Thebiotutor.com

A2 Biology OCR

Unit F214: Communication, Homeostasis and Energy

Module 1.2 Nerves

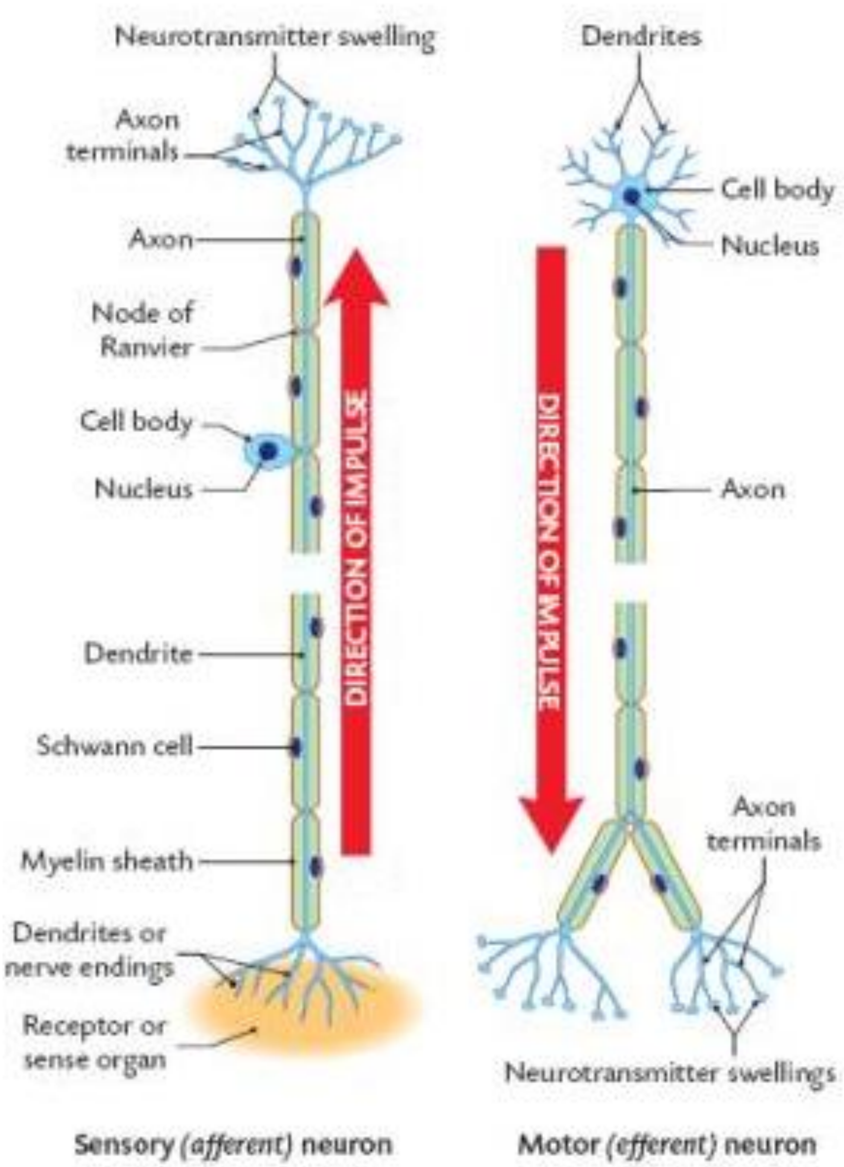
Notes

Outline the roles of sensory receptors in mammals in converting different forms of energy into nerve impulses.

- Sensory receptors are referred to as energy transducers
  - They covnert energy of the stimulus into electrical energy of an action potential
- Examples of sensory receptors include;
  - Light sensitive cells in the retina detect light intensity and range of wavelengths (colour).
  - Olfactory cells in the nasal cavity detect the presence of volatile chemicals.
  - Tastebuds detect the presence of soluble chemicals.
  - Pressure receptors in the skin detect pressure on the skin.
  - Sound receptors in the cochlea detect vibrations in the air.
  - Muscle spindles detect the length of muscle fibres.

Describe, with the aid of diagrams, the structure and functions of sensory and motor neurones.

