Unit VIII – Physiology Review (Problems: 1-6)

PROBLEM 1

- **What is the difference between receptor potential and generator potential?**
  - **Receptor potentials**: sensory fibers cannot detect the stimuli but must be aided by receptors which will detect them and cause the release of neurotransmitters leading to the generation of action potentials.
  - **Generator potentials**: sensory fibers are going to detect the stimulus and generate action potential if the stimulus is strong enough. Examples include: free nerve endings and capsulated nerve endings.
- **Intensity of stimulation depends on 2 factors. What are they?**
  - Number of action potentials.
  - Number of fibers involved.
- **What is the difference between tonic and phasic discharge:**
  - **Tonic**: there is continuous discharge.
  - **Phasic**: there is a change in the frequency of the discharge.
- **Which ion-channel is responsible for synaptic potentials?**
  - Sodium-channel.
- **Define dermatome.**
  - It is the area of skin which is supplied by spinal segments. It is important for diagnosing certain diseases. The most accurate examination to be done to check for the dermatome is stimulating pain (pain has the less overlap).
  - Dermatome is small in fingers and large in (?).
  - Clinically, pain is used to map dermatomes.
  - The following dermatomes are important:
    - ✓ C6: thumb.
    - ✓ C7: middle finger.
    - ✓ C8: little finger.
    - ✓ T4: nipple.
    - ✓ T10: umbilicus.
    - ✓ L3: knee.
    - ✓ L4: medial malleolus.
  - It is important to know each vertebra is corresponding to which spinal segment:

Cervical vertebrae (from C3 downwards)	+1 (example: if cervical vertebra is C4 → C4 + 1 = C5 spinal segment
Thoracic vertebrae (T1-T6)	+2
Thoracic vertebrae (T7-T9)	+3
T10	Is corresponding to L1 & L2 spinal segments
T11	Is corresponding to L3 & L4 spinal segments
T12	Is corresponding to L5 spinal segment
L1	Is corresponding to sacral segments

- **What are the superficial mechanoreceptors?**
  - **All of those which are starting with "M" are superficial:**
    - ✓ Merkel.
    - ✓ Meissner

      Note: the receptive field of these receptors is small.
- **What are the deep mechanoreceptors?**
  - **Deep receptors are**: pacinian and ruffini.

    Note: the receptive field of these receptors is large.
- **Corpuscles are rapidly adapting and detecting vibrations.**
- **Which receptor is responsible for reading Braille's letters?**
  - Merkel receptor.

- **What sensations are transmitted by dorsal column-ML pathway?**
  - Fine touch, vibration, pressure, conscious proprioception and 2-point discrimination. Notice that these sensations are transmitted ipsilaterally but then cross at the level of the medulla.
- **What sensations are transmitted by lateral spinothalamic tract?**
  - Pain and temperature contralaterally (fibers cross to the other side 2-3 segments above the level of entry to the spinal cord).
- **What sensations are transmitted by anterior spinothalamic tract?**
  - Crude touch contralaterally (fibers cross to the other side 1-2 segments above the level of entry to the spinal cord).
- **From where do the nuclei of hypothalamus receive sensations?**
  - **VPL nucleus**: from the body.
  - **VPM nucleus**: from the face (head and neck).
- **What are the 3 parts of trigeminal nucleus and the function of each one of them?**
  - **Principle nucleus**: which will be receiving fibers of fine touch (a lesion in this nucleus will lead to loss of fine touch sensation from the same side of the face).
  - **Spinal nucleus**: which will be receiving fibers of pain and temperature. These fibers are going to descend and thus a damage in pons or medulla can result in ipsilateral loss of pain and temperature of the face.
  - **Mesencephalic nucleus**: which will be receiving fibers of unconscious proprioception. From there, some fibers will go to the motor nucleus to stimulate stretch reflexes and others will go ipsilaterally to the cerebellum.
- **Where are Clark's nuclei present?**
  - **Clark's nucleus is only present between L2-T1:**
    - ✓ If information are coming from level lower than L2 → fibers are going to ascend with those fibers of conscious proprioception in the dorsal column until they reach the level of L2 where Clark's nuclei are present → and synapse will occur.
    - ✓ If information are coming from level higher than T1 → fibers are going to ascend with those fibers of conscious proprioception in the dorsal column and then terminate in accessory cuneate nucleus.
- **What is the difference between conscious and unconscious proprioception?**
  - **Conscious proprioception**: going to the cortex through the dorsal column-ML pathway.
  - **Unconscious proprioception**: going to the cerebellum through dorsal and ventral spinocerebellar tracts. Notice that fibers of the ventral pathway will cross while those of dorsal pathway will ascend without crossing.
- **In which sensory area of the cortex does a lesion result in a motor defect?**
  - Sensory area number 2.
- **Explain dorsal column-ML and spinothalamic pathways (1^{st},2^{nd} and 3^{rd} order neurons).**
  - **Dorsal column – ML pathway:**
    - ✓ 1^{st} order neurons: sensory fibers enter the spinal cord through the dorsal horn and ascend directly (without synapse) in the dorsal column as f.gracilis and f.cuneatus to terminate in n.gracilis and n.cuneatus of the medulla.
    - ✓ 2^{nd} order neurons: from n.gracilis and n.cunetus, fibers will cross (forming internal arcuate fibers) and ascend as medial lemniscus to terminate in the VPL nucleus of the thalamus.
    - ✓ 3^{rd} order neurons: from VPL nucleus of the thalamus to the post-central gyrus (sensory) of the cerebral cortex.
  - **Spinothalamic tract:**
    - ✓ 1^{st} order neurons: sensory fibers enter the spinal cord through the dorsal horn and ascend 2-3 segments to synapse and cross the midline.

