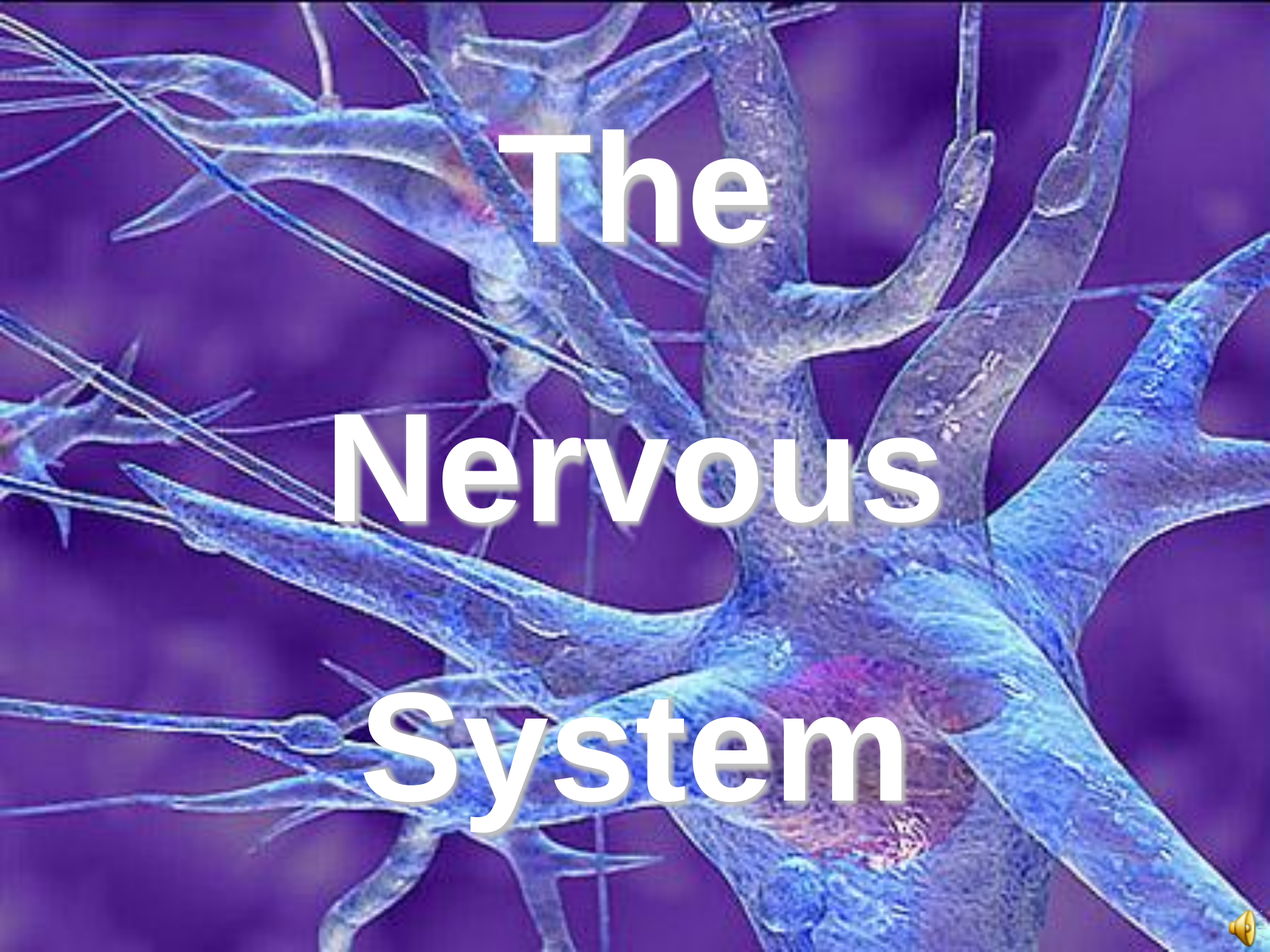
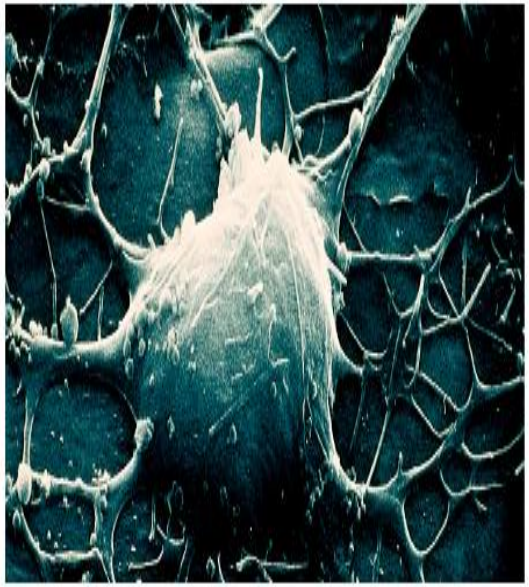
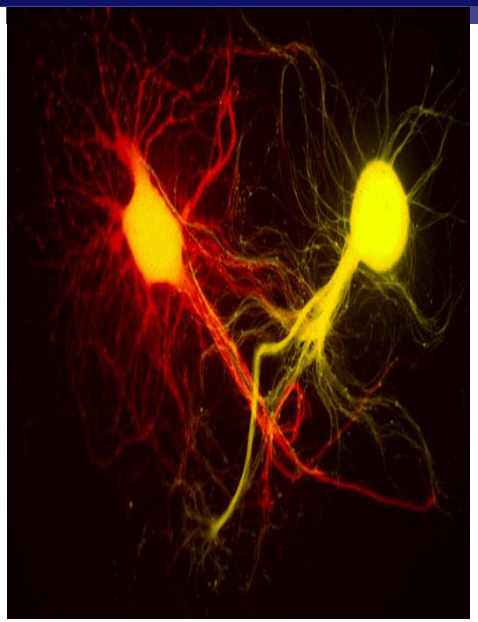
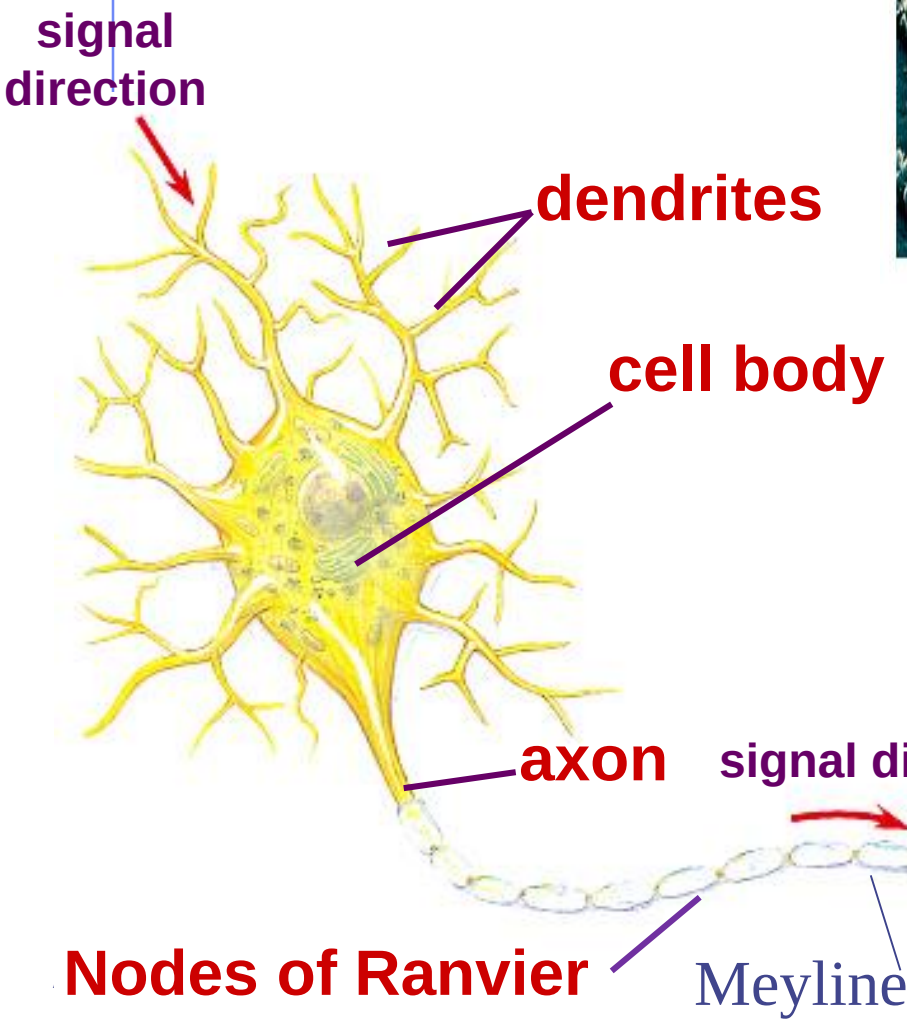

The
Nervous
System

- Neuron (nerve cell)