34.1 Sensory and motor neurons

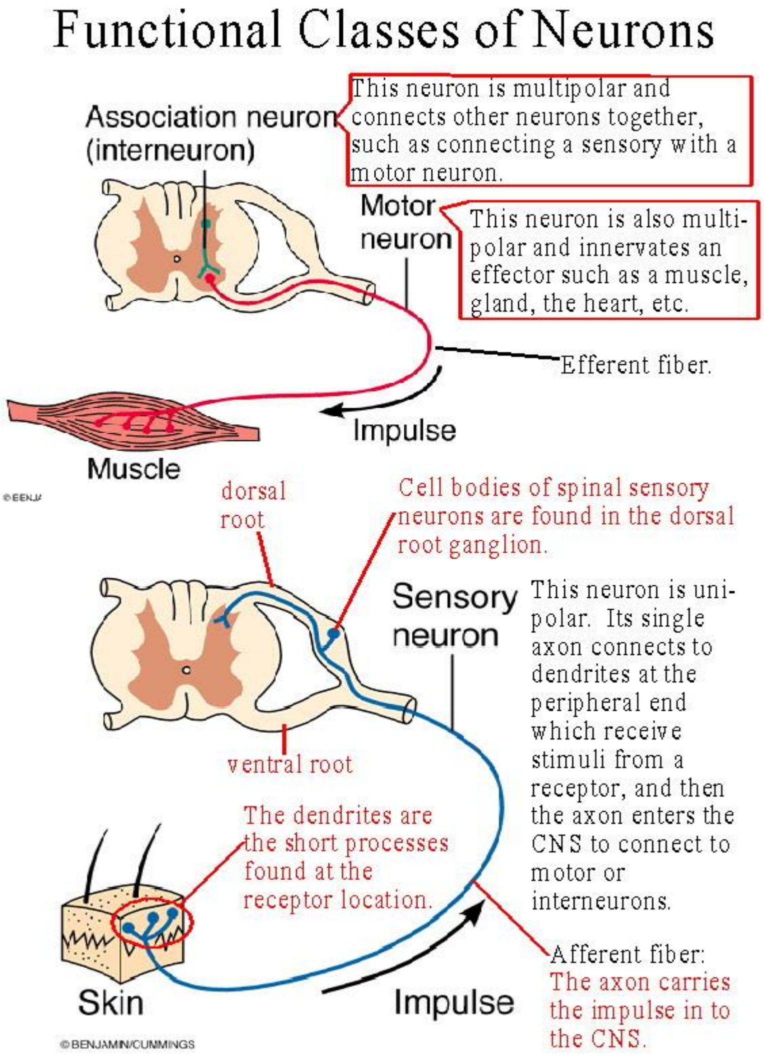


- **Sensory Neurone Structure**
    - Long Dendron
    - Short Axon
    - Cell body is outside the CNS
    - Cell body in the middle of the cell
    - Myelinated with Schwann cells
    - Many dendrites

- **Sensory Neurone Functions**
    - Brings an action potential from a sensory receptor to the CNS

- **Motor Neurone Structures**
    - Short or no Dendron
    - long Axon
    - Cell body is inside the CNS
    - Cell body at the end of the cell
    - Myelinated with Schwann cells
    - Many dendrites

- **Motor Neurone Functions**
    - Brings an action potential from the CNS to an effector (muscle / gland)

