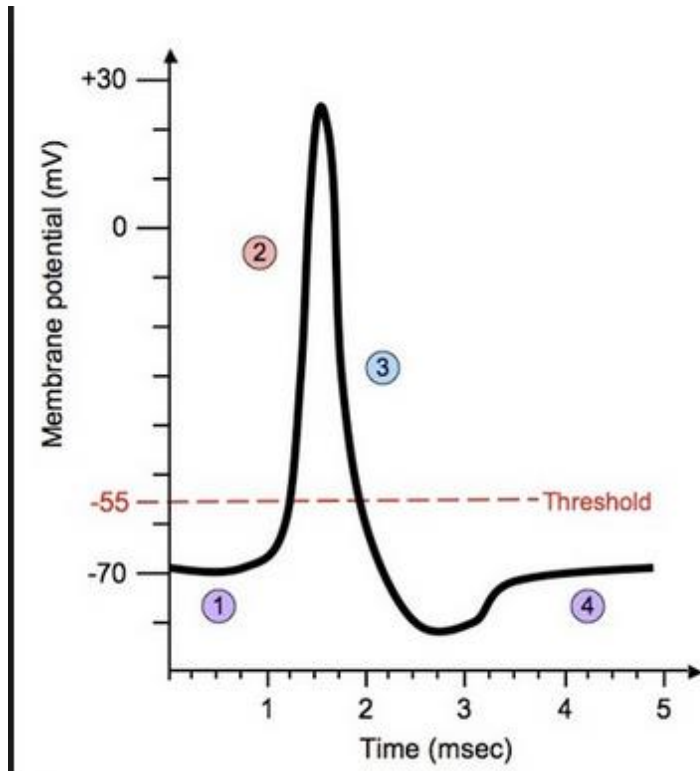


# Action potential graph

1. Resting potential
2. Stimulus reaches threshold potential (threshold potential)
3.  $\text{Na}^+$  channels open;  $\text{K}^+$  channels closed (depolarization)
4.  $\text{Na}^+$  channels close;  $\text{K}^+$  channels open (Repolarization)
5. Undershoot:  $\text{K}^+$  channels close slowly







- 1 **Resting Potential**  
Na<sup>+</sup>/K<sup>+</sup> pump
- 2 **Depolarisation**  
Voltage-gated Na<sup>+</sup> channel
- 3 **Repolarisation**  
Voltage-gated K<sup>+</sup> channel
- 4 **Resting Potential**  
Na<sup>+</sup>/K<sup>+</sup> pump

# Oscill Oscope



# oscilloscope

- An **oscilloscope**, previously called an oscillograph, and informally known as a **scope**, **CRO** (for cathode-ray oscilloscope), is a type of electronic test instrument that allows observation of constantly varying signal voltages, usually as a two-dimensional plot of one or more signals as a function of time.
- Oscilloscopes are used to observe the change of an electrical signal over time, such that voltage and time describe a shape which is continuously graphed against a calibrated scale. The observed waveform can be analyzed for such properties as amplitude, frequency, rise time, time interval, distortion and others.