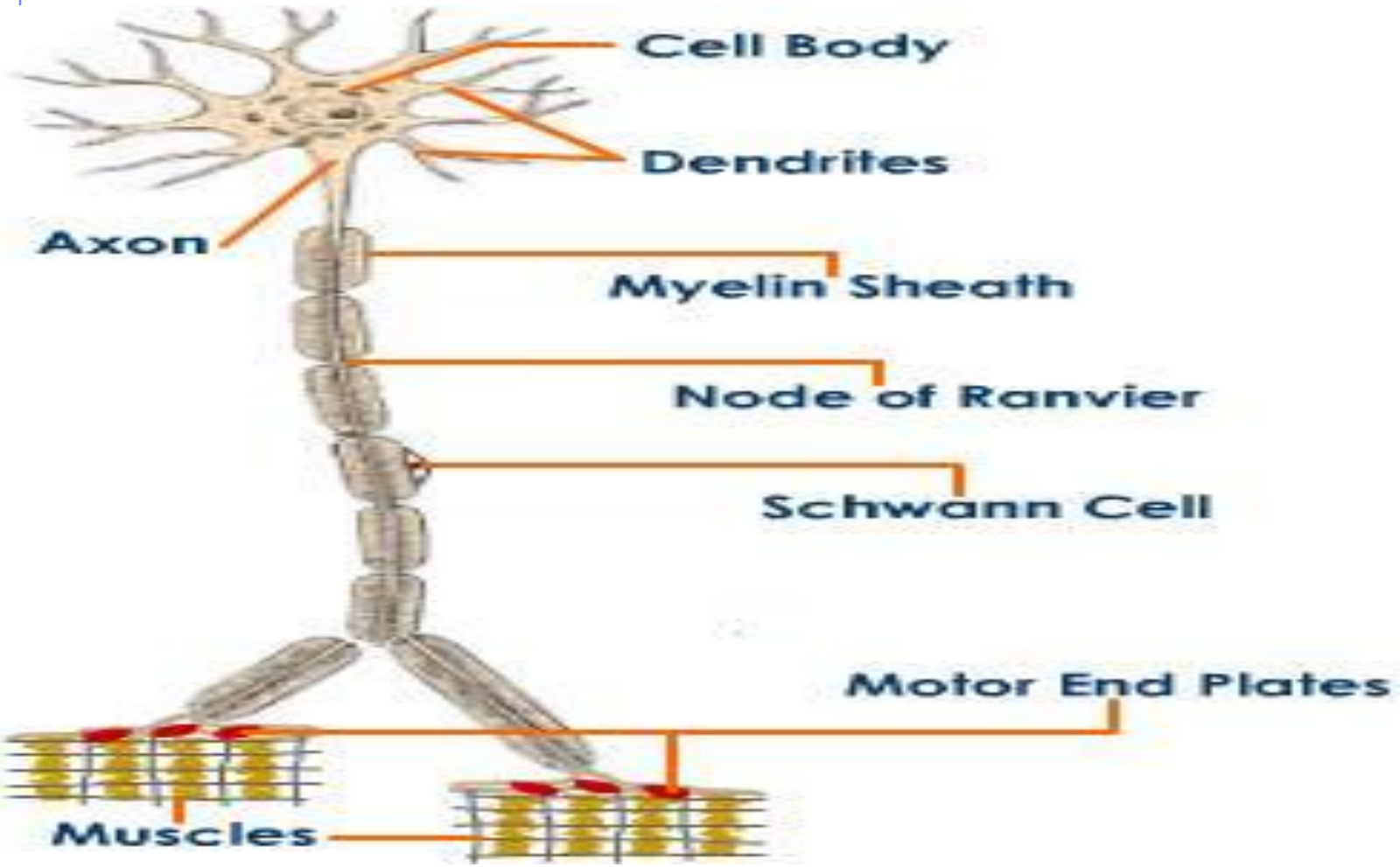






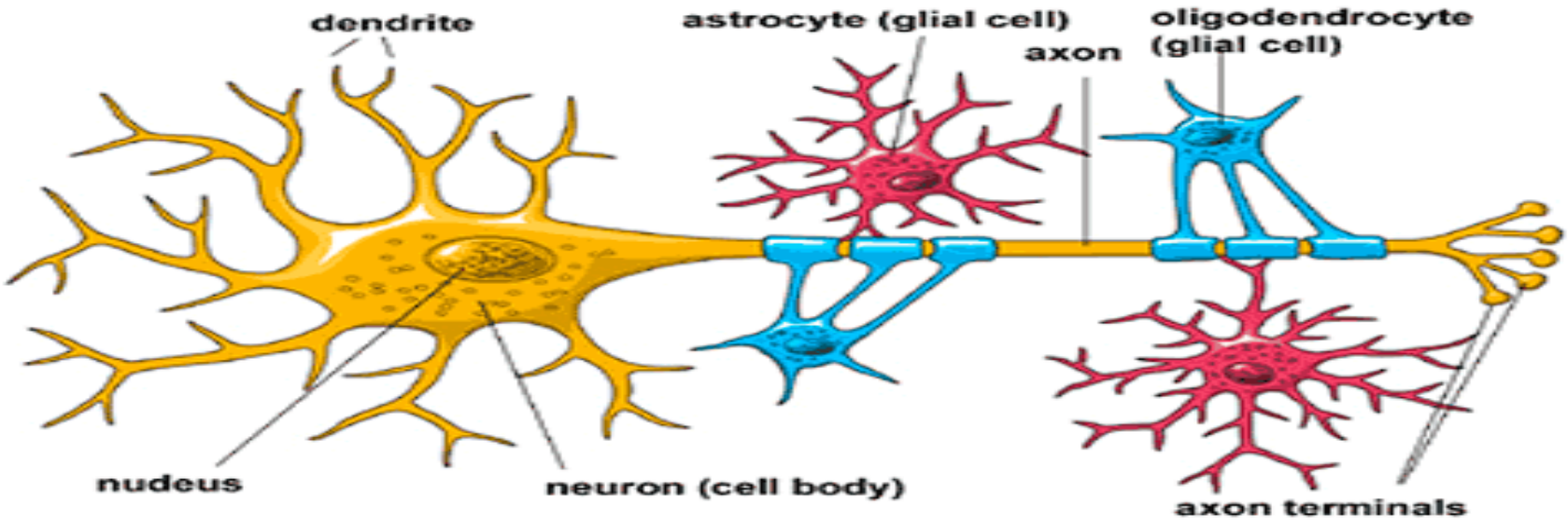
- Structure fits function, it have many entry points for signal one path out transmits signal

Neuron (nerve cell)



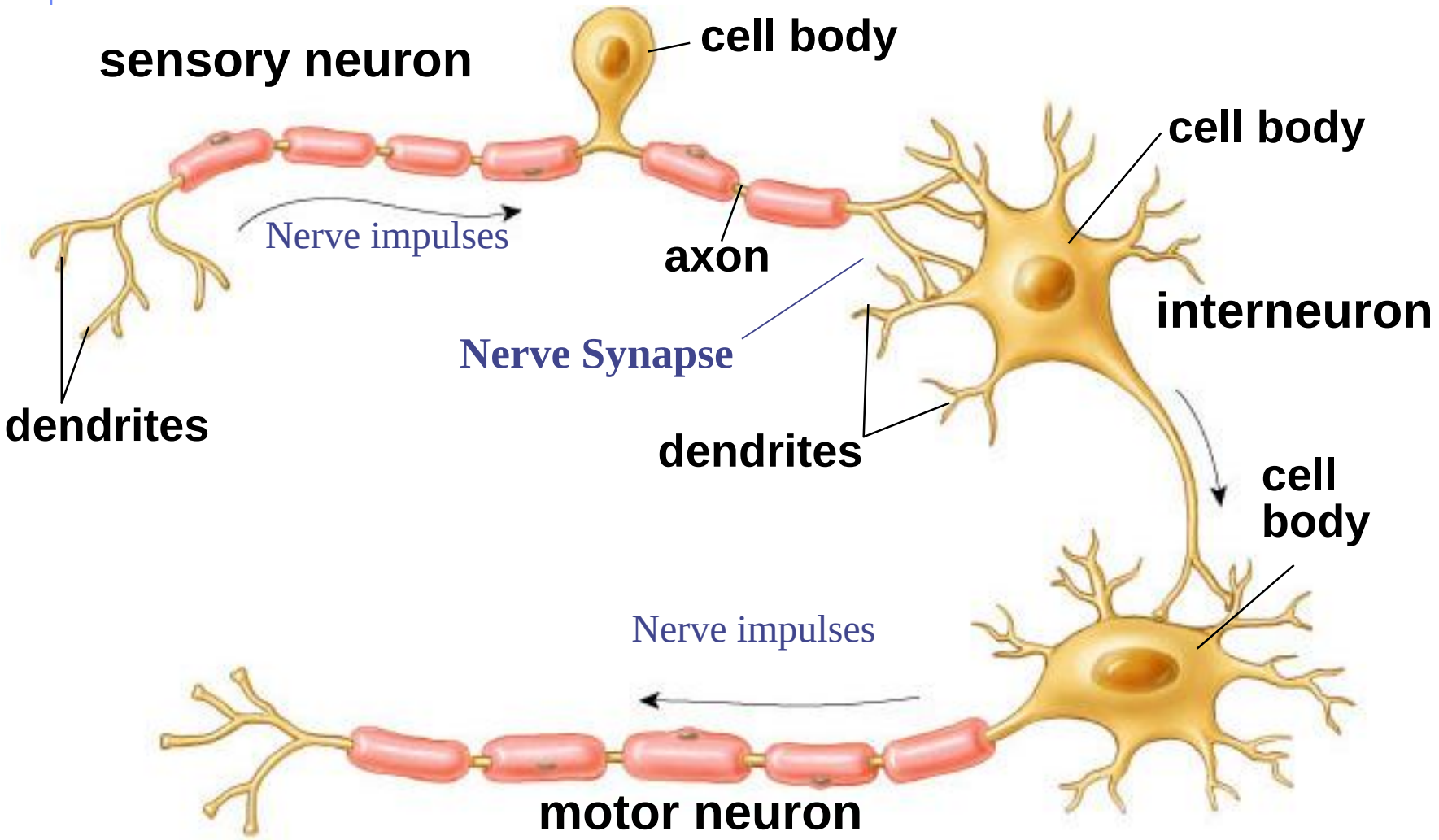
Neurons support

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



Types of neurons:-

1- Sensory neuron 2- Motor neuron

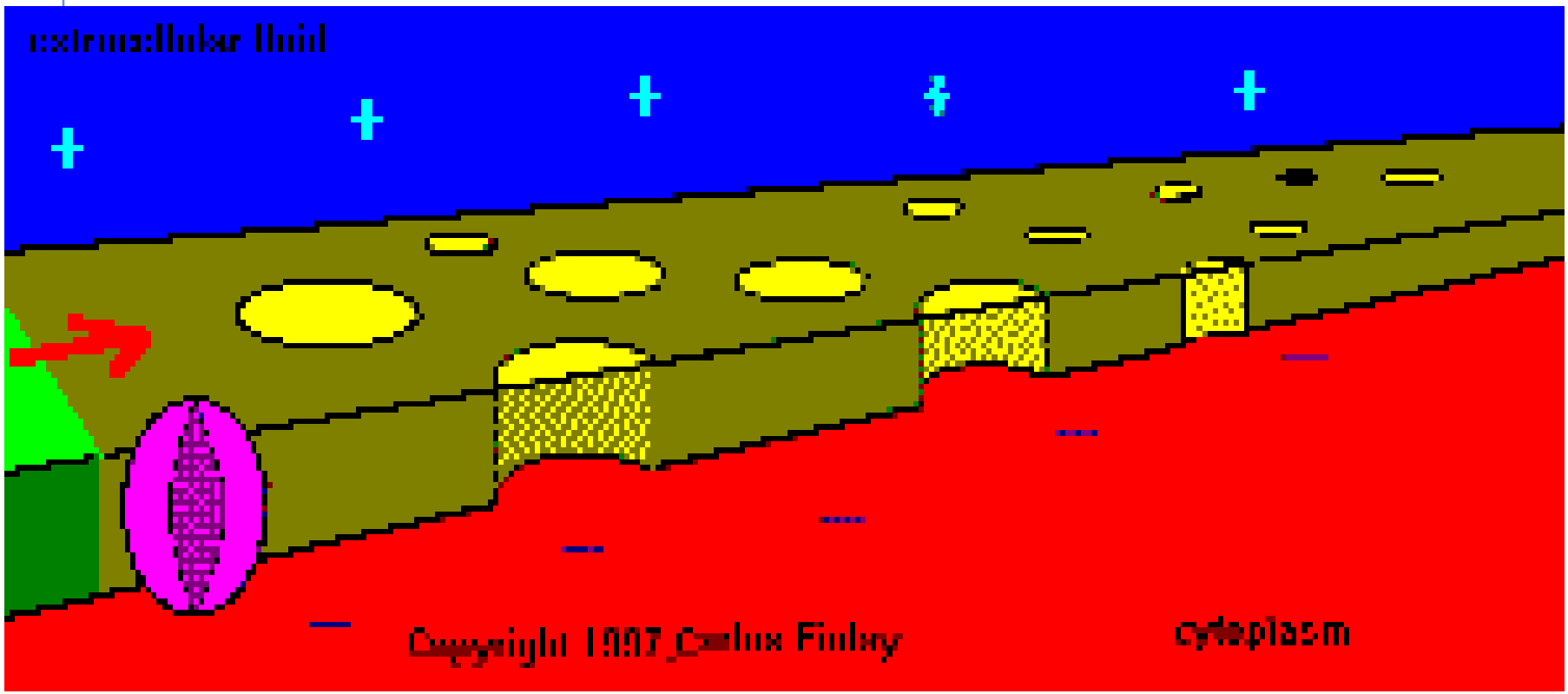


Excitability (Electric potential)