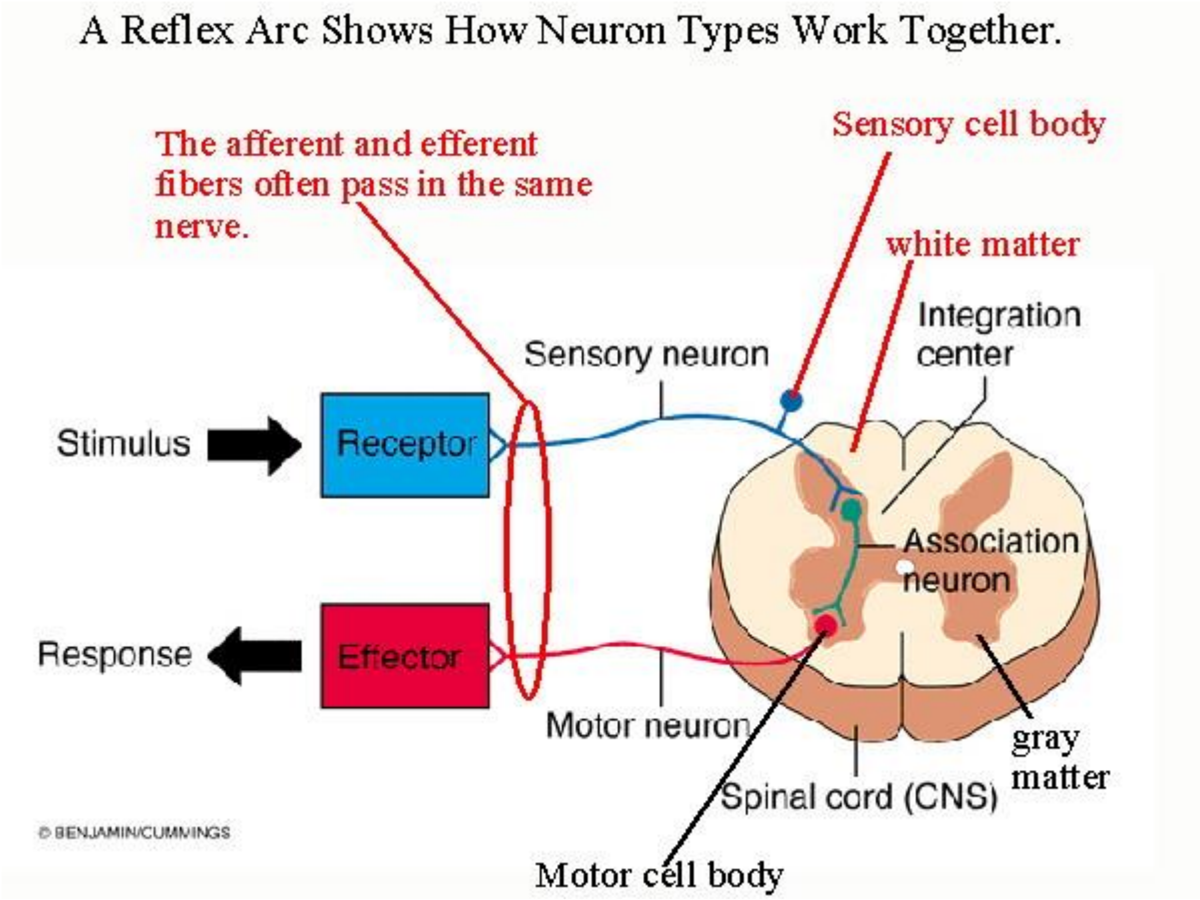


Structural Similarities & Differences

Sensory Neurone	Motor Neurone

Functional Similarities & Differences

Sensory Neurone	Motor Neurone

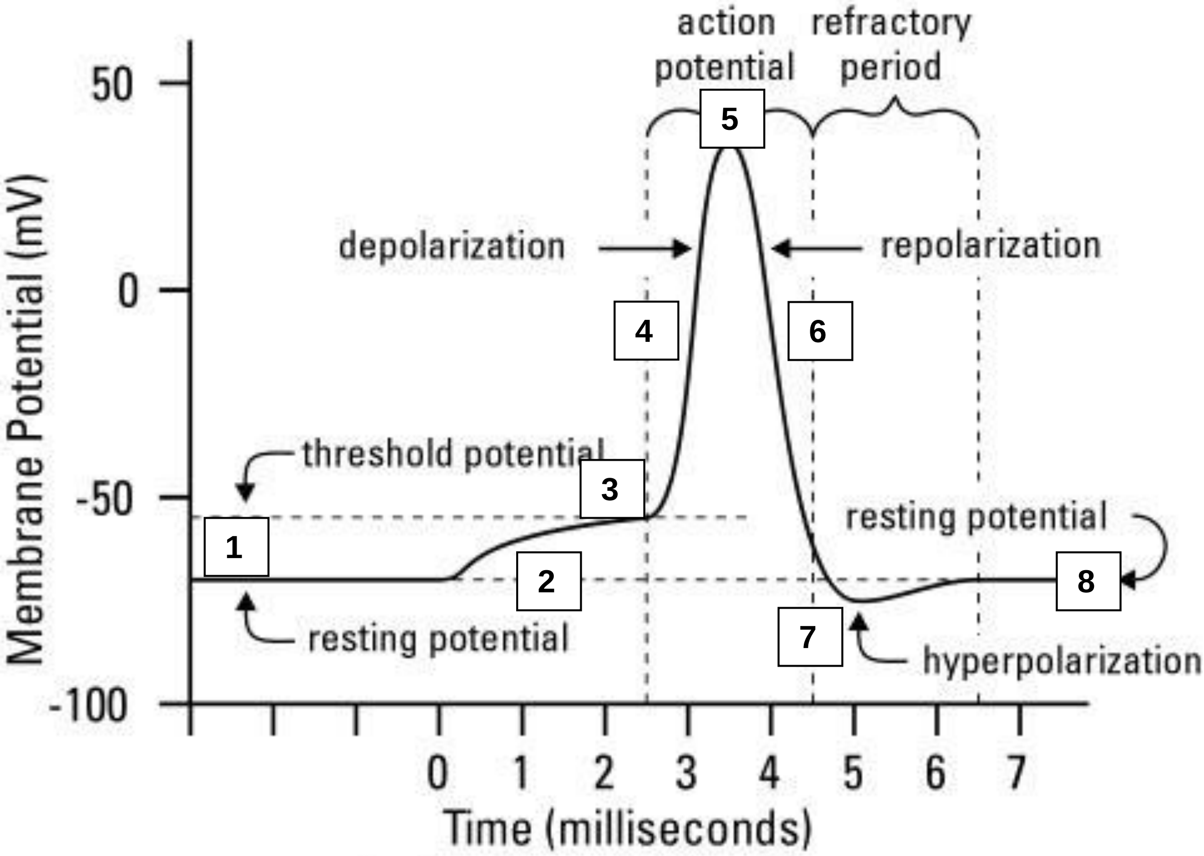


Describe and explain how the resting potential is established and maintained.