**Nervous system**

**Central nervous system**

**Peripheral nervous system**

**Brain**

**Spinal cord**

**Sensory pathways**

**Motor pathways**

**Somatic (voluntary) nervous system**

**Autonomic (involuntary) nervous system**

**Sympathetic division**

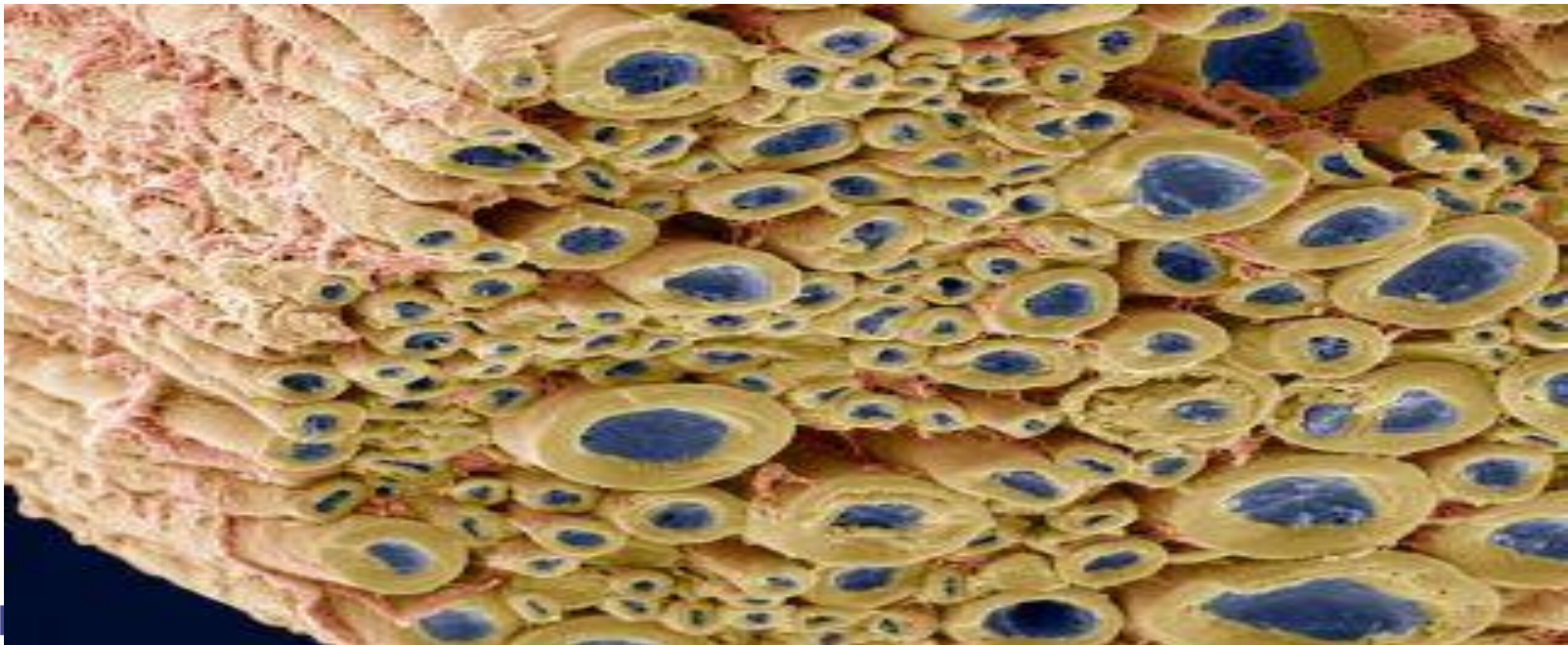
**Parasympathetic division**

- **Sympathetic** arousal & energy production “fight or flight”
- **Parasympathetic** calming & back to maintenance “rest & digest”



# Nerves

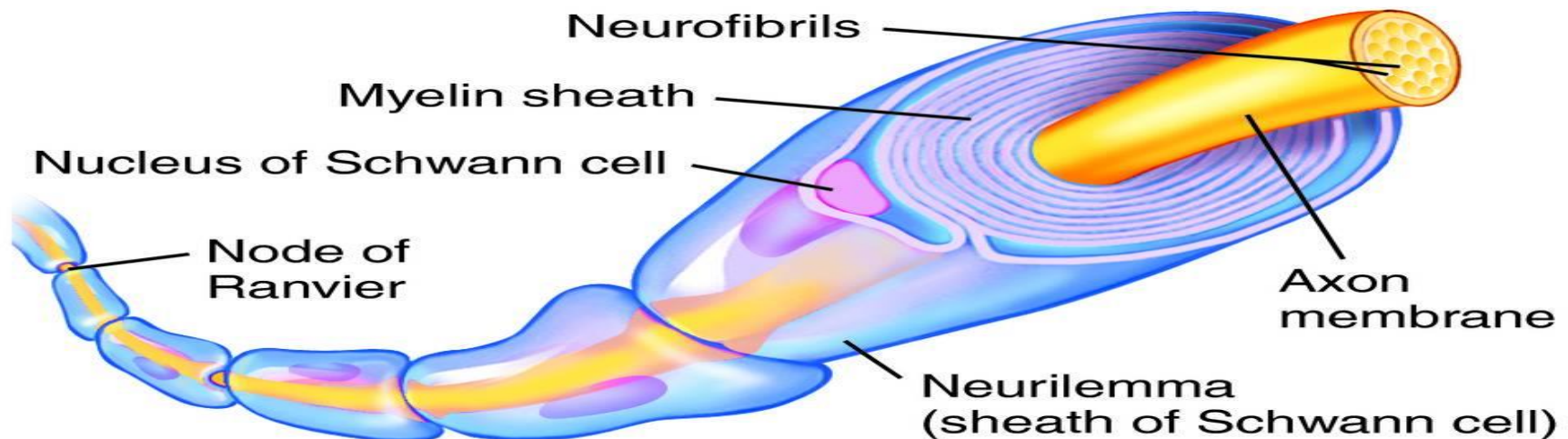
The nerve consists of a large number of nerve fibers, nerve fiber filiform consist of one axis is surrounded by a membrane fibrous sheath called the nervous Neurilemma consists of cells called Schwann cells, the nerve fibers are two types