1- **Resting potential**

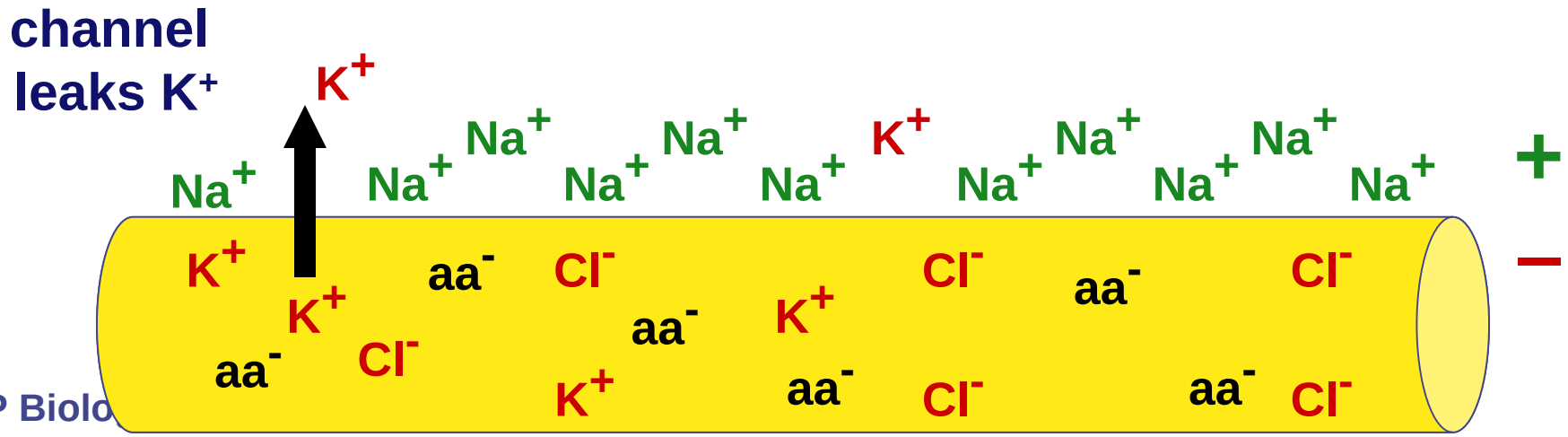
2-**Threshold potential**

3- **Action potential**



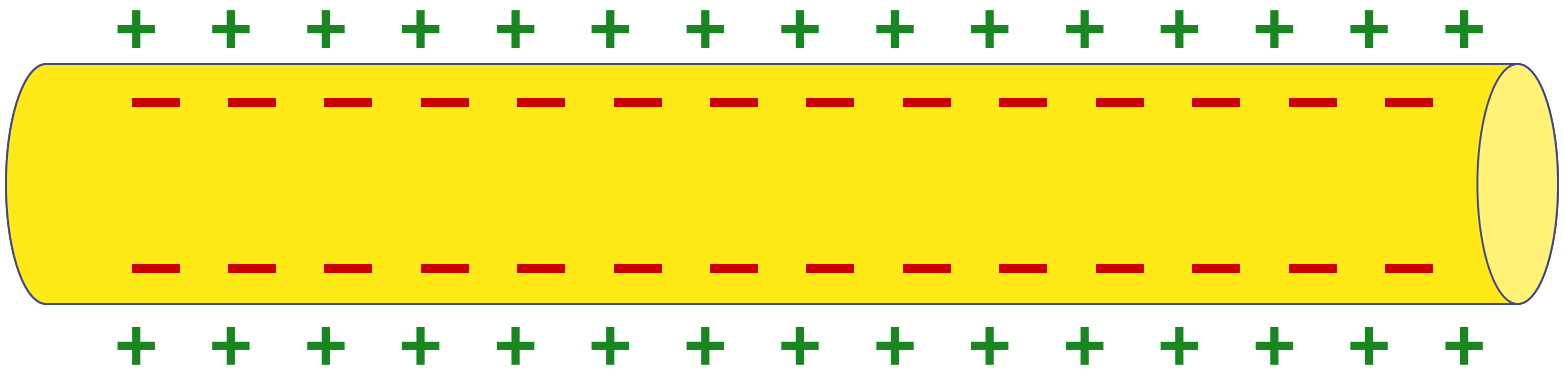
Cells: surrounded by charged ions

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



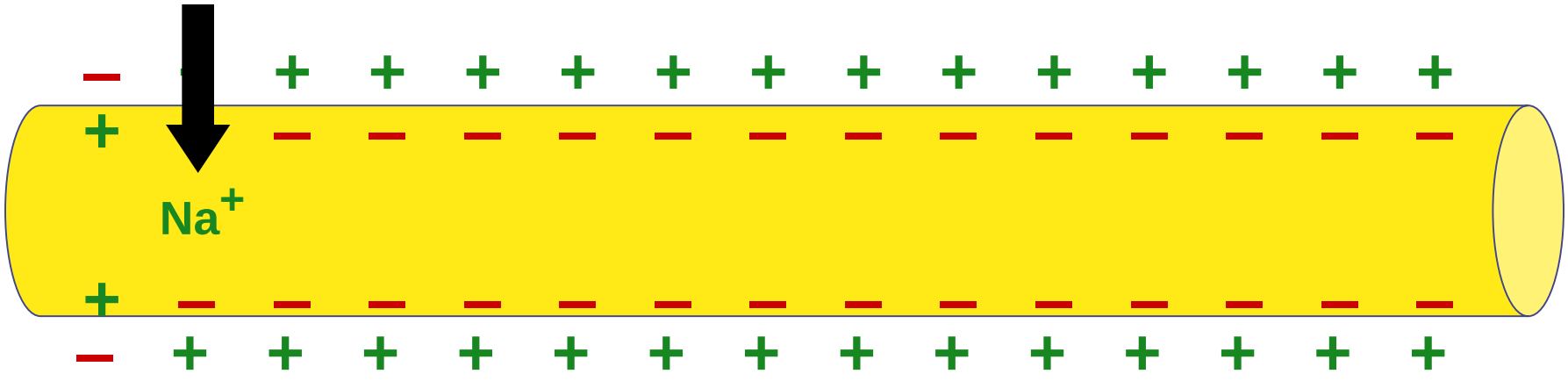
Cells have voltage!

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



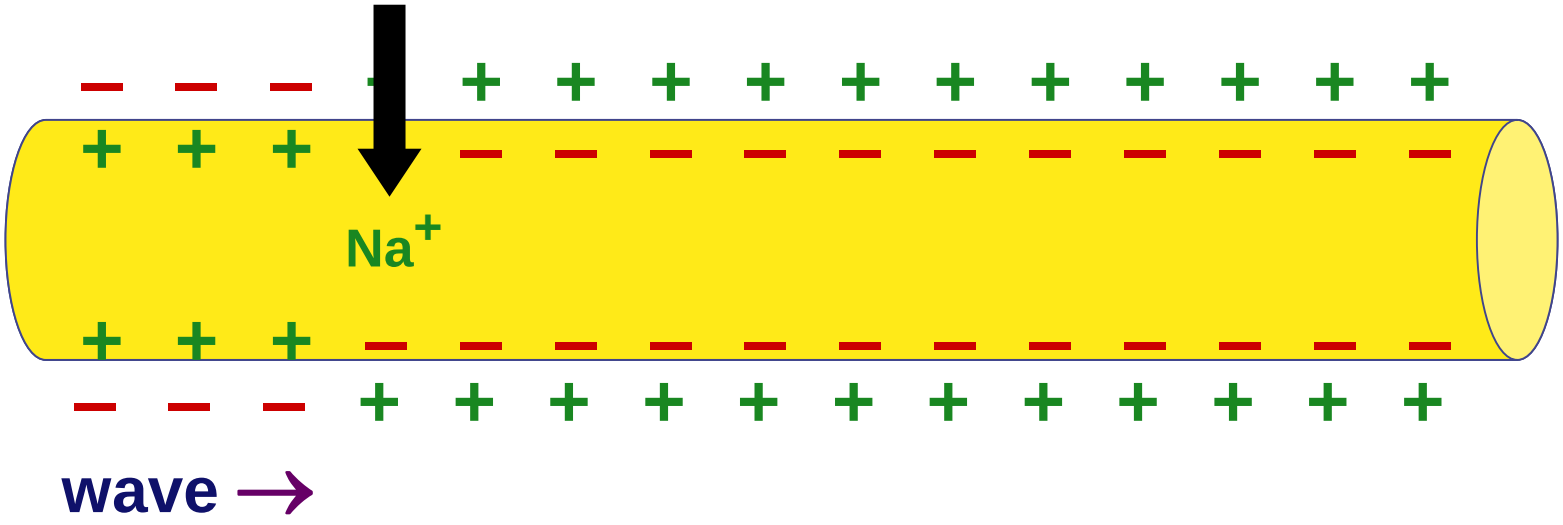
How does a nerve impulse travel?

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



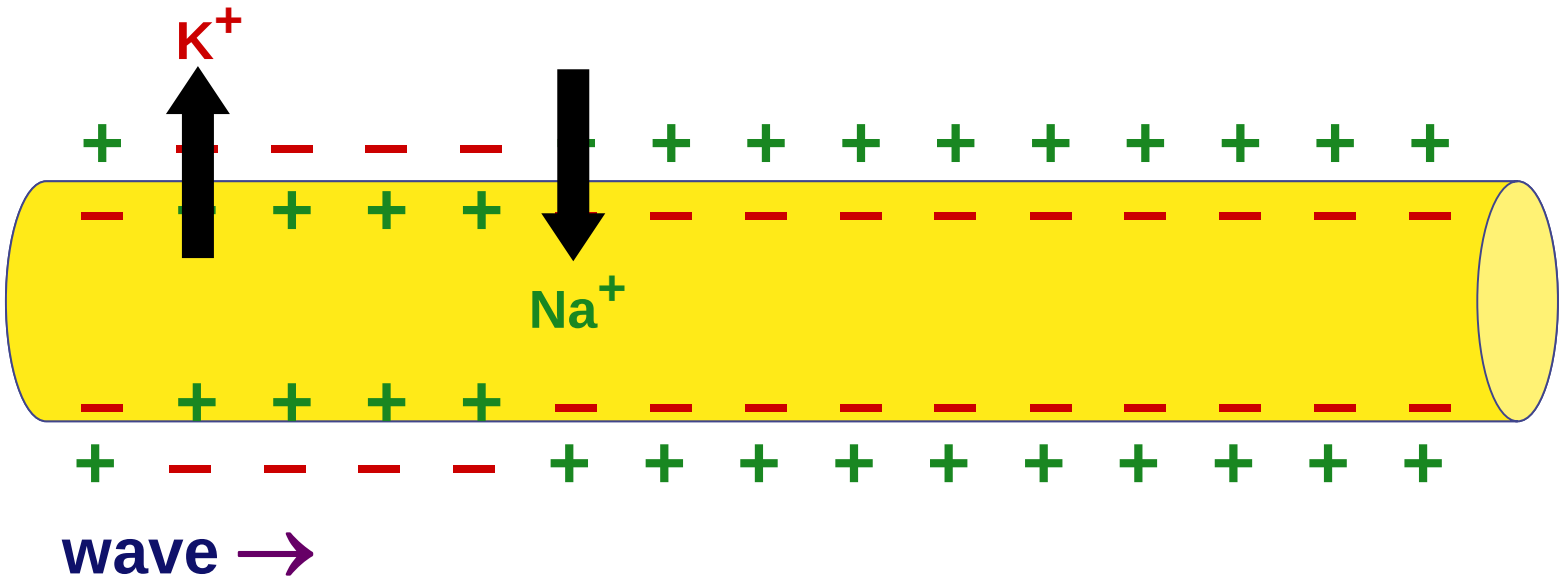
How does a nerve impulse travel?

- **Wave**: nerve impulse travels down neuron
  - change in charge opens other Na^+ gates in next section of cell
  - Na^+ ions continue to move into cell
  - "wave" moves down neuron = action potential



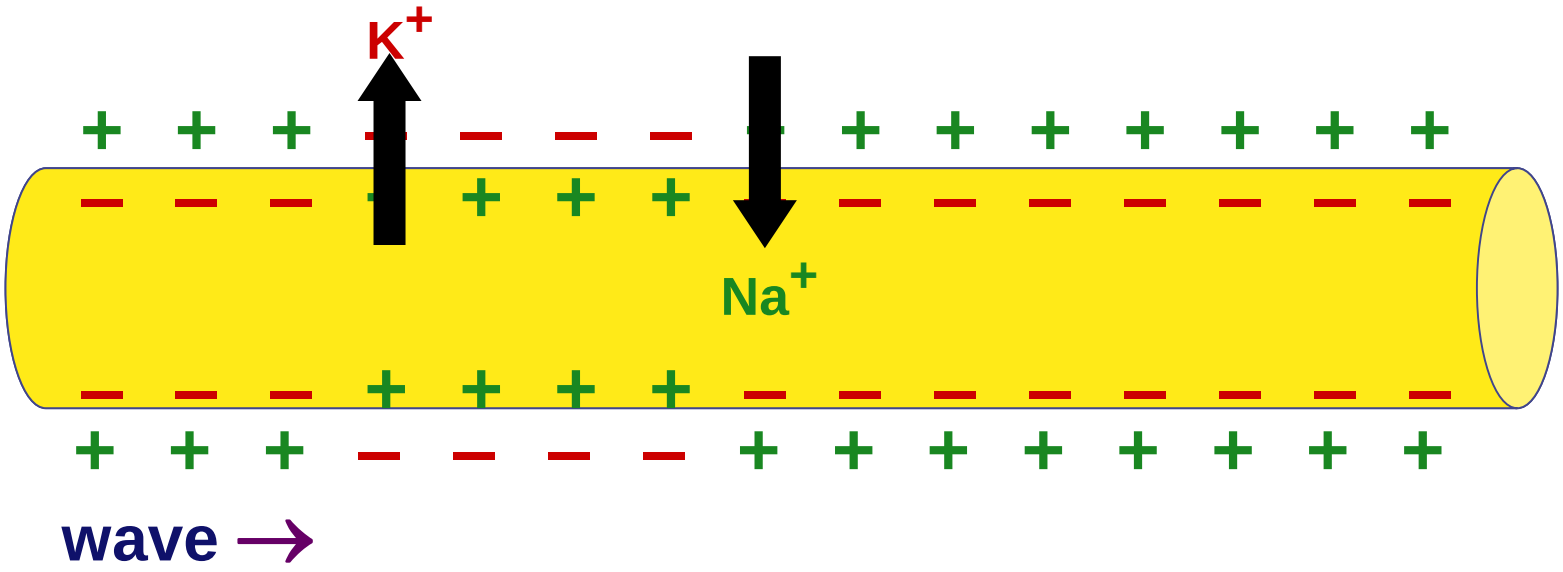
How does a nerve impulse travel?

