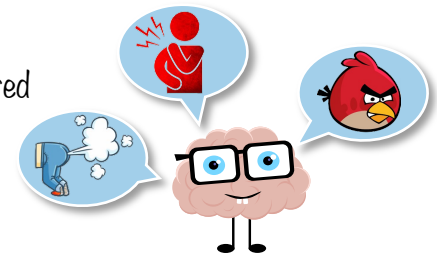
C2.2

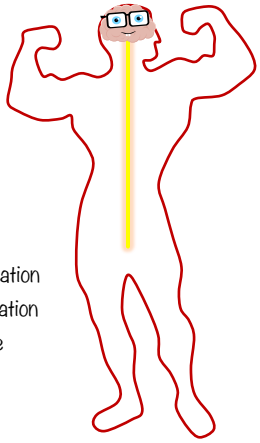
Neural Signaling

NERVOUS SYSTEM – comprised of cells which carry electrical impulses (signals) between the brain and the rest of the body via the spinal cord and nerves. Considered as the control center of the body. It can coordinate actions (muscles), transmit sensory information, control emotions, memory, etc...



CENTRAL NERVOUS SYSTEM "BIG BOSS"

CNS

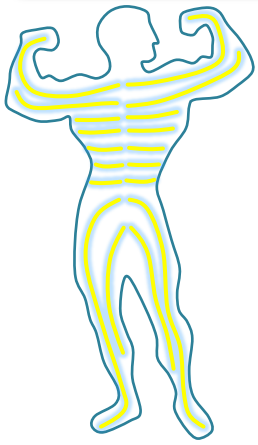


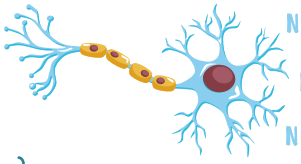
INCLUDES:
- Brain
- Spinal cord

PURPOSE:
- Receives information
- Interpret information
- Initiate response

PERIPHERAL NERVOUS SYSTEM "WORKER OF BIG BOSS"

PNS



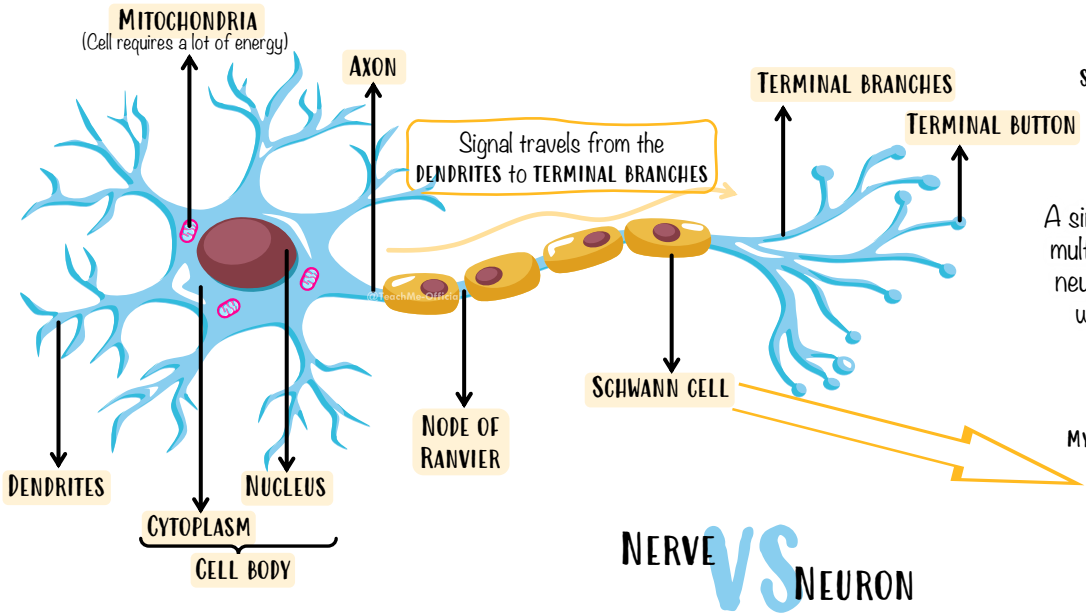


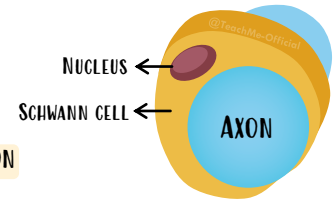
INCLUDES:
- Motor neurons
- Sensory neurons

} Peripheral nerves

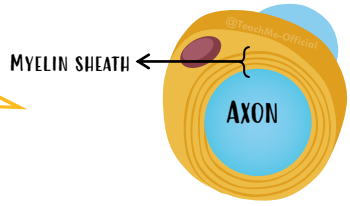
PURPOSE:
- Carry info away from CNS towards muscle
- Carry into to the CNS

NEURON – An individual cell that carries electrical impulses (signals) from one point in the body to another. Some neurons are long (1 meter) some very short (<1 millimeter).



