

The top left diagram shows the propagation of an action potential along an axon, distinguishing between a depolarized zone and a polarized zone. The top right diagram illustrates the sodium-potassium pump and sodium channels on the axon membrane. The bottom left diagram shows a neuron with labels for Dendrite, Cell body, Nucleus, Axon, Myelin sheath, Schwann cell, and Axon Terminal. The bottom right image shows a microscopic view of neurons.

# Human Physiology

## 6.5 Neurons and Synapses

### Essential idea:

- Neurons transmit the message, synapses modulate the message.

The diagram shows a neuron with labels: Dendrites, Cell body, Nucleus, Axon hillock, Axon, Myelin sheath, Synapse, and Postsynaptic cell. It also labels a Presynaptic cell and Synaptic terminals. An arrow indicates the direction of signal flow from the cell body towards the axon terminals.

### Nature of science:

- Cooperation and collaboration between groups of scientists—biologists are contributing to research into memory and learning. (4.3)
  - Traditionally psychologists and psychiatrists.
  - Include molecular biology, biochemistry, biophysics, medicine, pharmacology, and computer science.

The diagram illustrates the flow of information from Sensory input through Attention, Short-term memory, and Encoding to Long-term memory. It notes that unattended information is lost and that some information may be lost over time. A brain scan image shows various regions of the brain.

### Understandings

- Neurons transmit electrical impulses.
  - 85 billion neurons in human nervous system
  - Dendrites** carry impulses from other neurons (or receptors) toward the **cell body**.
  - The **axon** transmits the impulse away from the **axonal hillock** of the cell body.

The diagram shows a neuron with labels: Dendrite, Cell body, Nucleus, Axon, Myelin sheath, Schwann cell, Node of Ranvier, and Axon Terminal. An arrow indicates the direction of an action potential along the axon.

### Understandings

- The myelination of nerve fibres allows for saltatory conduction.
  - Myelinated** fibers are axons enclosed by sheaths of **myelin** provided by **Schwann cells**.
  - The outer layer of myelin is surrounded by a **neurilemma** (neurilemmal sheath) made up of the cytoplasm and nuclei of the Schwann cell.

The diagram shows a cross-section of a myelinated axon with labels: Neurofibrils, Myelin sheath, Nucleus of Schwann cell, Node of Ranvier, Axon membrane, and Neurilemma (sheath of Schwann cell). An electron micrograph shows the structure of the myelin sheath.

### Understandings

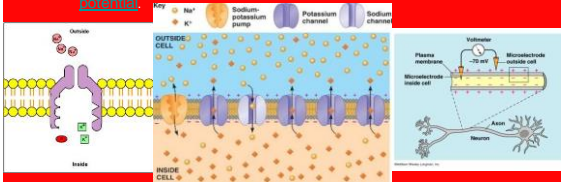
The myelination of nerve fibres allows for saltatory conduction.

- Impulse Conduction
  - Unmyelinated** fibers conduct impulses over their entire membrane surface.
  - Myelinated** fibers conduct impulses from node of Ranvier to node of Ranvier called **saltatory conduction**.
  - Saltatory conduction is many times faster than conduction on unmyelinated neurons.

The diagram illustrates the mechanism of saltatory conduction. It shows Na<sup>+</sup> entry depolarizing the membrane, which opens additional Na<sup>+</sup> channels, causing positive charge to flow into adjacent sections of the axon by local current flow. Labels include Schwann cell, Myelin sheath, and Axon.

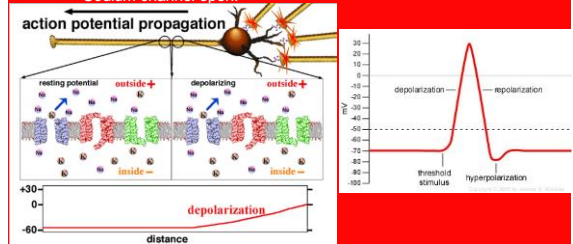
## Understandings

- Neurons pump sodium and potassium ions across their membranes to generate a **resting potential**.
  - Resting Potential (-70mV)
    - Due to active transport
    - **Sodium-potassium pumps** moves 3 Na<sup>+</sup> out for every 2 K<sup>+</sup> in.
    - Potassium ions pass (leak) through the membrane more readily than do sodium ions.
    - The outside has more positive charges.
    - This separation of charge, or potential difference, is called the **resting potential**.