- **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



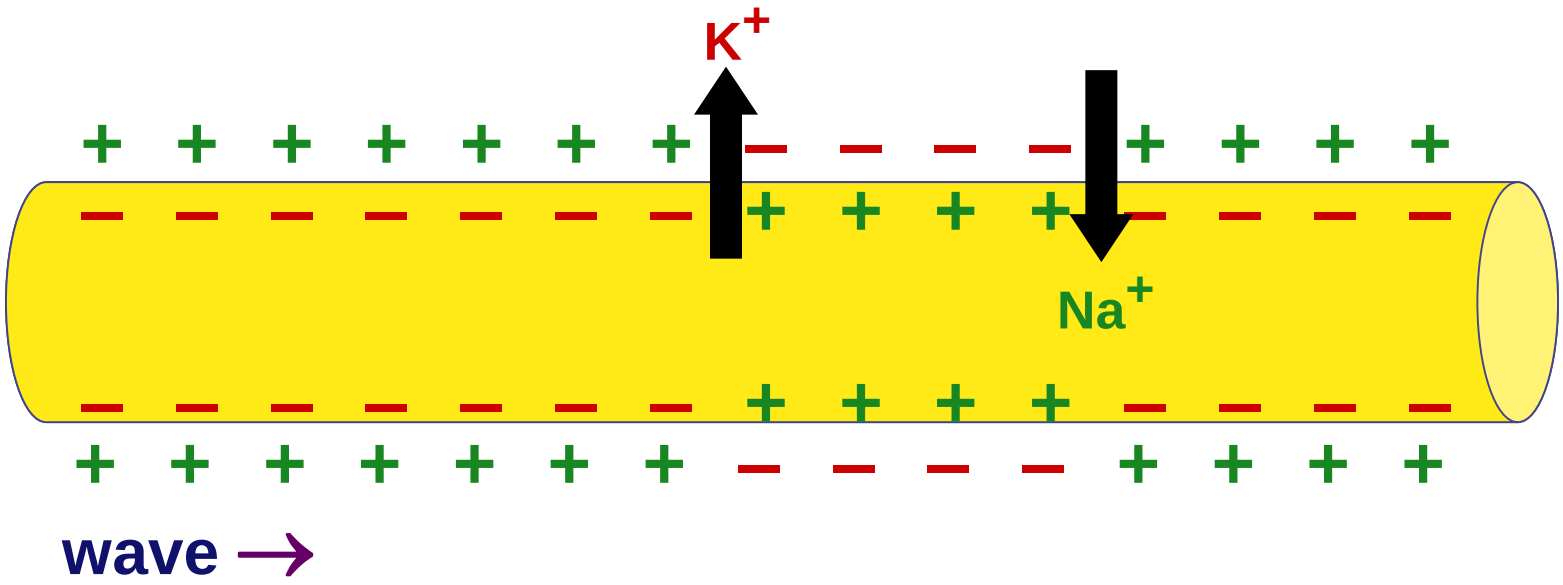
How does a nerve impulse travel?

- **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**



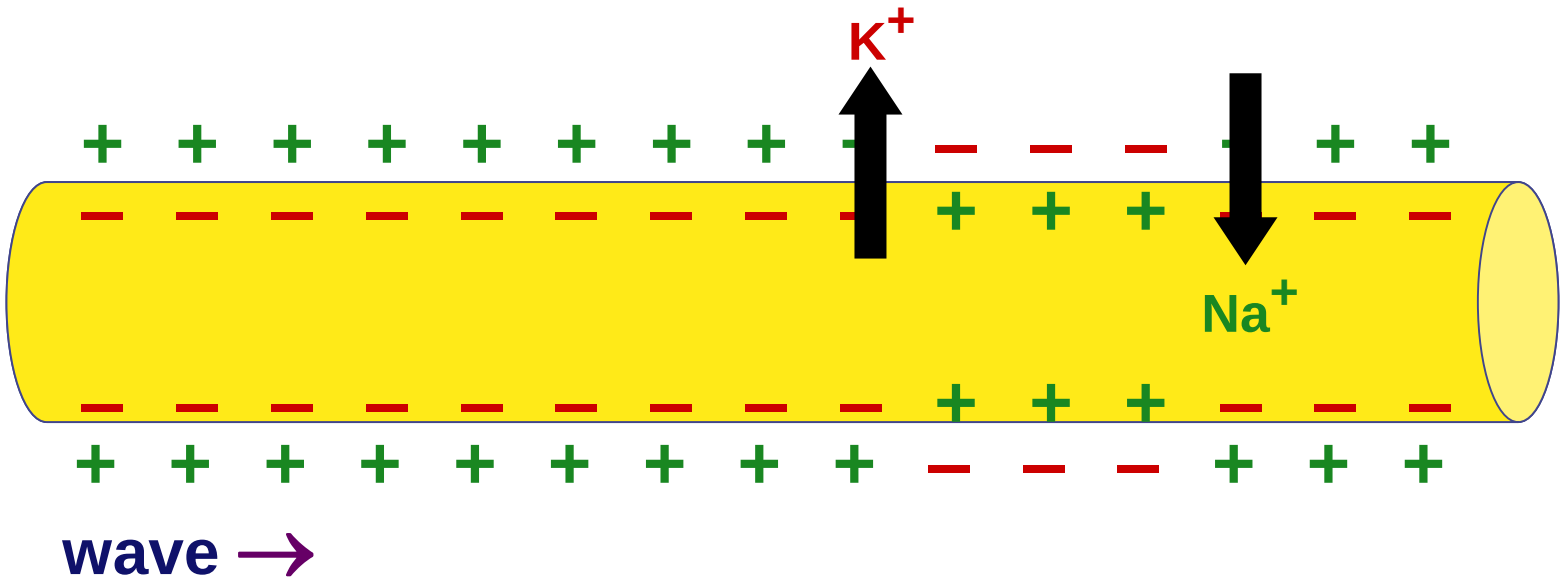
How does a nerve impulse travel?

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



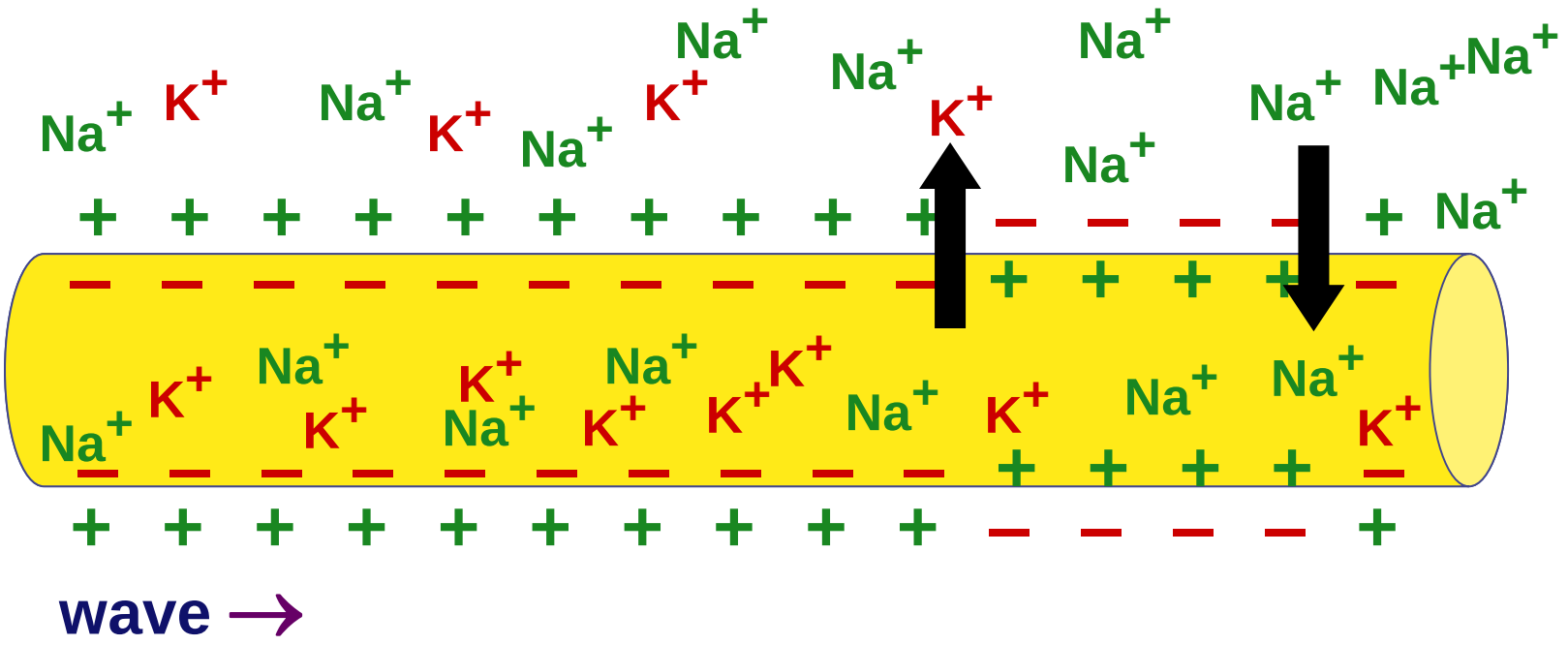
Voltage-gated channels

- Ion channels open & close in response to changes in charge across membrane
  - Na^+ channels open <u>quickly</u> in response to depolarization & close slowly
  - K^+ channels open <u>slowly</u> in response to depolarization & close slowly



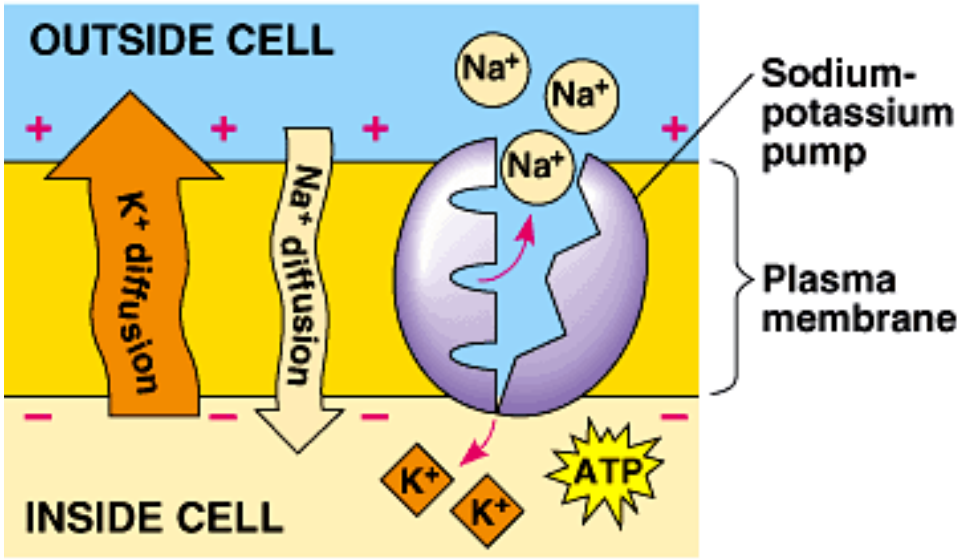
How does the nerve re-set itself?

- After firing a neuron has to re-set itself
  - Na^+ needs to move back <u>out</u>
  - K^+ needs to move back <u>in</u>
  - both are moving <u>against</u> concentration gradients
    - need a pump!!

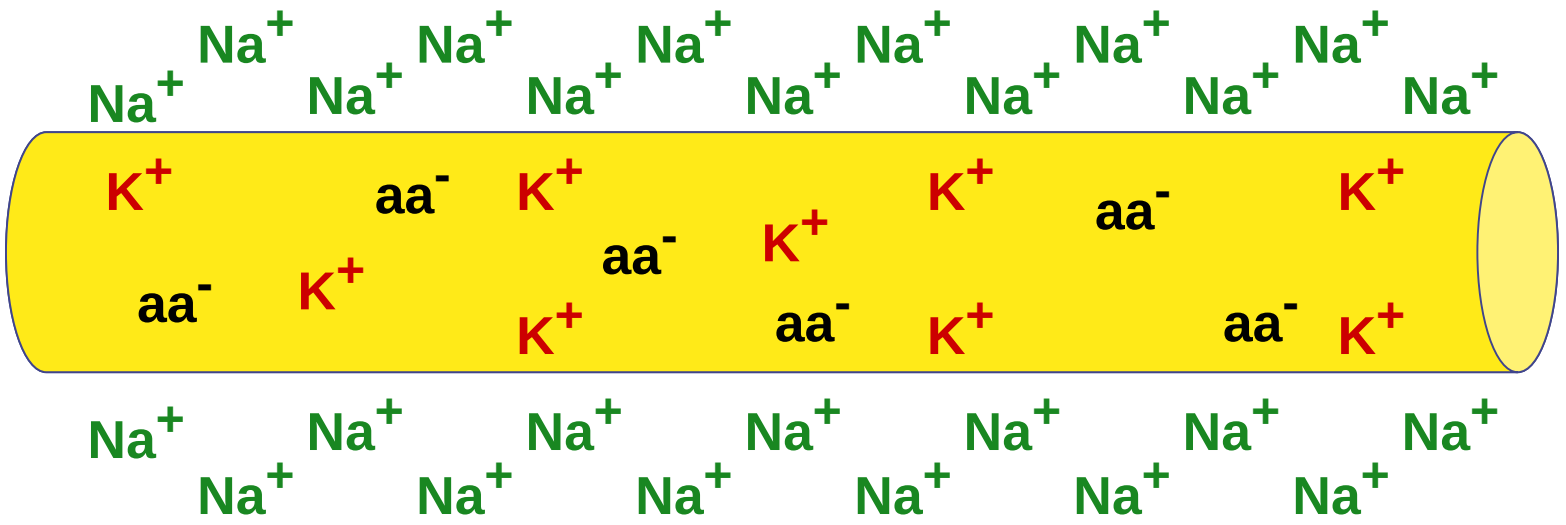


How does the nerve re-set itself?