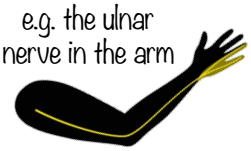


A single schwann cell will wrap itself multiple times around the axon of a neuron until it formes many layers which forms the myelin sheath

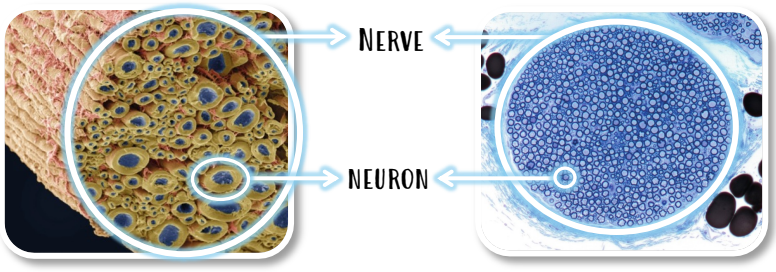


NERVE VS NEURON

e.g. the ulnar nerve in the arm



A bundle of many individual **NEURONS** grouped together forms a **NERVE**.



SEM
(Scanning electron microscope)

Light Microscope

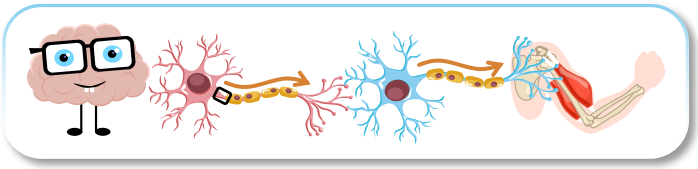
Blue = Axons
Yellow = Myelin Sheath

Neural Signaling

NERVE IMPULSE GENERATION

The detailed mechanism is explained in C2.2 HL

How a signal is transmitted from the neuron's **DENDRITES**, along the **AXON** all the way to the **TERMINAL BRANCHES**.



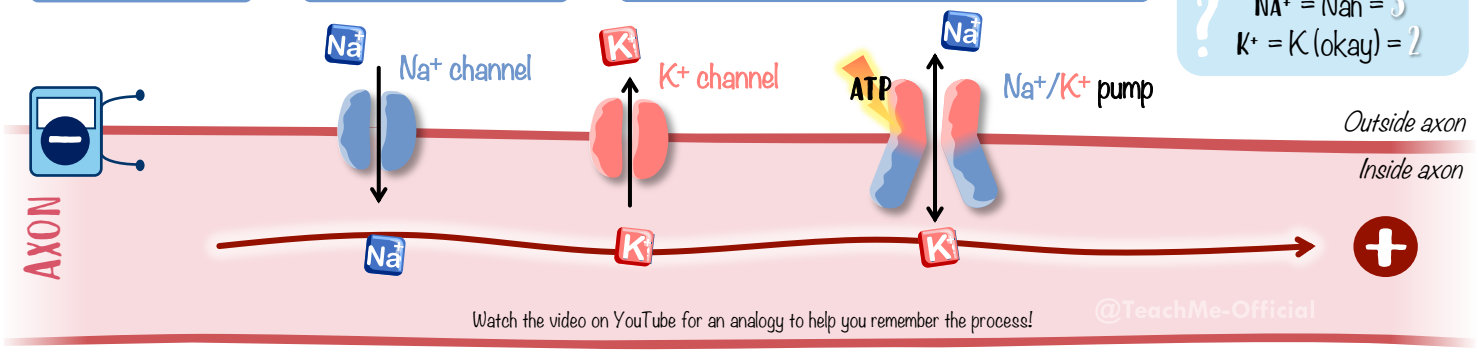
ACTION POTENTIAL – the sequence of events that allows an impulse (electrical signal) to be generated in a neuron.

Sodium ions flux in → Potassium ions flux out → Na^+/K^+ pump resets resting membrane potential

BEAUTIFUL TIP!

