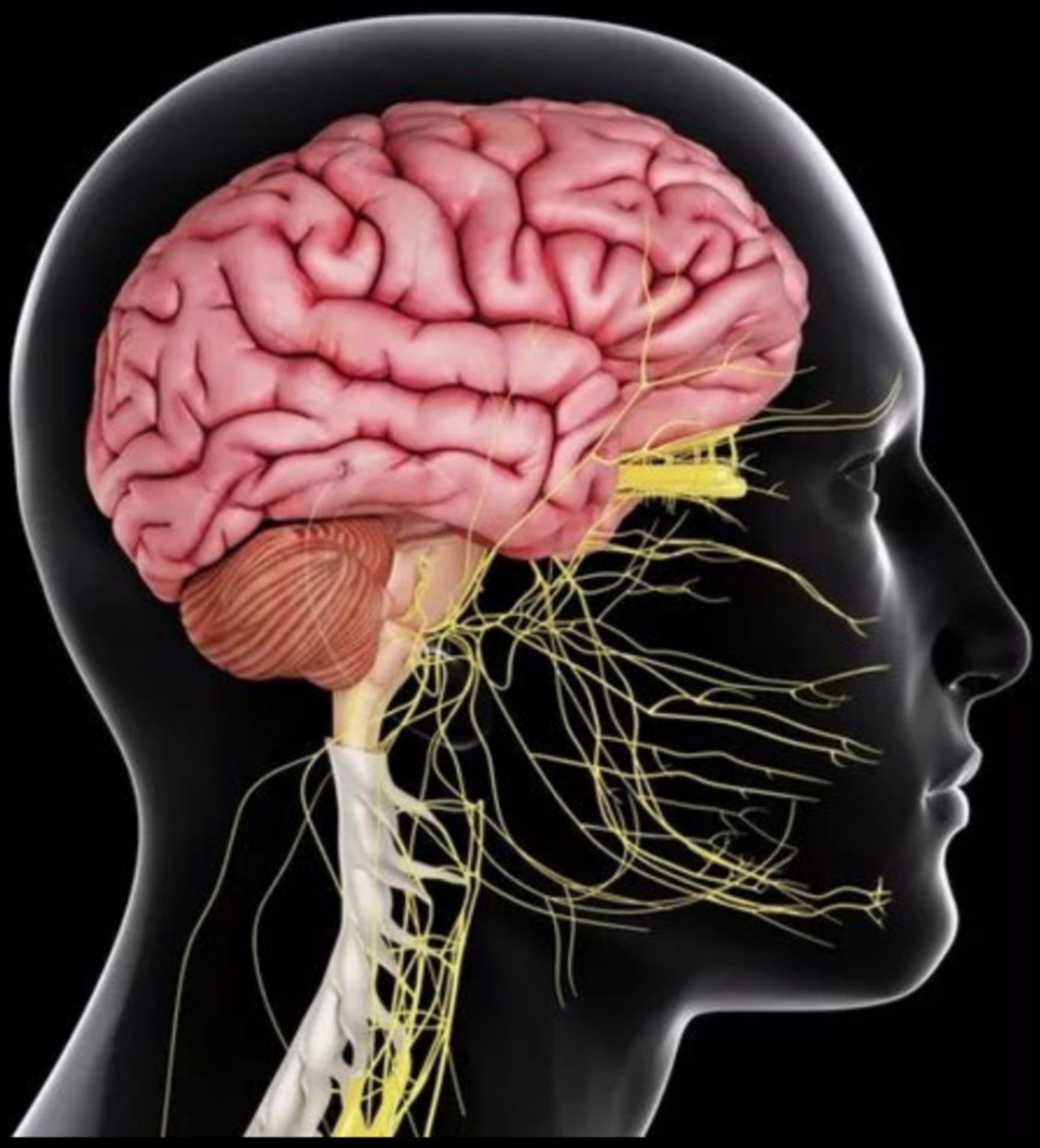
النادي الطبي

CENTRAL NERVOUS SYSTEM



SUBJECT : Bio- limbic- والمزيد

LEC NO. : 9-10

DONE BY : Nehoya

وَقُل رَّبِّ زِدْنِي عِلْمًا

lect 9 - Dr. nagi

Note: BG & Cerebellum
(motor) programers → بطيء → سريع

1

Nervous connection of BG : 2 main circuits نفس البداية والنهاية

integrate signal بدها ترد عليه حركيا

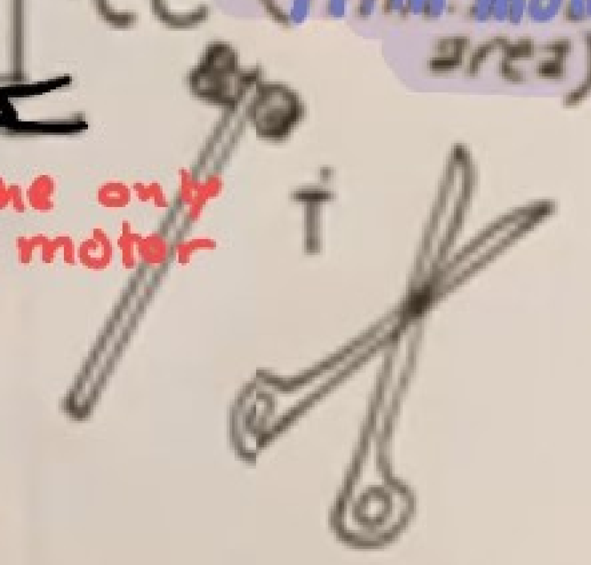
Time & scale → all BG signals

1 CC (Associative area) (complex) Cognitive → 2 plan Caudate → 3 صندوق البريد Globus → 4 Thalamus → 5 ended CC cortex (prefrontal * premotor * SMA)