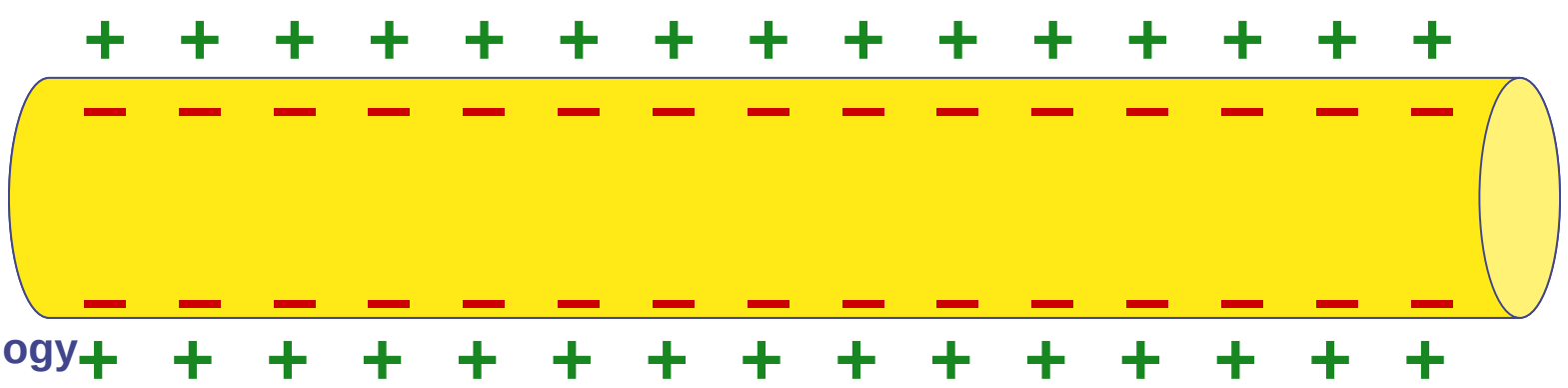
- Na^+ / K^+ pump
  - active transport protein in membrane
    - requires ATP
  - 3 Na^+ pumped out
  - 2 K^+ pumped in
  - re-sets charge across membrane



Neuron is ready to fire again (link)

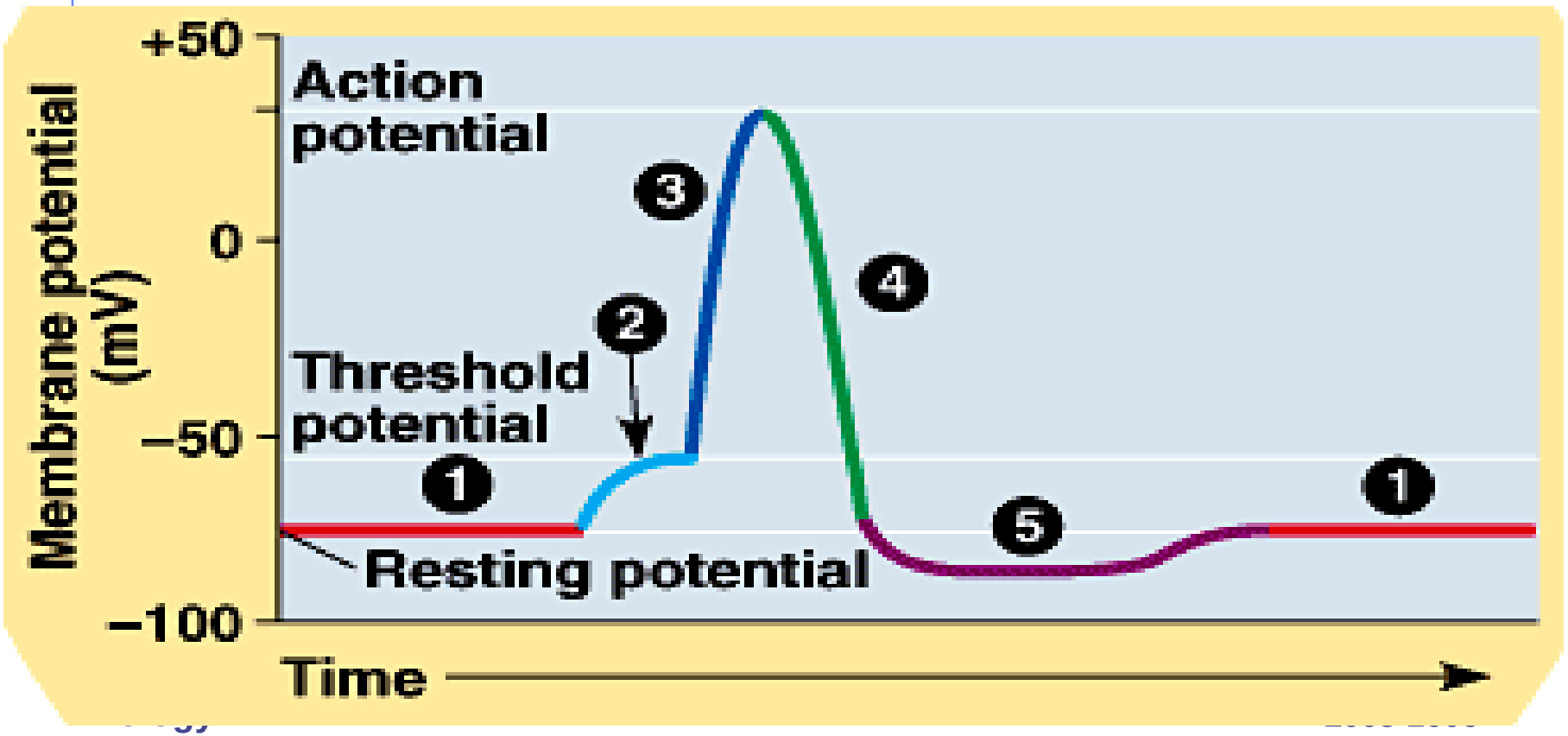


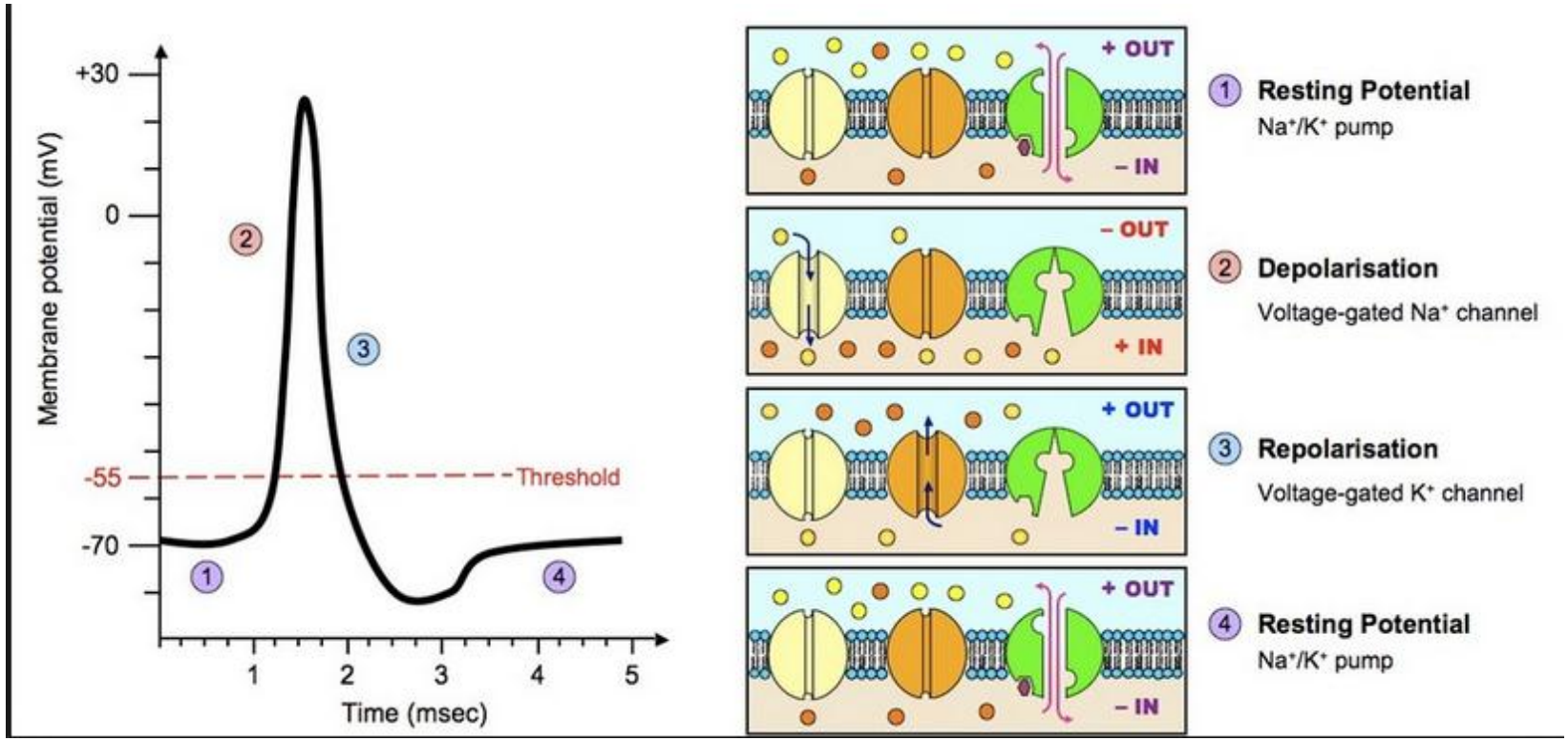
resting potential



Action potential graph

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




+30
0
-55
-70
Membrane potential (mV)
Threshold
1
2
3
4
5
Time (msec)
+ OUT
– IN
– OUT
+ IN
+ OUT
– IN
+ OUT
– IN
1 Resting Potential
Na+/K+ pump
2 Depolarisation
Voltage-gated Na+ channel
3 Repolarisation
Voltage-gated K+ channel
4 Resting Potential
Na+/K+ pump

Oscill Oscope

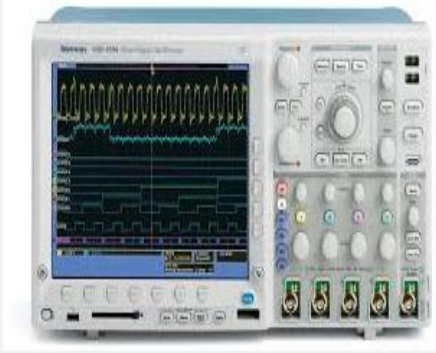






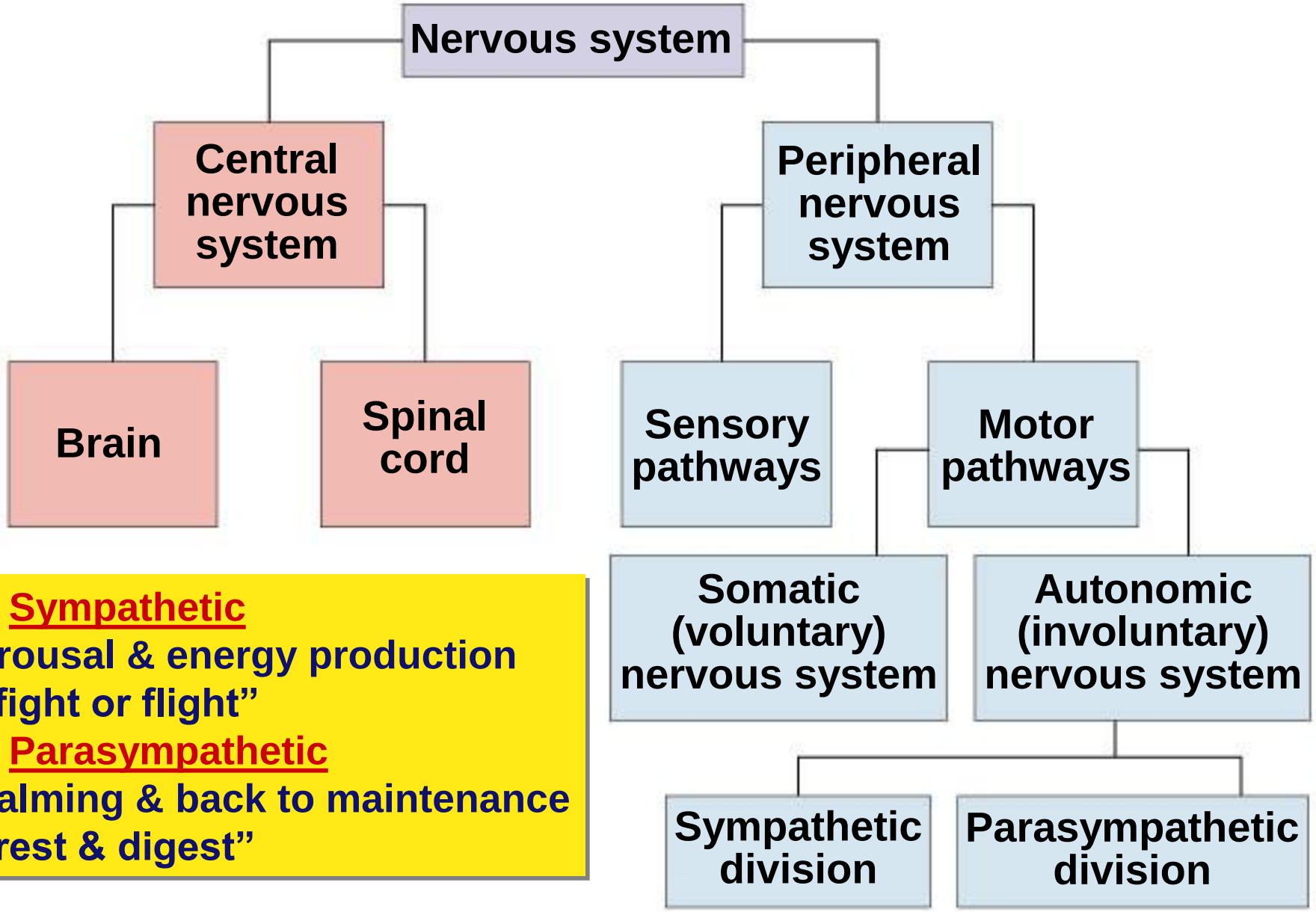






oscilloscope

- 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.



