**Lecture 9 – Electrical Signalling, Synapses**

**Action potential and nervous impulses (Marieb 4th Ed pp 363)**
The nervous system is an elaborate system which detects any changes in the external environment and adapts the body's internal environment accordingly. The stimulus is the factor of the external environment which changes, therefore a sensory receptor can pick it up – and away it goes!

The main **functions** of the nervous system is to **receive input (sensory)** and produce **output (motor)** – and in between there is some level of **integration**.

The **action potential** is the fundamental messaging system in the nervous system. Upon a stimulus, an action potential travels along the sensory route, and then via the motor route to have an effect. In between, it can also travel to higher centers within the CNS.

***Resting Membrane Potential (Marieb 4th Ed pp 374)***
The **resting membrane potential** is **generated because** of the **differences** in **ionic charges** between the **intra** and **extra cellular** environment. Bascially, the **cell membrane** has relatively **low $Na^+$** permeability compared to **$K^+$** permeability. This means $K^+$ is going to diffuse **more freely** out of the cell than $Na^+$ comes into the cell (At this point, think about the **relative concentrations** of both **ions** intra and extracellularly). Thus we have a **negative charge intracellularly** and **positive charge extracellularly**. But these charges are going to reach equilibrium? **Wrong**, because there is a **2nd pump** which **actively** keeps this gradient going – by pumping out **$3Na^+$** out of the cell, and **$2K^+$** into the cell. Hence the **difference** is **always maintained** (**~-70mV**). Because the charges are mainted extracellularly and intracellularly, what balances the excess positive charges on both sides? Extracellularly – we have the **$Cl^-$ ions**, and intracellularly we have the **anionic proteins**.

***Types of changes in membrane potential (Marieb 4th Ed pp 375)***
**Depolarisation:** This occurs if the resting membrane potential becomes more +ve (i.e.: less –ve). Influx of $Na^+$ means inside less –ve.
**Repolarisation:** This occurs if the resting membrane potential becomes more –ve (i.e.: less +ve). Exflux of $K^+$ means inside less +ve.
**Hyperpolarisation:** During repolarisation, the resting membrane potential becomes more –ve than usual. (i.e.: -70mV → -90mV)

***Stages/Events of the AP (Marieb 4th Ed pp 377)***
The **action potential** is generated when **voltage gated $Na^+$ channels** are **stimulated** to **open**. This only occurs when there is **local voltage currents**, so that the **resting membrane potential fluctuates** to an extent that the **threshold potential for $Na^+$ voltage gated channels are activated** (about **-50mV**). Once **activated**, there is a **tremendous influx of $Na^+$** into the cell. Naturally, the interior of the cell becomes more and more positive **(depolarisation).** This occurs for about **1ms**. When the interior becomes more positive than the exterior, then $Na^+$ influx begins to slow down. **$K^+$ channels** pick up the opportunity to **open**, therefore **$K^+$ ions move out (repolarisation).** This equalises the membrane potential to normal levels, but because the closing of $K^+$ channels is slow – there is an **undershoot period (hyperpolarisation).**

Note that an action potential will only occur if the **threshold potential is reached**, if not then nothing will happen. Most importantly, for one particular cell – the **size of the action potential** will always be the **same**.

***Propagation of an action potential (Marieb 4th Ed pp 380)***
Notice that propagating impulses in the nervous system reach extraordinary speeds. **Pain fibres (C fibres)** have a propagating speed of **0.5m/sec**, whilst **motor fibres (A/B fibres)** have a propagating speed of **150m/sec**. The huge difference can be attributed to a number of features of the nerve cell:

- **Axon diameter**: an ↑ axon diameter implies ↑ propagation speeds.
- **Myelination**: myelin sheaths increase the propagation speeds. This is done because there are breaks in these sheaths, called **Nodes of Ranvier**. The myelin acts as an

insulating material – therefore the AP jumps from one node to the next – therefore dramatically increasing the propagating speeds. **Saltatory conduction.**

**Note: For remaining information on Synaptic transmission read lecture notes → good summary.**

Main points:

- **EPSP** – excitatory post-synaptic potential (opening of $Na^+$ channels)
- **IPSP** – inhibitory post-synaptic potential (opening of $K^+$ channels)
- **Spatial Summation**: basically the sum of all the EPSP/IPSP
- **Temporal Summation**: basically if stimuli are given successively, after the $2^{nd}$ one – the result is greater due to summation of both stimuli
- **Presynaptic inhibition** – basically a neurotransmitter released from presynaptic neuron actually prevents more neurotransmitters being released from presynaptic neuron.