CC (*Premotor *supplement.) → Putamen excute → Pallidus → VA VL Thalamus → CC (Prim. motor area) تنفيذ (4)

Subconcious familiar — circute سائل عش

VA VL سكرتارية → the only motor



Efferent pathways: V n. (est) | Sub thal | Sub nigra | Red n. | RF

vestibulospinal tr — rubrospinal tr — reticulospinal tr

Ch. tr ●●●

CC ● A.choline → ⊕ Neostriatum
⊖ = ↓ < ● GABA
⊖ Substania nigra ● Dopamine → ⊕
↓ = ⊕ parkinson

Chorea (Huntington) ← A. choline / GABA — result inhibition ⊖

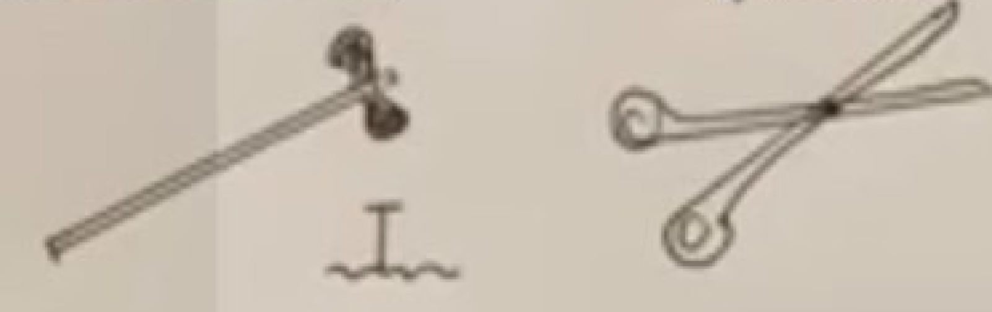
Parkinsonism — Dopamine — result excitation ⊕ 16

2

Functions of BG
Motor control & Behaviour

1. Caudate nucleus with CC
   Planning sequences of Cognitive Complex movement
   Control timing (rapid or slow)
   scale: (small or large)

2. Putamen circuit with Corticosp. system
   Excute subconscious learned pattern of movement — writing



3. Initiation & regulation of gross intentional movement
   Facial expression — swinging of arms with walk

4. GB (pallicidus) Posure taken to perform particular movement

5. BG mainly inhibitory to M. tone ⊖

Metabolic consideration
1. High O_2 consumption
2. High Copper content
   Wilson's disease ↓ ceruloplasmin
   ↑ Cu intoxication & degeneration of lenticular nucleus
   - Liver vomiting, ascites, Jaundice, weakness
   - Brain tremors, muscle stifness

3

ممحد على كلاي

Parkinsonism (Paralysis Agitans)

Substantia nigra ⊖ شلل رعاش

Causes
1. Cerebral atherosclerosis → -- dopamine receptors
2. D2 Dopamine receptor blockers e.g phenothiazine
3. Head trauma ⊖

Loss of dopaminergic inhibition ⊖ of putamen leading to: ↓
Imbalance between inhibition and excitation → excitation ⊕ عيان ناشف

rest 3 x 3

1. STATIC TREMORS (rhythmic) alternating
   - During rest — remations
   - Disappear by movement — asleep
   - Site (بسبح) pill rolling & mandible
2. RIGIDITY — Parkinsonian Rigidity
   - More in flexors → Flexion attitude
   - Lead-pipe i.e continuous or بتشنج
   - Cogwheel i.e series of catches
   - Cause ++ discharge in α & γ AHC
3. AKINESIA difficult initiating voluntary & spontaneous mov.
   - Face: masked (no expression).
   - Speech: monotonous. «lack well to move»
   - Gait: shuffling → short step
     legs short step
     arms no swinging

