# Elementary Physics and Chemistry for clinical Neurophysiology

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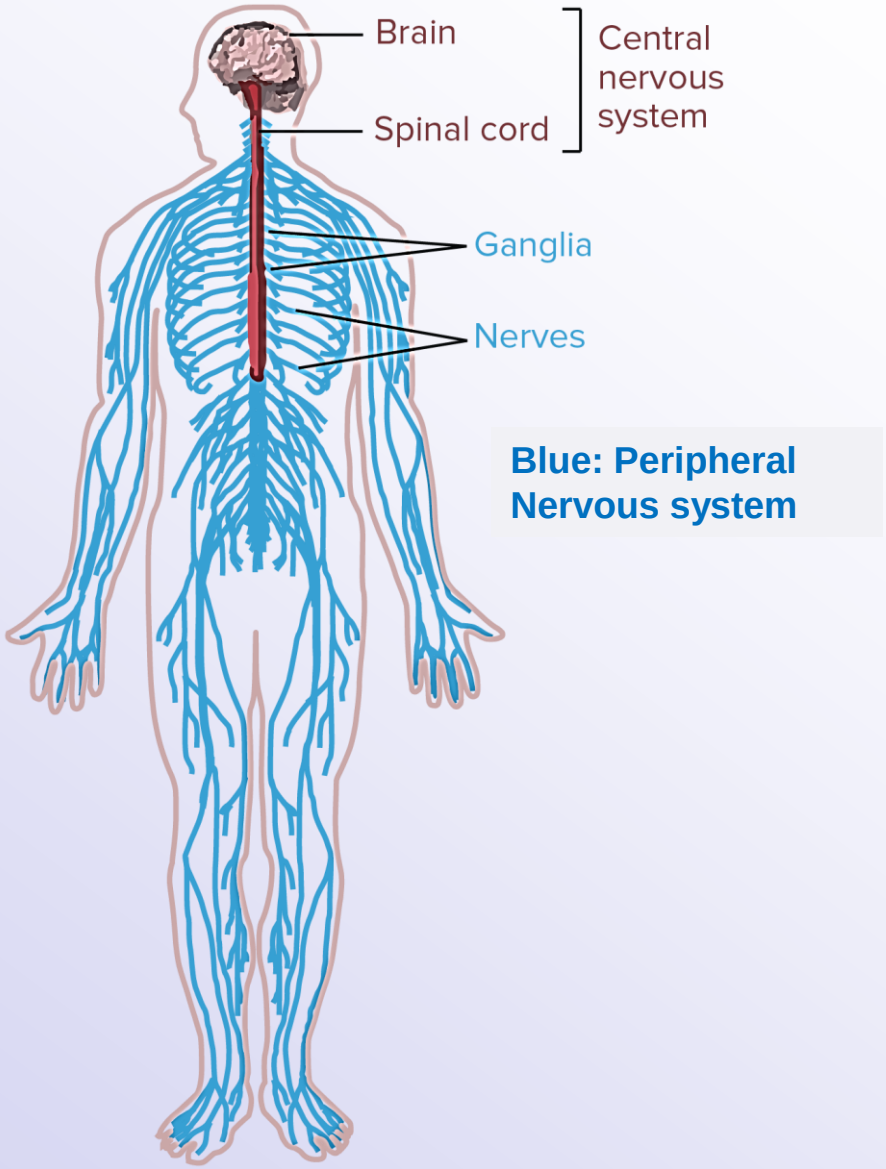
**Educational Tutorial, BCNEPS_10 October 2020**

# The nervous system

**Central Nervous System (CNS): Brain & spinal cord**

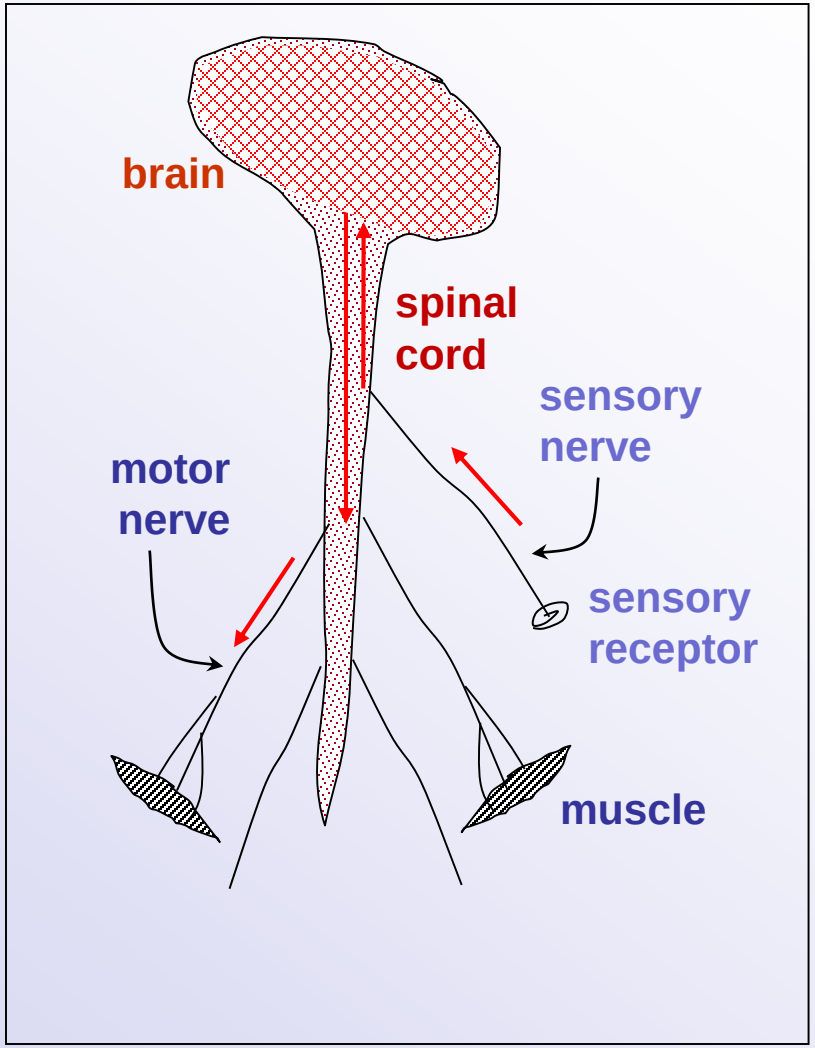
**Peripheral Nervous System (PNS)**



# Overall nerve signal directions in PNS

Sensory nerve

Motor nerve

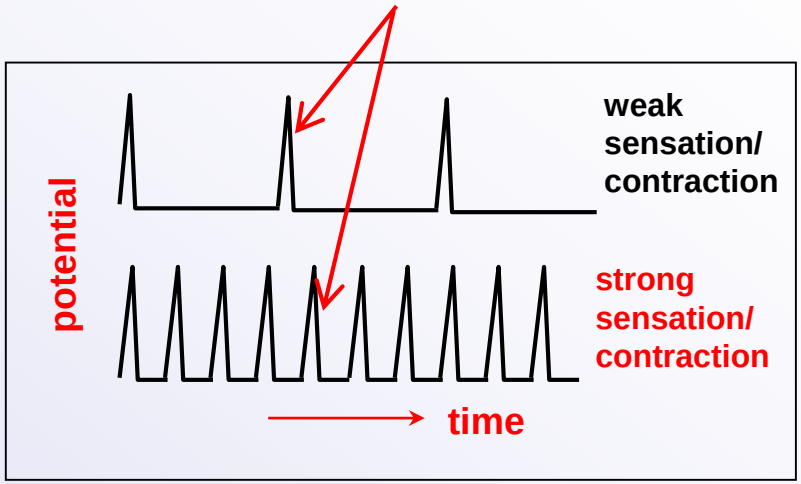


## Neural Signal

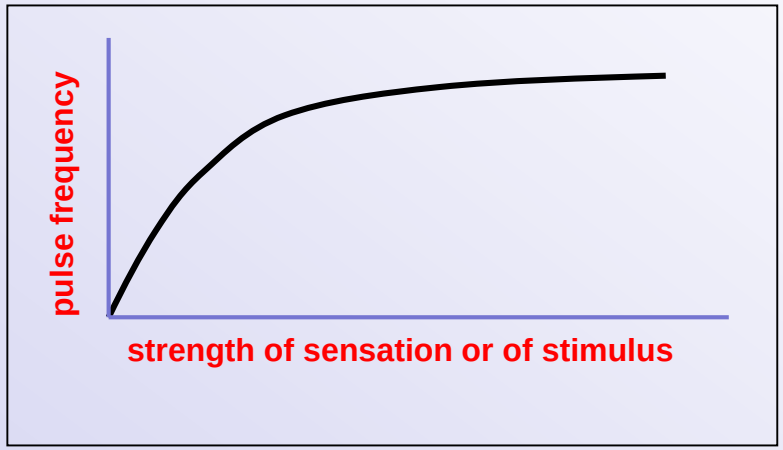
## Electrical → Digital, not Analog !

- Nerves carry electrical signals, called Nerve Action Potential (NAP)
- The NAPs are Digital, not Analog
- Digital signal communication is slow but ERROR FREE (we only know now!)

Nerve Action Potentials (NAP) same height but varying frequency to indicate strength