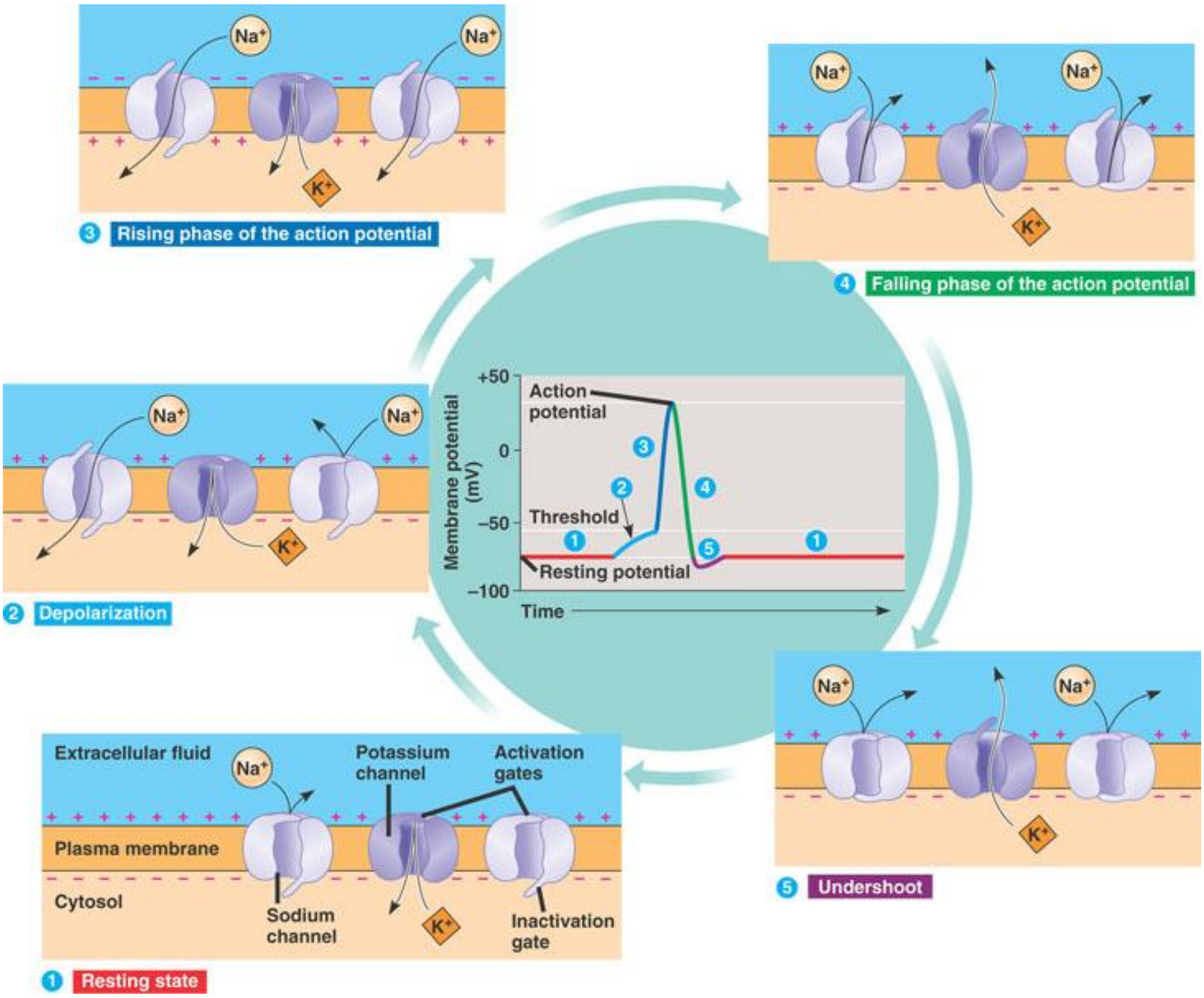
- When an action potential is not being conducted down a neurone the neurone is said to be at rest.
- When not conducting an impulse, the potential difference across the membrane is -60mV.
- How is this established and maintained?
  - Sodium-Potassium pumps actively transport 3Na+ ions out of the neurone for every 2 K+ ions in.
  - The axon contains organic anions, which the membrane is impermeable to.
  - Slight loss of K+ ions through the permeable membrane out of the neurone.
  - Membrane impermeable to Na+ ions.