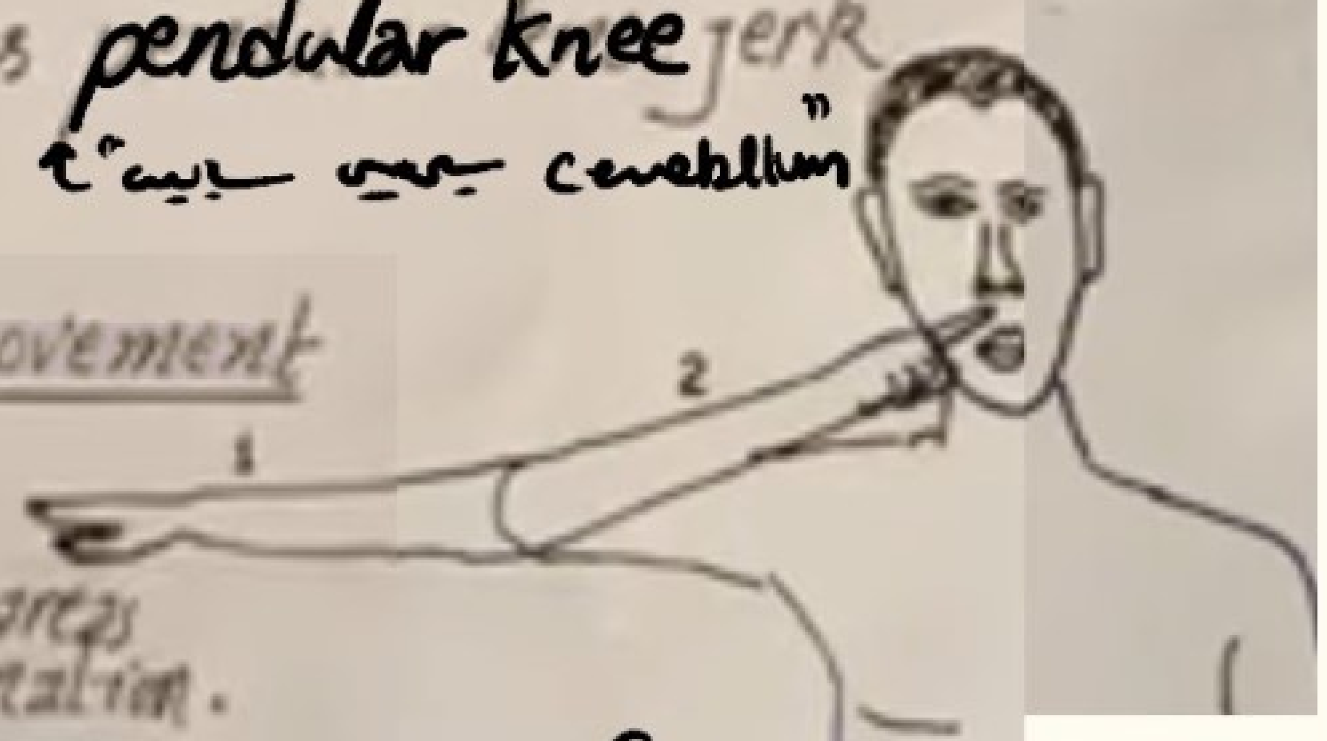
Tone تغير ← BG امراض → حركات لا ارادية

4

Ataxia (in) coordination of voluntary mov.
(in) abscense of motor lesion X UMNL / LMNL

manifestations
1. * Dysmetria ← اصبعه جنب انفه — * Finger to nose test
2. Dys diadokokinesia — صعوبة حركات متعاكسة
3. Dys arthria — صعوبة نطق → no coordination
4. Decomposition of movements — Heel - knee test
5. Drunken gait & Disturbance of posture — يمشي صعبه على اجره = مابعرف
6. * Kinetic tremor — بس يتحرك
7. Eye ball tremors — nystagmus (فتش فرامل)
8. Rebound

M Hypotonia & pendular knee jerk
(X neocer.) X⊕ = ↑⊖ «سابيه يحمي cerebllum»



3 Control of voluntary movement
1. Comands
   Cortical association areas integrate information.
2. Plans
   CC (premotor) BG Cerebellum — بطيء سريع
3. Excution
   Δ tr & extra Δ tr

«finger nose» test

(5)

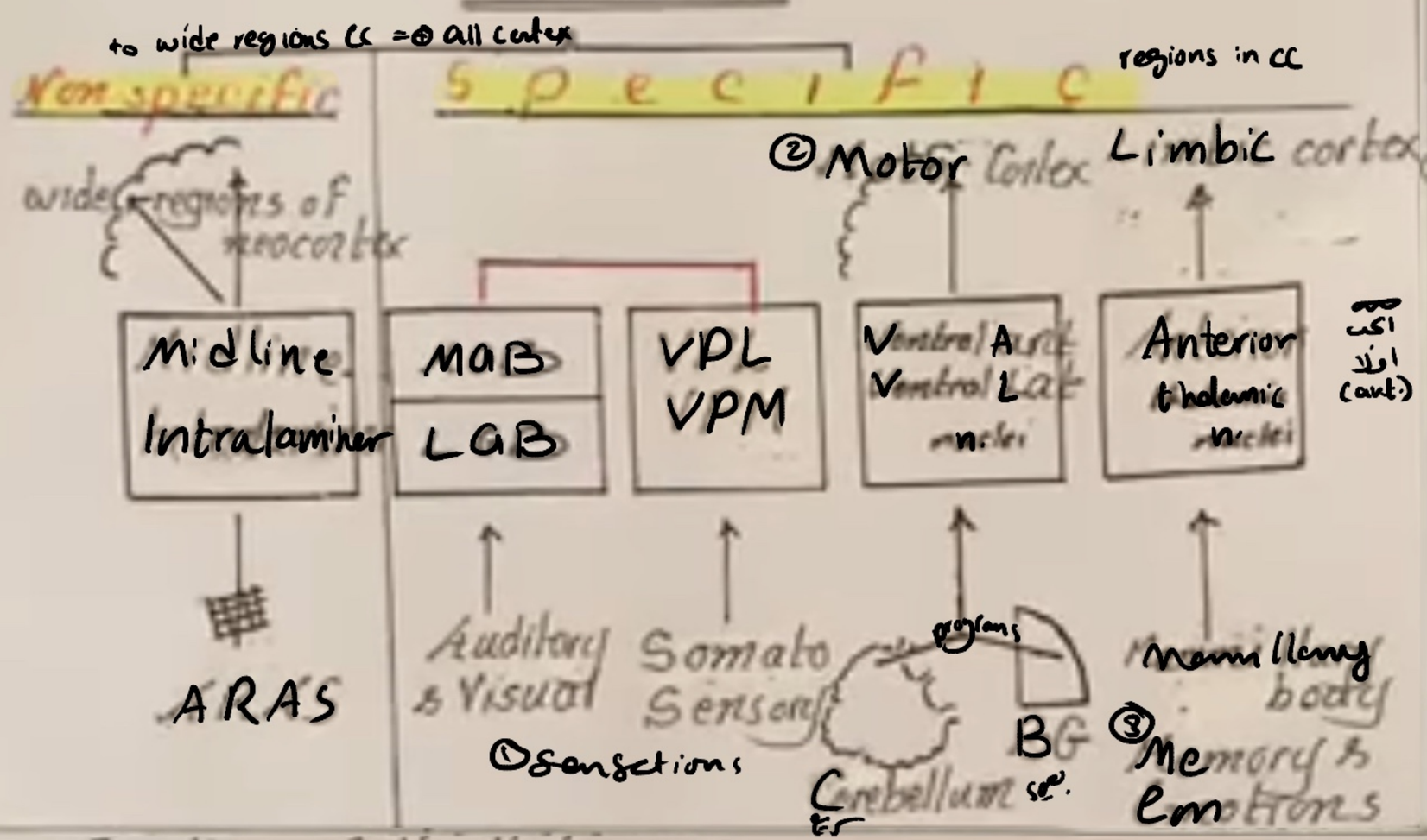
Thalamus

Gateway to CC (process infor. to CC)