# A- Myelinated nerve fibers

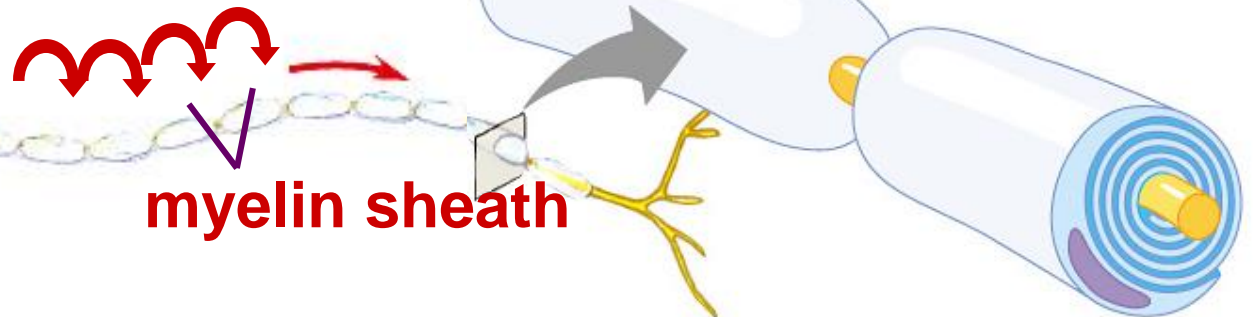
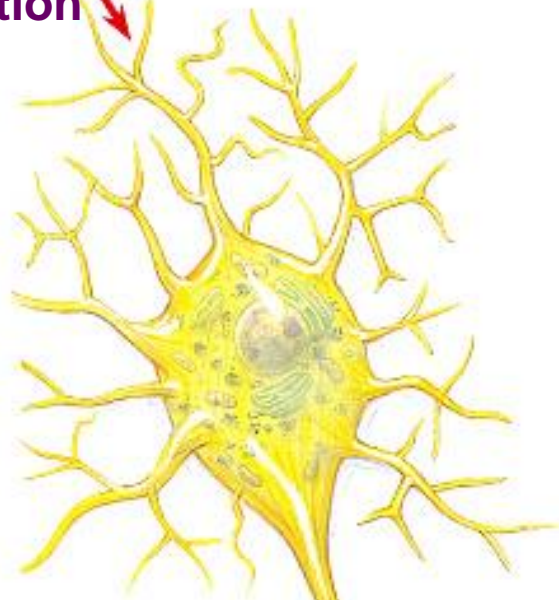
- The Axon is rounded by Myelin sheath which consists of fatty material protein complex in some areas, which are called contract Ranvir Node
- The sheath is an electrical insulator myeloid well axis which consists of amount of fat so it helps the transmission of electrical stimulus are good and faster than fiber is un myelinated nerve



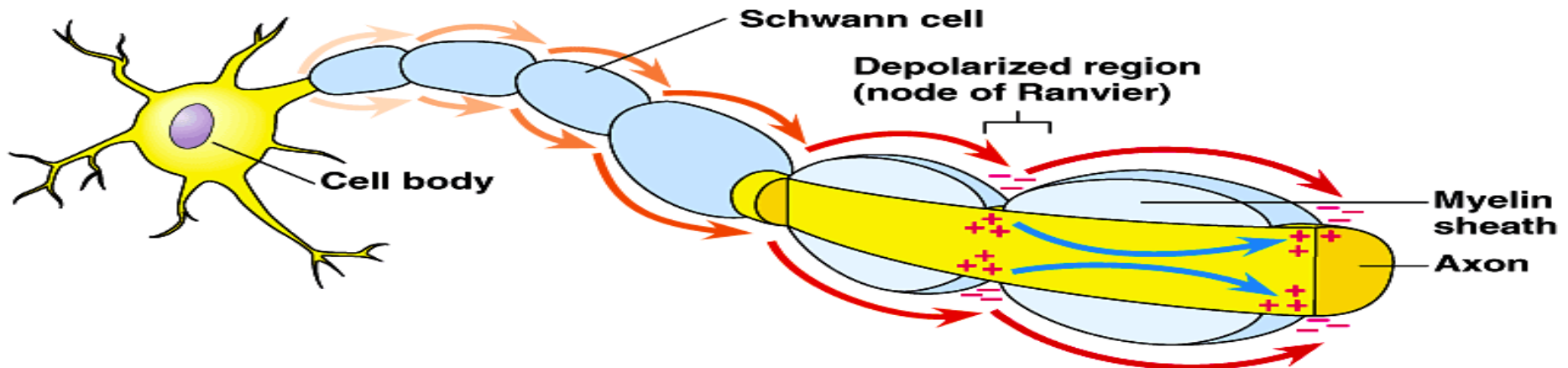
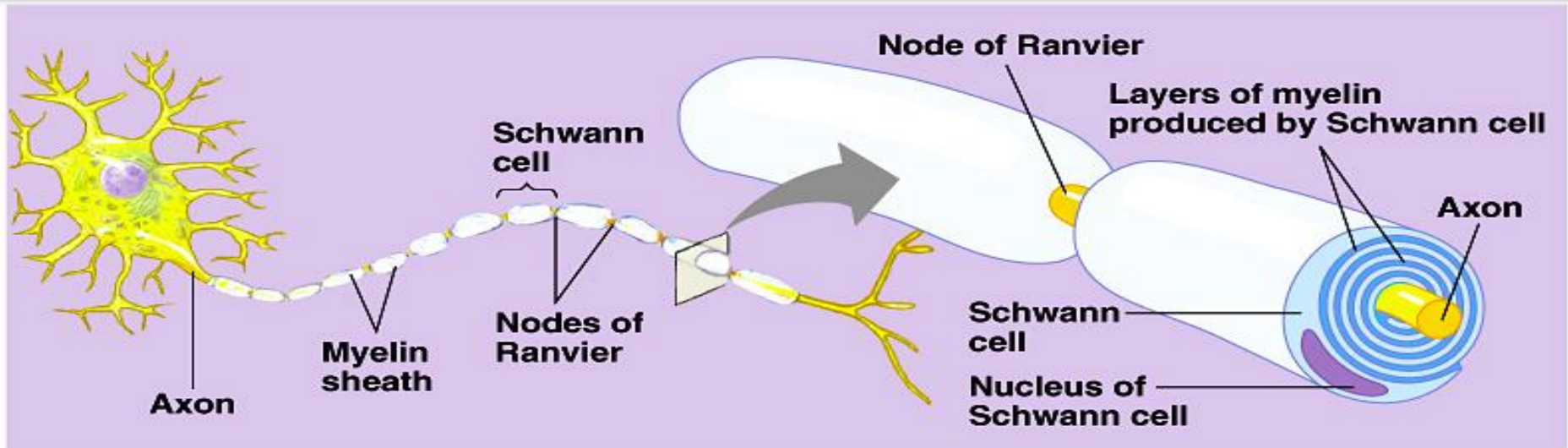
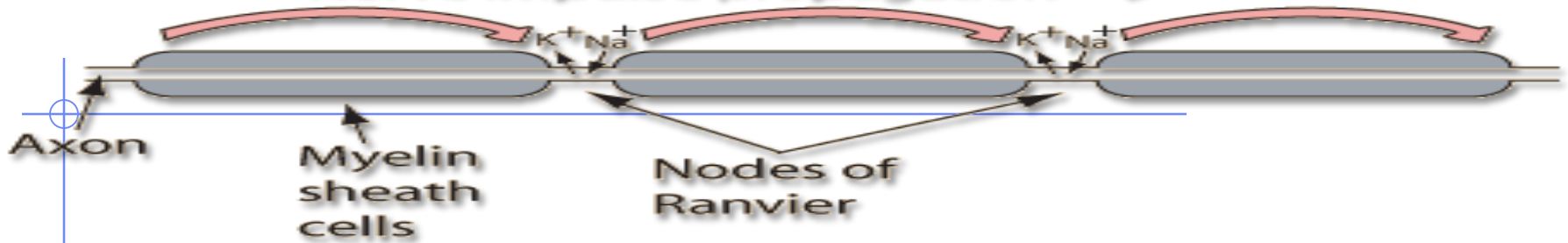
# Myelin sheath