- ✓ 2nd order neurons: they will ascend as spinal lemniscus to terminate in the VPL nucleus of the thalamus.
- ✓ 3rd order neurons: from VPL nucleus of the thalamus to post-central gyrus (sensory) of the cerebral cortex.

- **Lesion in which area will result in hemispatial neglect?**
  - Damage to the parietal lobe.
- **What is the difference between fibers transmitting fast-pain and those transmitting slow-pain?**
  - **Fast pain is transmitted by:** delta-fibers.
  - **Slow pain is transmitted by**: C-fibers.
- **Where are the 2nd order neurons responsible for transmission of visceral pain?**
  - In the medial side of dorsal column.
- **Which structures are responsible for suppression of pain?**
  - Periaqueduct.
  - Raphe nucleus.

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PROBLEM 2

- **What is the difference between a motor unit and a motor pool?**
  - **Motor unit**: one motor neuron and the muscle fibers which it innervates.
  - **Motor pool**: the number of motor neurons which are supplying the same muscle.
- **Monosynaptic reflex:**
  - **Sensory fibers:**
    - ✓ If dynamic (there is a sudden stretch of the muscle spindle): type Ia
    - ✓ If static (aiming to maintain position of the body): type Ia and type II
- **Which nerve fibers are responsible for initiating voluntary movements?**
  - Alpha and gamma motor neurons.
- **What is the sensory fiber of Golgi tendon organ?**
  - Type 1b
- **Compare between muscle spindle and Golgi tendon organ during active and passive muscle contraction?**
  - **During active contraction of a muscle**: spindles inhibited, golgi stimulated.
  - **During passive contraction of a muscle**: both spindles and golgi are stimulated.
- **Compare between upper and lower motor neuron lesions.**

UMN paralysis	LMN paralysis
No wasting of muscles	Wasting of muscles
Increased tone (spasticity/ clasp-knife)	Decreased or lost tone of muscles
Hyper-reflexia	Decreased or lost reflexes
Fasciculations are absent	Fasciculations are present
Babinski sign present	Babinski sign absent

- **What is the difference between spasticity and rigidity (which are seen with UMN lesion)?**
  - **Spasticity:**
    - ✓ Due to a lesion in the pyramidal system.
    - ✓ Speed-dependent (which means that there will be increased resistance when the examiner is trying to passively and rapidly move the arm of the patient).
    - ✓ Single group of muscles (antigravity).
    - ✓ Also described as clasp-knife: that is resistance will suddenly disappear due to activation of Golgi tendon organs leading to sudden relaxation in the muscle which is being stretched.
  - **Rigidity:**
    - ✓ Due to a lesion in the extra-pyramidal tracts.
    - ✓ Group of muscles will be showing rigidity.
    - ✓ In patients suffering from Parkinson's disease:

- ❖ *Lead-pipe is present*: in which resistance will always be present when the arm is stretched (there will be no sudden relaxation).
- ❖ *Cog-wheel*: due to a mixture of lead-pipe phenomena and tremors.

