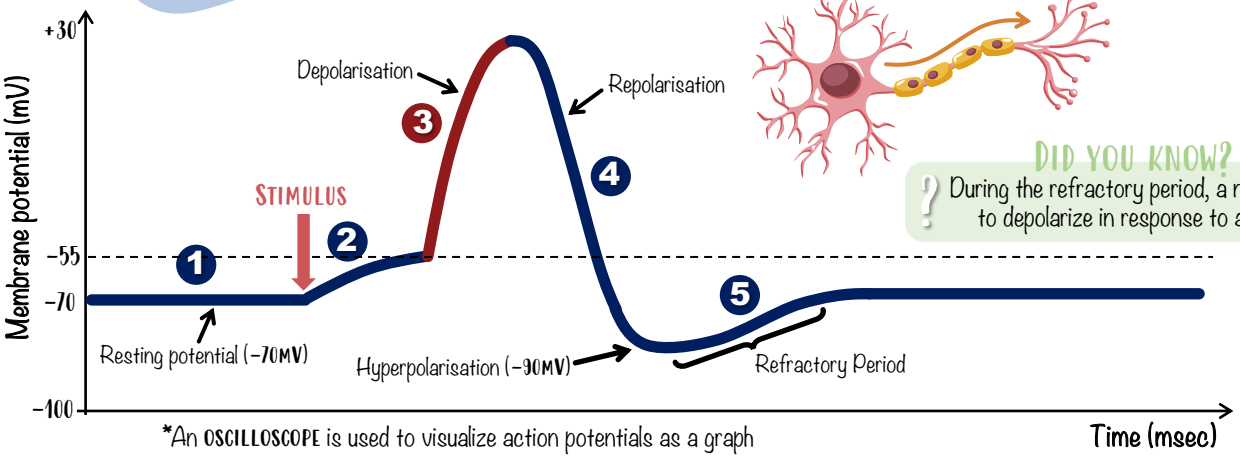
C2.2

Neural Signaling (HL)

NERVE IMPULSE GENERATION

The detailed mechanism!



*An **OSCILLOSCOPE** is used to visualize action potentials as a graph

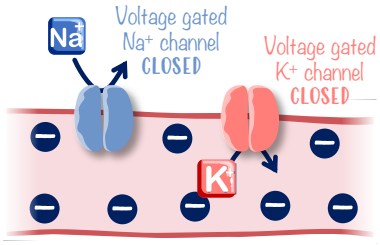
A signal is transmitted from the neuron's **DENDRITES**, along the **AXON** all the way to the **TERMINAL BRANCHES**.

DID YOU KNOW?

During the refractory period, a neuron is unable to depolarize in response to any stimulus.

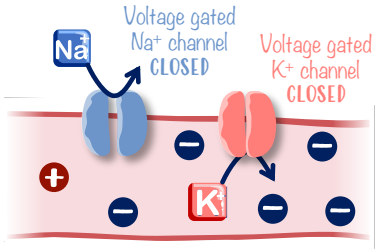
We now see the exact mechanism how an **ACTION POTENTIAL** can be represented as the curve seen above in **5** simple steps.

1 RESTING STATE (POTENTIAL)



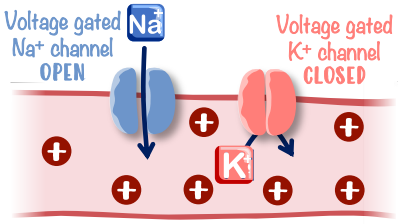
- High [Na^+] outside axon.
- High [K^+] inside axon.
- Membrane potential is negative.

2 STIMULUS ARRIVES



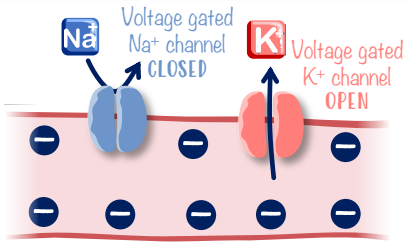
- Signal in the form of a positive charge arrives.
- Axon is slightly more positive.