signal  
direction

- made of Schwann cells
  - ◆ cells coat axon
    - insulate axon
  - ◆ saltatory conduction
    - signal hops from node to node
  - ◆ 150m/sec vs. 5m/sec (330mph vs. 11mph)

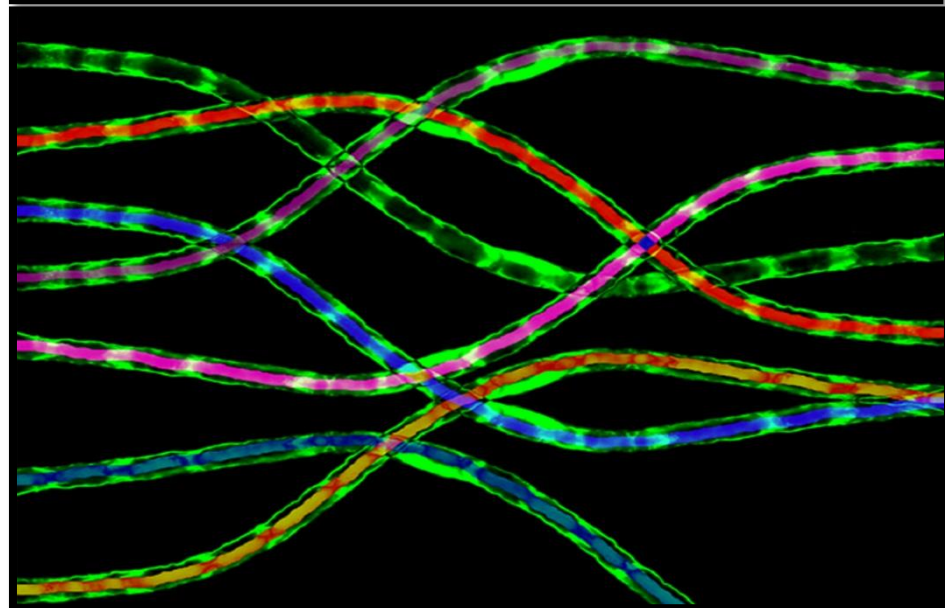


# Nerve impulse propagation →



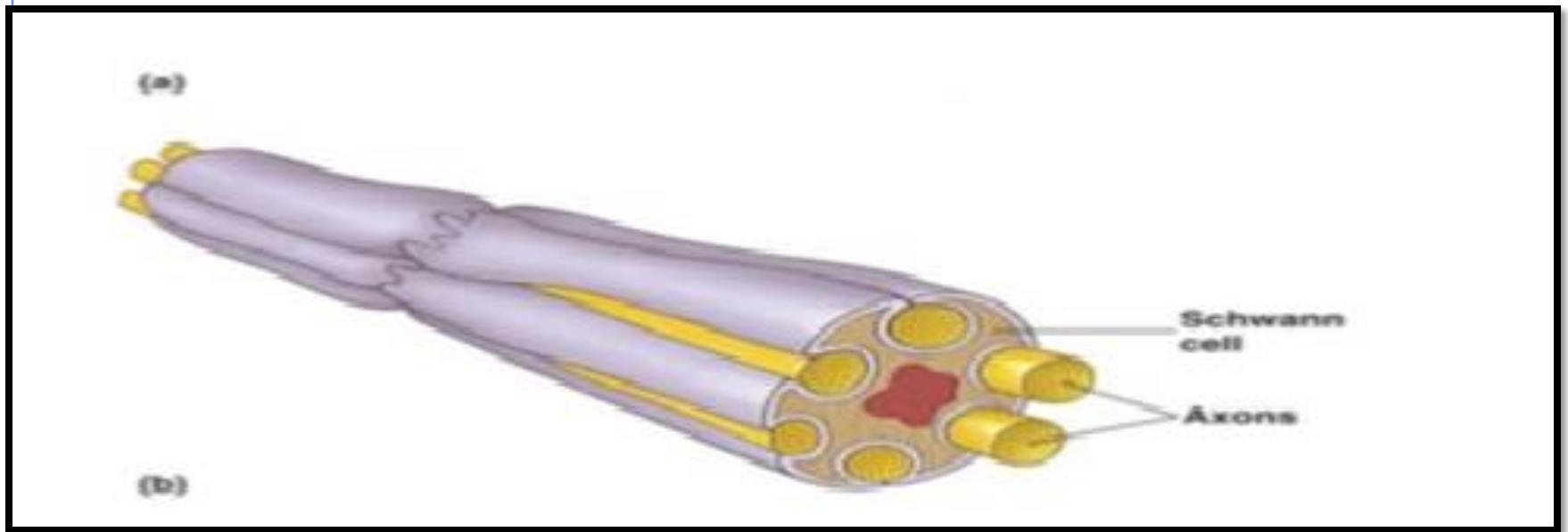


# Myelinated nerve fibers



## B- Un myelinated nerve fibers

- A nerve fibers is Un myelinated nerve fibers, and consists of a nerve surrounded by only nervous sheath .