- **What are the 3 levels of motor control?**
  - Spinal cord.
  - Brainstem
  - Cortex.
- **The spinal cord:**
  - **It has α-motor neurons which are connected to propriospinal tract. The propriospinal tract is classified to:**
    - ✓ Lateral part:
      - ❖ Controlling distal muscles (for fine/accurate movements).
      - ❖ It is a small tract.
      - ❖ It is ipsilateral (cannot control both sides of the body).
    - ✓ Medial part:
      - ❖ Controlling proximal axial muscles (does not provide precise movements but is involved in maintaining posture and balance of the body).
      - ❖ It is longer than the lateral part because it is controlling all axial muscles and thus must involve more spinal segments.
      - ❖ It is controlling both sides the body (axial muscles of both sides must contract together to maintain balance).
- **Which tracts of the brainstem will descend down to the spinal cord? And which one of them crosses?**
  - Tectospinal tract.
  - Reticulospinal tract: notice that this tract is important in anticipation and adjustment of balance.
  - Vestibulospinal tract.
  - **Rubrospinal tract → crosses.**
- **What are the differences between lateral and anterior corticospinal tracts (pyramidal tracts)?**
  - **One is indirect and going to the medial part of the ventral horn in spinal cord:**
    - ✓ It is not precise.
    - ✓ Represented by the ventral corticospinal tract 10% (its fibers doesn't cross).
  - **Another one is direct and going to the lateral part of the ventral horn in the spinal cord:**
    - ✓ It is very precise.
    - ✓ Represented by the lateral corticospinal tract 90% (its fibers cross in the medulla).
    - ✓ *Containing Betz neurons*: the largest neurons in the nervous system (1mm) – they are few in number – function in very precise movements (example: movements of the fingers).
    - ✓ Receiving 40% of information from area 2 in the post-central gyrus.

  Notes:
    - ✓ Corticospinal tract → controlling muscles of the body.
    - ✓ Corticobulbar tract → controlling muscles of the face (going to nuclei of cranial nerves).
- **Which neurons are responsible for imitation of movement?**
  - Mirror neurons.

PROBLEM 3

- **Which system is stimulating alertness and wakefulness?**
  - Ascending reticular activating system.
- **There is an area in the midbrain which will send 2 projections to the thalamus (both of them are cholinergic fibers):**
  - **One of these fibers will reach the sensory thalamus (in VPL nucleus) and then will reach the cortex (stimulatory).**
  - **The other fiber will terminate in the reticular nucleus of the thalamus which is inhibiting the cortex.**
    - ✓ If a person is exposed to a sensory stimulation:
      - ❖ *Direct*: there will be activation of sensory thalamus.
      - ❖ *Indirect*: there will be inhibition of reticular nucleus in the thalamus (inhibition of inhibition = stimulation).
        Therefore, the person will be in an alert state.
- **Which nucleus is the master pacemaker of circadian rhythm?**
  - Suprachiasmatic nucleus.
- **Which structure secretes melatonin?**
  - Pineal gland.
- **What is the difference between sensitization (synchronization) and desensitization (desynchronization) in EEG?**
  - **Sensitization**: big waves and low frequency.
  - **Desensitization**: small waves and high frequency.
- **Important for OSPE exam: matching stages of sleep (awake state, stage 2, stage 4 and REM sleep) with their corresponding EEGs.**
- **What are the characteristics of REM-sleep?**
  - Increased in the morning.
  - Brain is active but body is paralyzed (due to inhibition of the motor system).
  - Increased sympathetic stimulation.
  - High oxygen consumption in the brain.
  - There are structural complex dreams.
  - Composing 25% of sleep.
  - Ponto-geniculo-occipital complex is activated during REM-sleep and is responsible of rapid eye movement occurring during this stage.
- **What are the neurotransmitters responsible for sleep and those responsible for awakeness?**
  - **For sleep:**
    - ✓ Ventrolateral preoptic area (VLPO): GABAergic neurons in the hypothalamus suppressing alertness and promoting sleep.
  - **For awake state:**
    - ✓ Cholinergic neurons: in pons-midbrain region.
    - ✓ NE: from locus cerulous.
    - ✓ Serotonine: from Raphe nucleus.
    - ✓ Histamine: from tuberomamillary nucleus.
      Note: orexin is enhancing wakefulness through stimulation of locus cerulous and Raphe nucleus. People suffering from narcolepsy (irrisisted desire to sleep for 30s-30min) have too little orexin.
- **Adenosine induces sleep by inhibiting basal forebrain (which is normally responsible of thinking). On the other hand, caffeine makes us awake through inhibition of adenosine.**
- **In which stage does sleep-walking disorder occur?**
  - During early sleep (slow wave sleep stage). Night terrors also occur during early sleep.