- **Sympathetic**

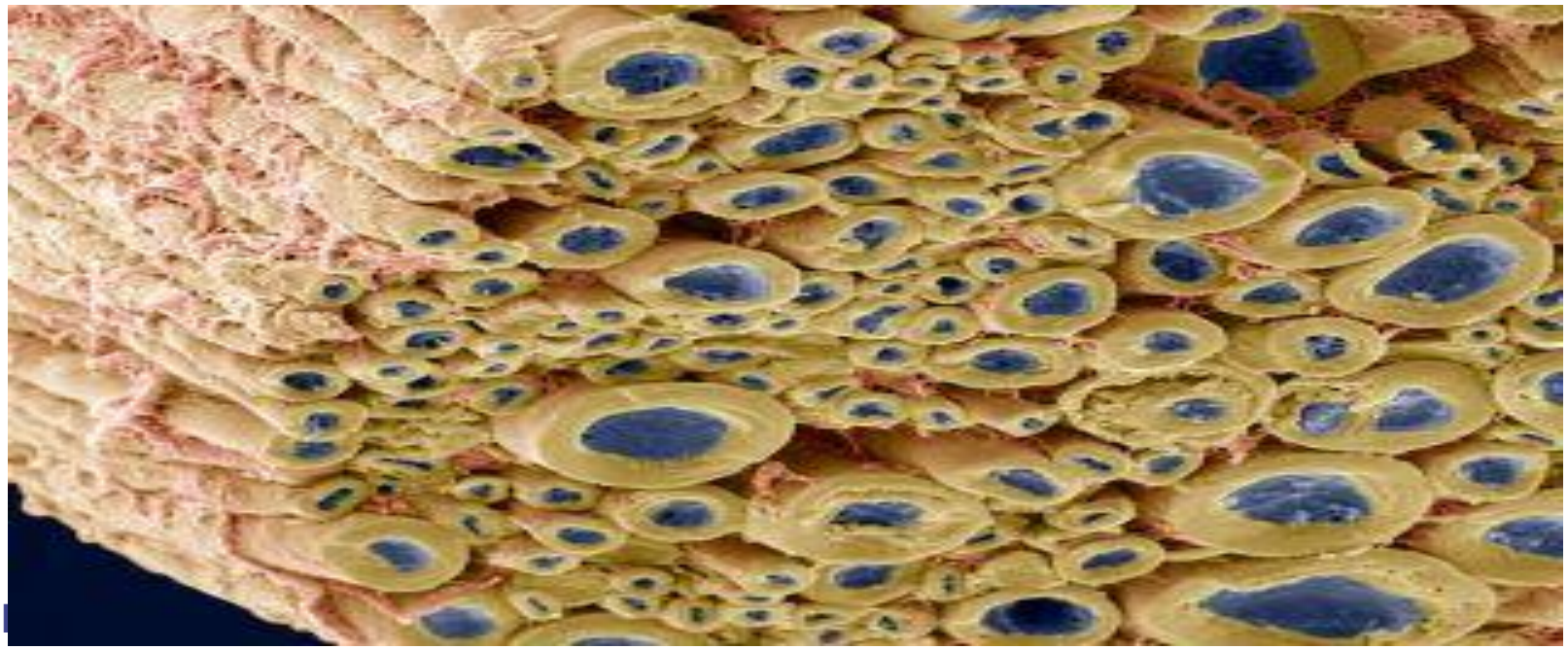
arousal & energy production
"fight or flight"

- **Parasympathetic**

calming & back to maintenance
"rest & digest"

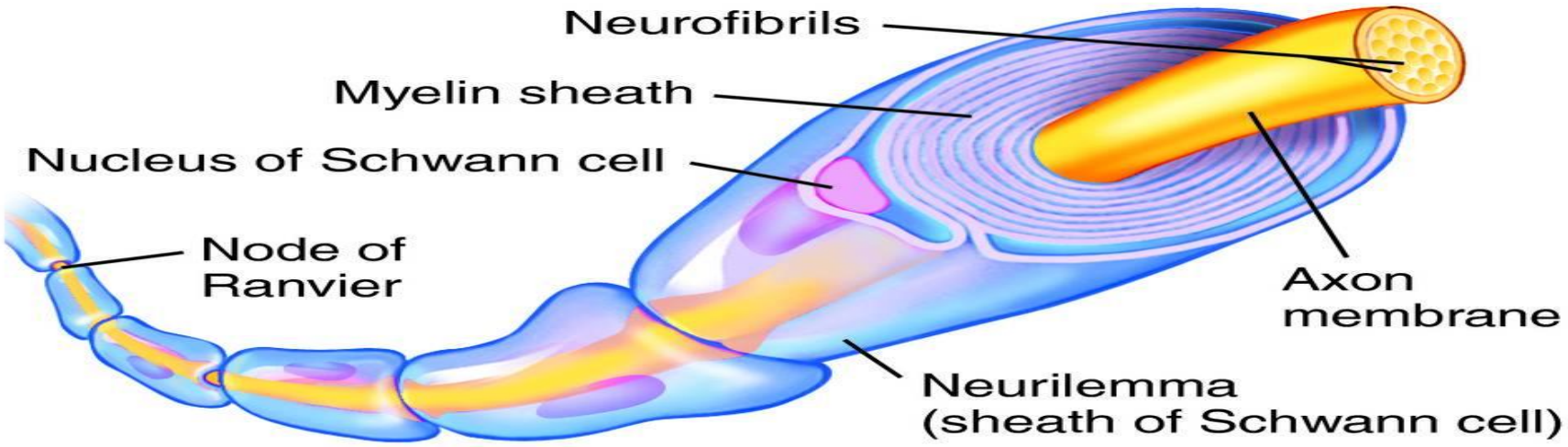
Nerves

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



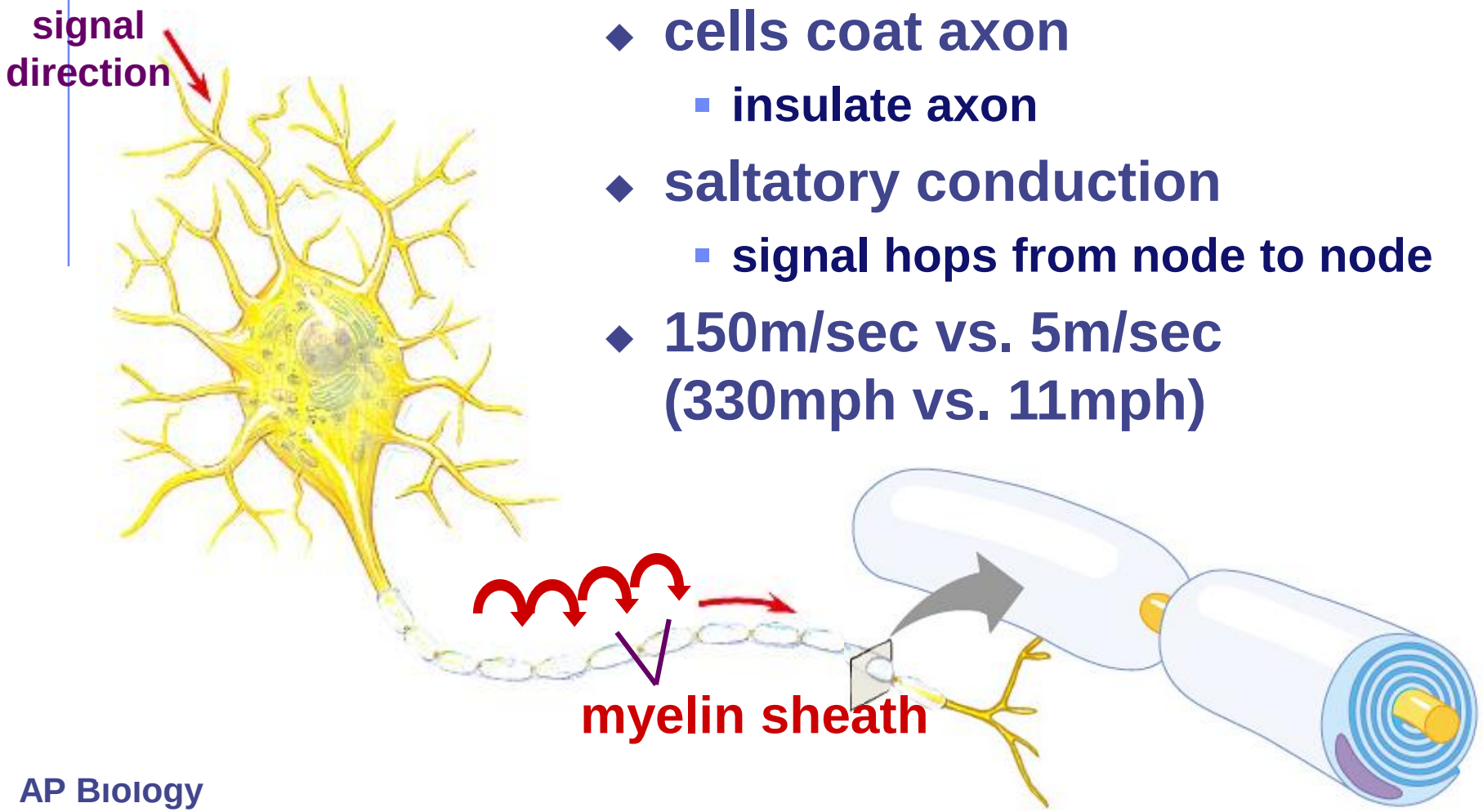
A- Myelinated nerve fibers

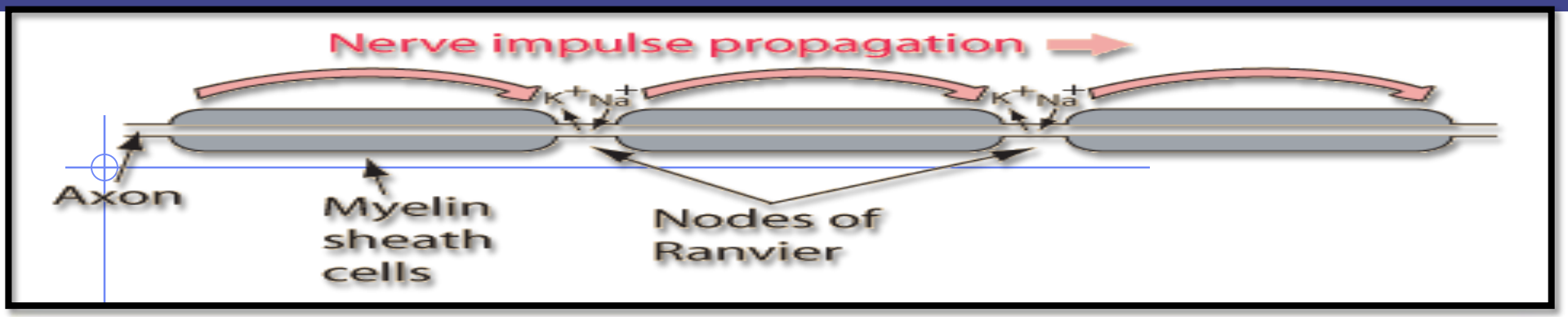
- The Axiss rounded by Myelin sheath which consists of fatty material protein complex in some areas, which are called contract Ranvir Node
- The sheath is an electrical insulator myeloid well axis which consists of amount of fat so it helps the transmission of electrical stimulus are good and faster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