# Neurotransmitters

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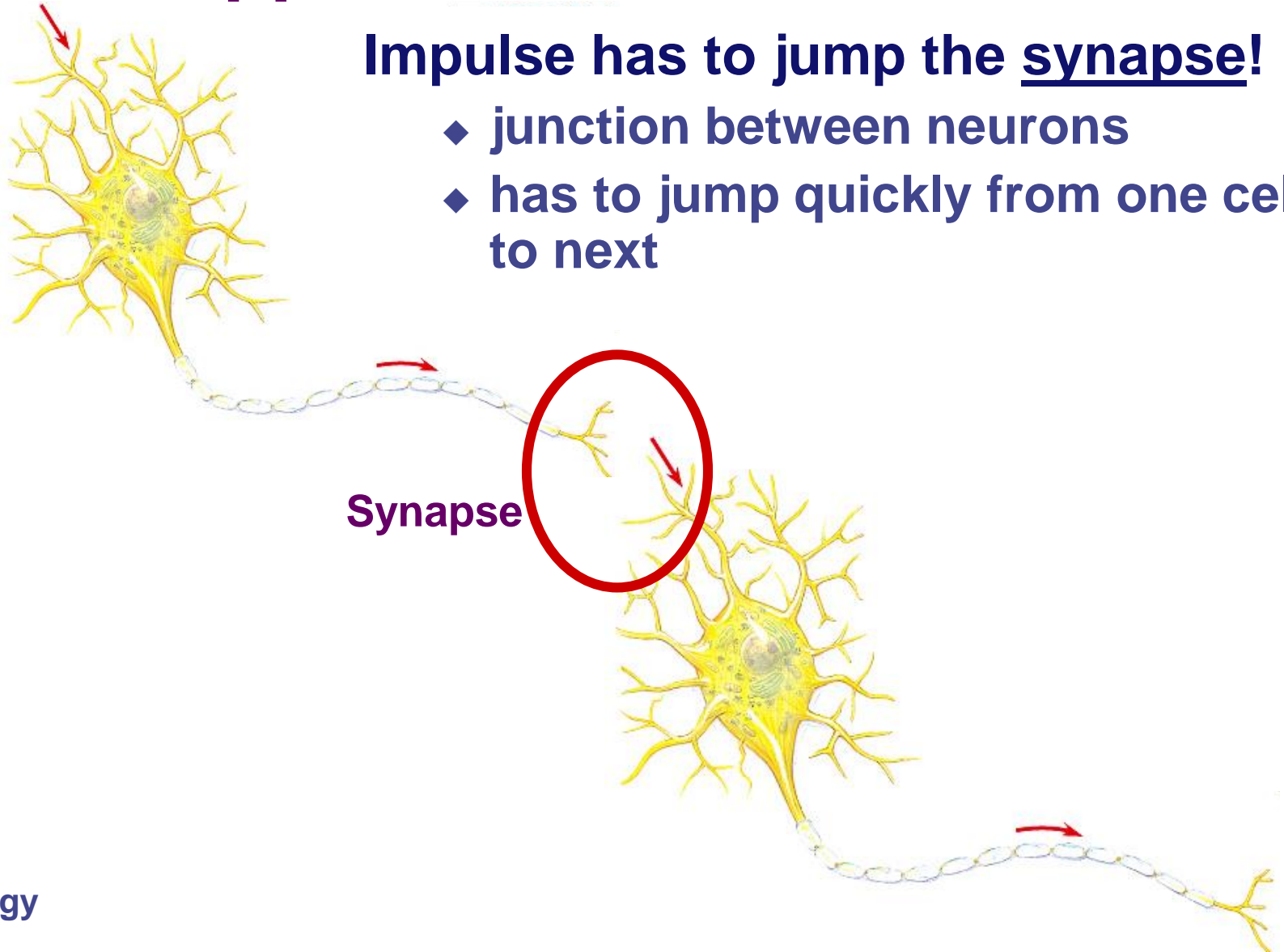
- **Acetylcholine**
  - ◆ transmit signal to skeletal muscle
- **Epinephrine (adrenaline) & norepinephrine**
  - ◆ fight-or-flight response
- **Dopamine**
  - ◆ widespread in brain
  - ◆ affects sleep, mood, attention & learning
  - ◆ lack of dopamine in brain associated with Parkinson's disease
  - ◆ excessive dopamine linked to schizophrenia
- **Serotonin**
  - ◆ widespread in brain
  - ◆ affects sleep, mood, attention & learning