- **In which stage do nightmares occur?**
  - During late sleep (REM-sleep stage).

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PROBLEM 4

- **Notice that corticobulbar tract is supplying all cranial nerves bilaterally except the following cranial nerves:**
  - Facial nerve (7^{th} CN).
  - Hypoglossal nerve (12^{th} CN).
- **Lesions of the facial nerve (7^{th} cranial nerve):**
  - **UMN lesion**: lower half of the face at the contralateral side will be paralyzed.
  - **LMN lesion**: half of the face will be paralyzed at the same side.
- **Lesions of the hypoglossal nerve (12^{th} cranial nerve):**
  - **If you ask the patient to take his tongue off → and the tongue is deviated to the right side → look to the tongue:**
    - ✓ If there is atrophy and fasciculation → this indicates a lower motor neuron lesion in the right side (same side). Notice that the uvula will deviate toward the normal side (to the left).
    - ✓ If there is no atrophy or fasciculation → this indicates an upper motor neuron lesion in the left side (opposite side) above the level of the medulla.
- **What is the difference between decorticate and decerebrate postures?**
  - **Decorticate posture**: occurs when the lesion is above the red nucleus.
  - **Decerebrate posture**: occurs when the lesion is below the red nucleus.
- **The most powerful metabolic regulator of blood flow to the brain is: CO_2 level.**
- **What is the difference between lateral and medial medullary syndromes?**
  - **Lateral medullary syndrome**: occlusion mostly to vertebral artery or less often to posterior inferior cerebellar artery (posterior spinal artery in caudal medulla).
  - **Medial medullary syndrome**: vertebral and anterior spinal arteries.
    Note: that occlusion of vertebral artery can cause both (lateral and medial) medullary syndromes.
- **Speech center has all the capabilities of communication with other people. It is composed of 2 main areas:**
  - **Broca's area**: which is present in the frontal lobe (motor area).
  - **Wernicke's area**: which is present where parietal, occipital and temporal lobes meet (it functions in understanding words either written or heard).
- **What are the 3 main types of aphasia. What are the differences between them?**

Broca's aphasia	**Non-fluent/ good comprehension/ poor repetition.**
Wernicke's aphasia	**Fluent/ poor comprehension/ poor repetition.**
Conductive aphasia	**Fluent/ good comprehension/ poor repetition.**

- **If someone touches something and he cannot identify it → the defect is in corpus callosum.**

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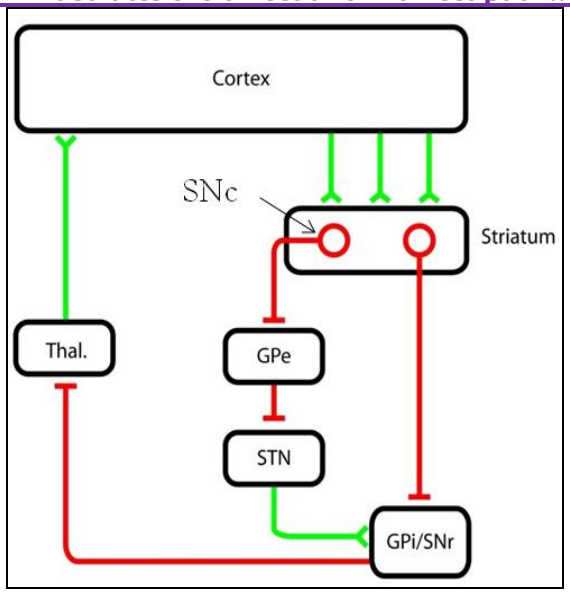
PROBLEM 5