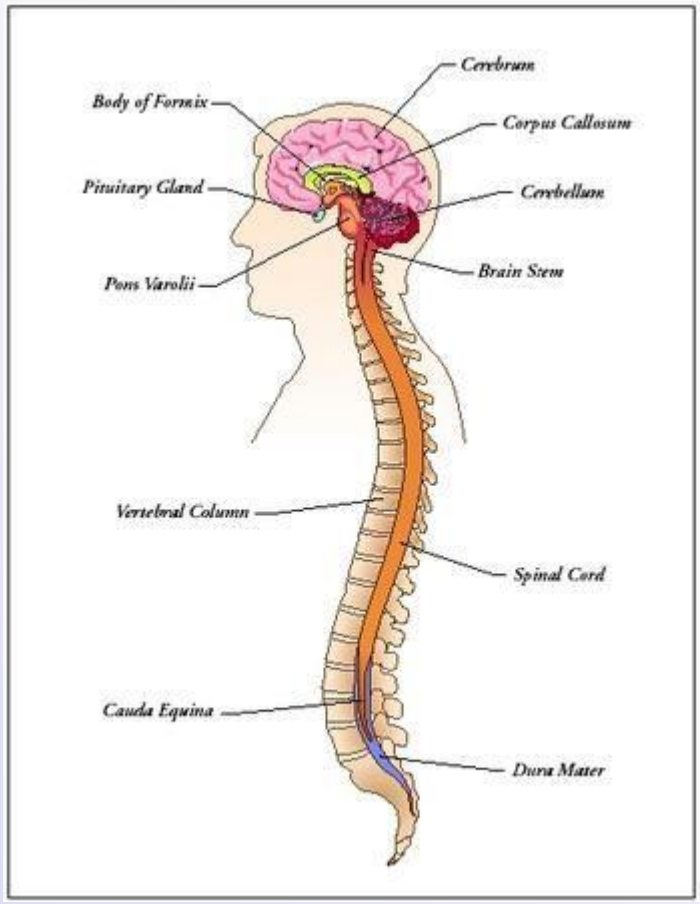



Frequency: repetition of pulse per unit time



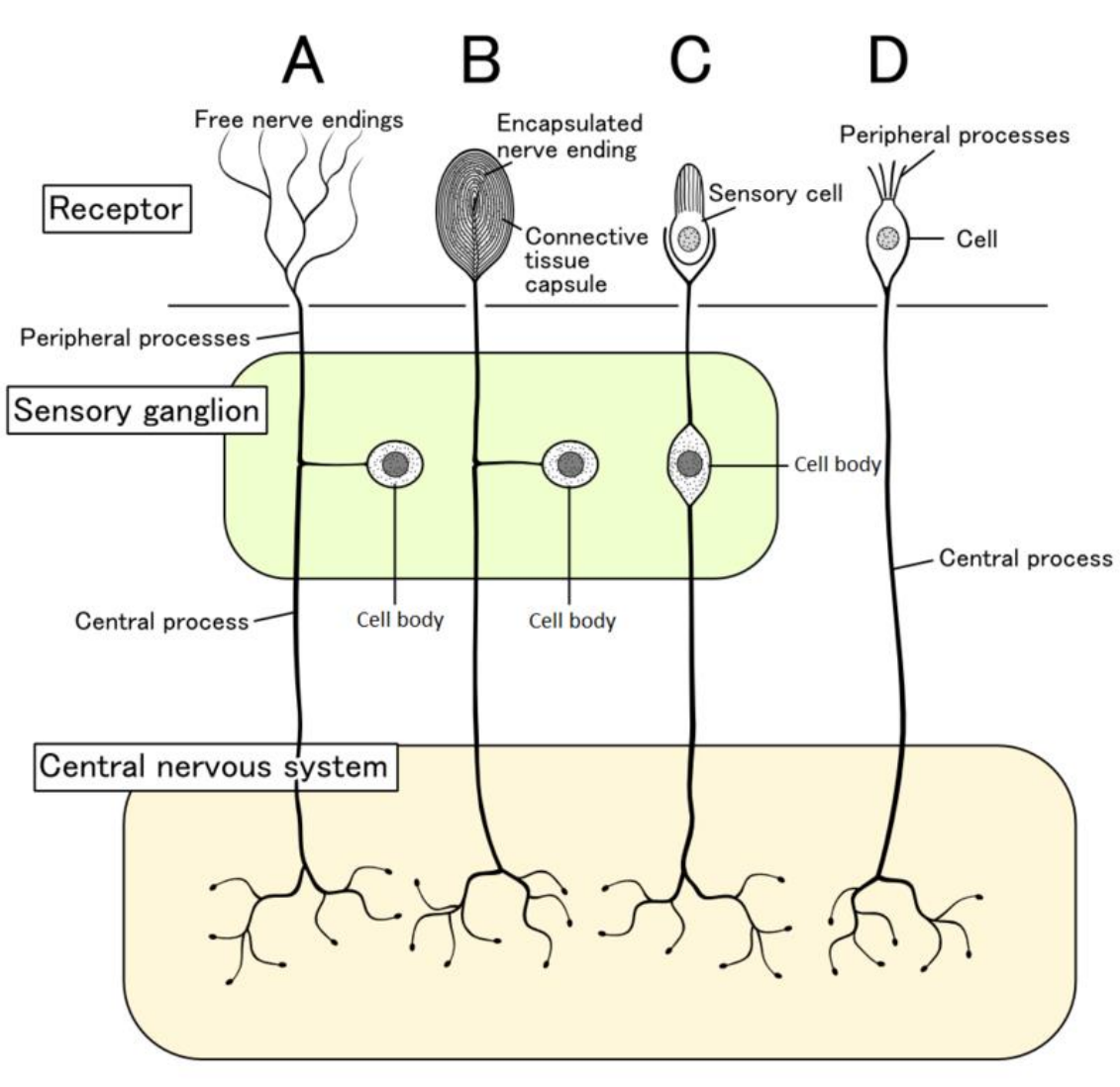
# Origin of nerve action potentials

## Brain: 100 billion neurons ($10^{11}$, 10,000 crore)

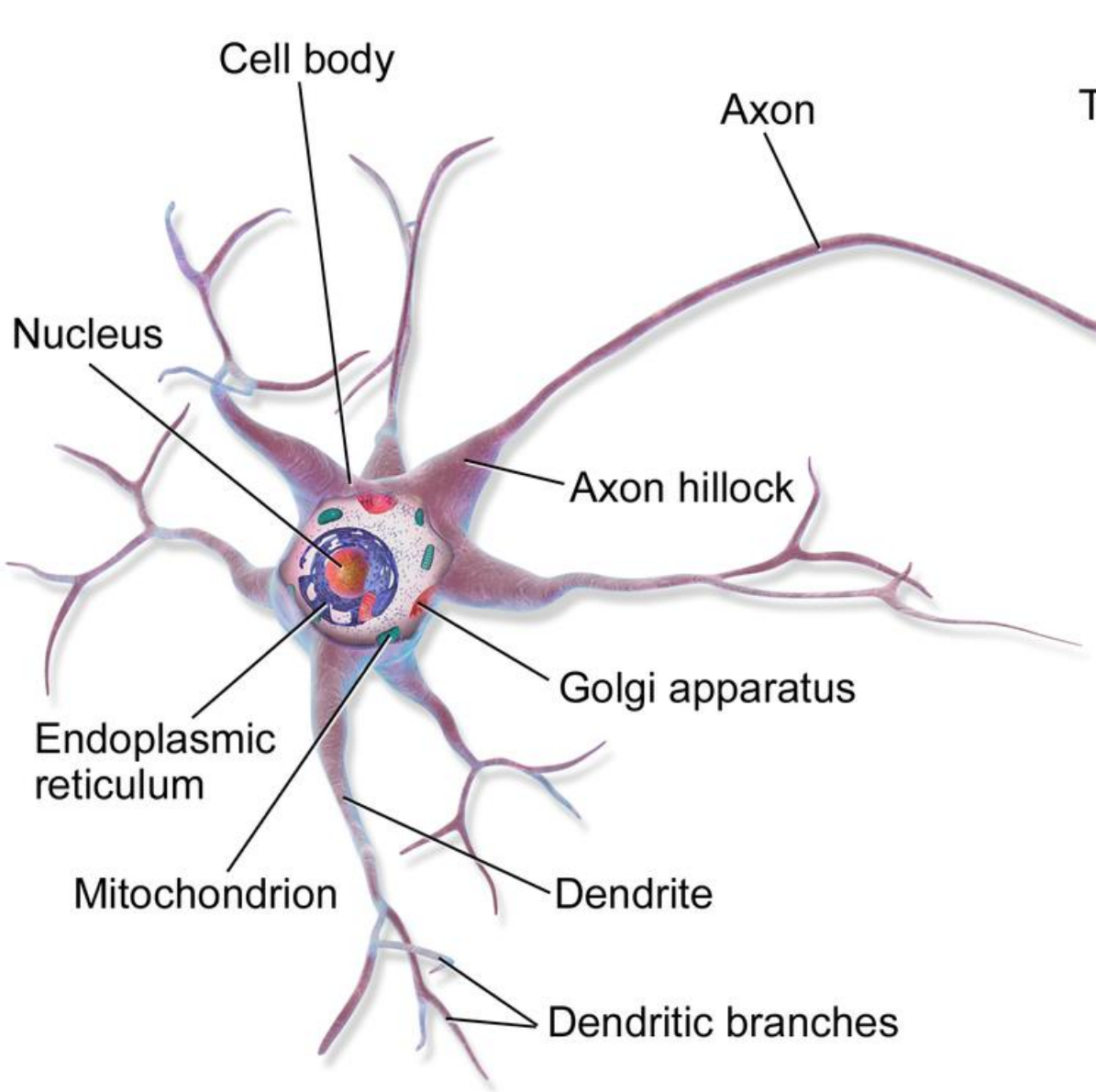


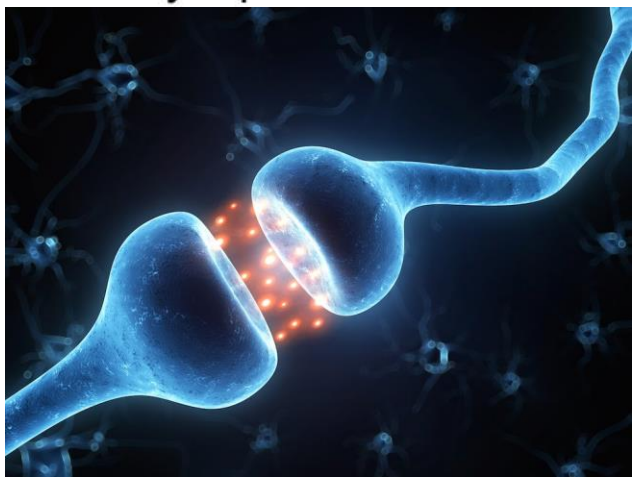
# Origin of nerve action potentials: Sensory

## Mechanical/ optical/ thermal/ chemical



# Neuron: Cell Body, Dendrites, Axons



# Origin of membrane potentials of neurons (resting Potential)

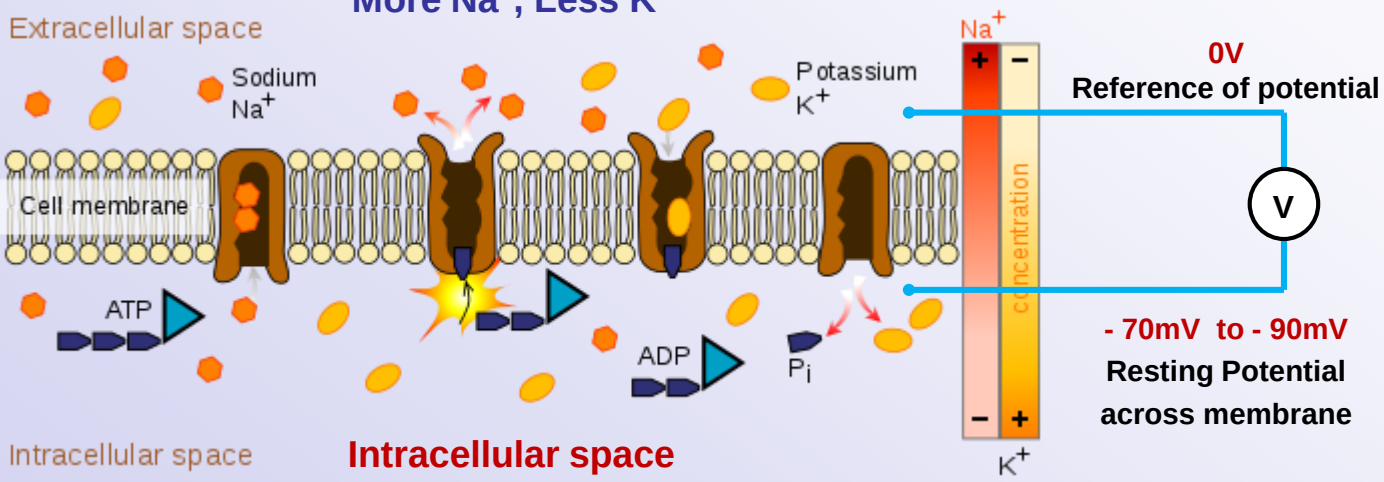
## Chemical Viewpoint

- **Diffusion**
- **Ion Pump**

**Through Ion Channels**

**Extracellular space**

**More $Na^+$, Less $K^+$**




**Intracellular space**

**More $K^+$, Less $Na^+$**

Nernst potential (for any species of ion)

$$E = Constant.T \ \ln \frac{Ion\ conectration\ outside}{Ion\ concentration\ inside}$$

**Net potential is due to combination of all ion species**

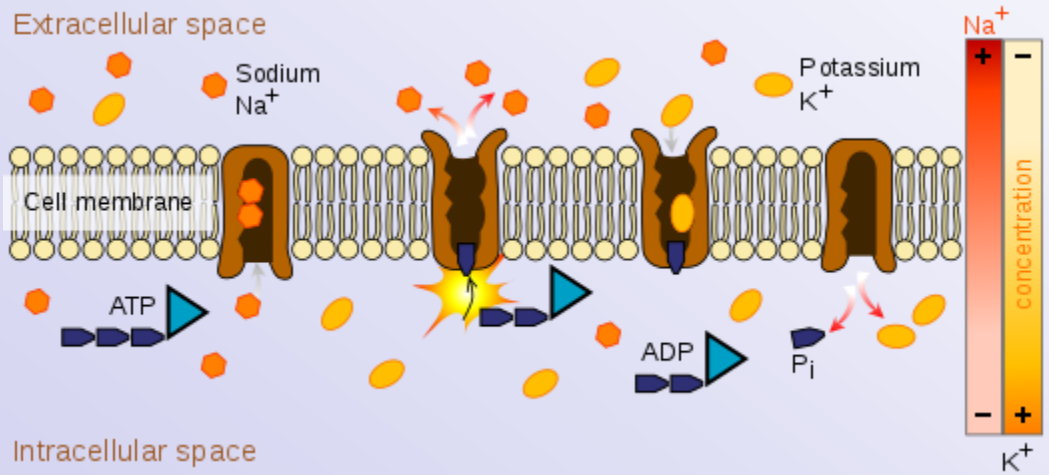
# Origin of membrane potentials of neurons