3 DEPOLARIZATION



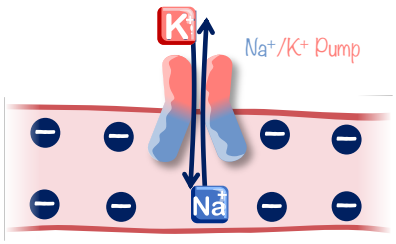
- If threshold potential is reached, voltage gated Na^+ channels open.
- Sodium diffuses into the axon to **DEPOLARIZE** the membrane.
- Membrane potential is positive.

4 REPOLARIZATION & HYPERPOLARIZATION



- Voltage gated K^+ channels open.
- Potassium diffuses out of the axon to **REPOLARIZE** the membrane.
- Membrane potential is negative, but even lower than resting potential.

5 RESETTING THE RESTING POTENTIAL



- Na^+/K^+ Pump pumps sodium out and potassium into the axon.
- Resets resting membrane potential.
- Na^+ & K^+ are returned to their original locations.

Key Terms

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

RESTING POTENTIAL – When the neuron is not transmitting an impulse; **NEGATIVELY** (-70mV) charged inside compared to the outside.

THRESHOLD POTENTIAL – The minimum potential needed to initiate an action potential (-55mV).

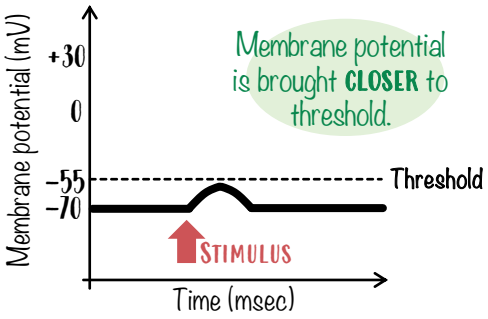
BEAUTIFUL TIP!

Na^+ = Nah = 3
K^+ = K (okay) = 2

C2.2 Neural Signaling (HL)

Excitatory Postsynaptic Potential (EPSP)

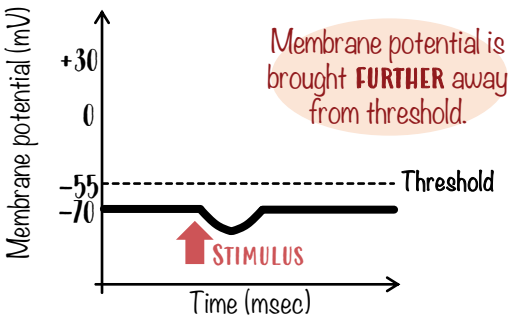
(Local depolarization in the postsynaptic neuron)



Membrane potential is brought **CLOSER** to threshold.

Inhibitory Postsynaptic Potential (IPSP)

(Local hyperpolarization in the postsynaptic neuron)

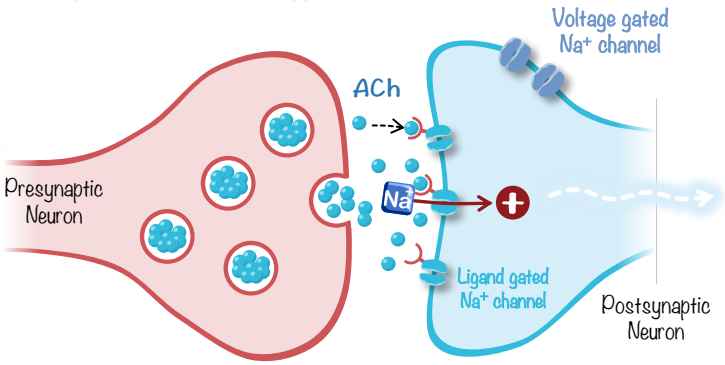


Membrane potential is brought **FURTHER** away from threshold.

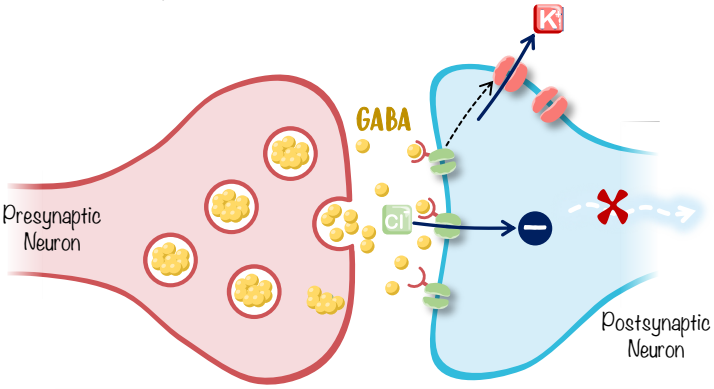
DID YOU KNOW?