Na^+ = Nah = 3

K^+ = K (okay) = 2



"Nerve impulse (electrical signal) is the **ACTION POTENTIAL** propagated through the neuron"

NOTE: Don't blame yourself if you don't TRULY understand. This process cannot be fully understood with the detail provided in SL alone.

Some Definitions

MEMBRANE POTENTIAL – The charge difference across a membrane.

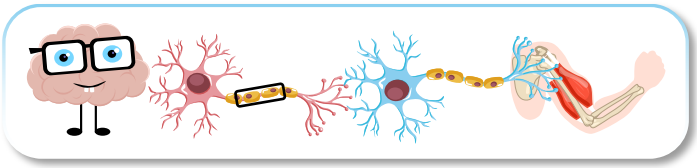
RESTING POTENTIAL – when the neuron is not transmitting an impulse, it is **NEGATIVELY** charged inside (compared to the outside) as the Na^+/K^+ pump pumps $3Na^+$ out of the cell and $2K^+$ into the cell.

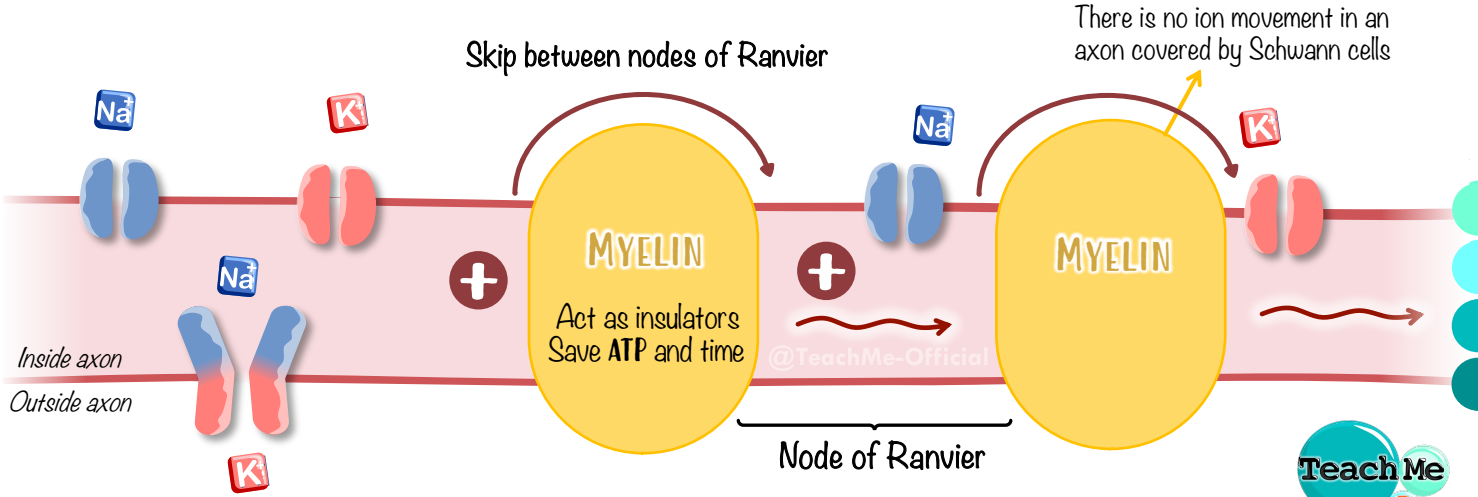
POLARIZED – Any extremes in the charges: the outside negative and inside positive (or vice versa).

SPEED OF NERVE IMPULSE

The detailed mechanism is explained in C2.2 HL

MYELIN: Allows the transmission of action potentials **FASTER** than non-myelinated axons (skip between nodes of Ranvier).
AXONS: Greater diameter results in **FASTER** transmission than smaller diameter.