Describe and explain how an action potential is generated.
&
Interpret graphs of the voltage changes taking place during the generation and transmission of an action potential.

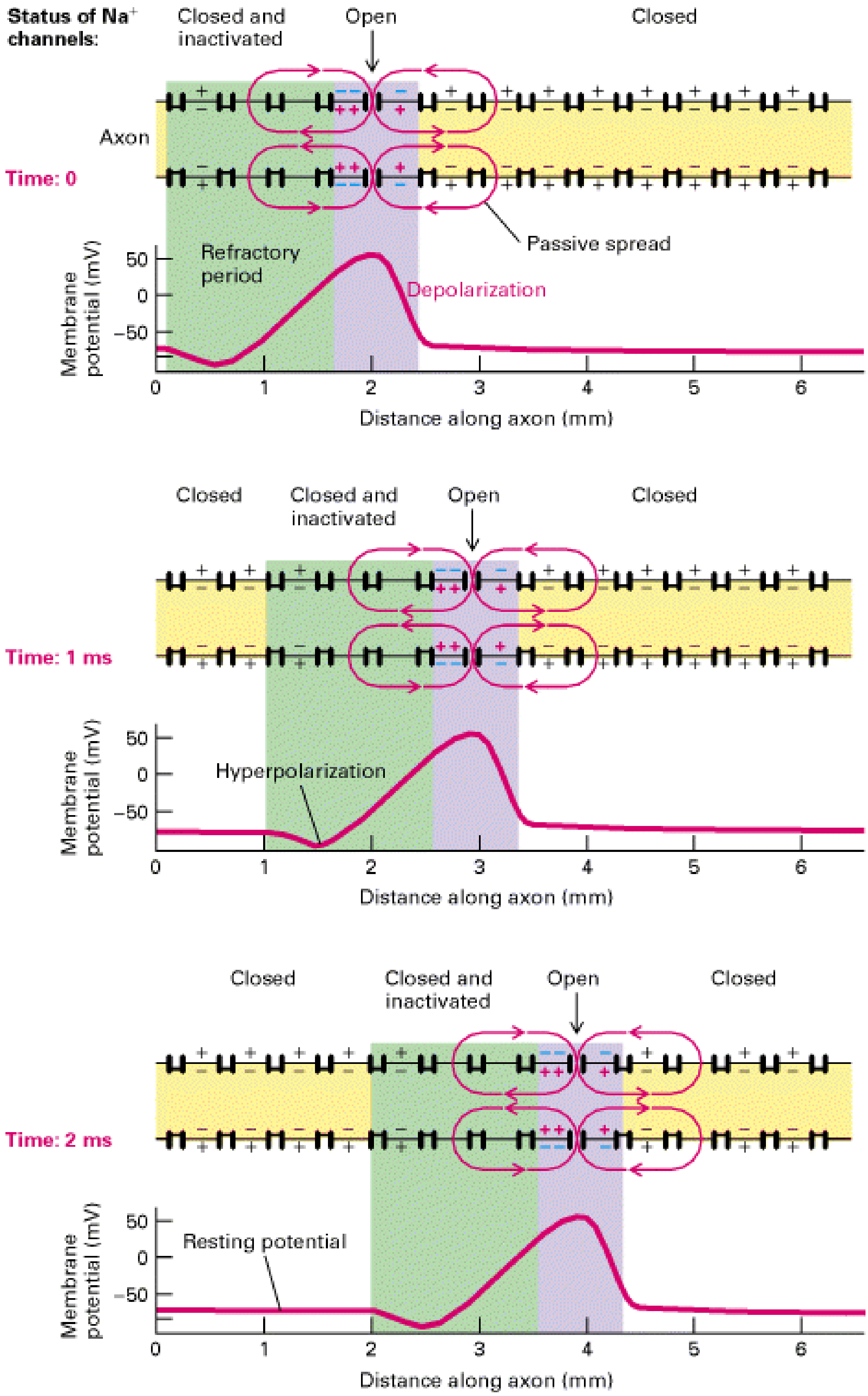
1. The membrane is at resting state; -60mV inside compared to outside. Polarised.
2. Na+ ion channels open and some Na+ ions diffuse into the neurone.
3. The membrane depolarises- it become less negative with respect to the outside and reaches the threshold potential of -50mV.
4. Voltage-gated sodium ion channels open and many Na+ ions enter. As more Na+ ions enter, the more positively changed the cell becomes, compared to outside.
5. The potential difference across the membrane reaches +40mV. The inside is now positive compared to the outside. The Na+ ion channels shut and the K+ ion channels open.
6. K+ ions diffuse out of the cell, bringing the potential difference back to negative compared with the outside - repolarisation.
7. The potential difference overshoots slightly, making the cell hyperpolarised.
8. The original potential difference is restored, so the cell returns to its resting state.