Highest subcortical SENSORY centre

حسة الوحيد مابتديش عالـ thal. olfactory = CN 1 بزة واحد

Thalamic nuclei



Functions of the thalamus

1. Relays station for all SENSATIONS except olfaction.
4. Non specific thalamic nuclei → excitability of CC (Sleep & Walkfulness)
3. Memories coding, storing & recalling
   Relays autonomic & emotional signals to hypoth. & limbic system
2. Relays motor signal from BG & cerebellum to motor cortex

Thalamic syndrome involves one side

Cause Cerebrovascular stroke (ischemia or hge)

Damage Posterior nuclei

Results

1. Hemianesthesia
2. Burning or aching sensation with mood swings
   Pain threshold is elevated Pain obeys all or non law.
3. Serious akinetic mutism Pt tends not to move or speak (not paralysed) with ocular problem.
4. May Korsakoff's syndrome (chronic memory disorder) alcohol vit B12
5. May Fatal familiar insomia → death

لا يتحرك ولا يتكلم

Note most thalamic neurones are excitatory and release Glutamate
some " " (interneurones) are inhibitory & release GABA

THE BASAL GANGLIA: The basal ganglia (B.G.) are subcortical masses of gray matter that include the following nuclei: (1)The caudate nucleus. (2)The lentiform (or lenticular) nucleus This consists of 2 parts (a) An outer part called the putamen (b) An inner part called the globus pallidus, which is further divided into external and internal segments. Both the caudate nucleus and putamen are called the corpus striatum.
(3) The subthalamic nucleus (= subthalamus or body (4)The substantia nigra (in the midbrain).

CONNECTIONS OF THE BASAL GANGLIA

The B.G. constitutes a basic part of the extrapyramidal system. Their afferent (input) fibers are derived mainly from the cerebral cortex to the corpus striatum, while their efferent (output) fibers originate mainly from the globus pallidus. Their connections can generally be divided into 3 parts:

(A) Cortical connections of the basal ganglia

(1) Putamen circuit: Fibres start from the cortical motor areas and end at the putamen, from which new fibers arise and end at the internal globus pallidus. From the latter, fibers arise and relay at the thalamic ventrolateral nucleus, from which fibers arise and finally end at the cortical motor areas, especially the primary motor area (area 4).

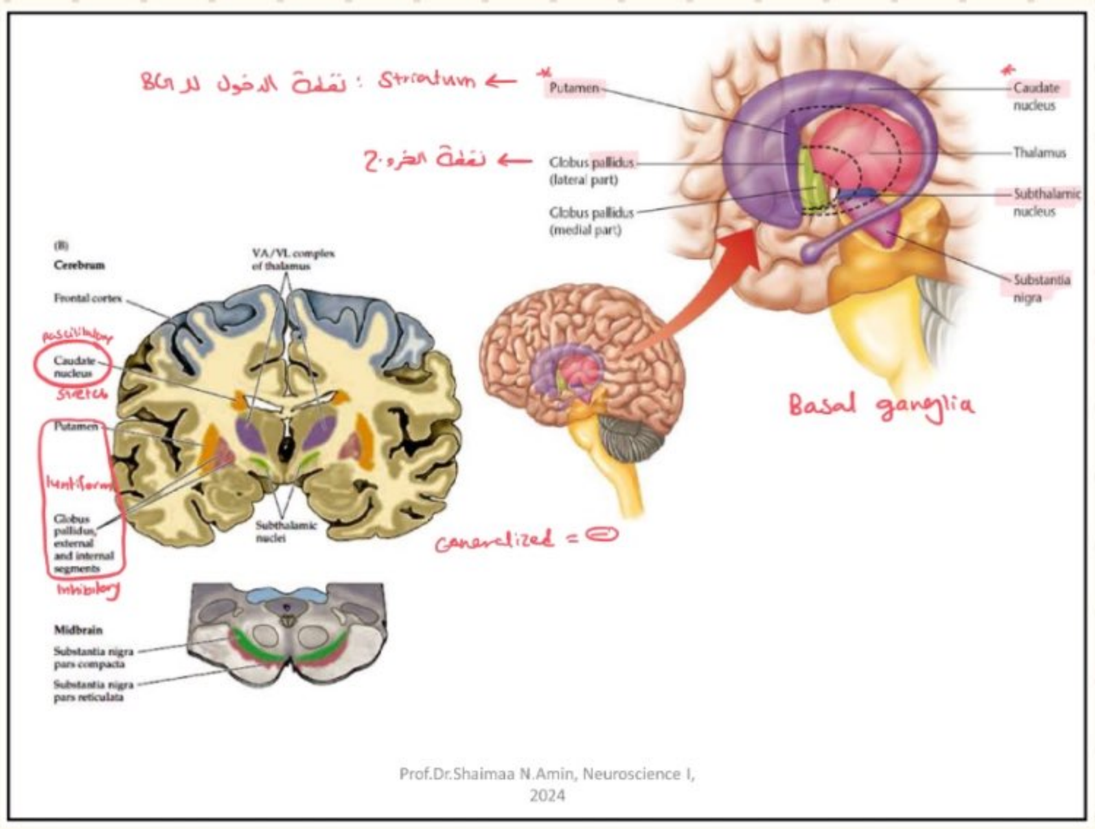
(2) Caudate circuit: Fibres start from both the cortical motor and sensory association areas and end at the caudate nucleus, from which new fibers arise and end at the internal globus pallidus. Fibers arise from the latter and relay at the thalamic ventrolateral nucleus, from which fibers arise and finally end at the cortical motor association areas.