## Physics Viewpoint (mine)

**Based on size distribution of ionic charges on two sides of the membrane**

**Extracellular space**

**More $Na^+$, Less $K^+$**




**Intracellular space**

**More $K^+$, Less $Na^+$**

**Ion Diameter**

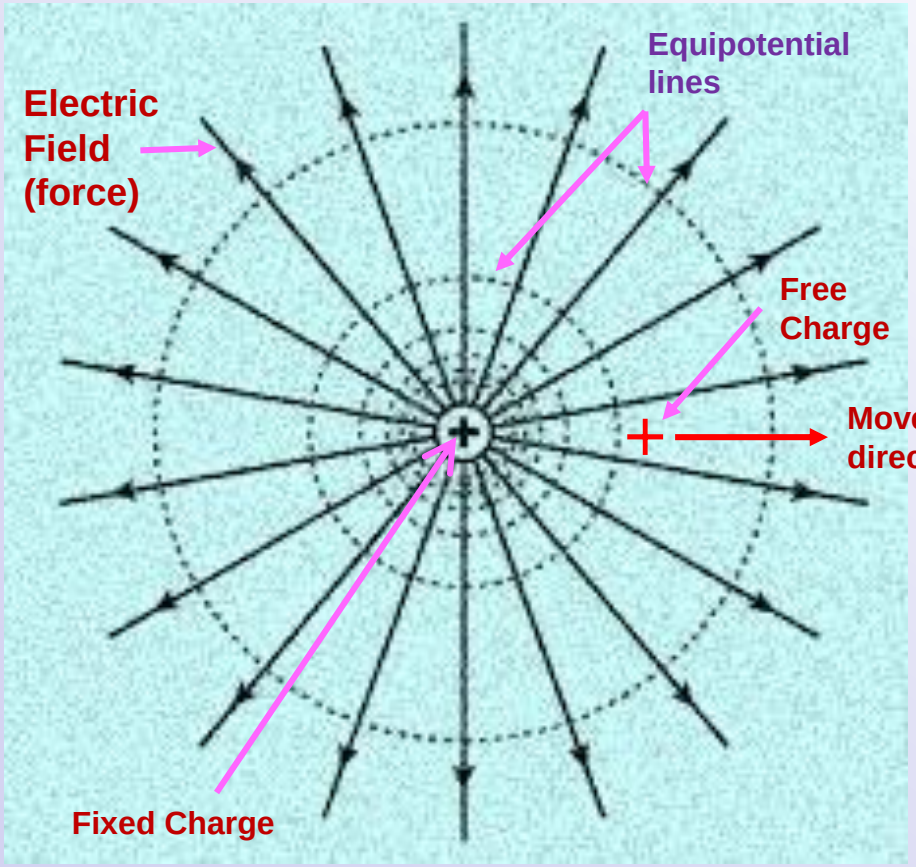
**$Na^+$, 1.02A**

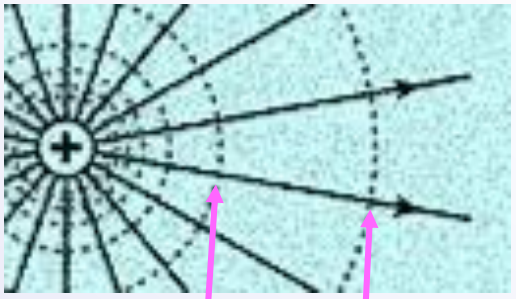
**$K^+$, 1.38A**

**Details >>>**

# Seeking origin of membrane potentials of neurons

## Physics Viewpoint (mine)

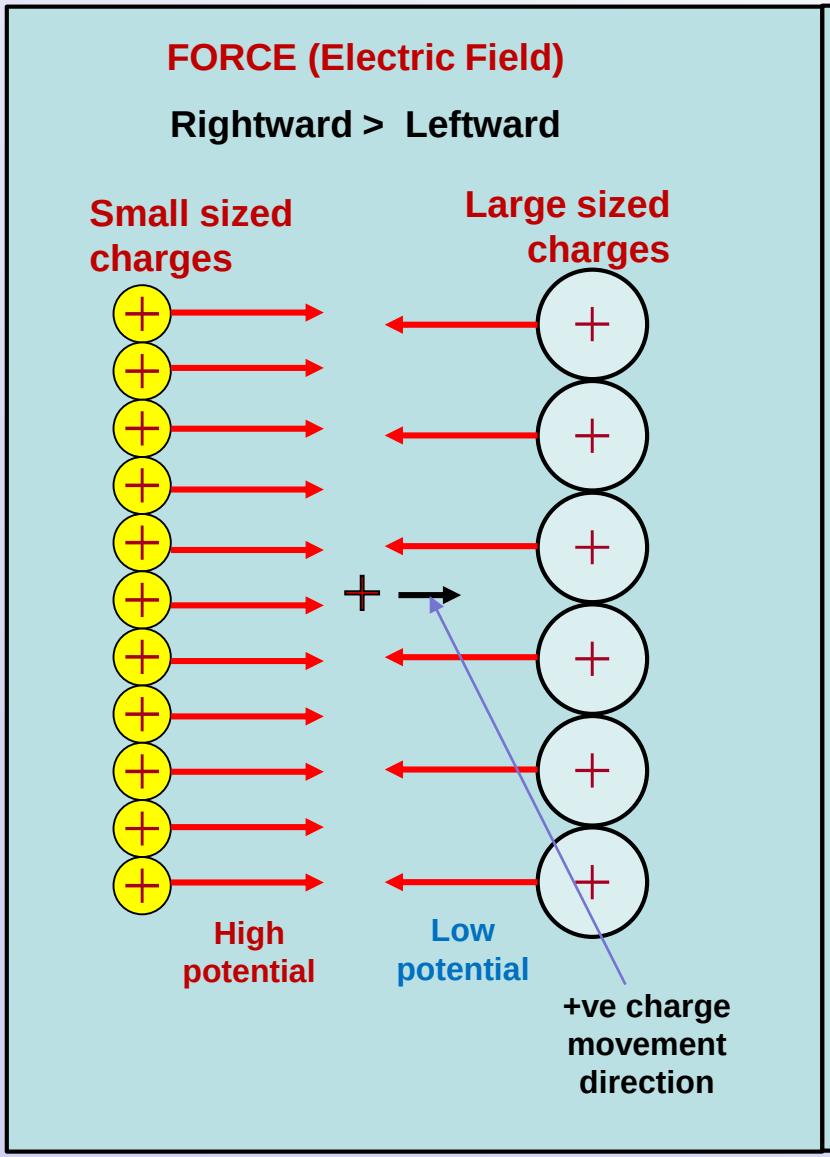


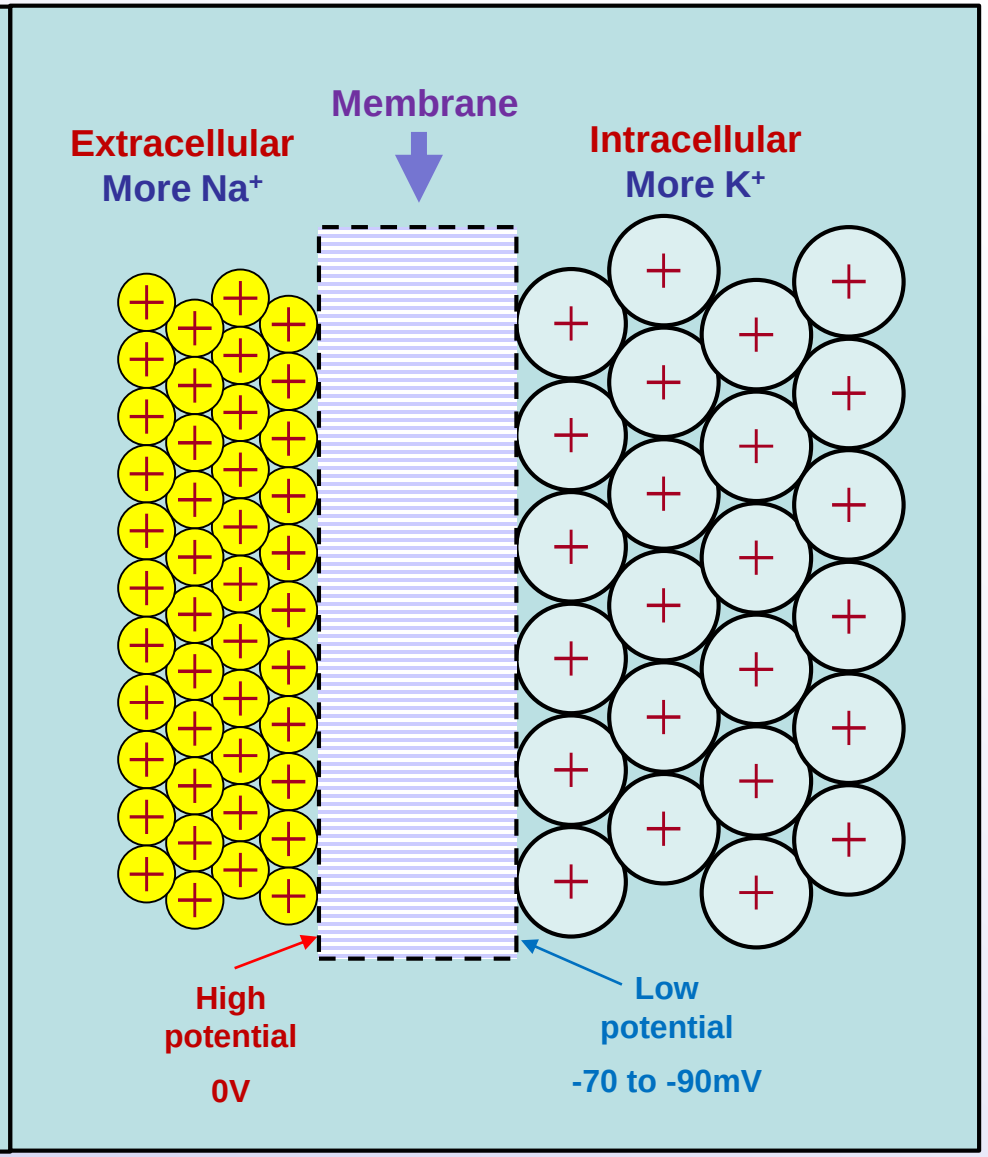




| | | |
|---|---|---|
| For Example | + 1V | 0V |
| | 0V | - 1V |

**No negative charge needed to create the –ve potential**

# Origin of membrane potentials of neurons
## Physics Viewpoint (mine)

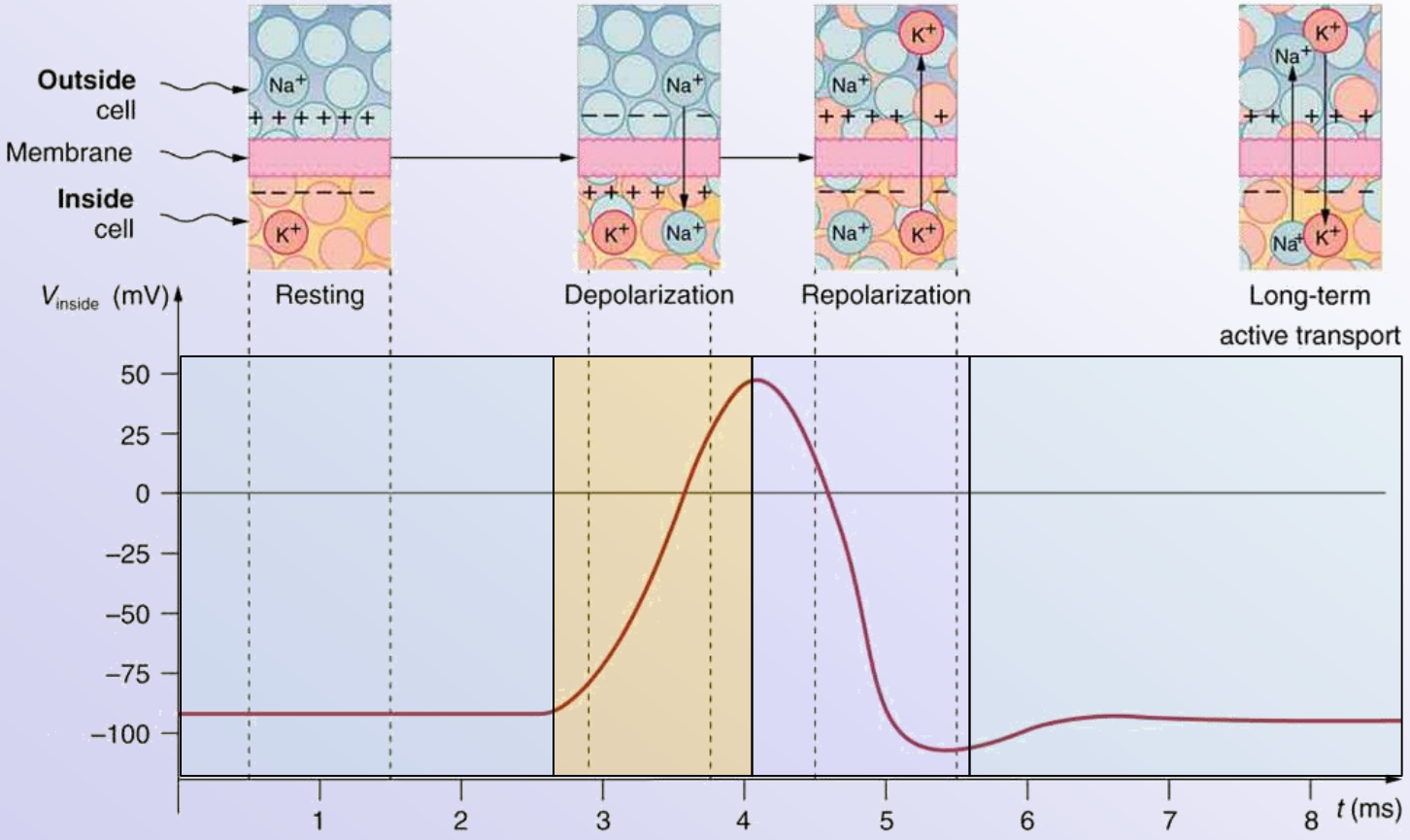


# Nerve Action Potential (NAP)

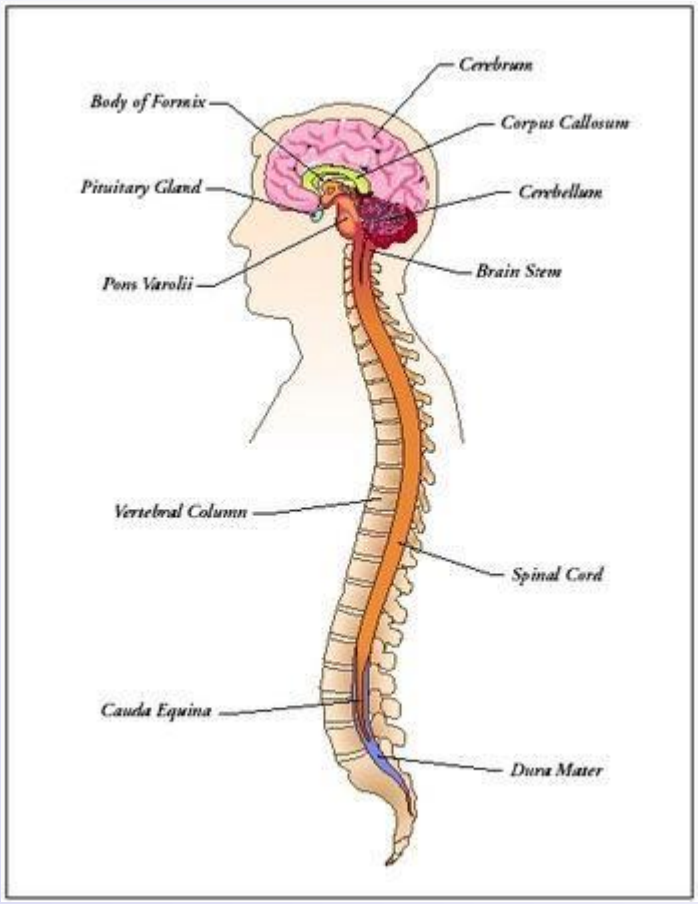
**Same amplitude always for a particular cell type**