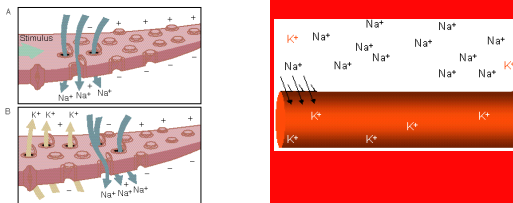
## Understandings

- A nerve impulse is only initiated if the **threshold potential** is reached.
  - Stimulation causes a disruption of the resting potential.
  - When localized membrane potential reaches -50mV.
  - Sodium channel open.



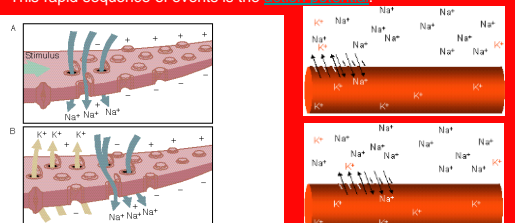
## Understandings

- An **action potential** consists of depolarization and repolarization of the neuron.
  - The inner membrane becomes less negative as **threshold potential** is achieved at the trigger zone
  - **Sodium channels** open, sodium ions rush in, and the membrane potential changes and becomes **depolarized**.



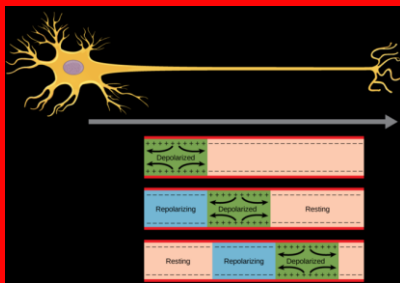
## Understandings

- An action potential consists of depolarization and repolarization of the neuron.
  - At the same time, **potassium channels** open to allow potassium ions to leave the cell, the membrane becomes **repolarized**, and resting potential is reestablished.
  - This rapid sequence of events is the **action potential**.



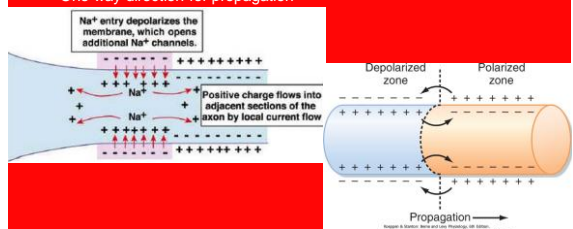
## Understandings

- Nerve impulses are action potentials propagated along the axons of neurons.



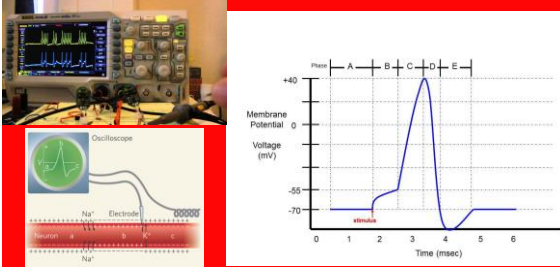
## Understandings

- Propagation of nerve impulses is the result of **local currents** that cause each successive part of the axon to reach the **threshold potential**.
  - Local currents form where depolarized and polarized areas meet
  - At -50mV sodium channels open
  - One way direction for propagation



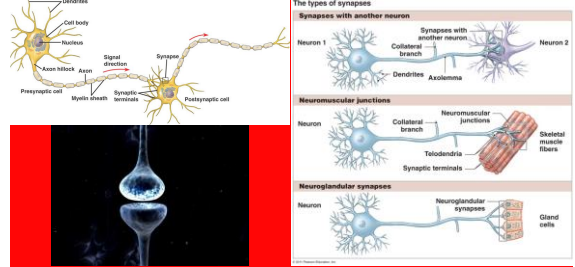
## Applications and Skills

- Skill: Analysis of oscilloscope traces showing resting potentials and action potentials.
  - Electrodes are on each side of the membrane.
  - What is happening at "A", "B", "C", "D", "E"?