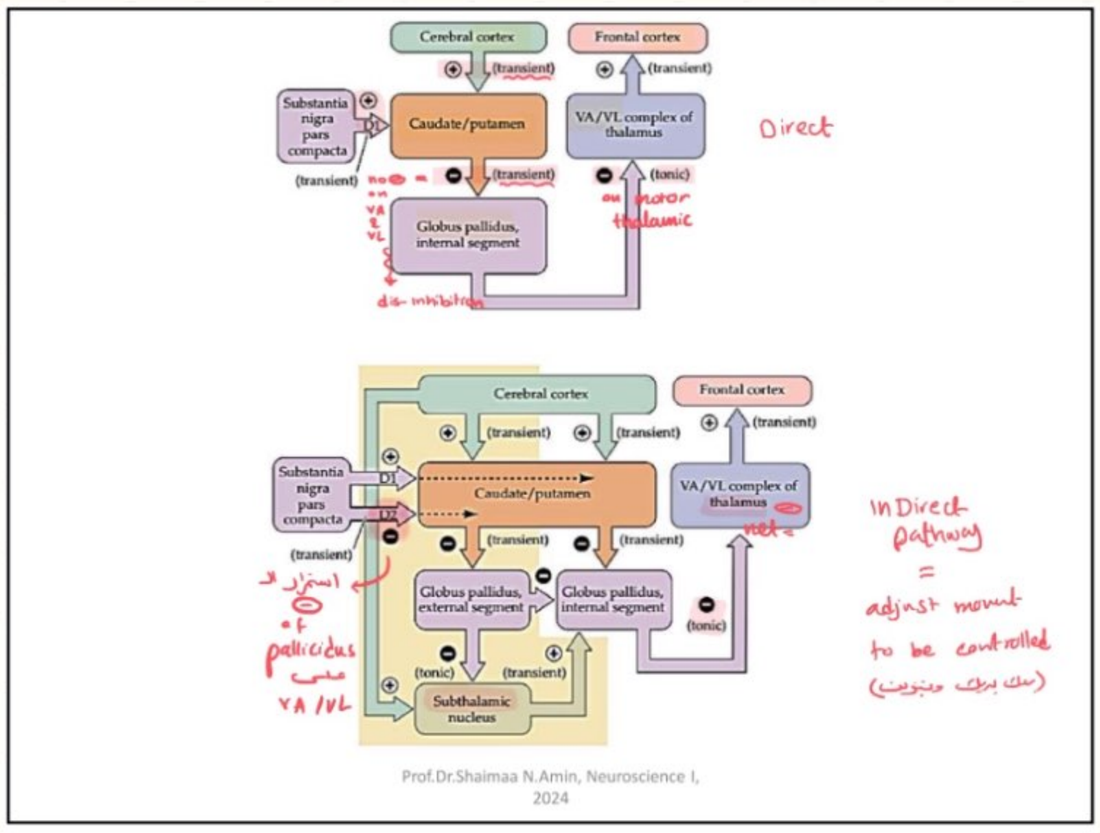
(B) Interconnections of the basal ganglia

(1)A negative feedback interconnection between the external of the globus pallidus and the subthalamus.
(2) Dopaminergic nigrostriatal connection.
(3) GABA-ergic striato-nigral striato-pallidal projections.

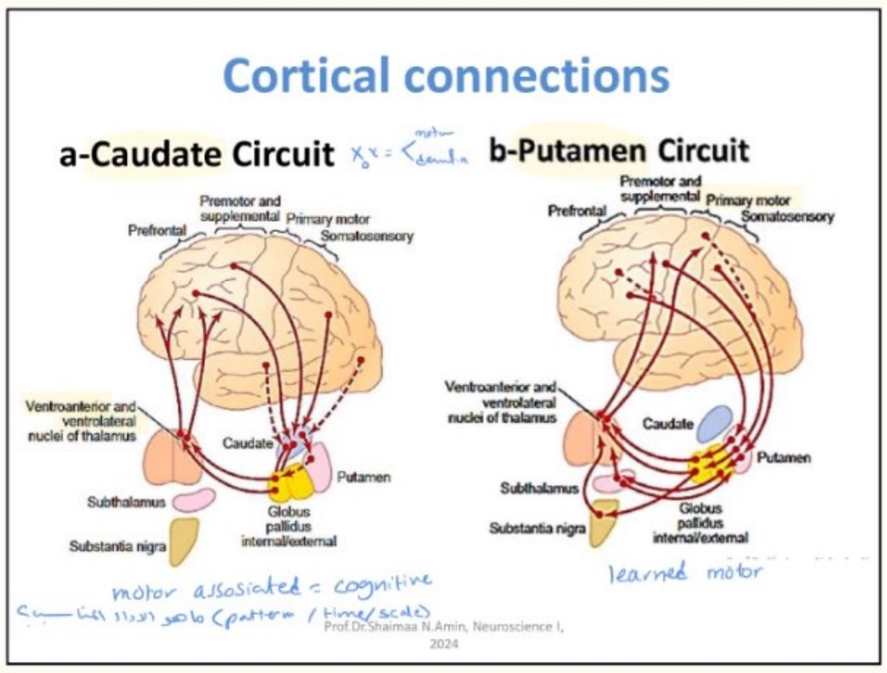
(C) Brain stem connections of the basal ganglia

Fibers from the globus pallidus project to (a) reticular formation, (b) The red nucleus, (c) The vestibular nucleus (d) The inferior olivary nucleus. Signals from the B.G. are transmitted through such connections to the spinal centres via the extrapyramidal tracts.

