6.5 The Nervous System

The Nerve Impulse

Resting Potential - the electrical potential (charge difference) across a membrane that is not conducting an impulse (-70 mV)

Action Potential – the electrical potential across a membrane as is passes a nerve impulse. This is an "all or nothing" response. (-40 mV)

Threshold Potential – the minimum change in membrane potential necessary to produce an action potential

- At rest, there is a higher [Na^+] outside the axon and a higher [K^+] inside the axon. Cl^- inside the axon creates a charge difference or resting potential. There is an external positive charge.
- When an impulse travels down a neuron, voltage-gated Na^+ channels open and Na^+ flows into the axon. This causes the potential difference to reverse → **depolarization**
- This causes the neighbouring Na^+ channels to open and results in the movement of the action potential down the membrane.
- K^+ channels are opened and K^+ moves out of the axon to restore the potential difference → **repolarization**
- The depolarization causes the Na^+ channels to close.
- Waves of depolarization followed by repolarization move down the axon, carrying the impulse.
- Now the Na^+ and K^+ are in the wrong positions. The Na^+ - K^+ pump is used to transport the ions back to their original positions

- A nerve impulse moves down an axon like “the wave” moving around a stadium of people. The wave travels around, but the people stay in place. (standing up = depolarization; sitting back down = repolarization)

- Once the impulse reaches the synapse (the space between neurons) neurotransmitters carry it across the synapse to the next neuron

- Impulses (waves of depolarization) will travel faster down myelinated neurons.

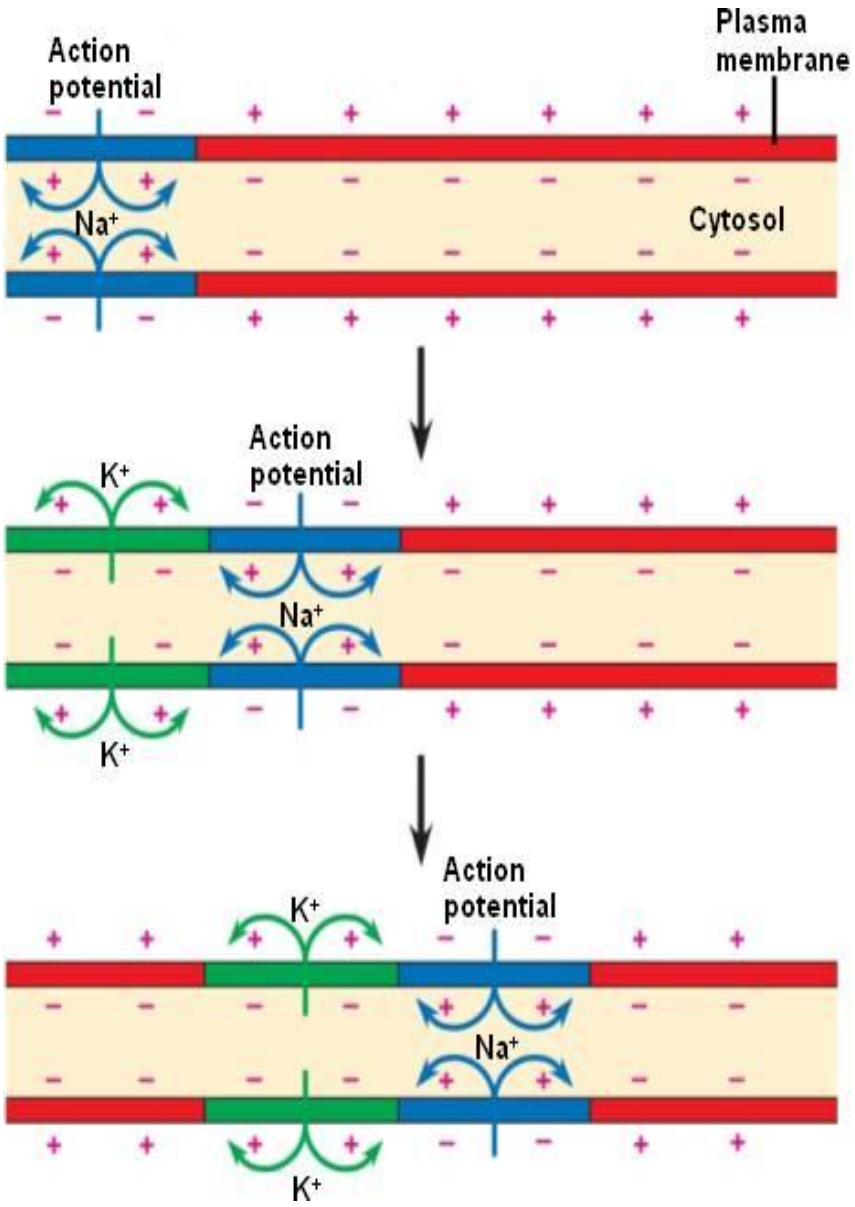
- Depolarization only happens at the nodes of Ranvier, the spaces without a myelin sheath.