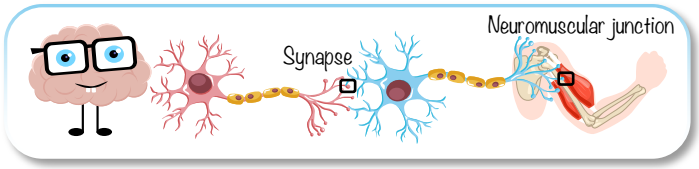


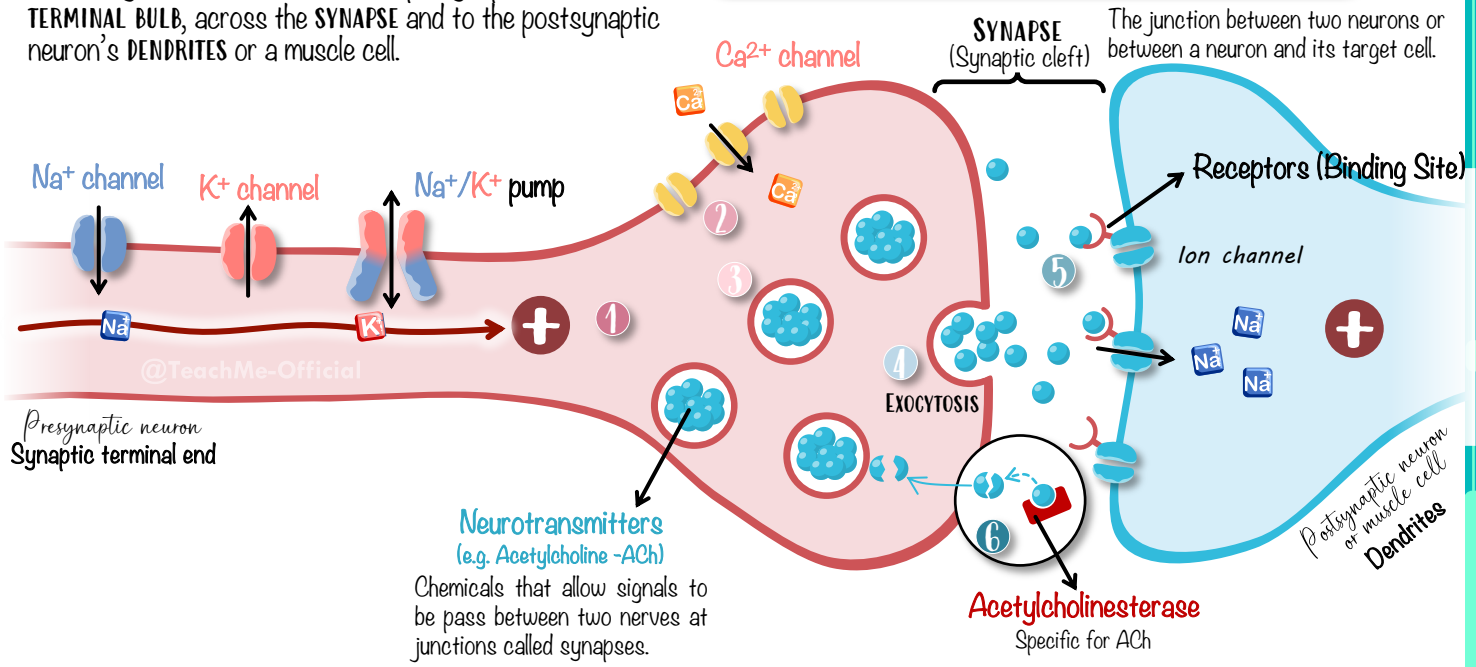


Neural Signaling

Synaptic Transmission

How a signal is transmitted from a presynaptic neuron's **terminal bulb**, across the **synapse** and to the postsynaptic neuron's **dendrites** or a muscle cell.

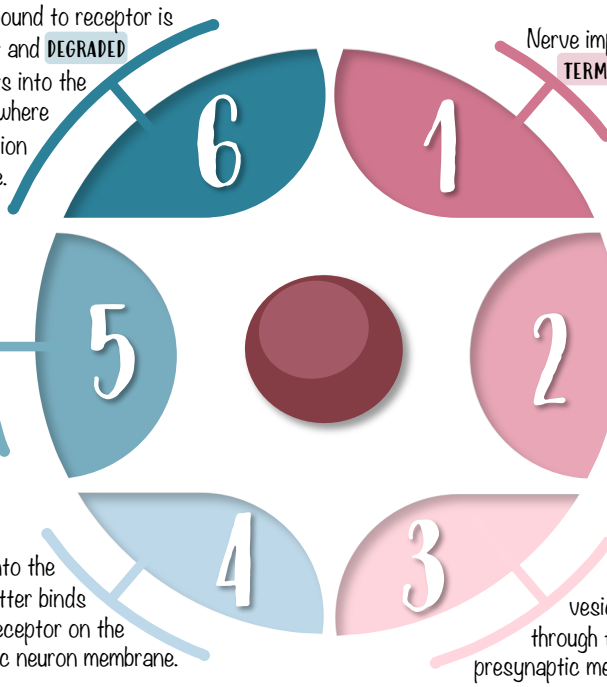




Neurotransmitters
(e.g. Acetylcholine -ACh)
Chemicals that allow signals to be pass between two nerves at junctions called synapses.