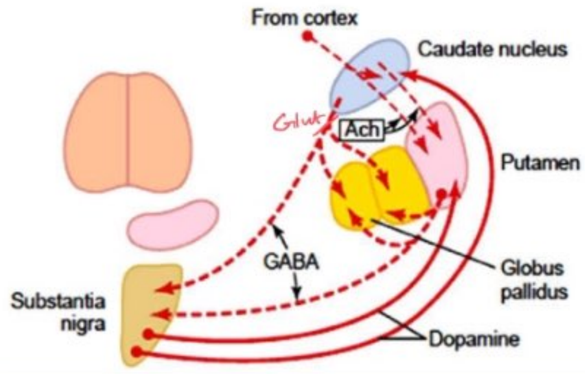




Cortical connections

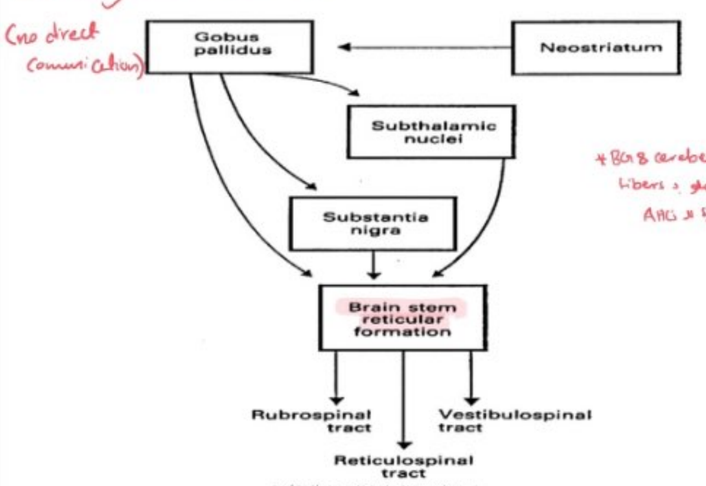


Interconnections of the basal ganglia



1- C .Cortex→ Glutamate → Neostriatum
2- Neostriatum → GABA → Substantia nigra
3- Substantia nigra → dopamine → Neostriatum

Brain stem connections



NEUROTRANSMITTERS IN THE BASAL GANGLIA These are multiple and include the following:

1. Acetylcholine (mainly from intra-striatal neurons).
2. Dopamine (from the nigrostriatal neurons).
3. GABA (from the striato-nigral and striaio-pallida/ neurons).
4. Norepinephrine, serotonin, and enkephalin (from the neurons that project from various centres in the brain stem to the basal ganglia).
5. Glutamate (from the cortico-striatal and subthalamic neurons).

Acetylcholine, glutamate, and norepinephrine are excitatory transmitters, while all the remaining transmitters are inhibitory, and the balance between inhibition and excitation in the B.G. maintains normal motor function. Normally, the inhibitory effect predominates (which decreases the excitatory discharge of the B.G. Also, the discharge of the B.G. to the thalamus is mainly inhibitory via GABA-ergic nerve fibers. These factors decrease the excitatory discharge from the thalamus to the cortical motor areas.

** The predominance of inhibitory neurons in the B.G. makes the circuits described above (especially the putamen circuit and its associated circuits) act as negative feedback loops that stabilize the motor control system and prevent excessive and undesirable movements.

Excessive deposition of copper in the liver and B.G. occurs in Wilson's disease resulting in their damage (= hepatolenticular degeneration). Also, if the bile pigments' blood level increases markedly, they cross the blood-brain barrier and deposit in the B.G. leading to their damage).

FUNCTIONS OF THE BASAL GANGLIA

The functions of the B.G. are purely motor and include the following :

(A) Control of the muscle tone: The lentiform nucleus decreases the muscle tone by inhibiting the vestibular nucleus and activating the inhibitory reticular formation. On the Other hand, the caudate nucleus increases muscle tone by stimulating the facilitatory reticular formation and the vestibular and inferior olivary nuclei. However generalized stimulation of the B.G. decreases the muscle tone (indicating a predominance of the inhibitory effect of the lentiform nucleus).

(B) Control of voluntary movements: for already Programmed moves

(1) The B.G. discharges before the movements start and is concerned with planning and programming of movements:(a) The putamen circuit is concerned with the execution of learned patterns of movement (b) The caudate circuit is concerned with converting thoughts into motor actions. This involves the determination of (i) The pattern of movements to be used and their sequence, (ii) The timing and rapidity of performing the movements (iii) The scale (intensity) of movements. An example of such a function is what happens to a person who sees a lion (he automatically and rapidly turns away, begins to run, and even attempts to climb a tree).

(2)As a part of the extrapyramidal system, the B.G. initiates subconscious automatic movements (e.g., swinging the arms during walking).

PARKINSON'S DISEASE:

This is due to lesions of the substantia nigra, which leads to degeneration of the dopaminergic nigrostriatal fibers(resulting in a marked reduction of the dopamine content in the B.G.).It occurs more in old age (because there is normally a steady loss of the dopaminergic neurons and receptors in the B.G. with the progress of age) and is hastened by atherosclerosis and prolonged use of phenothiazine tranquilizers (which block the D)? receptors).

Manifestations of Parkinson's disease (Parkinsonism) Parkinsonism is characterized by both hyperkinetic features (rigidity and static tremors) and hypokinetic features (akinesia and bradykinesia).