**Yes or No → Hence Digital (binary)**



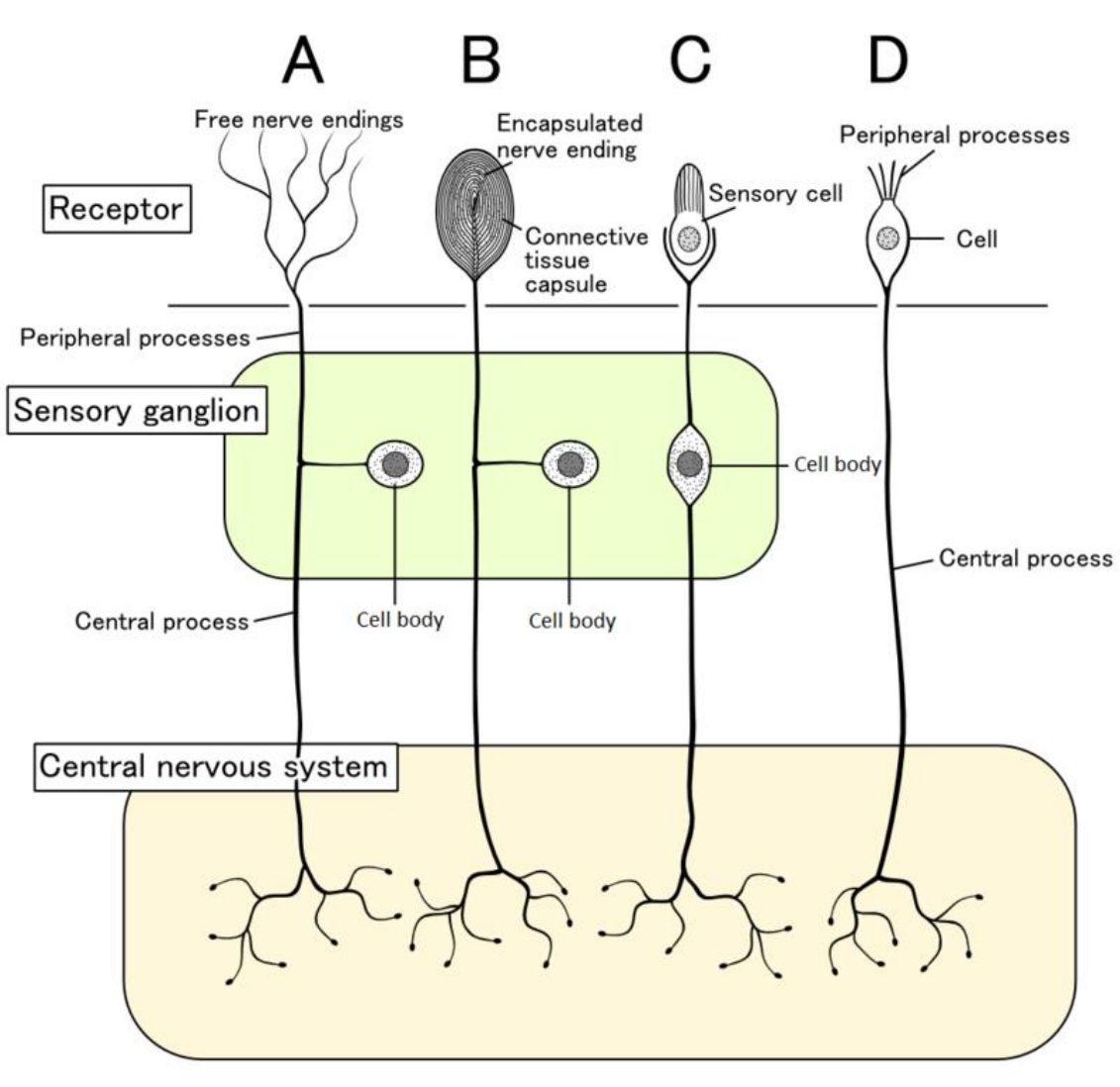
# Nerve action potentials

## Created in neurons in the brain

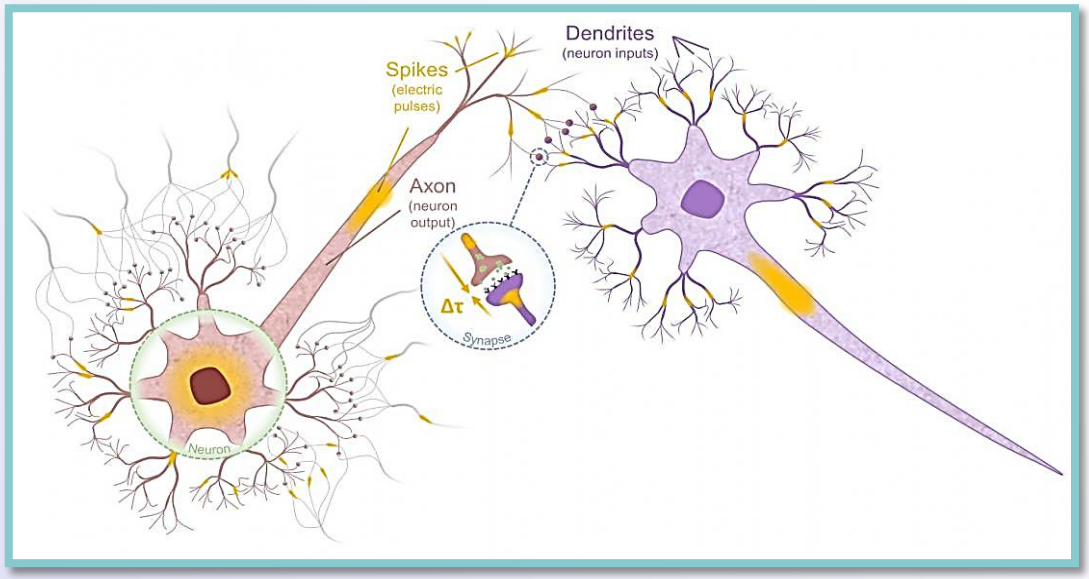


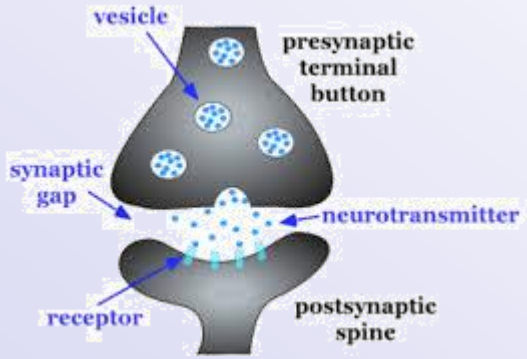
# Nerve action potentials

## Created at the Sensory organs: Mechanical/ optical/ thermal/ chemical

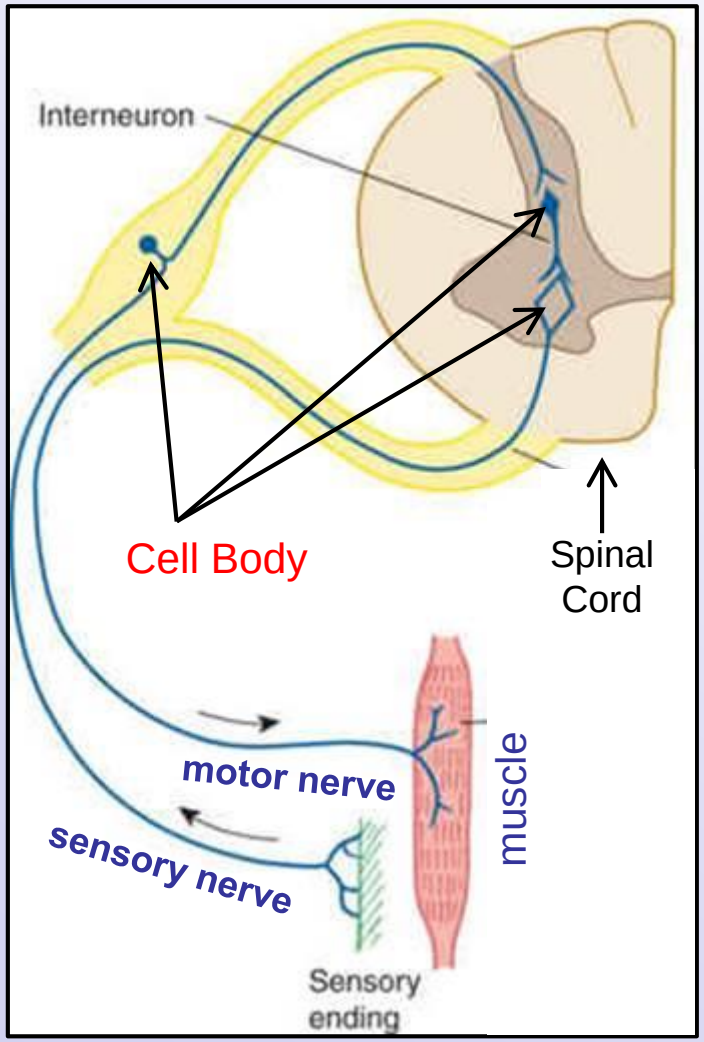


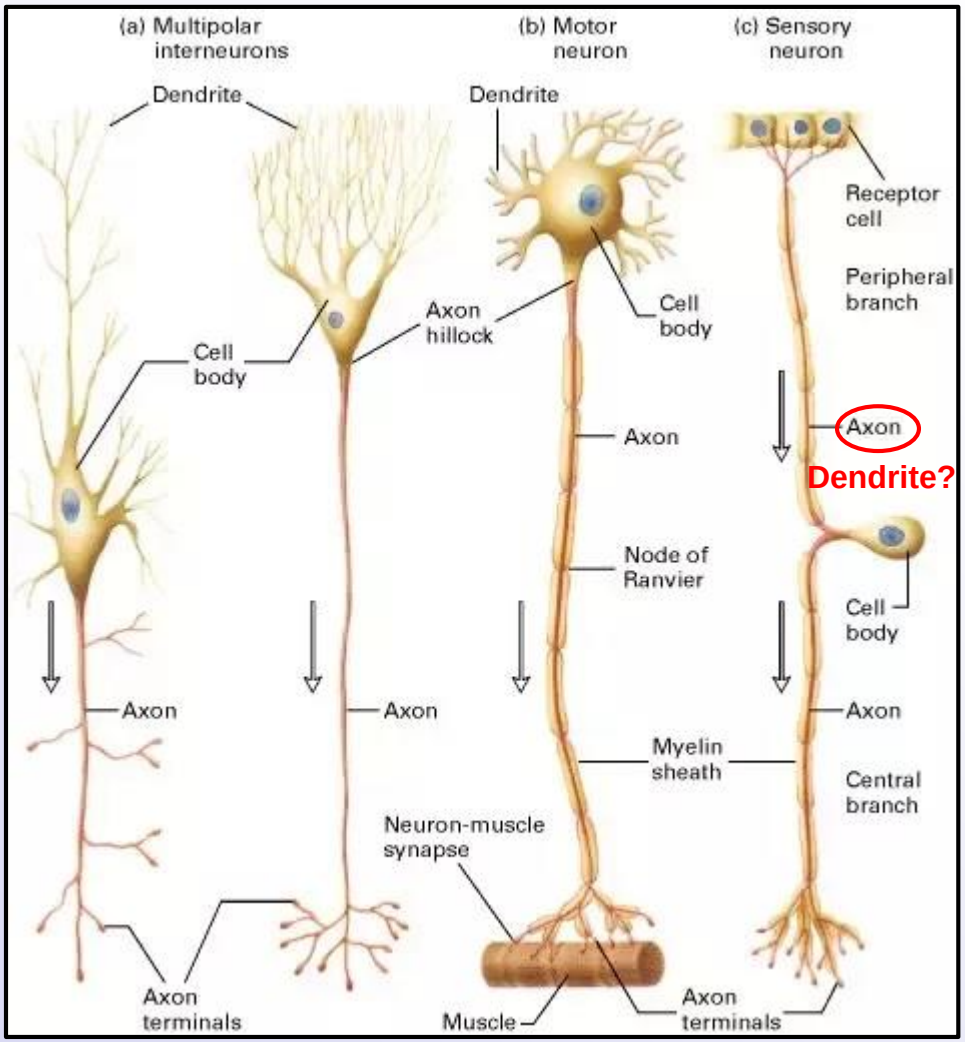
# Relaying of nerve impulses: Neuro transmitters at Synapse, Motor End plates