The **SUM** of all stimuli affect the outcome.

ALL OR NOTHING – there is no such thing as a "strong" or "weak" impulse: the action potential either get triggered (if the threshold is surpassed) or nothing happens at all (if the threshold isn't met).



EXCITATORY NEUROTRANSMITTERS (example is **ACETYLCHOLINE**) generate an action potential by increasing the permeability of the postsynaptic membrane to positive ions such as Na^+. They cause the inside of the neuron to become more positive.



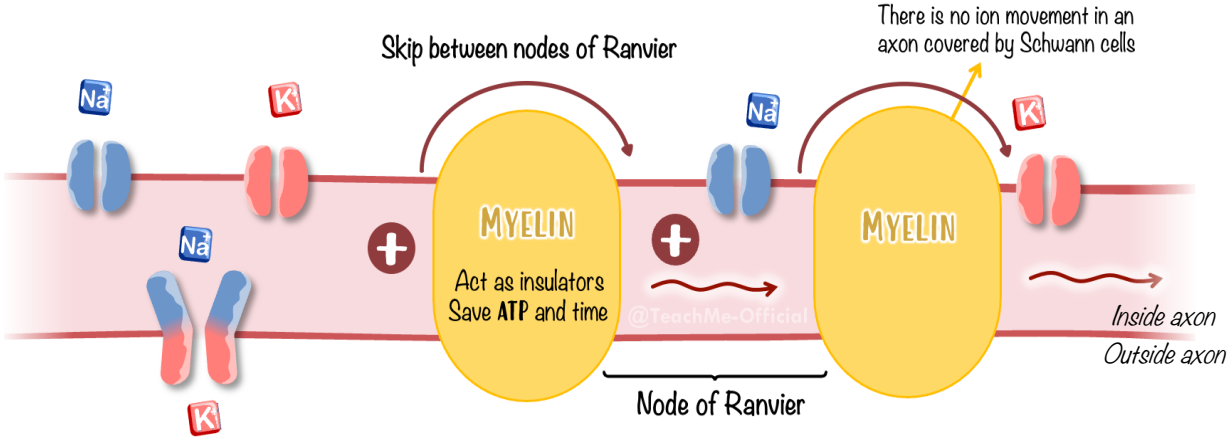
INHIBITORY NEUROTRANSMITTERS (example is **GABA**: Gamma-Amino Butyric Acid). These cause **HYPERPOLARIZATION** of the neuron, which **INHIBITS** action potentials by **(1)** increasing the permeability of the postsynaptic membrane to negative ions such as Cl^-. Along with the **(2)** outflux of K^+, they cause the inside of the neuron to become more negative.

Saltatory Conduction

The mechanism was explained in **C2.2 SL**

The name given to the phenomenon whereby an action potential jumps from one node of Ranvier to the next as an impulse progresses along a **MYELINATED** axon.

In non-myelinated axons, the **WHOLE** axon must be depolarized and then repolarized.



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

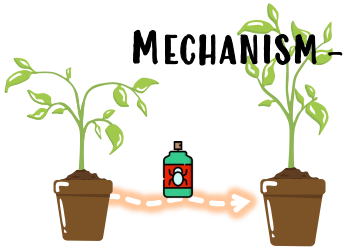
Neural Signaling (HL)

What can affect transmission at the synapse?

NEONICOTINOIDS (EXOGENOUS)