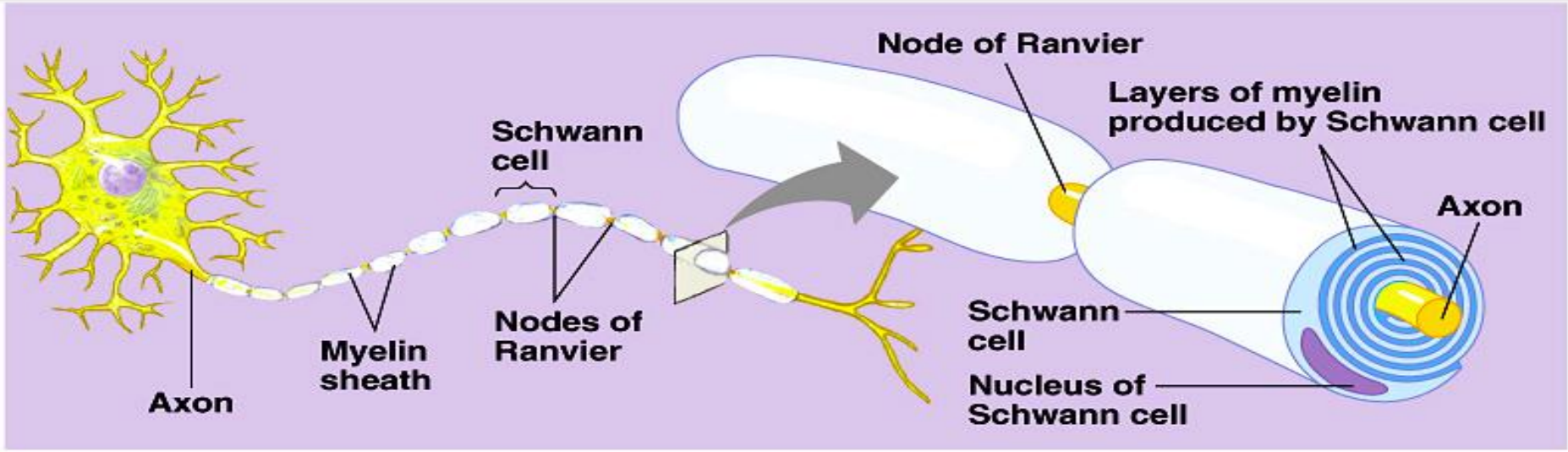


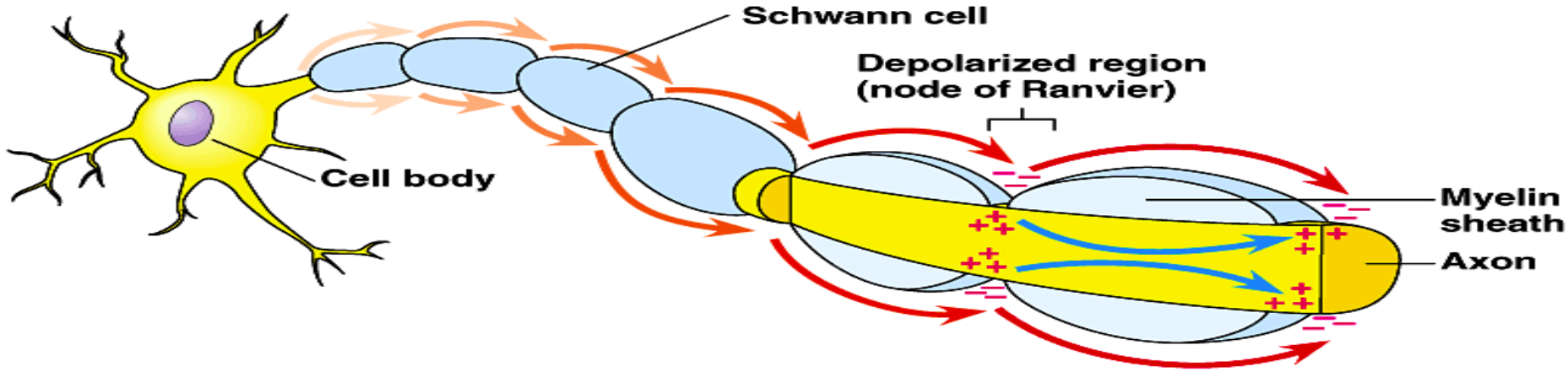
Myelin sheath

- 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)

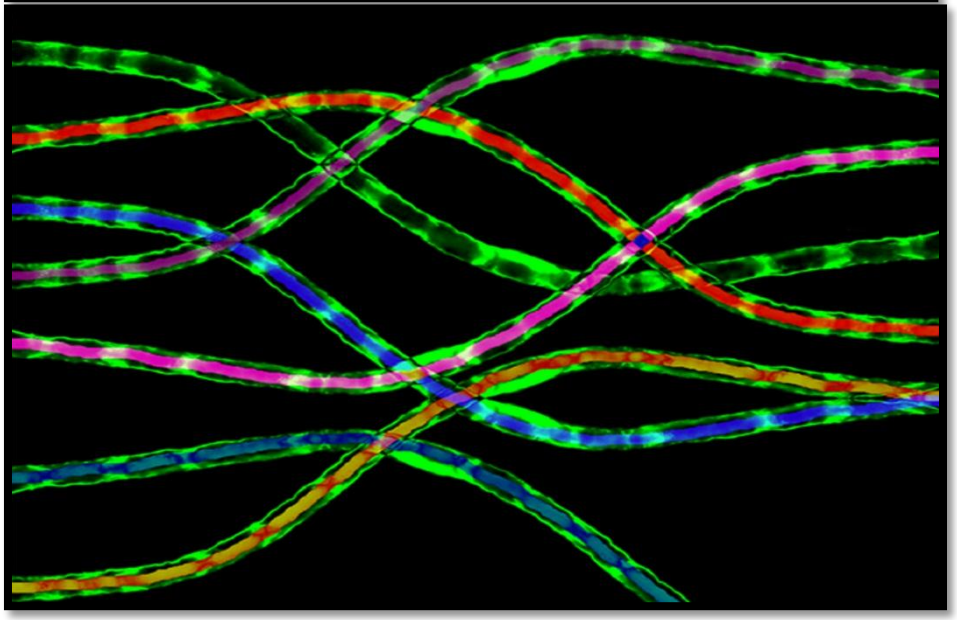



Nerve impulse propagation
K+
Na+
K+
Na+
Axon
Myelin sheath cells
Nodes of Ranvier


Node of Ranvier
Layers of myelin produced by Schwann cell
Schwann cell
Axon
Schwann cell
Nodes of Ranvier
Myelin sheath
Axon
Schwann cell
Nucleus of Schwann cell

