**This is the first lecture for Dr.Louai .**

**NEUROPHYSIOLOGY**

**Introduction to the nervous system :**

Anatomically, nervous system is divided into :

1) Central nervous system (CNS)

2) Peripheral nervous system (PNS)

As we took previously that GI system has a lot of neurons working as a functional unit so It can be considered as a 3rd division of the nervous system ( **enteric nervous system** )

Whatever there was 2 or 3 divisions , CNS & PNC each cannot work separately , they must work together to perform a complete function.

Functionally, the nervous system divide into :

1) sensory " transport the input to CNS "

2) processing in between

3) motor "transport output from CNS "

As a conclusion the nervous system is divided into : 1)input 2)processing 3)output

(Nervous system is similar to computer input devices: mouse and keyboard, processing inside the case , output : screen and printer )

**Now we are going to talk about them in details .**

**CNS** is divided functionally into 3 levels :

1) spinal cord

2)Brainstem , diencephalon , basal ganglia

3)cerebral cortex

1st level; spinal cord has special functions and these are : 1)conducting impulses from the brain to the periphery and vice versa

2)Reflexes have circuits to most of functions of our body , the function of spinal cord circuits to brain and higher levels is turning these reflexes on & off OR increasing/decreasing the velocity . But heart core circuit present in spinal cord and there is some reflexes that can perform alone, starting from reflexes of couple of neurons or muscle to walking circuit .

The doctor mentioned an example about a decerebrated cat that walks on a treadmill through the control of spinal cord reflexes even though it’s brain was cut off .

Therefore the spinal cord is not just a conductor , there're some reflexes that it can do it alone and heart core circuit is for many functions/movements without the need of higher levels control .

2nd level , Brain stem and subcortical :

Anything between spinal cord and cerebral cortex which consists of : brain stem " medulla , midbrain, pons " , thalamus , basal ganglia , cerebellum , limbic System

Brain stem functions:

\*spinal cord controls outside reflexes

Whereas brain stem’s function is to control reflexes of internal systems of the body such as; heart rate , Blood pressure , respiration, temperature and balance .

basal ganglia , subcortical and limbic system Control emotional pattern and feeding reflexes

3rd level , Cortex " consciousness " :

And its functions are : 1) big storage of memory

2) personality or consciousness ;it controls everything even the spinal cord reflexes in consciousness , also controls internal reflexes such as eating even if subcortical decides to eat and the brain refuses that so it will inhibit eating so the brain dominates everything , it also can control emotions .

**So it controls these reflexes at a conscious level which means that it determines personality .**

3) Processing information producing higher functions , which is responsible about high processing starting from sensation to thought and complex functions such as language .

\*A Pathway consists of more than one neuron , each neuron conducts impulses to another unit in order to reach a final destination .

- sensory pathway is from the receptor (sensation ) to the cortex .

\*Conducting information by one neuron is easier and faster because synapsing takes time , although most pathways consist of more than one neuron because we need more cell bodies for information processing .

* Neurons are made of :

1.dendrites 🡪 receive impulses

2. Cell body 🡪 for processing

3.Axon 🡪 conduction of information without processing

4.Terminal 🡪transform impulses to another neuron

since the cell body is for processing ,there will be more than one type of neurons according to cell bodies :

1. **Unipolar (pseudopolar)** : neuron for conduction without processing , because processing will occur in another neuron so the cell body here has nothing to do with processing the information.

Ex: 1st neuron in sensory system

2) **bipolar** : only little processing but not complicated Ex : 1st order neuron in retina " the most common ex. " , and special sensations; vision , smell and hearing .

1. **Multipolar** : form 99% of neurons , multiple dendrites so the information must reach the cell body first , it's function is analyzing and deciding which information must be conducted and which not to be conducted .

\***multipolar has more than one type and shape according to the function and the nature of processing**.

Ex: pyramidal cells in cortex , purkinje cells in cerebellum

-NEUROGLIA-

1)oligodenterocyte for myelination

\* Role of myelination :

1-decrease ATP consumption

2- increase velocity

3- isolation

\*\***Isolation**: the proper function of a neuron depends on the composition of ions around it.

- if the axon was unmyelinated and there was more influx of ions from outside to inside we need more ATP for exchange and it will change the composition of ions around other neurons in the same region changing the function or the priority of these neurons .

(if an axon was passing between several cells and axons in CNS ,during action potential if this axon was unmyelinated a massive change of ions will occur as well as more ATP are required to get back to the normal state. And in the case of firing two or more action potentials, ion composition around other neurons will be changed ) .

**So the role of myelination Is to decrease the exchange of ions in each action potential and this is isolation .**

1. ependymal cells : their function is to make cerebrospinal barrier
2. microglial cells : for phagocytes
3. astrocyte : functions – blood brain barrier

* give the proper environment for the neuron : nutrition ,removing neurotransmitters and controlling ions .
* support since neurons have small , thin dendrites so support is needed to maintain their shape .
* has a function in learning and memory ( we'll talk about it later )

\*study white and gray matters from the slides \*

***SYNAPSES***

- the site of communication and transfer of information from one neuron to another .