# Peripheral Neurons



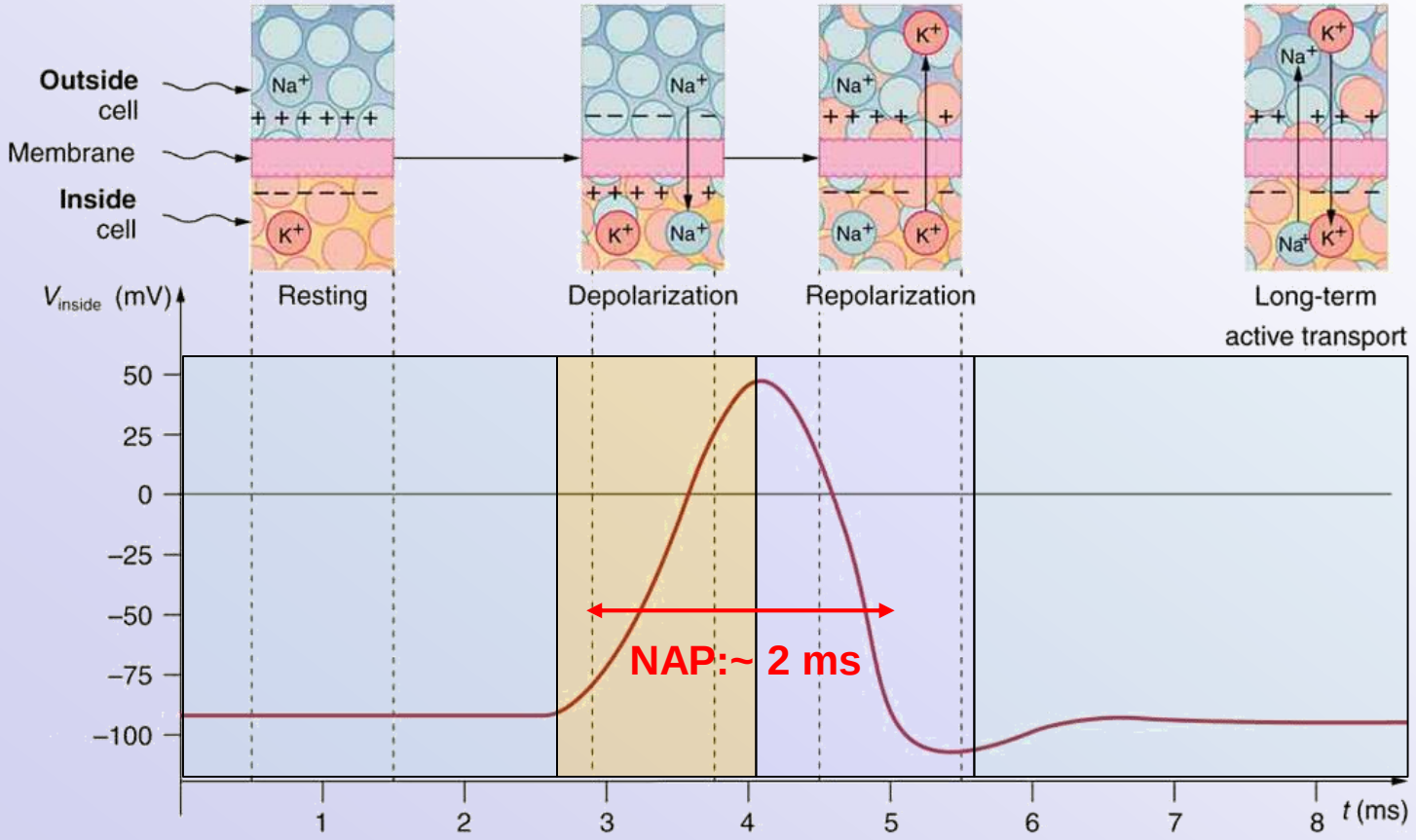



# Nerve Action Potential (NAP)

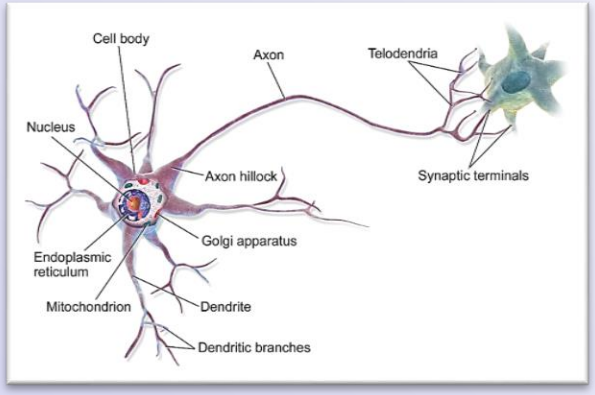
## variation with time at a single point

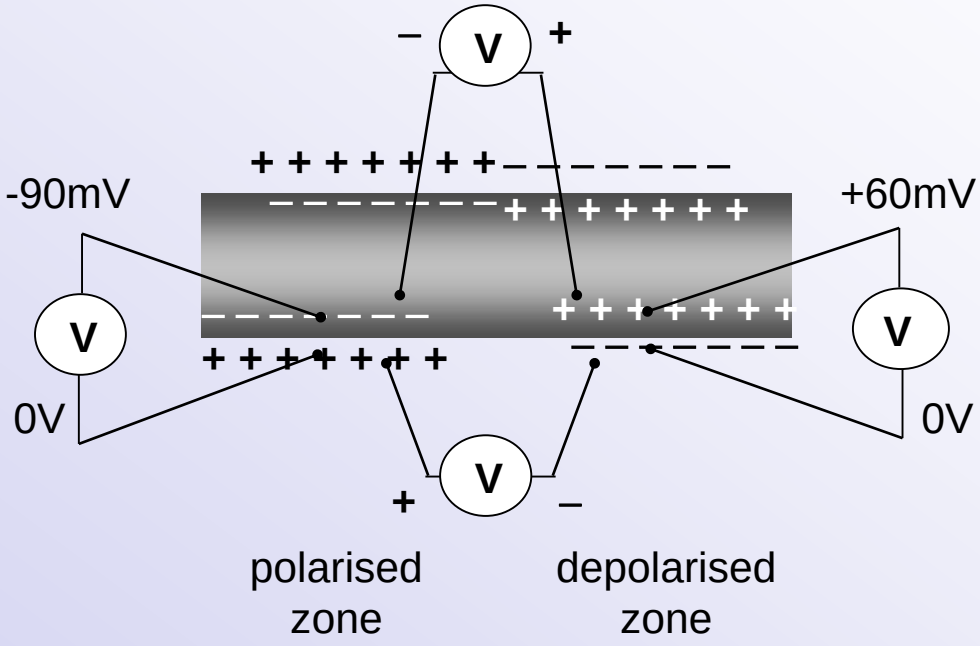
**Same amplitude always for a particular cell type**

**Yes or No → Hence Digital (binary)**



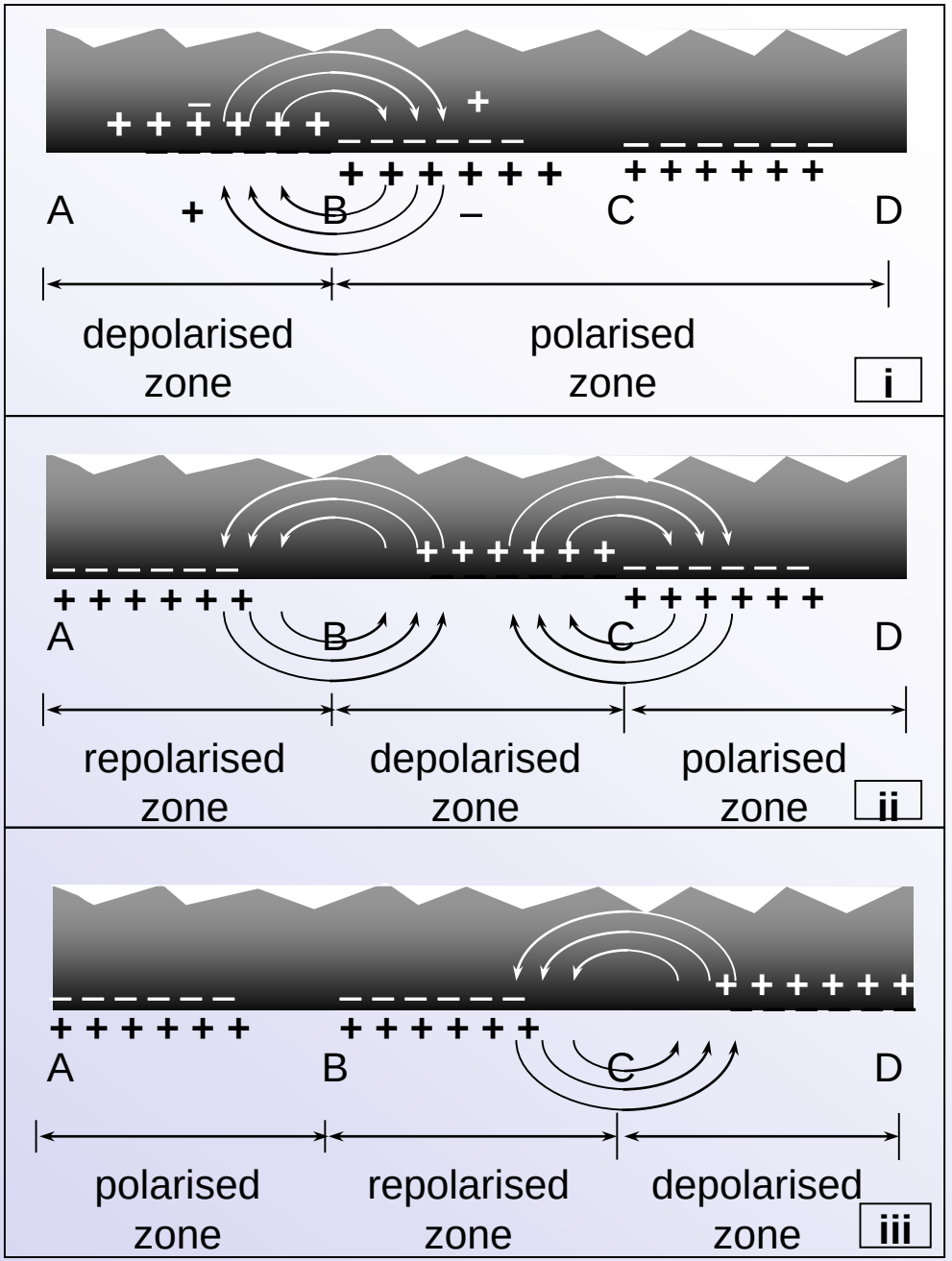
# Potentials between adjacent polarized and depolarized zones



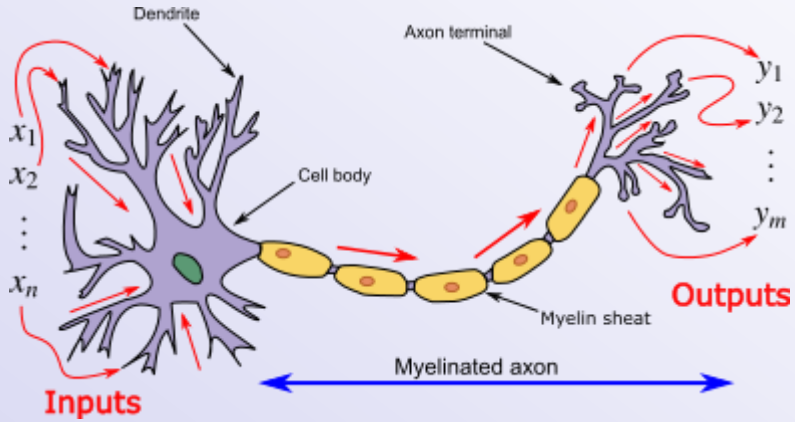



## Propagation of action potential (from left end)

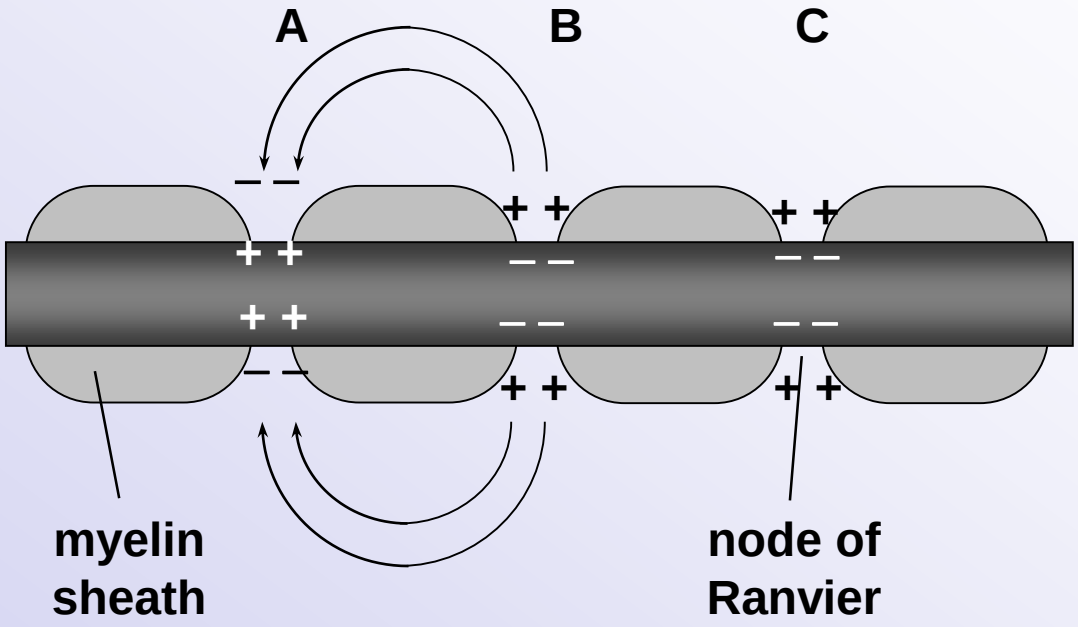
- External and internal current
- Charge transfer and reversal of membrane potential in resting zone
- Formation of adjacent depolarised zone
- Process repeats