# What happens at the end of the axon?

Impulse has to jump the synapse!

- ◆ junction between neurons
- ◆ has to jump quickly from one cell to next



# Role of chemical transmitter

- When the nervous impulse reached to the ends of nerve fibers that lead to the secretion of chemical conductors that moves in a way to spread to other nerve cell surface or to the surface of the muscle fiber as the lead in ways unknown to the de polarization of the membrane fiber and then be instructing a neurological or muscle contraction

# Role of chemical transmitter

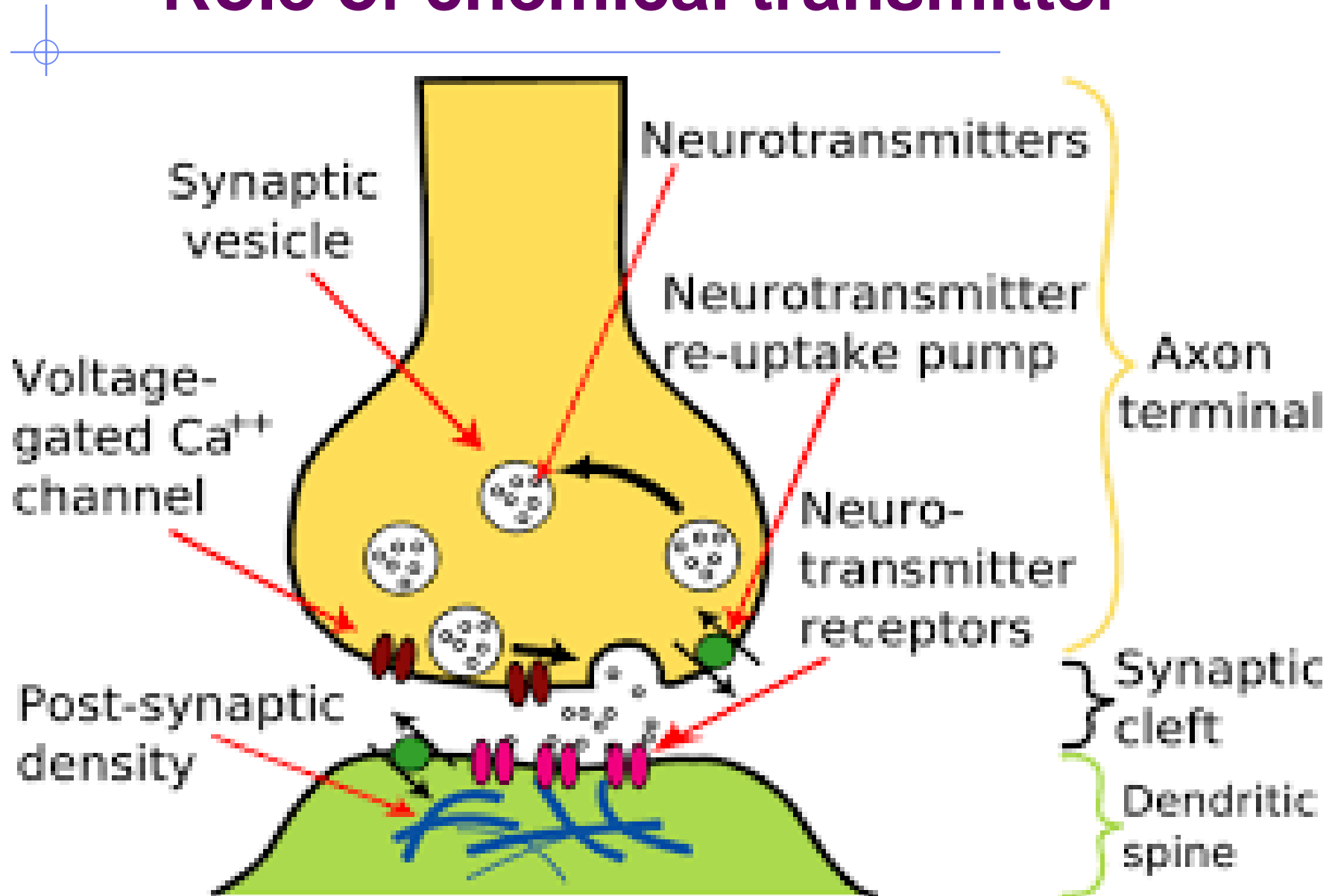
- To the membrane returns to the state of polarization again must removed the chemical material quickly and this is done chemical decomposition by carrier enzymes like Colin esterase enzyme (Cholinesterase) which analyzes acetylcholine, this leading to increased permeability to sodium and potassium ionic as well as changing the voltage of the membrane by chemical material are: -