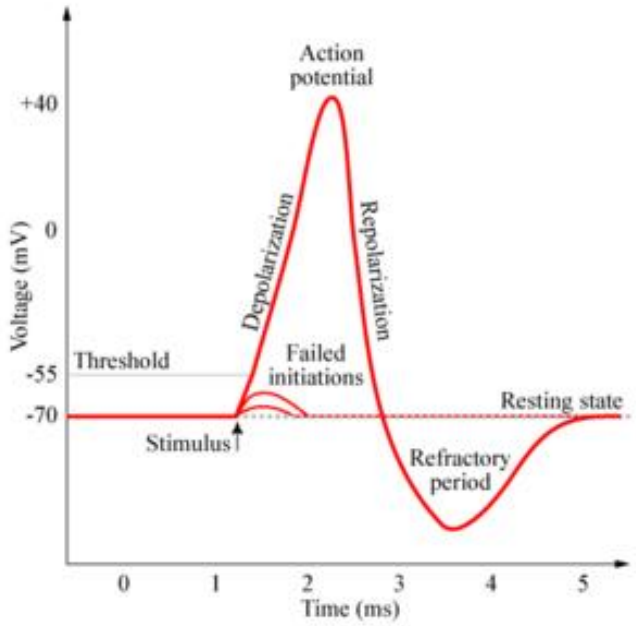
- The impulse jumps from one node to another speeding up the impulse.
  (like a “wave” passing around a stadium with many empty sections. It doesn’t stop at the empty sections, so it travels faster)