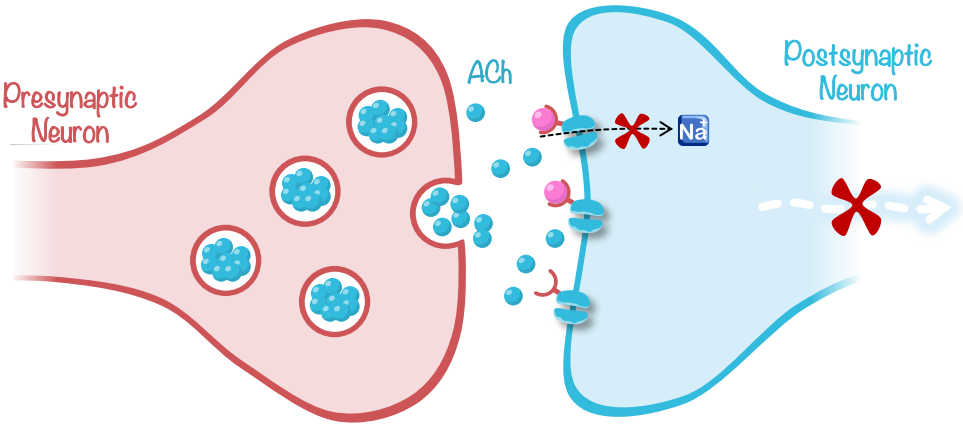
New class of insecticide 

EXOgenous chemicals produced **OUTSIDE** body
ENDOgenous chemicals are produced **WITHIN** the body

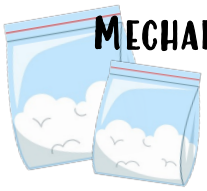


MECHANISM – Binding postsynaptic receptors that normally bind the neurotransmitter **ACETYLCHOLINE**. Prevents the opening of sodium channels and hence **NO PROPAGATION OF ACTION POTENTIAL**. Also, they are not released from receptor OR broken down in the synaptic cleft. Hence receptor is **PERMANENTLY** blocked. Leading to paralysis of the affected insect and eventually... death.

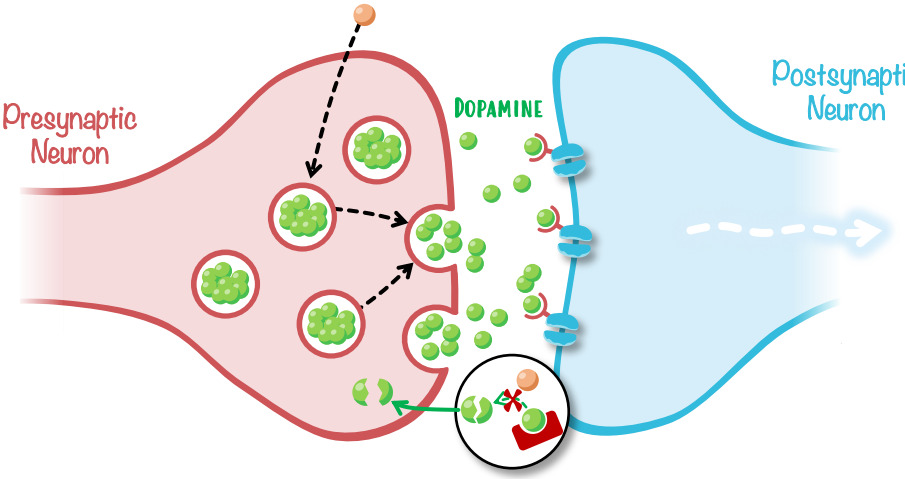
The introduction of such pesticides is useful for farmers to get rid of pests and recover their crops.



COCAINE (EXOGENOUS)



MECHANISM – Affects action of neurotransmitter called **DOPAMINE**, which is associated with feelings of reward, pleasure, motivation and being productive. Cocaine **(1) PREVENT THE REMOVAL OF DOPAMINE** from the synapse and **(2)** stimulates dopamine-releasing neurons to release dopamine that is usually held in reserve. **MORE DOPAMINE = HAPPIER!**