The synapse may happen between one neuron and another neuron on any part of the neuron such as :

1)dendrites 2)cell body " the most common 2 sites "

3)axon 4)terminals

Synapse can either be : A) **ELECTRICAL SYNAPSE** in cardiac muscle , or:

B) **CHEMICAL SYNAPSE** which is the most common between neurons using neurotransmitters

-Chemical synapse consists of : 1- presynaptic part from the first neuron and it releases neurotransmitters

2- synaptic cleft in between

3- postsynaptic part which has the receptors

\* So what happen in the chemical synapse ?

An action potential changes the resting membrane potential in the presynaptic part which causes the opening of voltage gated Ca++ channels , once Ca++ enters this will result in the release of neurotransmitters from vesicles to the cleft and then attach to the receptors of postsynaptic neuron , after that we need to detach these neurotransmitters to end its effect . this detachment occurs through several ways :

1] breaking this neurotransmitter by enzymes such as acetylcholine (Ach) esterase .

OR 2] picking up and returning these neurotransmitters to the neuron by transporters (to be discussed later on)

-function of the synapse depends on the type of receptor on the postsynaptic neuron more than the neurotransmitter itself , so the same neurotransmitter may perform different functions when it binds to different receptors .

**TYPES OF RECEPTORS** :

* 1. ion channel receptors

binding the neurotransmitter to the receptor opens an ion channel . when Na+ channel opens it causes excitation, and when k+ or cl- channels open inhibition occurs .

\*notice that we didn’t say depolarization , repolarization or hyperpolarization because we're talking about the neuron as a whole not the membrane **, so anything increases the chance for depolarization is called excitation and what decreases this chance is called inhibition** .

* 1. second messenger receptors

attachment results in the activation of a second messengers such as G protein , its function might be the opening of channels same as ion channel receptors , OR the activation of metabolic enzymes to increase/decrease the metabolism or the action potential resulting in excitation/inhibition , OR by changing the characteristics of neurons to make 2nd messenger or the expression of DNA for new proteins.

As a conclusion the function of the 2nd messenger type receptor is not always related to excitation or inhibition , it can perform other functions .

2ND MESSENGERS are :

1. G-protein which work with cAMP
2. PLC system which works through Ca++

They can perform more than one function and they have a big amplification in the signal through the G-protein receptor .

**How to control the function of neurotransmitters :**

1) agonist : any molecule that attaches to the same site where the neurotransmitter attaches on the receptor and performs a function , **the best agonist is the neurotransmitter itself.**

2) antagonist : any molecule that attaches to the same site where the neurotransmitter attaches on the receptor and doesn't perform a function instead it prevents the neurotransmitter from doing its function.

- if a neurotransmitter’s function is to excite, the antagonist prevents this excitation and doesn't do inhibition .

For ex : if a neuron has an automatic firing at 100 and if we put the specific neurotransmitter for this neuron the action potential becomes 500 but if the antagonist is present it will be maintained at 100 therefore the antagonist will not inhibit it, it decreases the neuron’s potential to 90 or 80 so it stops the excitation without inhibition .

3) allosteric modulation : any molecule that doesn't bind to the same site where the neurotransmitter binds .

It effects the agonist to make it stronger ( including the neurotransmitter ) by increasing or decreasing its function but mainly it increases the function .

* now what's the difference between agonist and allosteric modulation ?

1] allosteric modulation increase the effect of neurotransmitter .

For ex : if there's a receptor for a certain neurotransmitter when binding occurs it will open an ion channel with a diameter of 2 micrometers for 2 sec. then it will be closed whereas during allosteric modulation it will cause the opening of a channel with 5 micrometer diameter and for 20 sec. so it strengthens and increases the effect of the agonist .

2] agonist by itself will function but allosteric alone has no function .

**AFFINITY & EFFICIENCY**

-AFFINITY is how much the neurotransmitter is able to bind to the receptor.

-EFFICIENCY : the strength that is required to activate the receptor .

\*Allosteric modulation increases/decreases ( usually increases ) the efficiency .

-to understand the principle of efficiency and the effect of allosteric modulation let’s take this example :

if we assume that we have a neurotransmitter for the receptor A which is a G-protein receptor producing c-AMP after attachment , upon attachment 100 molecule of c-AMP are produced , but if I want to decrease this neurotransmitter to make a drug I make a molecule which binds to the receptor A at the same site and performs the same function so it's an agonist but when it binds to receptor A, it produces 72 c-AMP instead of 100 . so the efficiency is less than the original neurotransmitter ( 72% of its efficiency ) .

you have to refer to the slides for some topics since the doctor assumed that we already knew them.

special thanks for my friend Hala najjar ☺

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