  Non-myelinated neuron – 2 m/s
  Myelinated neuron – 120 m/s

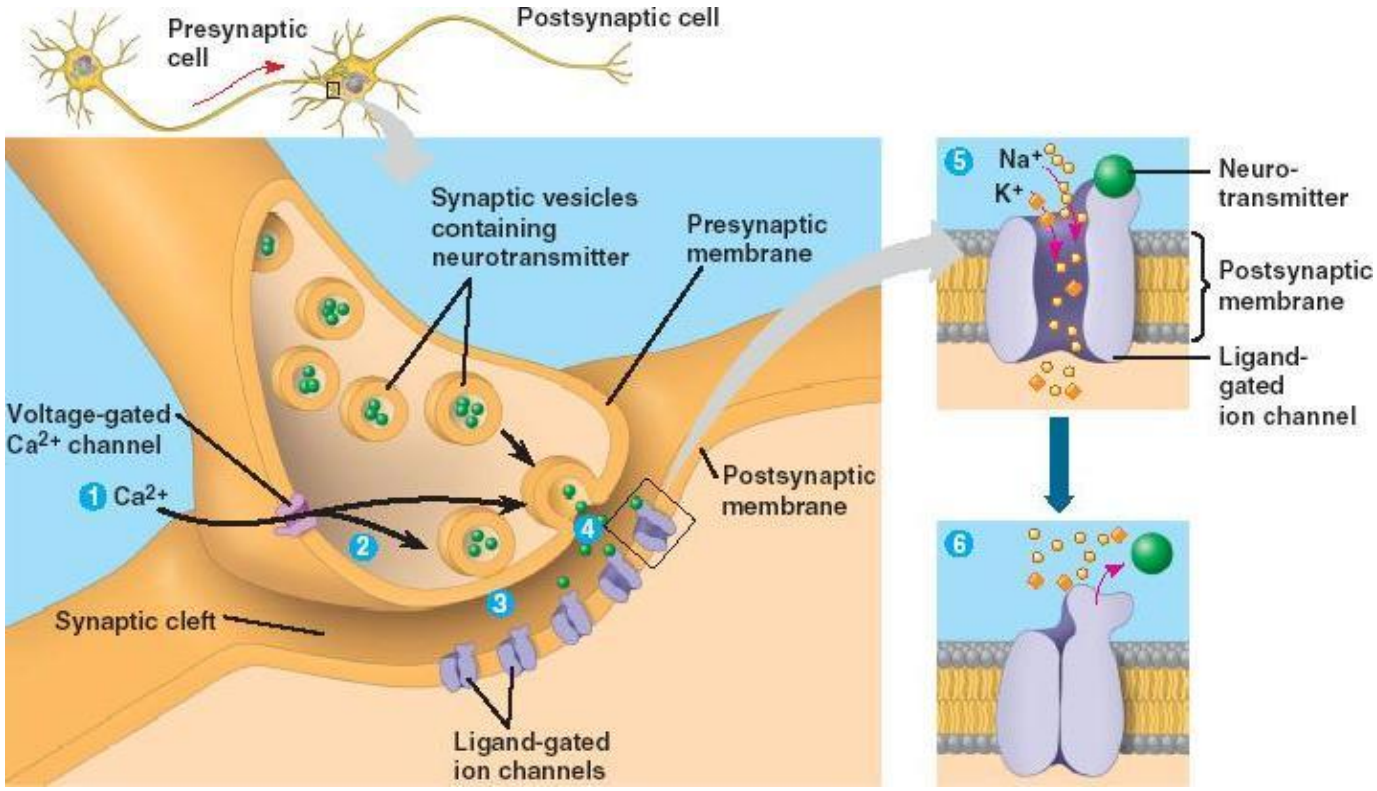
- Action potentials are “all or nothing” events. An action potential will occur if the threshold potential is reached.

- It is the frequency not amplitude of an action potential that the nervous system uses to determine the intensity of a stimulus


Action potential
Plasma membrane
Na+
Cytosol
Action potential
K+
Na+
K+
Action potential
K+
Na+
K+


Action potential
+40
0
Voltage (mV)
-55
-70
Threshold
Depolarization
Repolarization
Failed initiations
Resting state
Stimulus
Refractory period
0
1
2
3
4
5
Time (ms)

Synaptic Transmission



A **synapse** is a space between two neurons or between a neuron and another cell (ie – muscle cell or gland)

1. An action potential depolarizes the plasma membrane of the pre-synaptic terminal.

2. Voltage-gated Ca^{2+} channels in the membrane open, triggering influx of Ca^{2+}.

3. The elevated Ca^{2+} concentration causes synaptic vesicles to fuse with the pre-synaptic membrane.

4. The vesicles release neurotransmitters (eg – Acetylcholine, dopmine, serotonin) into the synaptic cleft. They diffuse across the synapse.

5. Neurotransmitters bind to gated receptor proteins on the post-synaptic membrane. Na^+ ions diffuse through the channels passing the depolarization (impulse) along.

6. Neurotransmitters release from the channels and the channels close. The neurotransmitters are rapidly removed and recycled back to the pre-synaptic neuron