1-acetylcholine

2- epinephrine and norepinephrine

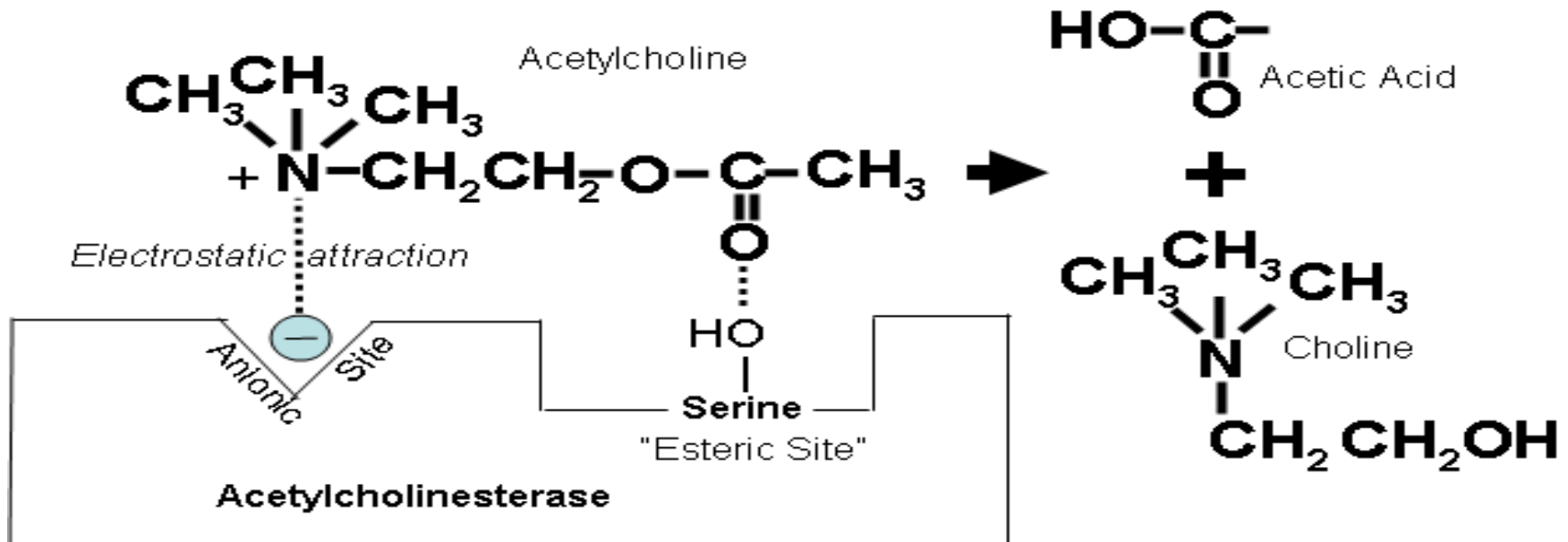
3- histamine .

