# Central Nervous System

Neurophysiology

Sheet #1

*Dr. Luai Zghoul*

Organization of the Nervous System:

1. Peripheral Nervous System: detection and conduction of impulses from the periphery to the CNS.
2. Central Nervous System: integration, execution and processing. It constitutes the brain and the spinal cord as its main gross anatomical divisions. From a physiological perspective the CNS is further divided into 3 functional levels; firstly the spinal cord and the third would be the cerebral cortex (outer foldings of the brain) and between them we have sub cortical division which includes many anatomical structures including cerebellum, brain stem, medulla, thalamus, basal ganglia and hypothalamus…

   (Some people consider the Enteric Nervous System as a separate subdivision)

   1. Spinal Cord: conduction of impulses from CNS to the peripheral NS and vice verse, an additional function is analysis and execution of reflexes which are controlled by the cerebral cortex or the sub cortical division. You can compare this to a company with many levels, so an employee can carry out certain tasks individually but is also taking orders from higher levels of management ( in our case sub cortical division and cerebral cortex).
      The spinal cord has internal build-up circuits that carry out complex functions (such as reflexes) without any control from higher levels for example walking in animals. *Dr. Luai then showed a video of a de-cerebrated cat walking with some gait only to show how the spinal cord can carry out this function independent of the higher level control and he pointed out how this is inapplicable to humans were a de-cerebrated human would otherwise be rigid and cannot walk.*
      *https://www.youtube.com/watch?v=wPiLLplofYw*
      People who have paralysis still have reflexes.
   2. Sub cortical level: responsible for internal reflexes (which are unconscious) that maintain proper constant internal environment, for example regulating respiration, blood pressure, thirst, feelings, emotions …
   3. Cerebral Cortex: responsible for memory, thinking, decision-making, speech, language, personality … in other words higher complex levels of human functions which are difficult to define. Analysis and thinking are two of the most important functions which will shape one's personality and thoughts. Analysis and thinking

cannot be carried out without memory hence the main storehouse of the cerebral cortex is for memory. The memory needed for thinking and decision making is stored in the frontal lobe, spatial memory is stored in the parietal, that of hearing is in the temporal lobe and vision in the occipital.

Hippocampus converts memory and forms memory (processive memory) but doesn't store it.

Question asked by student: How did we know which part of the brain is associated with which functions such as those functions which are difficult to be defined?

By 3 main ways, firstly by observing changes that occur to people/animals after strokes secondly stimulation and recording and thirdly which is more in humans is functional MRI; were the person is doing a function (for example we ask the person to think about a decision) and we can observe the exact parts of the brain functioning during the decision making process etc…

Functional organization:

1. Sensory: input (sensation)
2. Motor: output (executive function, movement/secretion)
3. Integrative: processing, analyzing and integrating between the sensory and the motor.

- Sensory information (impulses) starts first at a receptor then to the periphery and the CNS and the signal could stop at any level ($1^{st}$/$2^{nd}$) or just continue to the cortex and could also give a branch to the spinal cord or subcortex then continue to the cortex. So the sensory pathway can stop at any level and even of it stops at the spinal cord level it'll continue to the cortex.
- The receptor converts the signal from one type of energy to impulses or electrical energy for instance, chemical energy as in taste, olfaction and pain (mainly chemical), mechanical energy such as touching, pressure and hearing and electromagnetic energy/photons in vision.
- Motor starts from higher order, even though there is a motor function of the spinal cord and the subcortex but initiation of motor function starts from the cerebral cortex reaching the effectors (muscle/gland).
- Parts of neuron: cell body, axon, dendrites and nerve terminals which forms synapses with other neurons. Axons conduct impulses (action potential) away from cell body, dendrites receive impulses, and cell body does processing (graded potential only).

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Action potential is initiated at axon hillock.
Difference between action potential and graded?
Amplitude in graded potential is variable but in action potential it is all or none, also summation in graded potential.

Morphological types of neurons:

In pseudopolar or unipolar (cell body is peripheral) the signal is conducted directly without passing through the cell body and so this type of neuron is used in cases were no analysis/processing is needed such as in PNS. So here the cell body only has the non-electrophysiological function of producing proteins.

Bipolar neurons do *some* integration and processing/analysis and so these neurons are needed in special sensation such as vision, olfaction, hearing etc...

Most other neurons in CNS are multipolar where modification/integration of impulses occurs in deep analytical brain processes such as thinking.
They aren't all the same they have different shapes according to the dendrites and this can tell the level of analysis it carries out. Why does the dendrite determine that? Because of the third characteristic of graded potential where it is variable and decremental (with distance) unlike action potential which is all or none.

Pathway: the route and the neurons which transport certain information. For e.g. somatosensory pathway. Now the fastest way to transport and impulse would be through 1 neuron not several neurons because otherwise there'd be a delay due to the many synaptic clefts. But why is it that we conduct the impulse through many neurons from one destination to another? This is because not all of them go to their destined site and some are used for analysis/regulation/processing. The more complex the sensation the more neurons involved.

There are 2 types of synapses; electrical and chemical both are slower than action potential. Electrical synapses mostly exist in smooth and cardiac muscle. In the nervous system, it is in the glial cells and astrocytes and not in the neurons, whereas synapses that exist between neurons are almost completely chemical synapses.