- **If there is sufficient cortical stimulation** → this is going to excite the putamen → resulting in inhibition of globus pallidus internus → therefore, the thalamus will be stimulated → initiating the movement.
  - **Notes:**
    - ✓ ↑ **inhibition of thalamus**: hypokinesia.
    - ✓ ↓ **inhibition of thalamus**: hyperkinesias
- **When MSNs fire → they cause movement to occur.**
- **Major output of basal ganglia pathway is represented by:**
  - Globus pallidus internus (GPi).

- Substantia nigra reticulate (SNr).
  Notice that both of these are inhibiting the thalamus through secreting the neurotransmitter GABA.

- **The following diagram illustrates the direct and indirect pathways of basal ganglia:**



  - **Direct pathway** → responsible for movement.
  - **Indirect pathway** → causes no movement.

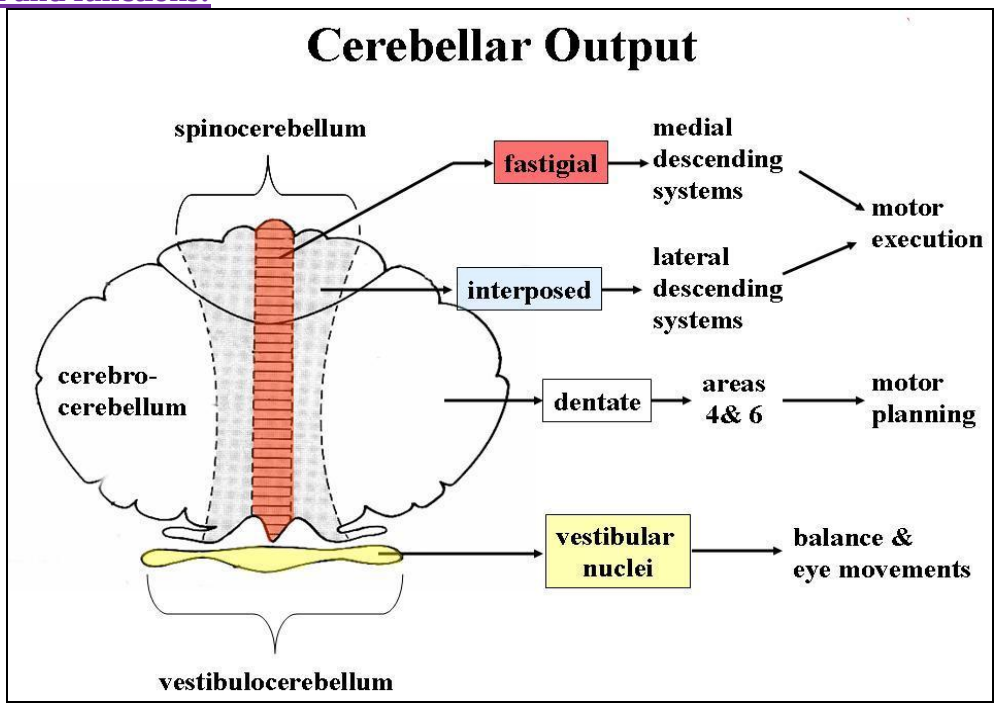
- **Notice that acetycholine (ACh) is always causing no movement while dopamine is always causing movement** ☺ **وبطتنا بطت بطن بطتكم**

- **What are the 4 cardinal signs of Parkinson's disease?**
  - Tremor at rest.
  - Slowness of movement (bradykinesia).
  - Rigidity: cog-wheel.
  - Micrographia: small writing.

- **In Parkinson's disease:** there is degeneration of dopaminergic neurons in substantia nigra compacta.