## Understandings

- Synapses are junctions between neurons and between neurons and receptor or effector cells.
  - Occur between two neurons.
  - Occur between sensory receptor and neuron.
  - Occur between effectors (muscle or gland)



## Understandings

- When presynaptic neurons are depolarized they release a neurotransmitter into the synapse.
  - The synaptic cleft is about 20nm.
  - An action potential reaches the **synaptic knobs** of an axon.
  - Calcium ions rush inward.
  - Calcium fuses with synaptic vesicle receptors.

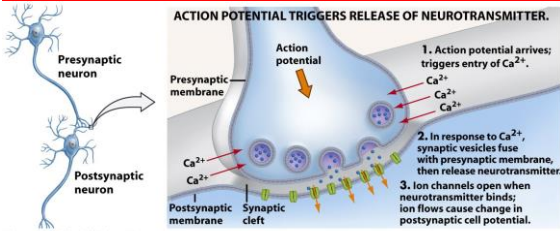


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## Understandings

- When presynaptic neurons are depolarized they release a neurotransmitter into the synapse.
  - **Synaptic vesicles** fuse with the presynaptic membrane.
  - This releases neurotransmitter into the synaptic cleft.
  - Post-synaptic neuron receptors bind the neurotransmitter.
  - Action potential is generated on post-synaptic neuron or cell.

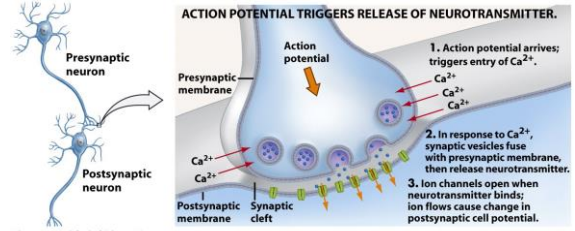


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## Applications and Skills

- Application: Secretion and reabsorption of acetylcholine by neurons at synapses.
  - Acetylcholine is main neurotransmitter in muscle
  - Cholinergic Synapses
    - o Choline from diet + acetyl from aerobic respiration.
    - o Acetylcholinesterase breaks down bound neurotransmitter immediately.
    - o Choline is reabsorbed and converted into acetylcholine.

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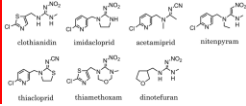
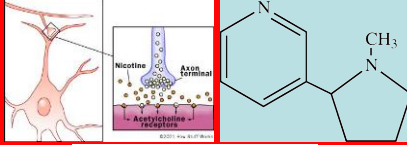
## Applications and Skills

- Application: Blocking of synaptic transmission at cholinergic synapses in insects by binding of neonicotinoid pesticides to acetylcholine receptors.



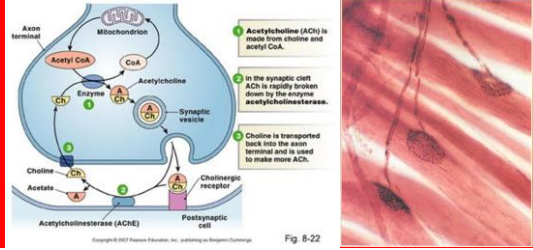
## Applications and Skills

- Application: Blocking of synaptic transmission at cholinergic synapses in insects by binding of neonicotinoid pesticides to acetylcholine receptors.
  - Nicotine binds to the acetylcholine receptors in cholinergic synapses.
  - Neonicotinoids are synthetic and similar to nicotine.



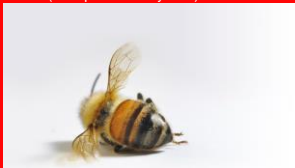
## Applications and Skills

- Application: Blocking of synaptic transmission at cholinergic synapses in insects by binding of neonicotinoid pesticides to acetylcholine receptors.
  - Acetylcholinesterase doesn't break down Neonicotinoids.
  - Receptors are blocked leading to paralysis and death



## Applications and Skills

- Application: Blocking of synaptic transmission at cholinergic synapses in insects by binding of neonicotinoid pesticides to acetylcholine receptors.
  - Nicotine is a natural pesticide.
  - Neonicotinoids are good insecticides.
    - Larger number of cholinergic synapses in insects.
    - Safe for humans?
      - Doesn't bind as well to mammalian receptors.
    - Issues? (Collapse of honeybees)



End