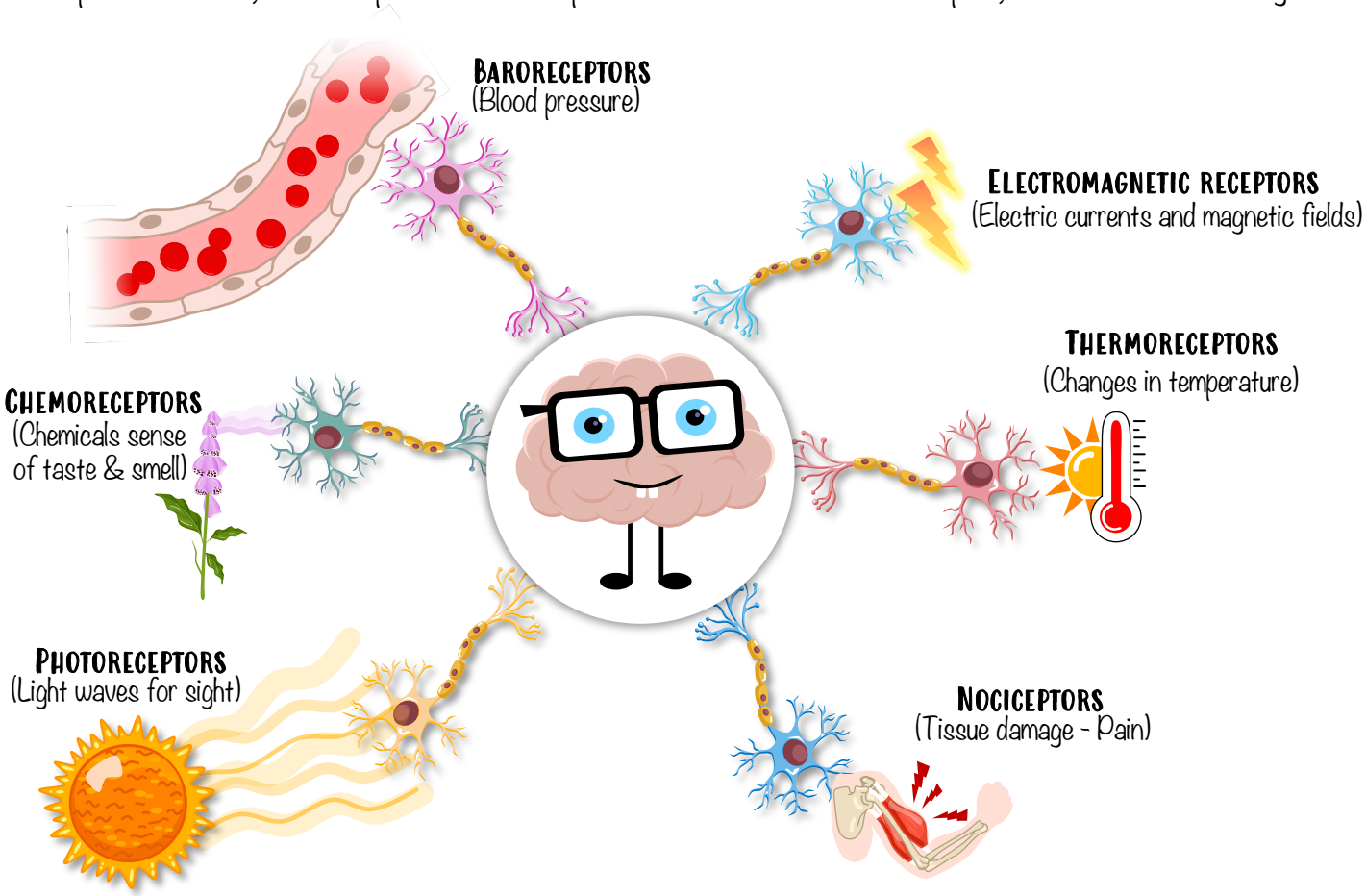


The brain adapts to an unnatural reward pathway and becomes less sensitive to natural reinforces. This increases likelihood of seeking drugs instead of relationships, food or other things.

Over time, tolerance may develop, higher doses are no longer affective, constantly want more doses. There are other side effects as well.

Neural Signaling (HL)

Sensory nerves can specialise to sense various types of stimuli such as light for sight, or chemicals which can be interpreted as taste, other for pressure or even pain. When a nerve acts as a receptor, different names will be given:



More detail is provided in section C3.1 about this topic

- ✓ Receptor neuron: A neuron that converts a physical stimulus of some kind into the first action potential which is then transmitted between neurons until it reaches the brain.
- ✓ Nerve endings have channels for positively charged ions, which open in response to a stimulus (see examples above).
- ✓ If a sufficient stimulus reaches the threshold potential, a nerve impulse is propagated and carried to CNS for the brain to interpret.

Hot chilli peppers contain the chemical capsaicin which binds to **NOCICEPTORS** and trigger them to open their ion channels – this information is interpreted as pain or heat.

MEDICATIONS can affect the process, for example pain killers

CONGENITAL ISSUES may cause a lack of pain sensation (not as good as it sounds)

notes