- **In Huntington's chorea**: the lesion is in the indirect pathway.

- **The image below illustrates the 3 components of cerebellum, their corresponding nuclei and functions:**



- **Cerebellar units (30 million units):**
  - **Mossy fibers (they are responsible for execution of movement).**
  - **Climbing fibers (responsible for correction of wrong movements).**
- Notice that the output of cerebellum is from deep cerebellar nuclei.
- **Cerebellar lesions:**
  - **There is no paralysis (Why?)** → because the motor system (corticospinal tract) is not affected.
  - **There is no sensory loss (Why?)** → because the cerebellum is not involved in transmitting sensations.
  - **These lesions will produce ipsilateral effect**. The dorsal spinocerebellar tract is reaching the cerebellum without crossing. Ventral spinocerebellar tract will cross at the level of entry to the spinal cord but it will recross again within the cerebellum (converting back to ipsilateral).
  - **There is hypotonia (decrease in muscle tone)** → because the cerebellum is involved in producing balance and maintaining posture through production of muscle tone.
  - **Vestibular effects (vomiting, nausea, unsteadiness and nystagmus):** the 8th cranial nerve is projecting from the vestibular system in inner ear → passing to vestibular nucleus (in medulla) → and then to cerebellum → aiding in maintenance of balance.
  - **Incoordination of movements known as ataxia.**
  - **Intention tremor**. Not that there are 2 types of tremor:
    - ✓ Resting tremor: occurring with lesions in extrapyramidal tracts or basal ganglia.
    - ✓ Intention tremor (which is happening during movement): occurring with lesion to the cerebellum.
  - **Dysmetria**: it is described as an inability to judge distance or scale so there will be lack of coordination of movement typified by the undershoot or overshoot of intended position with the hand, arm, leg or eye.
  - **Dysarthria**: condition in which problems effectively occur with the muscles that help produce speech, often making it very difficult to pronounce words.
  - **Tendon reflexes may be pendular** (متدلّ) due to hypotonia or not affected.
  - **A lesion in the medial part of the cerebellum** → producing axial/truncal ataxia.
  - **A lesion in the lateral part of the cerebellum** → producing appendicular ataxia (incoordination of fine movements mediated by the limbs).
  - **Dysdiodochokinesia**: difficulty in performing rapid alternating movements (supination/pronation).
- **Ataxia:**
  - **Truncal ataxia**: resulting for vermis lesion yielding a wide-based drunk-like gait (tandem gait).
  - **Appendicular ataxia**: resulting from lesion in lateral parts of the cerebellum. This will lead to incordination of movements in distal parts of limbs (finger-nose, heel-shin).
- **If there is a left cerebellar tumor:**
  - **The left side of the body will be affected (ipsilateral).**
  - **This will result in cerebellar ataxia which is characterized by:**
    - ✓ Swaying to the right in standing position (toward the normal side).
    - ✓ The patient will be steady on the right leg (because it is normal).
    - ✓ The patient will be unsteady on the left leg (because it is the one which is affected).
    - ✓ The patient will have ataxic gait (incoordinated).

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PROBLEM 6

- **Hydrocephalus types (focus on communicating and non-communicating):**
  - **Non-communicating**: occurring when there is obstruction of CSF flow in ventricles.

- **Communicating**: occurring when there is impaired CSF absorption in arachenoid granulations.
- **Normal pressure**: it is a form of communicating hydrocephalus in which CSF is not absorbed. The ventricles will be dilated and there will be thinning of the brain (death of brain cells) → resulting in the triad of:
  - ✓ Dementia.
  - ✓ Apraxic gait.
  - ✓ Urinary incontinence.

  Note: this condition is treated by peritoneal shunt.
- **Hydrocephalus ex vacuo**: when there is brain damage → the damage area will be occupied by CSF which will lead to compression and act as if there is a tumor.

- **What are the structures which compose the blood-brain barrier (BBB) (memorize 2-3 points for the exam):**
  - Pinocytotic vesicles.
  - Mitochondria.
  - Inter-endothelial tight junctions.
  - Basal lamina.
  - Astrocyte foot.
  - Pericytes.