Action Potential in a Neuron



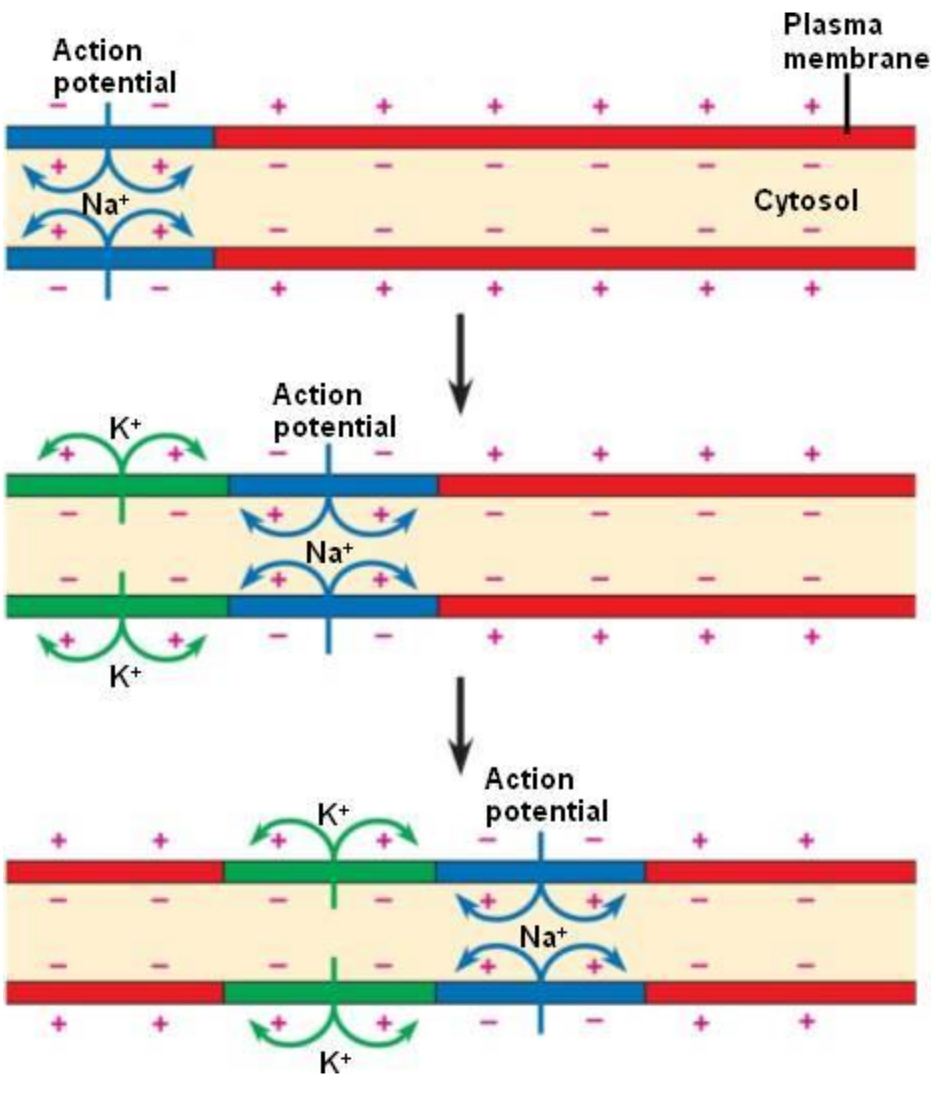
Na+
K+
3 Rising phase of the action potential
4 Falling phase of the action potential
2 Depolarization
5 Undershoot
1 Resting state
+50
0
−50
−100
Membrane potential (mV)
Action potential
Threshold
Resting potential
Time
Extracellular fluid
Plasma membrane
Cytosol
Potassium channel
Activation gates
Sodium channel
Inactivation gate



Status of Na+ channels:
Closed and inactivated
Open
Closed
Axon
Time: 0
Passive spread
Refractory period
Depolarization
Membrane potential (mV)
50
0
−50
0
1
2
3
4
5
6
Distance along axon (mm)
Closed
Closed and inactivated
Open
Closed
Time: 1 ms
Hyperpolarization
Membrane potential (mV)
Distance along axon (mm)
Closed
Closed and inactivated
Open
Closed
Time: 2 ms
Resting potential
Membrane potential (mV)
Distance along axon (mm)

Describe and explain how an action potential is transmitted in a myelinated neurone, with reference to the roles of voltage-gated sodium ion and potassium ion channels.