# Speeding up: Myelinated axons



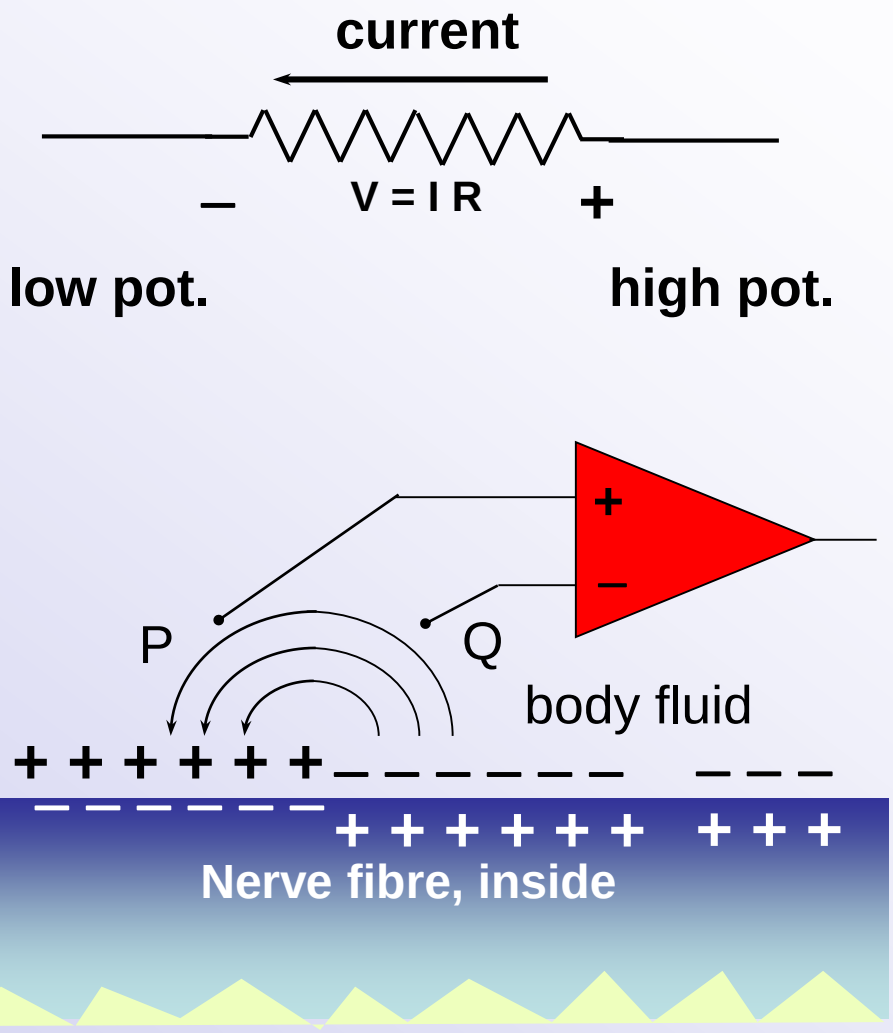

- External and internal current jumps from node to node
- Charge transfer proceeds along length much faster