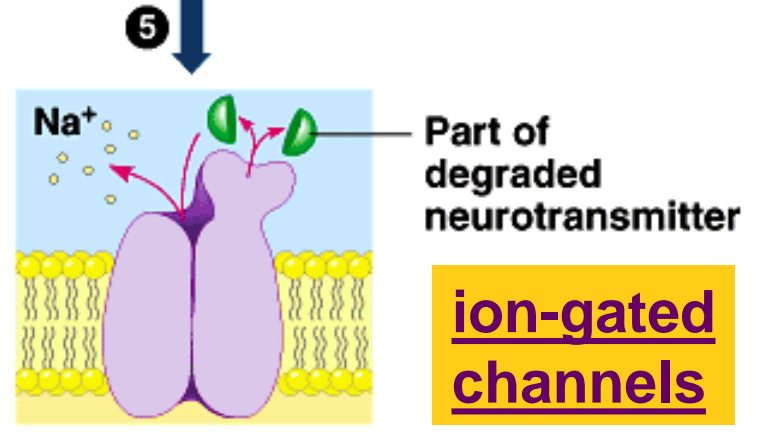
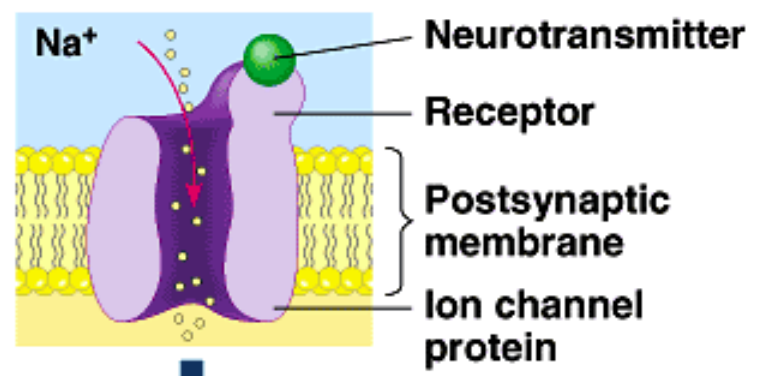
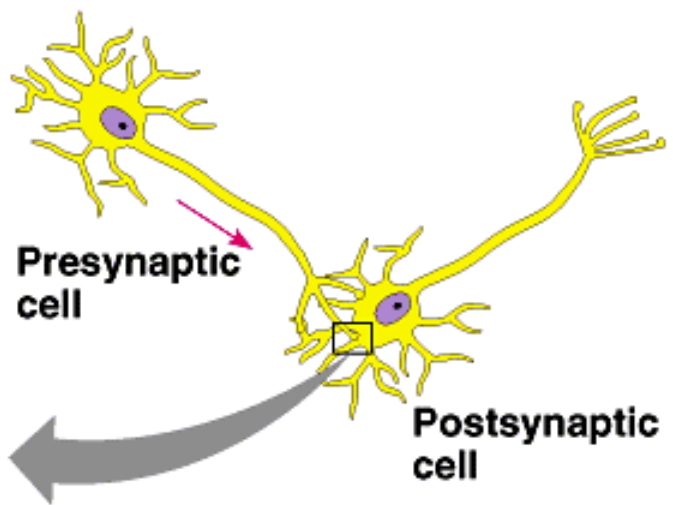
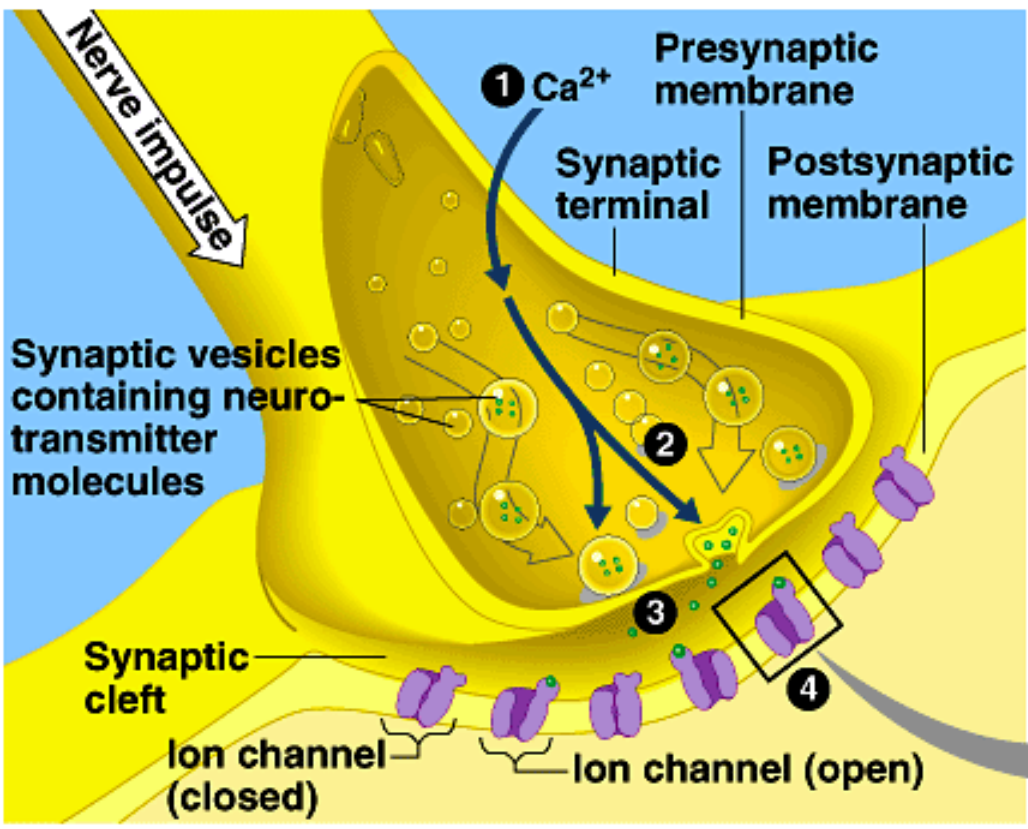
# Role of chemical transmitter



# Acetylcholine

- **Acetylcholine** is an organic chemical that functions in the brain and body of many types of animals, including humans, as a neurotransmitter—a chemical released by nerve cells to send signals to other cells.
- Its name is derived from its chemical structure: it is an ester of acetic acid and choline, it **has functions both in the peripheral nervous system (PNS) and in the central nervous system (CNS) as a neuromodulator.**





**ion-gated channels**

**Chemical synapse: follow the path**

- action depolarizes membrane
- triggers influx of Ca<sup>+</sup>
- vesicles fuse with membrane
- release neurotransmitter to cleft
- neurotransmitter bind with receptor
- neurotransmitter degraded / reabsorbed



# Nerve impulse in next neuron

- **Post-synaptic neuron**

- ◆ triggers nerve impulse in next nerve cell

- chemical signal opens “ion-gated” channels
- $\text{Na}^+$  diffuses into cell
- $\text{K}^+$  diffuses out of cell