- The myelin sheath is created by Schwann cells
- The myelin sheath is an insulates the axon
- The myelin sheath makes the axon impermeable to Na and K ions
- Between the Schwann cells are gaps- called the Nodes of Ranvier, which contain Voltage-gated Sodium and Potassium ion channels, allowing ionic exchange to occur.
- Depolarisation can only occur at the nodes of ranvier.
- The action potential 'jumps' from one node to the next- Saltatory conduction.



Outline the significance of the frequency of impulse transmission.

A stimulus at the higher intensity will cause the sensory neurons to produce more generator potentials.

↓

More frequent action potentials in the sensory neurone

↓

More vesicles released at the synapse

↓

A higher frequency of action potentials in the postsynaptic neurone

↓

A higher frequency of signals to the brain

↓

A more intense stimulus

Compare and contrast the structure and function of myelinated and non-myelinated neurones.

Myelinated Vs Non-myelinated

• Myelinated	Non-myelinated
33% of Neurones	66% of Neurones
Schwann cells wrap around <u>individual</u> neurones	Schwann cells wrap around <u>several</u> neurones
Action Potential jumps from Node of Ranvier to Node of Ranvier	Action Potential moves along the neurone in a wave motion
Action Potential travels around 100-120 $m\ s^{-1}$	Action Potential travels around 2-20 $m\ s^{-1}$
Tend to be longer in length	Tend to be shorter in length

- **What affect does neurone diameter have on transmission of impulse?**

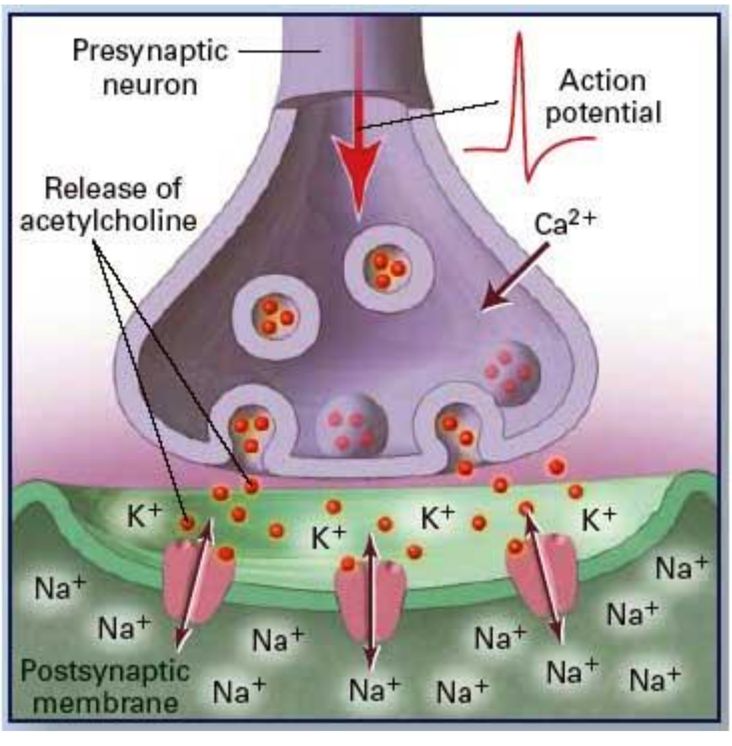
- **Myelinated neurones**
  - 100-120ms-1
  - Up to 1m transmission distance
  - Fast response time
  - Used in movement
  - 1/3 of all neurones
  - One neurones is surrounded by one Schwann cell, wrapped round many times

- **Non-myelinated neurones**
  - 2-20ms-1
  - mm or cm transmission distance
  - Slow response time
  - Used in breathing and digestion
  - 2/3 of all neurones
  - Many neurones are surrounded by one Schwann cell

Describe, with the aid of diagrams, the structure of a cholinergic synapse.
&
Outline the role of neurotransmitters in the transmission of action potentials.

- The synaptic knob contains:
  - Many mitochondria
  - A large amount of smooth ER
  - Vesicles containing acetylcholine
  - There are also voltage gated sodium ion channels in the membrane