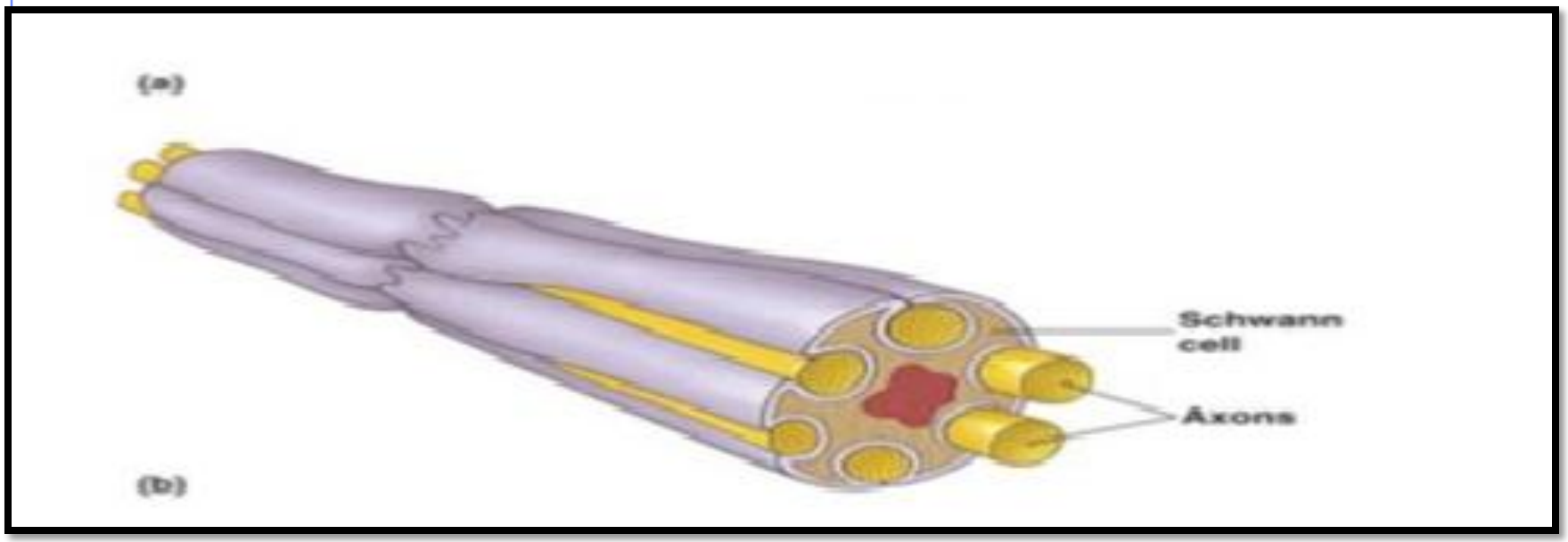

Schwann cell
Depolarized region (node of Ranvier)
Cell body
Myelin sheath
Axon

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 .**



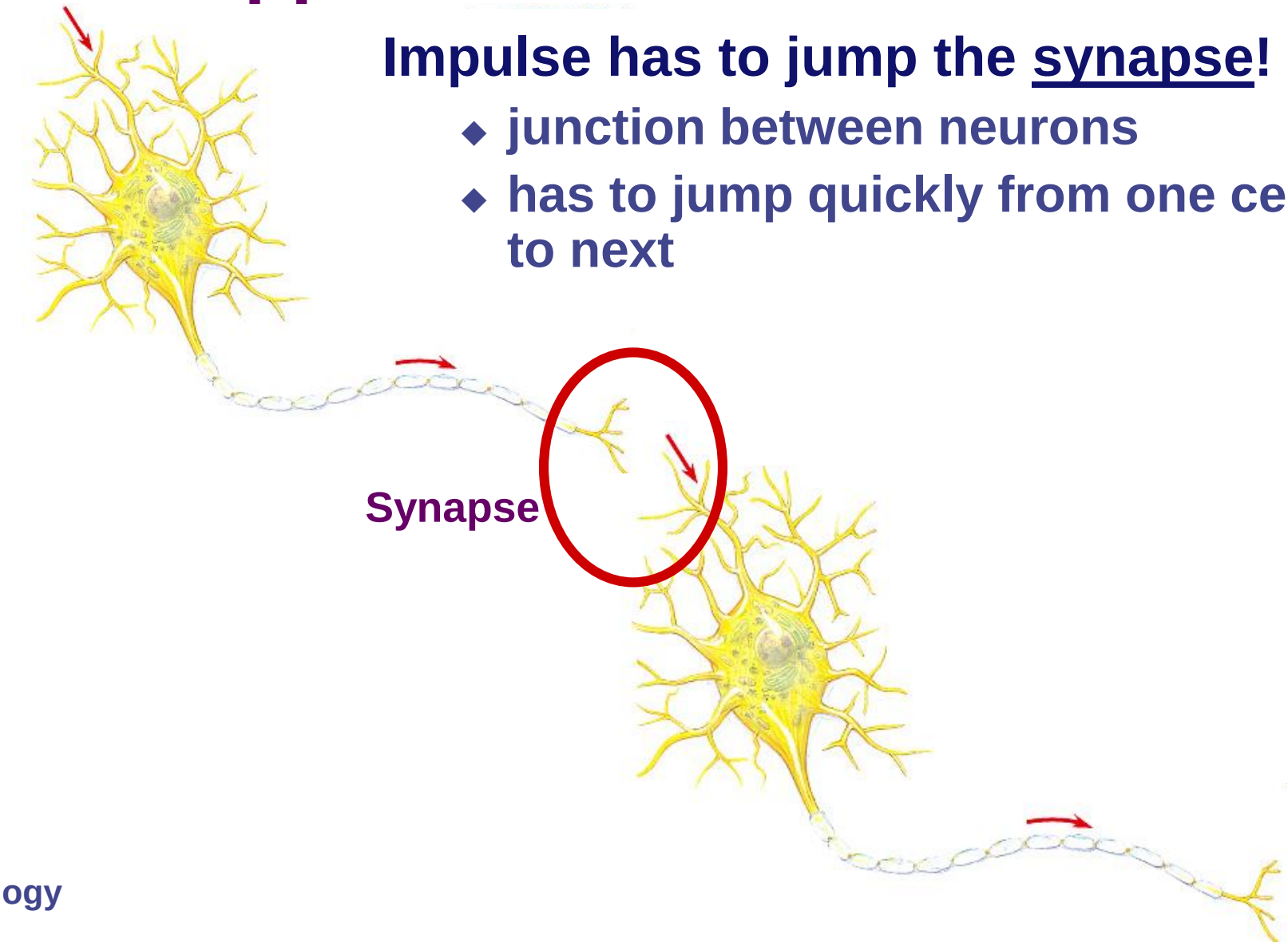
Neurotransmitters

- 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

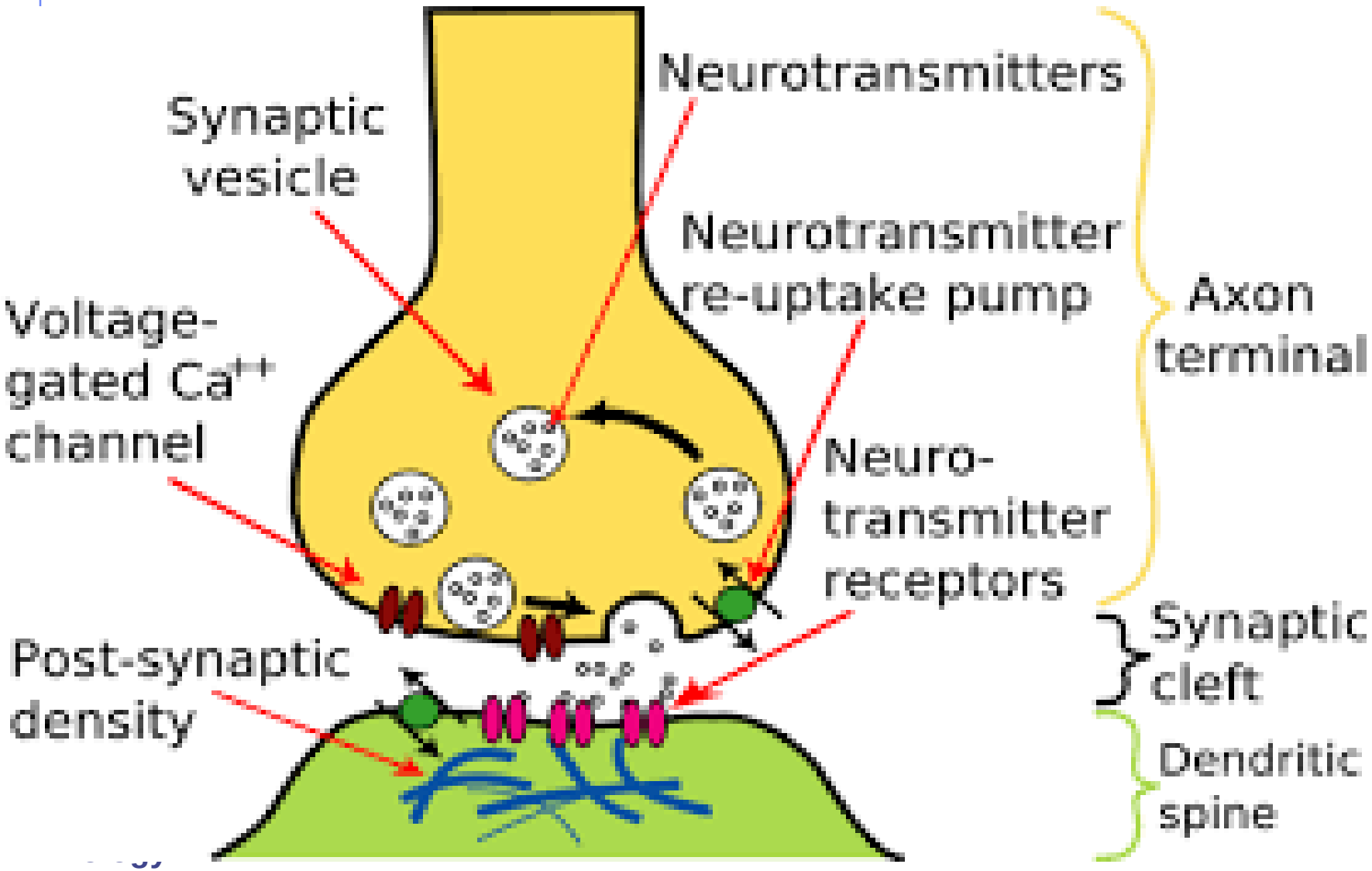
- **To the membrane returns to the state of polarization again must removed the chemical material quickly and this is done chemical decomposition by carrier enzymes like Colin esterase enzyme (Cholinesterase) which analyzes acetylcholine, this leading to increased permeability to sodium and potassium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

1-acetylcholine

2- epinephrine and norepinephrine

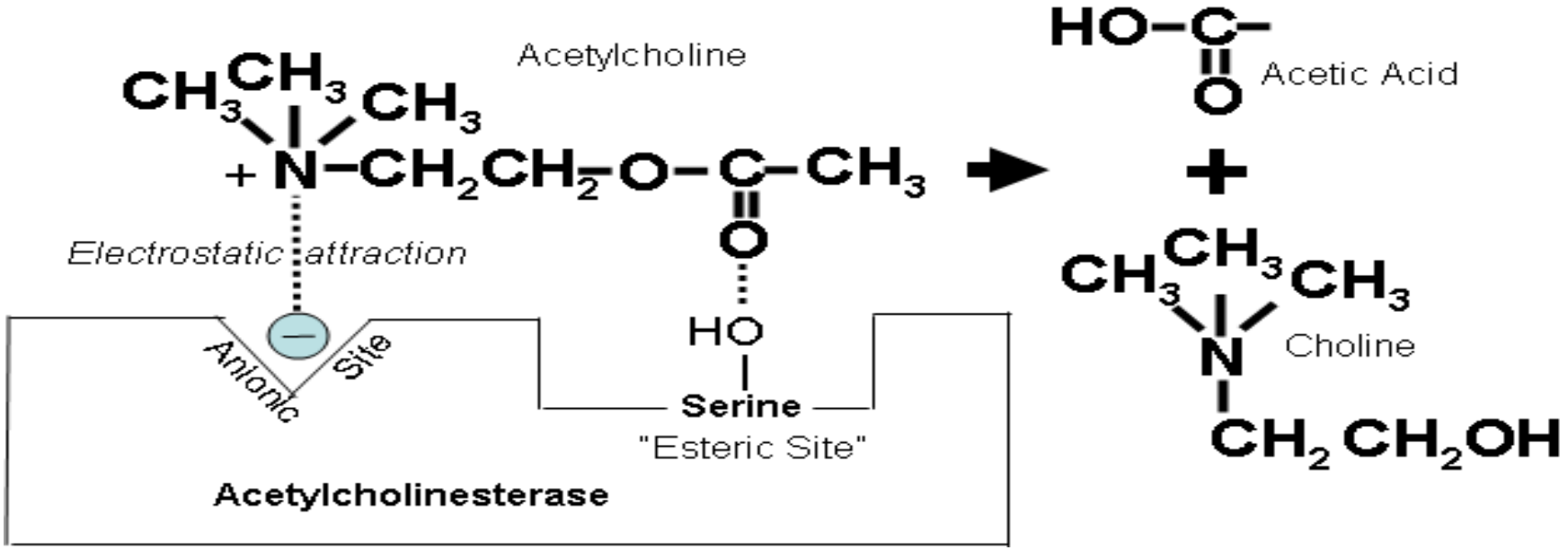
3- histamine .

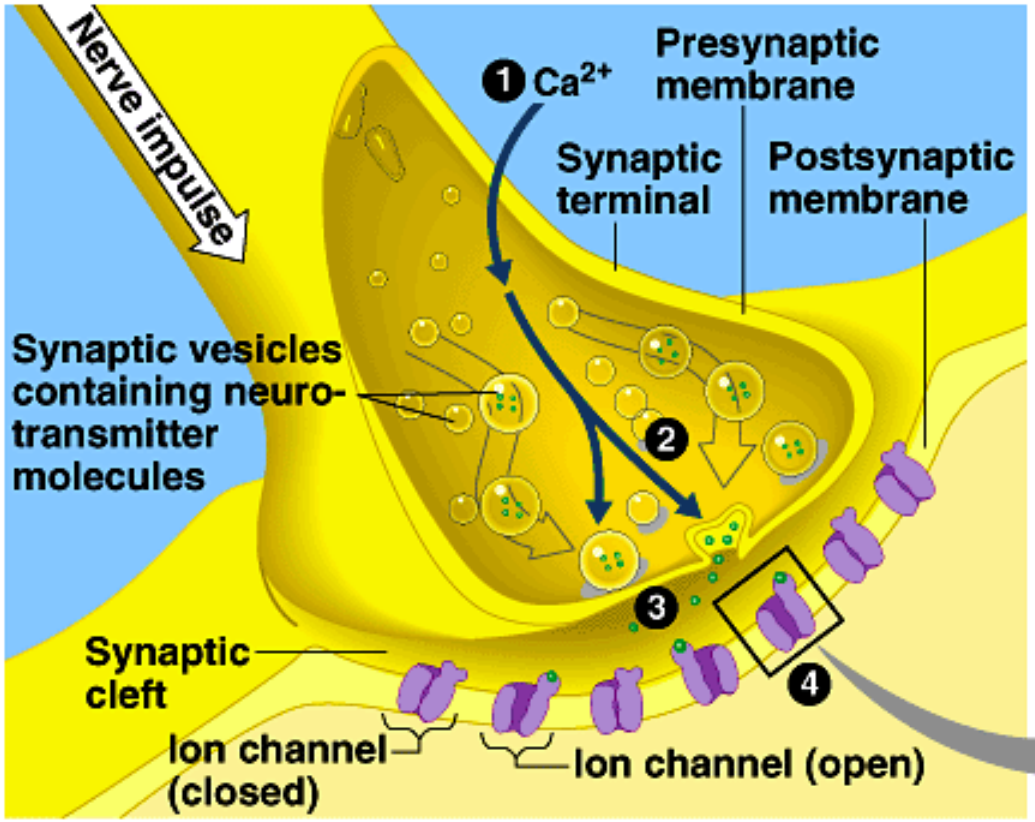
Role of chemical transmitter

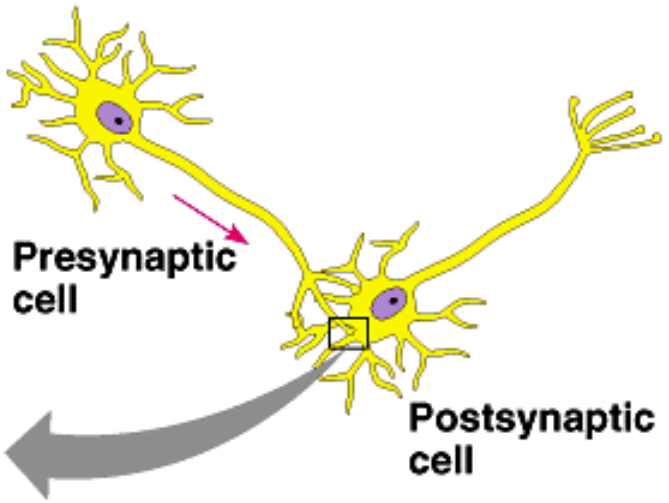


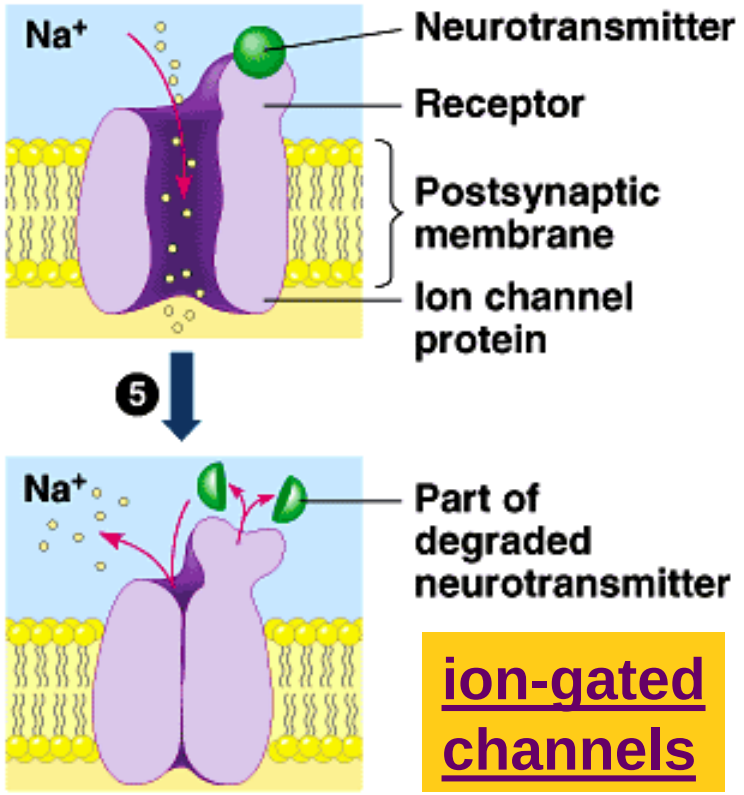
Acetylcholine

- **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.**









Chemical synapse: follow the path

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

ion-gated channels

Nerve impulse in next neuron

- **Post-synaptic neuron**
  - **triggers nerve impulse in next nerve cell**
    - **chemical signal opens "ion-gated" channels**
    - **Na^+ diffuses into cell**
    - **K^+ diffuses out of cell**