Acetylcholinesterase
Specific for ACh

Summary Steps of Synaptic Transmission



1. Nerve impulse arrives at the **terminal button**, depolarizing the presynaptic membrane.
2. This triggers Ca^{2+} uptake into terminal buttons.
3. Ca^{2+} activates pathway that moves vesicles containing **neurotransmitter** through the cell. Vesicles fuse with the presynaptic membrane (**exocytosis**).
4. Neurotransmitter released into the **synaptic cleft**. Neurotransmitter binds with a protein receptor on the postsynaptic neuron membrane.
5. Binding results in an ion channel opening resulting in sodium ions diffusion. This initiates the **action potential** in the post synaptic neuron (depolarized).
6. Neurotransmitter that is bound to receptor is released back into the synaptic cleft and **degraded** by enzymes and then **reuptake** occurs into the terminal buttons (of presynaptic neuron) where they are **reassembled** (recycled). Results in ion channel closing on post-synaptic membrane.

Neural Signaling

CORRELATION This section is useful for CASE-BASED QUESTIONS!

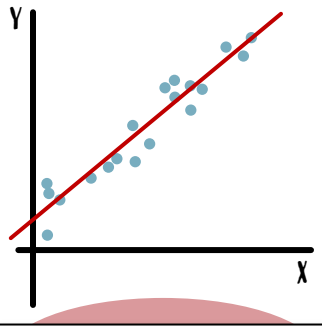
A correlation coefficient quantifies the STRENGTH of a LINEAR RELATIONSHIP between two variables. Denoted by (R).

Independent variable (X) – the factor being changed
Dependent variable (Y) – the factor being measured

BIG BRAIN TIP!

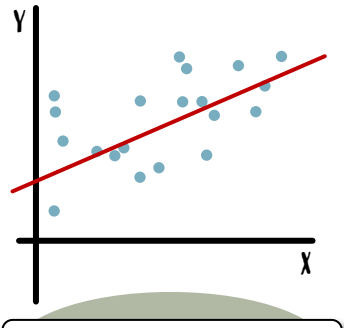
You may be asked to describe the correlation between two variables in different contexts. Make sure you refer to both the **STRENGTH** and **DIRECTION** of that correlation.

The closer to R=1 the stronger the (**POSITIVE**) correlation. R=0 indicates NO (positive) correlation.



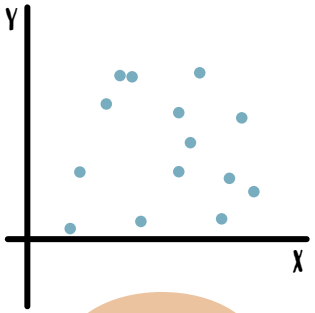
Strong positive correlation

Examples
X – hours studied per week
Y – test scores



Weak positive correlation

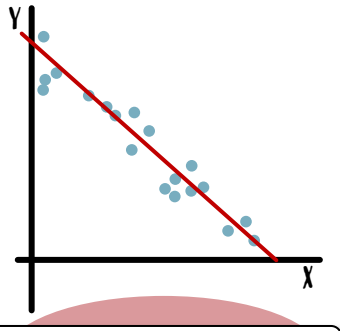
X – hours of sleep per night
Y – height



No correlation

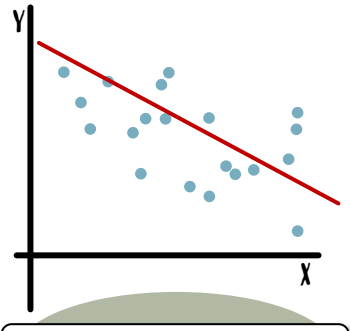
X – shoe size
Y – intelligence

The closer to R=-1 the stronger the (**NEGATIVE**) correlation. R=0 indicates NO (positive) correlation.



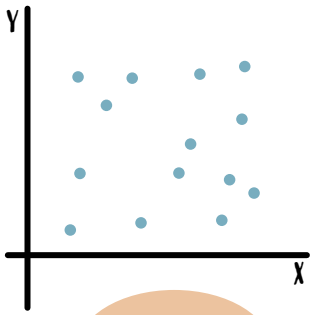
Strong negative correlation

Examples
X – cigarettes smoked per day
Y – lung function



Weak negative correlation

X – daily screentime (hours)
Y – quality of sleep



No correlation

X – favorite color
Y – annual income

R^2 gives a clue into the VARIANCE in the data. R^2 = 1 indicated NO variance (data points close to line of best fit).

notes