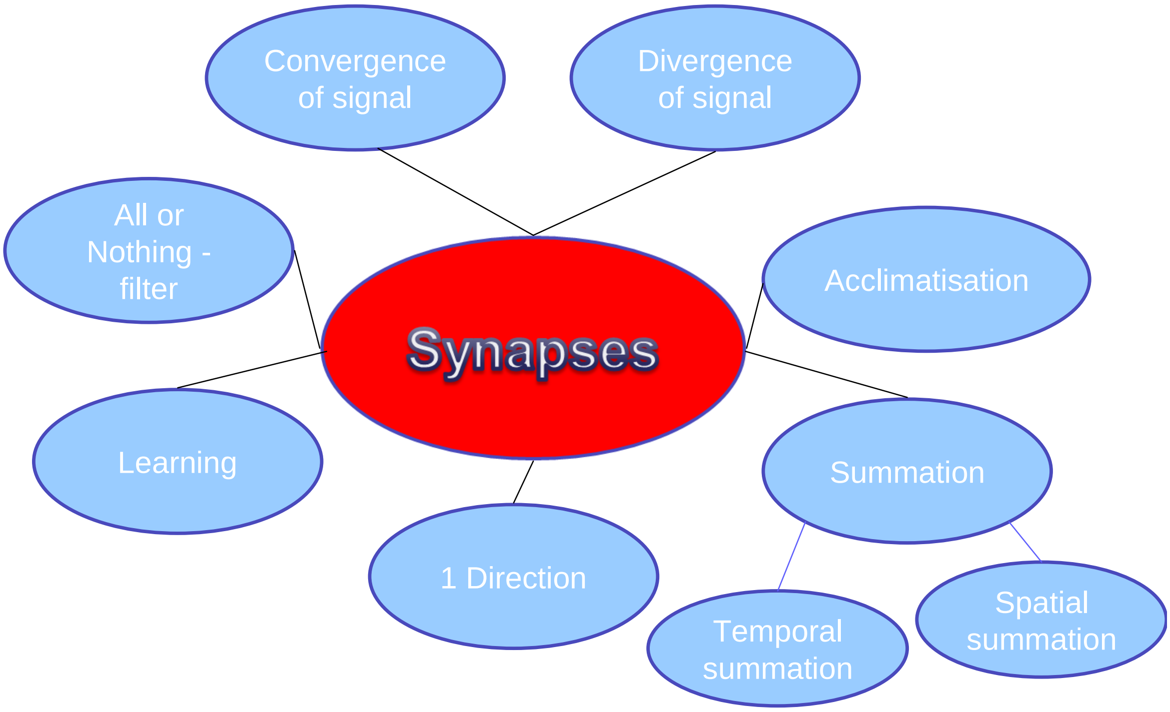
- The postsynaptic membrane contains:
  • Specialised sodium ion channels that will only open when acetylcholine binds to them



- A neurotransmitter is a chemical that diffuses across the cleft of the synapse to transmit a signal to the postsynaptic neurone.
- They cause the generation of a new action potential in the postsynaptic neurone.
- In cholinergic synapses the neurotransmitter is acetylcholine.
- It is stored in vesicles in the synaptic knob, and when the action potential arrives, the voltage gated calcium ion channels open.
- Calcium ions diffuse into the synaptic knob.
- This causes the vesicles to migrate to the pre-synaptic membrane.
- The vesicles fuse with the pre-synaptic membrane
- Acetylcholine is released into the cleft by exocytosis.
- It diffuses across the cleft and binds to receptor sites on the sodium ion channels on the postsynaptic membrane.
- Sodium ions diffuse across the synaptic membrane into the postsynaptic neurone,
- This creates a generator potential.
- If the generator potential is sufficient, the potential across the membrane reaches the threshold potential, and a new action potential is created.
- Acetylcholine is released from the receptor sites and moves back into the cleft.
- The acetylcholine is hydrolysed into choline and ethanoic acid
- Choline and ethanoic acid are taken back into the pre-synaptic neurone where they are repackaged back to form acetylcholine and are stored in vesicles ready until the next action potential arrives.

Outline the roles of synapses in the nervous system.

- Several presynaptic neurones may converge together to allow signals from different parts of the nervous system to create the same response.
- One presynaptic neurone may diverge to several post synaptic neurones to allow one signal to be transmitted to several parts of the nervous system- one may elicit a response, and one may inform the brain.
- They ensure that signals are transferred in only one direction- only the presynaptic knob contains acetylcholine in vesicles and the post synaptic membrane has the complementary receptors
- They can filter out unwanted low-level signal, possibly created by a low level stimulus. Several vesicles of acetylcholine must be released for an action potential to be created in the post synaptic neurone.
- Low level signals can be amplified by summation (when several small potential charges combine to produce one larger charge in the potential membrane). If a low-level stimulus is persistent, it can generate several successive action potentials in the presynaptic neurone. The release of many vesicles of acetylcholine in a short space of time will enable the postsynaptic generator potentials to combine together to produce an action potential.
- Acclimatisation- after repeated stimulation, a synapse may run out of vesicles containing the transmitter substance. The synapse is said to be fatigued. This helps avoid overstimulation of an effector, which could damage it.
- The creation of specific pathways in the nervous system is thought to be the basis of conscious thought and memory.


Convergence of signal
Divergence of signal
All or Nothing - filter
Synapses
Acclimatisation
Learning
Summation
1 Direction
Temporal summation
Spatial summation