(1) MUSCLE RIGIDITY

This occurs in all muscles (but the tendon jerks are usually not exaggerated). When the limbs are passively moved, it is either continuous lead-pipe rigidity) or interrupted cogwheel rigidity). It is primarily an alpha rigidity that occurs due to a release phenomenon. Destruction of the dopaminergic neurons releases the corpus striatum from dopamine's inhibitory effect, which leads to increased output of excitatory signals to the cortical motor areas, which consequently discharge excess excitatory signals to the spinal alpha motor neurons via the corticospinal tract resulting in rigidity.

(2) AKINESIA OR HYPOKINESIA (LACK OF MOVEMENTS)

This is associated with bradykinesia (= slow movements) and is manifested by (a) Marked difficulty in initiating voluntary movements (b) Mask face clue to lack of facial expression (c) Slow, monotonous and low-volume speech (d) Shuffling gait, i.e., walking rapidly in short steps without lifting the legs from the ground (e) Absence of the associated movements e.g., swinging of the arms during walking.

The real cause of akinesia is unknown. However, it was found that dopamine is also decreased in the limbic system, which might greatly reduce the psychic drive of the motor activity, leading to akinesia.

(3) STATIC TREMOR

This tremor appears during rest and disappears during sleep and on doing voluntary movements. It occurs at a rate of 3-6 or 8 cycles per second due to regular alternating contraction of the antagonistic muscles (probably due to oscillation of activity in the feedback circuits after the loss of their inhibition caused by dopamine deficiency). It is marked in the upper limbs and in the hands; it often appears as pill-rolling movements.

THE THALAMUS

The thalamus is a subcortical mass of gray matter located at the lateral wall of the third ventricle. It contains the following nuclei:

(A) Nonspecific projection nuclei: These include mainly the middle and intralaminar nuclei. They receive signals from the reticular formation and discharge to almost all areas of the cerebral cortex.

(B) Specific projection nuclei

(I) Ventro-posterior nucleus (VPN): Its lateral part (VPLN) receives the spinal and medial lemnisci while its medial part (VPMN) receives the trigeminal lemniscus, and both parts then project to the cortical sensory areas in the postcentral gyrus.

(2)Lateral geniculate body This projects visual impulses to the occipital lobe (refer to the visual pathway in special senses).

(3)Medial geniculate body This projects auditory impulses to the temporal lobe (refer to the auditory pathway in special senses).

(4)Ventrolateral nucleus (= thalamic motor nucleus) This receives signals from both the cerebellum and the basal ganglia and projects to the cortical motor areas (playing a major role in the control of motor functions).

(5)Anterior nucleus: This receives signals from the hypothalamus and discharges to the cortical, limbic lobe.

(6)Dorsomedial and dorsolateral nuclei: These are association nuclei that receive signals from other thalamic nuclei, then the dorsomedial nucleus projects to the prefrontal cortical area, while the dorsolateral nucleus projects to the prefrontal cortex nucleus projects to the cortical association areas.

FUNCTIONS OF THE THALAMUS

(I) The thalamus conveys all sensations to the cerebral cortex because its nuclei are relay stations in the pathways of (a) Epicritic sensations from the opposite side (the VPN), (b) Visual signals (the lateral geniculate body), (c) Auditory signals (the medial geniculate body).

(2) The intralaminar and middle nuclei are the center for the perception of protopathic (crude) sensations and slow pain from the opposite side. (paleospinothalmic)

(3)The thalamus is a relay station for signals from the contralateral cerebellum and ipsilateral basal ganglia to the cortical motor areas (through the lateral ventral nucleus).

(4)The nonspecific projection nuclei are relay stations in the ascending reticular activating system.

(5)The thalamus is a part of the systems concerned with (a) Recent memory and emotional reactions (through its connections with the hypothalamus and limbic lobe, page 129) (b) The high intellectual functions (through its connections with the cortical association areas) (c) The behavior and personality (through its connections with the prefrontal cortical areas).

THE THALAMIC SYNDROME

This is a disease that results from thrombosis, or a branch of the posterior cerebral artery called the thalamogeniculllate artery (which supplies a large part of the thalamus, especially its lateral and posteroventral parts). It leads to the following manifestations on the opposite side of the body:

(I) Early in the disease, all sensations are completely lost. The facial sensations are usually less affected because the damage occurs mainly in the VPLIN (while the VPMN is little affected).

(2) The loss of kinaesthetic sensations results in sensory ataxia.