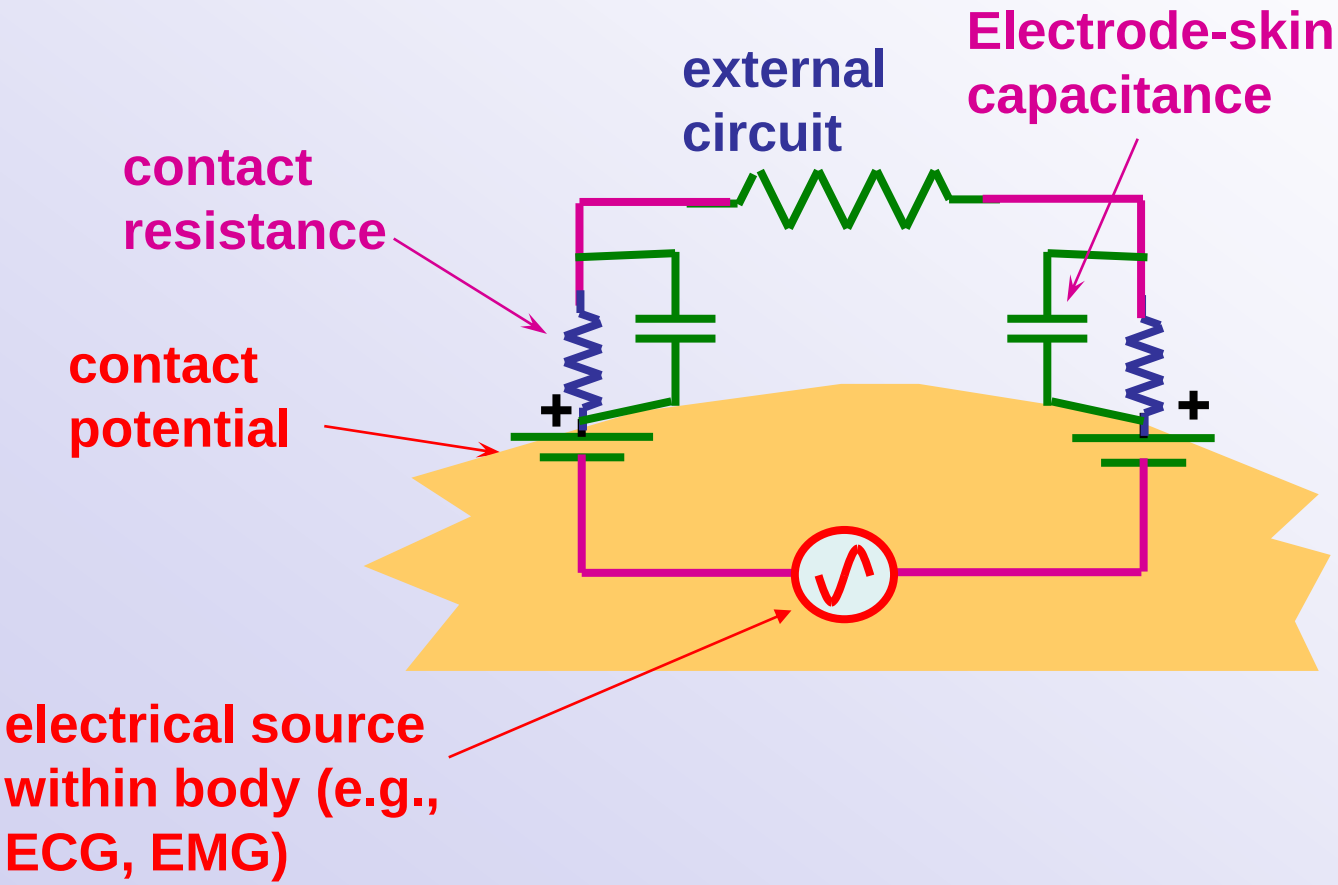
# Biopotential measurement, basic ideas

**Current through resistance creates potential drop across R**

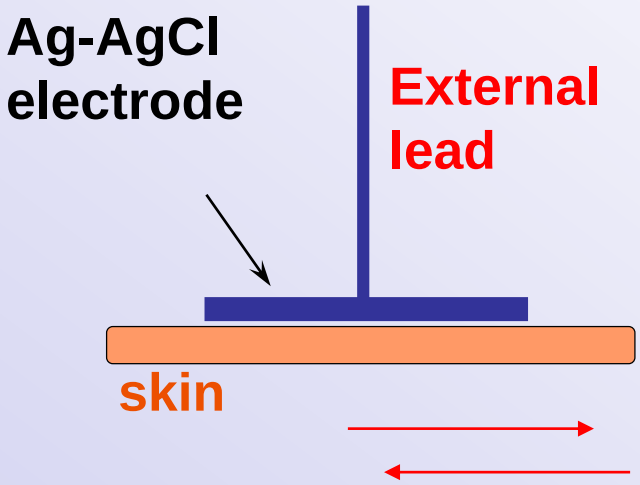
**V = IR**



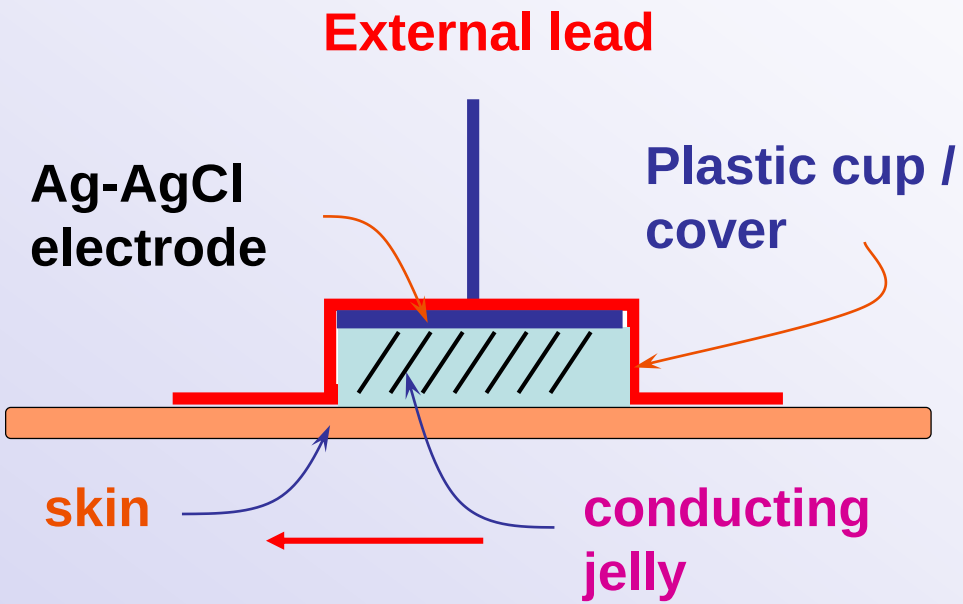
# Skin Electrode Interface



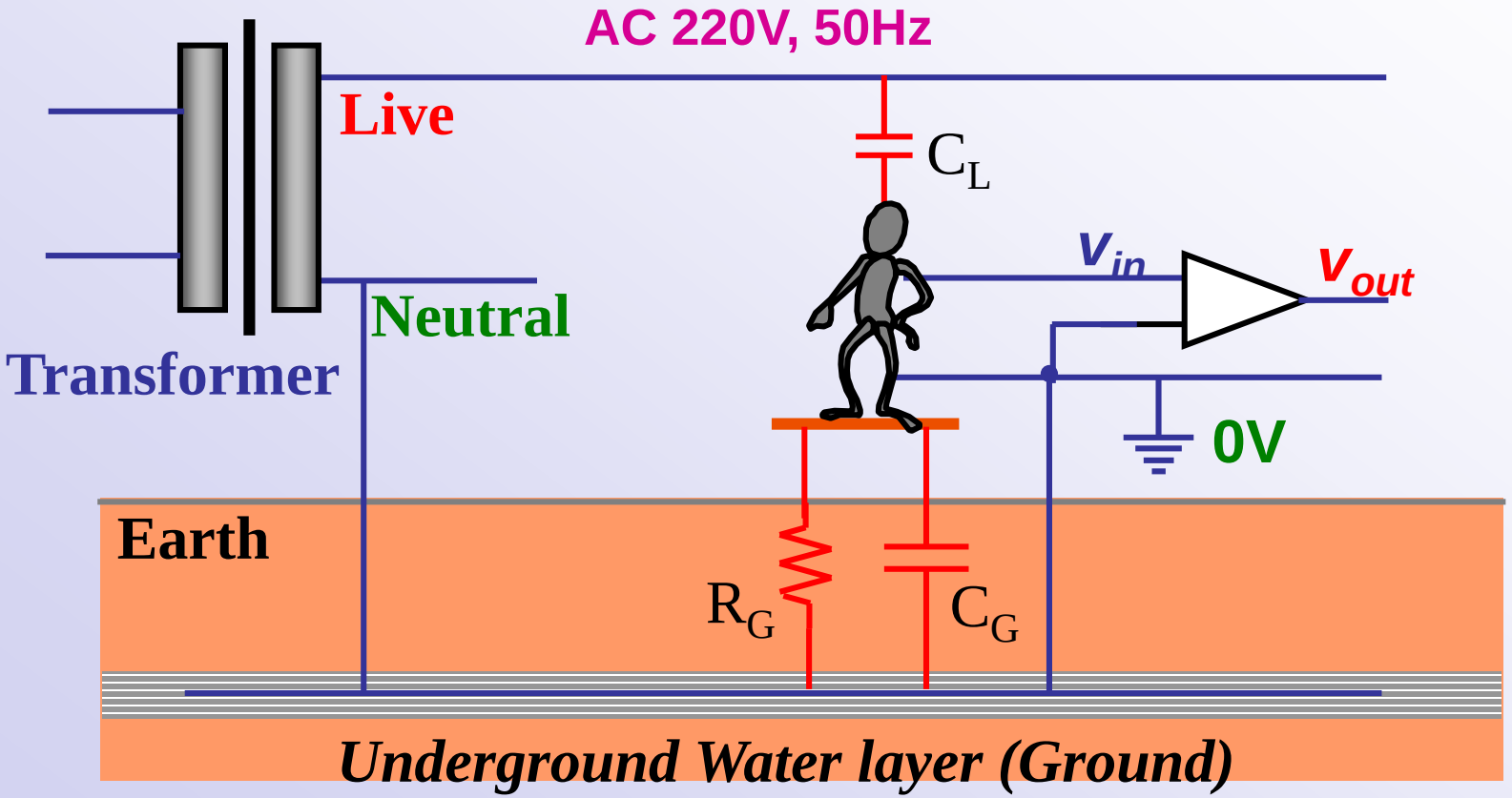
# Motion artifact and elimination

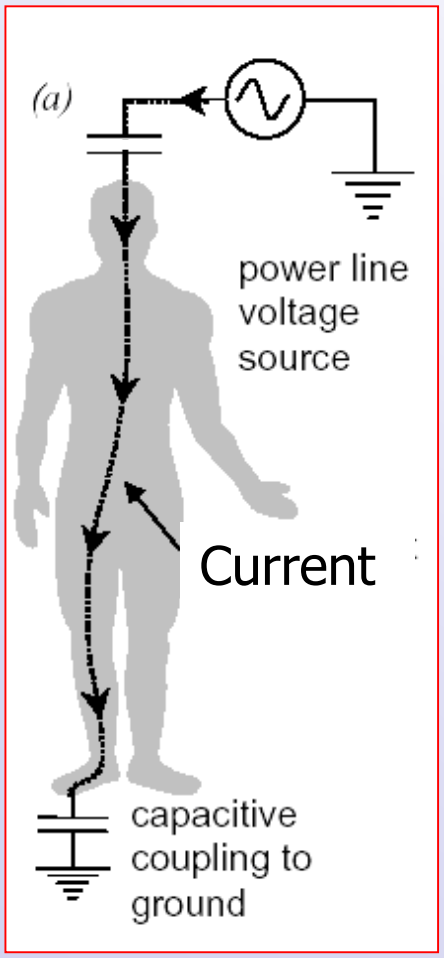



## Solution:
## Floating electrodes

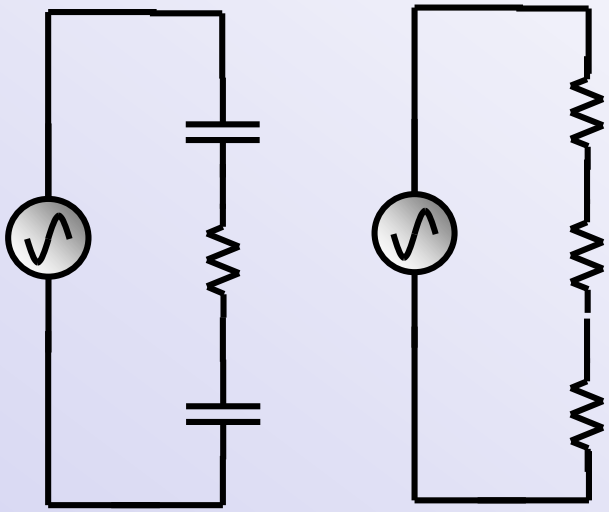


# Source of 50Hz noise






**Line frequency noise:**
**the same all over the body**
**: Common ModeNoise**

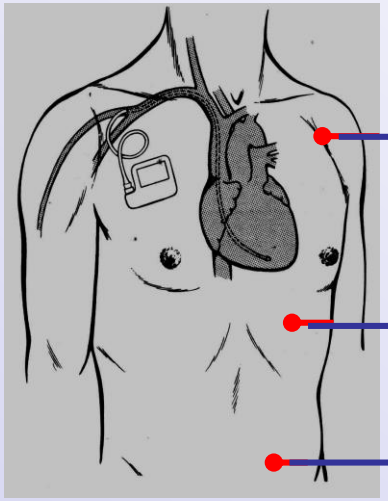


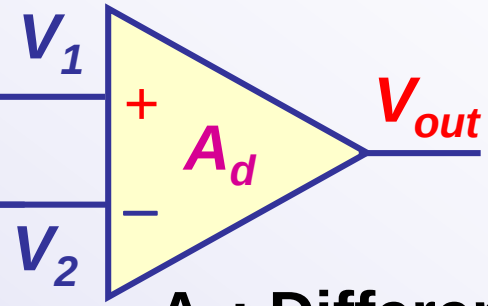
**100MΩ**

**1kΩ** } **Negligible potential**

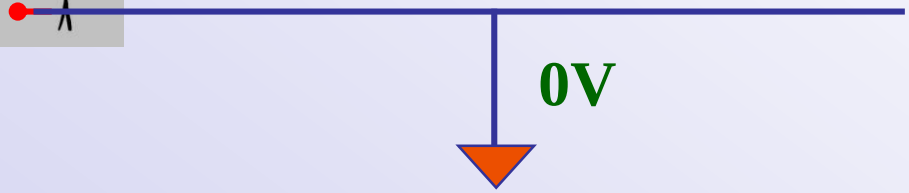
**1MΩ**

# Differential amplifier can eliminate common mode noise






$A_d$: Differential gain




V1= CM noise + ECG

V2 = CM noise

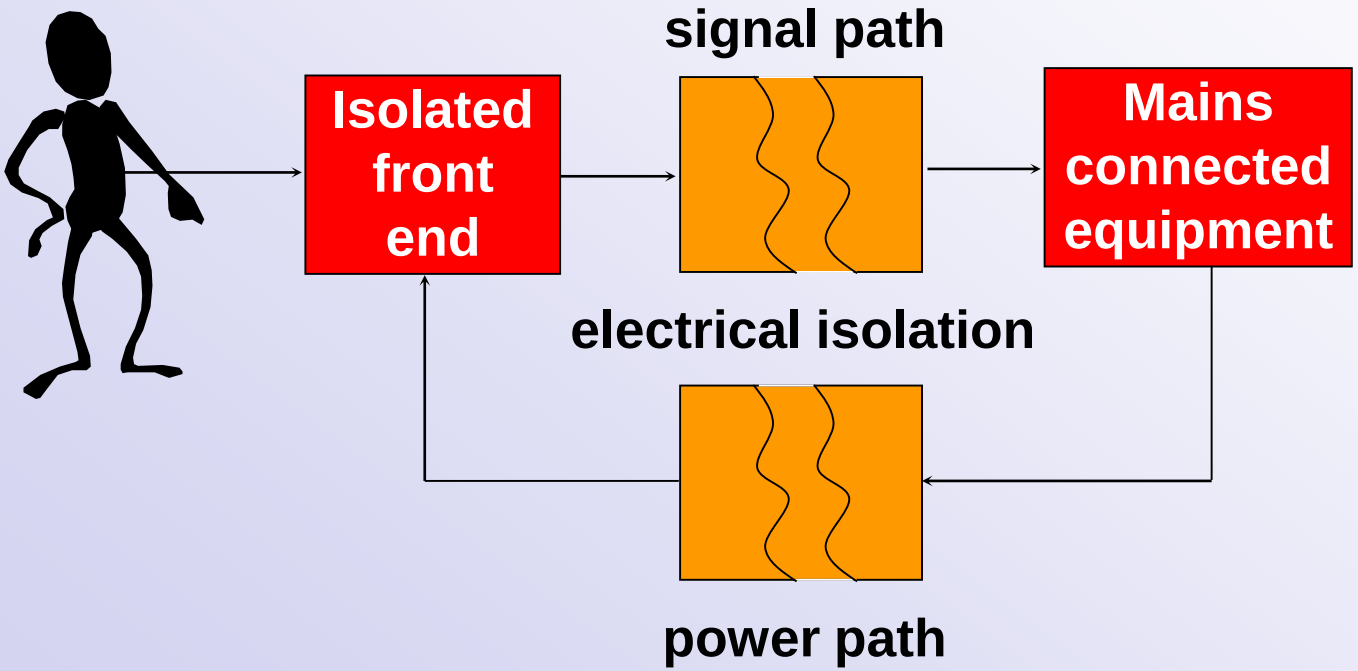
Vout = Ad (V1 - V2 ) = Ad . ECG

# Patient Safety, Electrical isolation

**Normal shock hazard : 75mA**
**(Skin surface contact)**

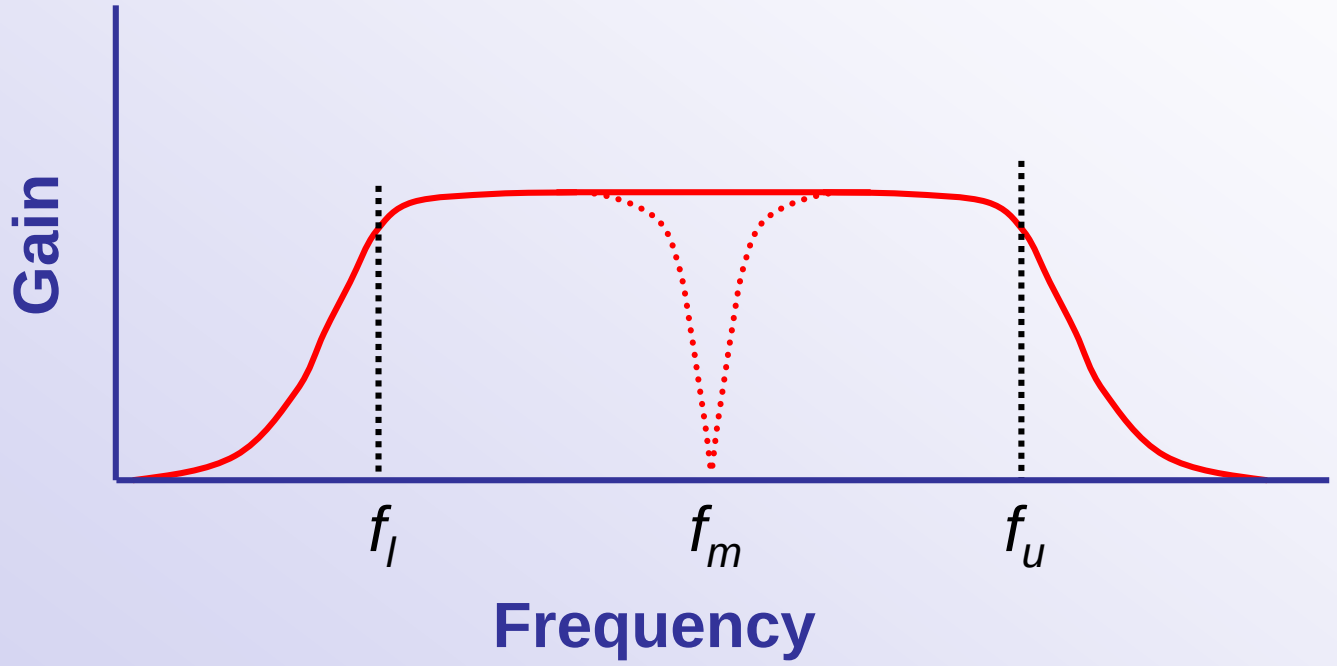
**Microshock hazard : 50mA**
**For electrode direct to heart**

**Normal transformers not adequate**



# Frequency filtering

## Gain and Phase considerations



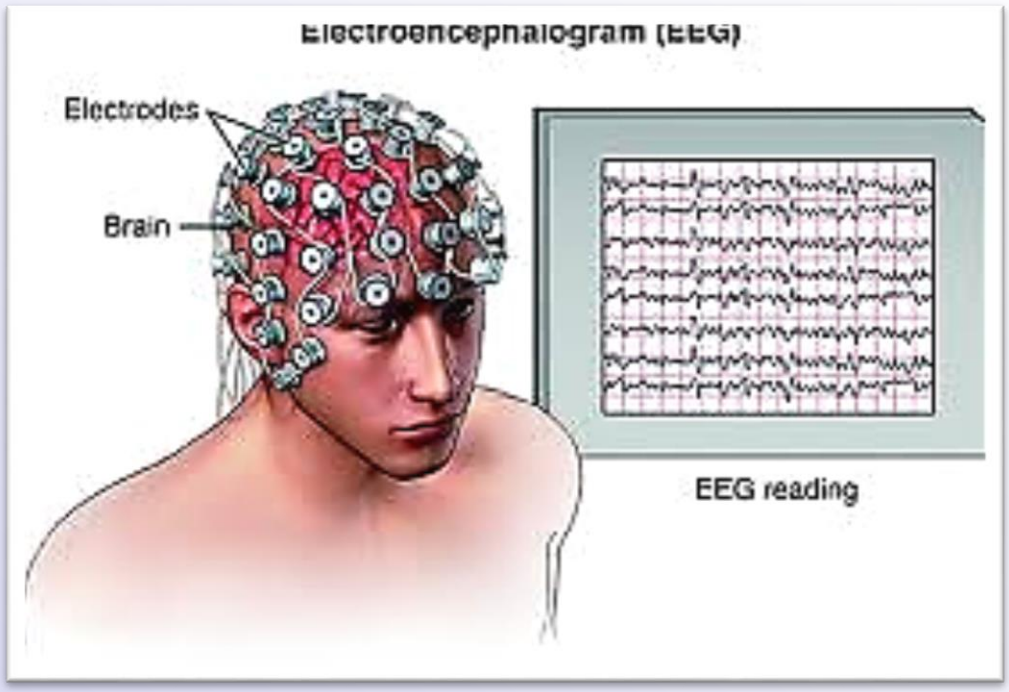
# Evoked Response system, developed by author in Bangladesh in 1988

**With expertise gained through a link with Sheffield, UK**

**Still working,**

**PC, interface circuitry, software have been changed**

# Electro Encephalography, basics-1

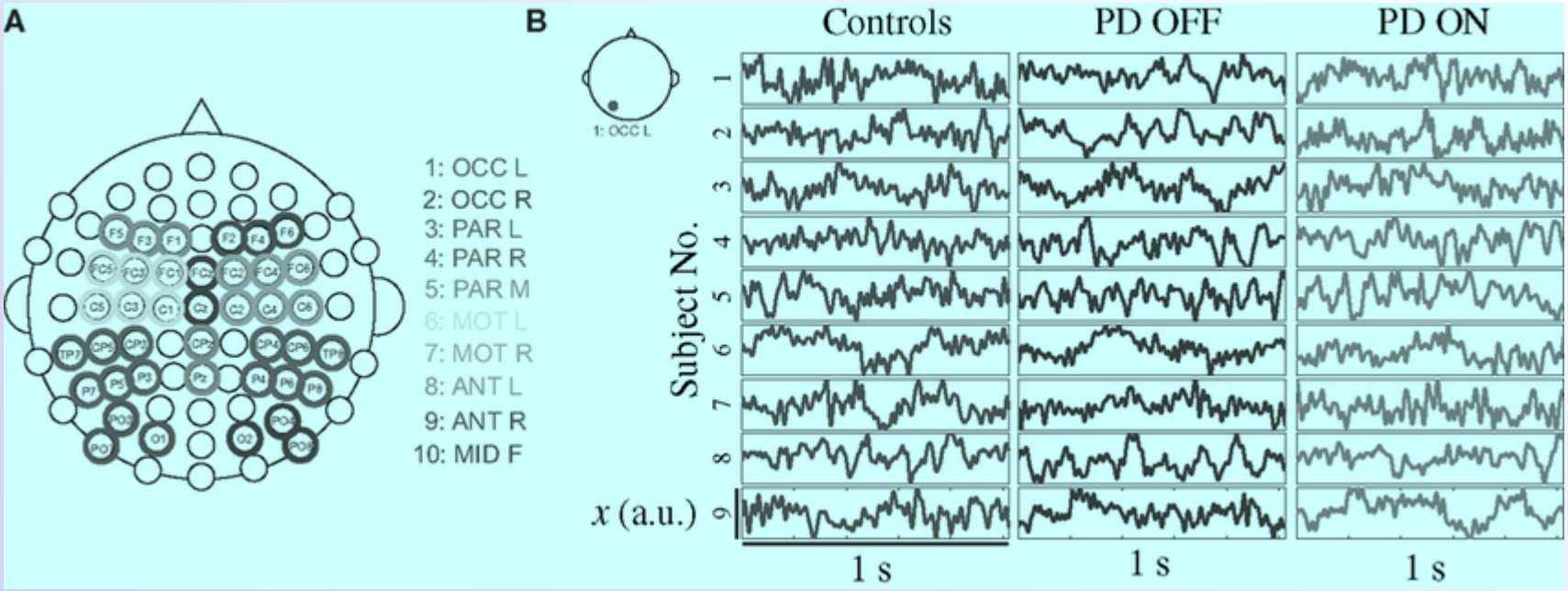


# Electro Encephalography, Electrode connections

# Electro Encephalogram (EEG)

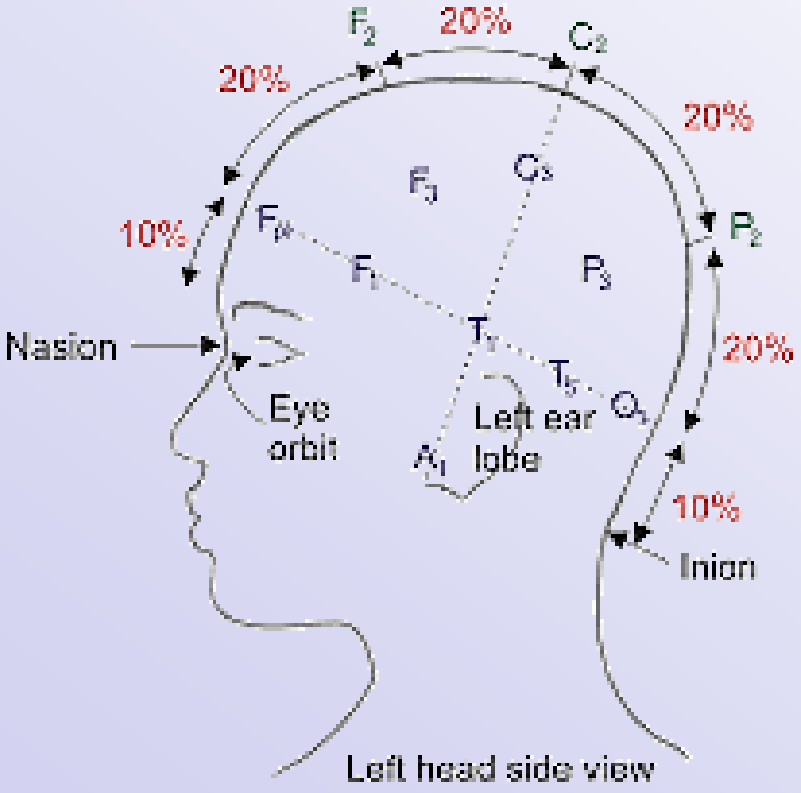
**Effect of locations, subject's condition, pathologies**

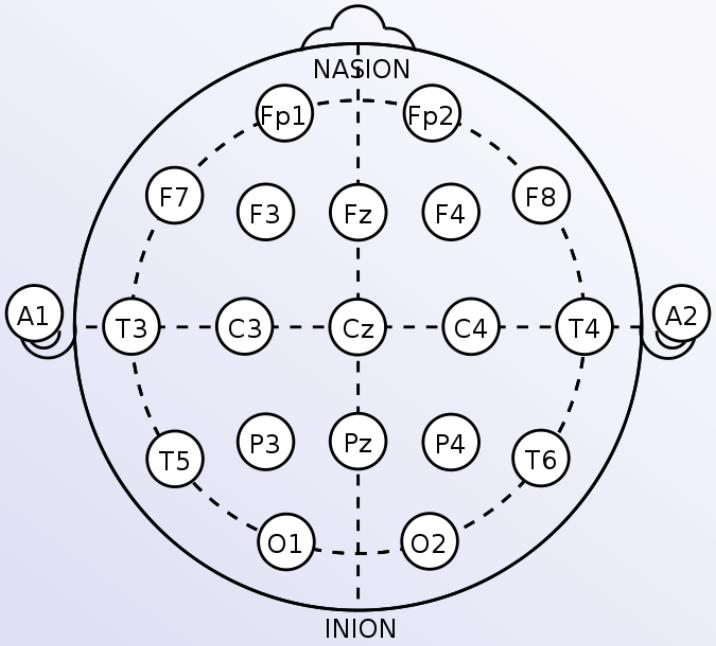
**Based on empirical observations over many years**



# Electro Encephalogram (EEG)

## Standardised Electrode placement

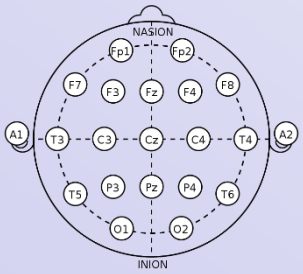


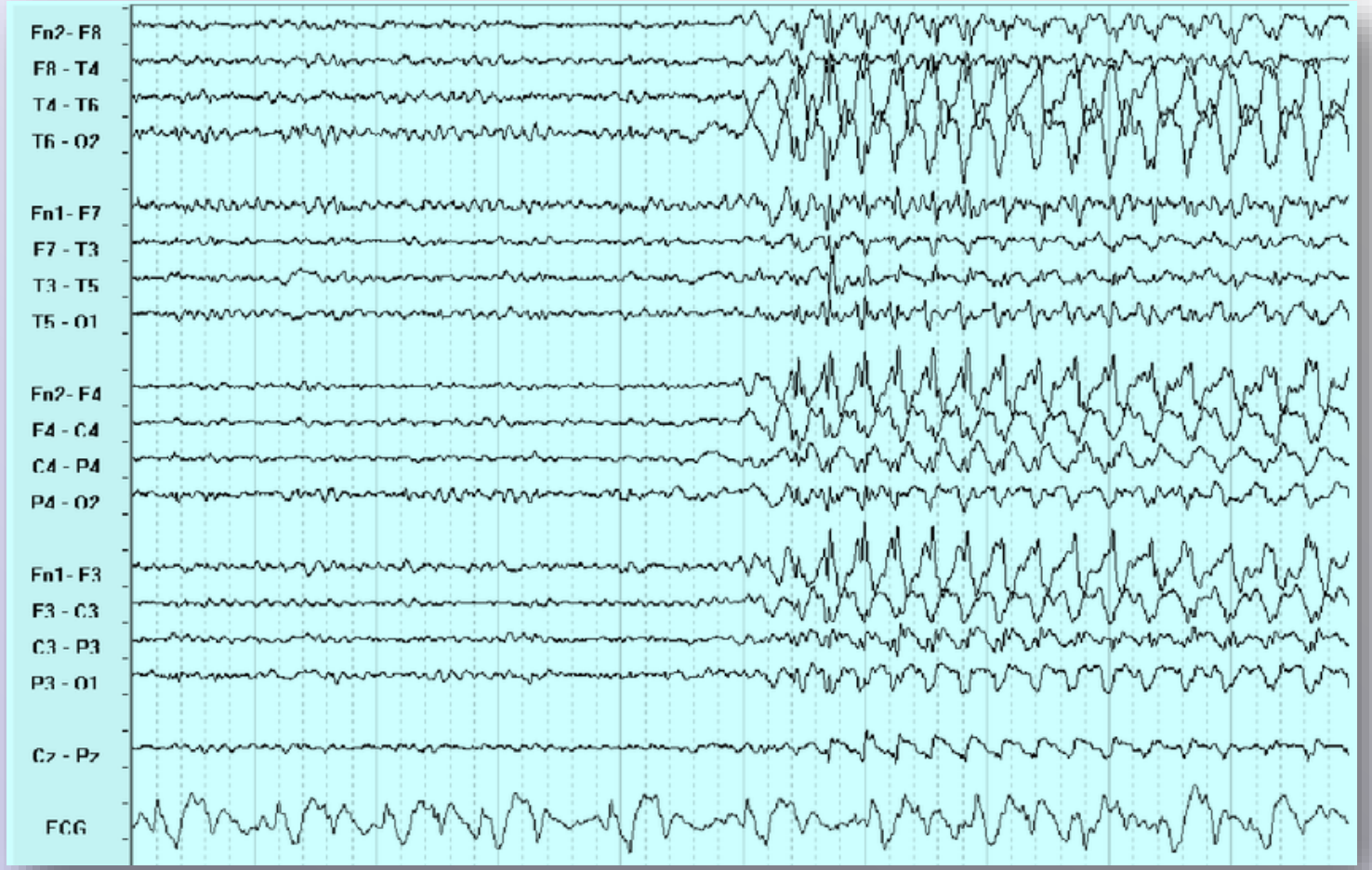



# Electro Encephalogram (EEG)

**Standardised Electrode placement**

**interference of billions of neuronal impulses**

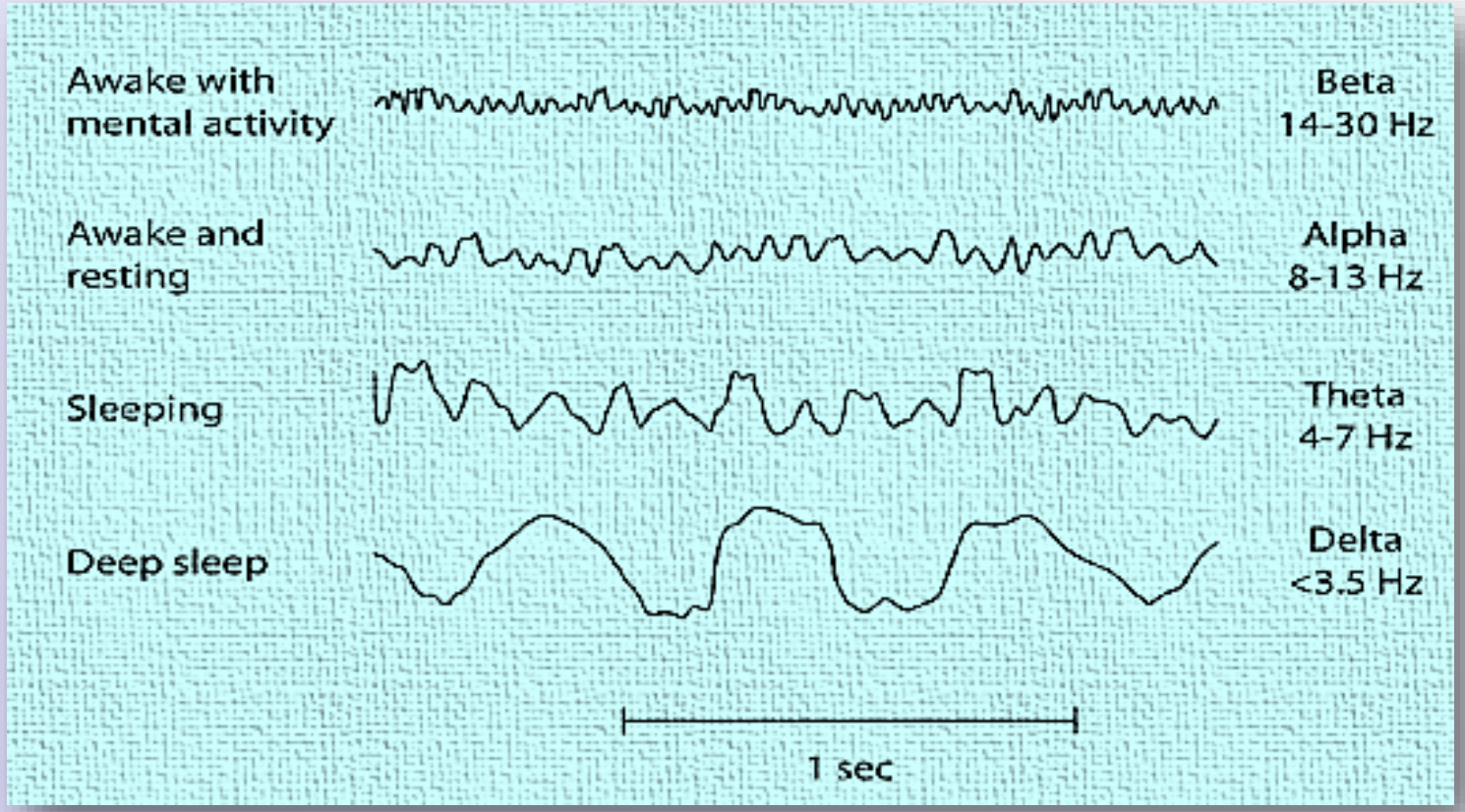


# Electro Encephalogram (EEG)

## Subject conditions

## EEG Frequency bands



# Thank You