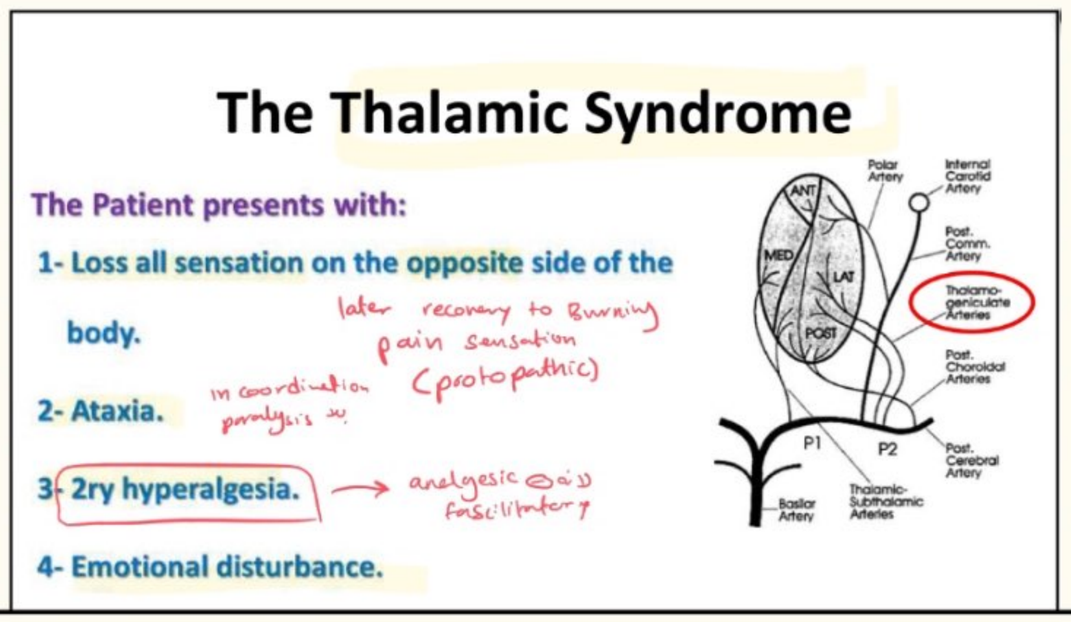
(3)Within the next few weeks or months, protopathic crude) sensations recover. Emotional disturbances accompany this, and although the threshold of pain is elevated, it is accompanied by an exaggerated central effect called thalamic hyperpathia. The latter is **a release phenomenon** that occurs due to the facilitation of the intralaminar and middle nuclei (probably due to interruption of the signals that activate the analgesic brain areas).

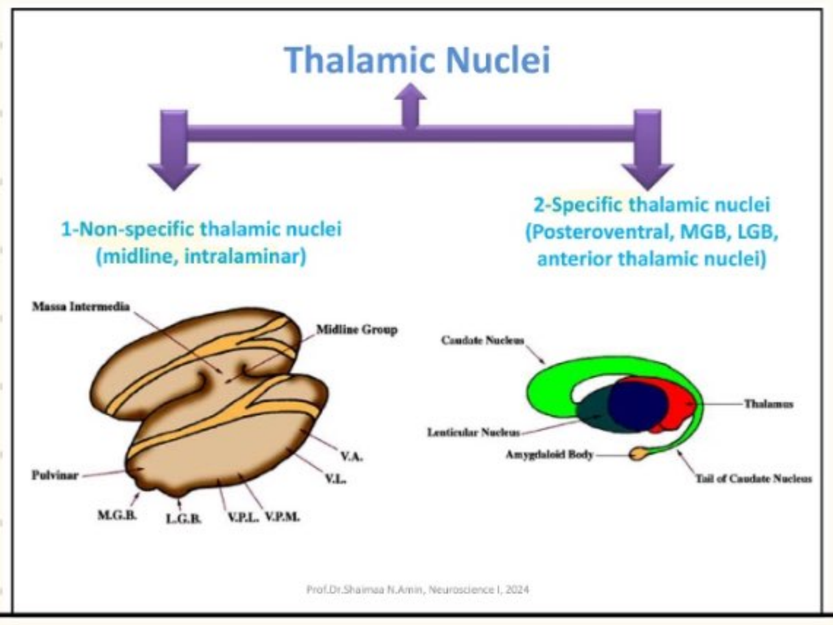
(4)The epicritic (= line) sensations are permanently lost, resulting in loss of both tactile Localization and discrimination and astereognosis.

(5)Damage to the ventrolateral nucleus (= thalamic motor nucleus) leads to the following:

(a)Loss of the cerebellar control on the cortical motor areas, which results in asthenia (= muscle weakness or paresis), hypotonia, and manifestations of cerebellar ataxia.

(b)Interruption of the connections between the basal ganglia and the cerebral cortex may result in abnormal movements similar to those occurring in chorea and athetosis.





Motor CAUSES OF TREMORS

1. Static tremor: This occurs in Parkinsonism. It is present during rest and is associated with hypertonia.
2. Kinetic tremor: This occurs in neocerebellar disease. It is especially present at the end of movements and is associated with hypotonia. عيان هـــايب → intentional tremor

ATAXIA

This means incoordination of voluntary movements, and it is either sensory or motor (sometimes mixed in the thalamic syndrome).

(A)Sensory ataxia: This occurs as a result of lesions (or diseases) of the proprioceptive sensory pathways, commonly in the dorsal column of the spinal cord (= the gracile and cuneate tracts).

The manifestations (features) of sensory ataxia include (a) Loss of dorsal column sensations (b) +ve Romberg's sign. There is a stamping gait high steppage gait with a slap when the foot reaches the floor), and the patient walks at a broad base and always looks at his feet.

(B)Motor ataxia: This is due to defects in the coordinating system of voluntary movements.

(C) Mixed ataxia: as ataxia in thalamic syndrome.

	SENSORY ATAXIA	MOTOR ATAXIA
Most common cause	Tabes dorsalis	Neocerebellar disease
Gait	high steppage (stamping gait)	Staggering (drunken gait)
Romberg's sign	Positive	Negative
Effect of vision	Corrected by vision	Not affected by vision
Deep sensations	impaired or lost	Normal
Tremors	Absent	Kinetic tremors present
Nystagmus	Absent	Present
Speech	Normal	Scanning or staccato

ASSESSMENT OF COORDINATION (TESTS FOR ATAXIA)

(A) COORDINATION TESTS IN THE UPPER LIMBS

(I) Finger-to-nose test: Ask the patient to extend his arm. then to place his forefinger on the tip of his nose, first with open then with closed eyes.

(2) Finger-to-finger test: Ask the patient to extend both arms and then touch the tips of his 2 fingers. first with open then with closed eyes. امكانية عمل حركات متعاكسة بنفس الوقت م

(3) Tests for Adiadochokinesia: Ask the patient to pronate and supinate his hand repeatedly or tap his leg with his hand rapidly.

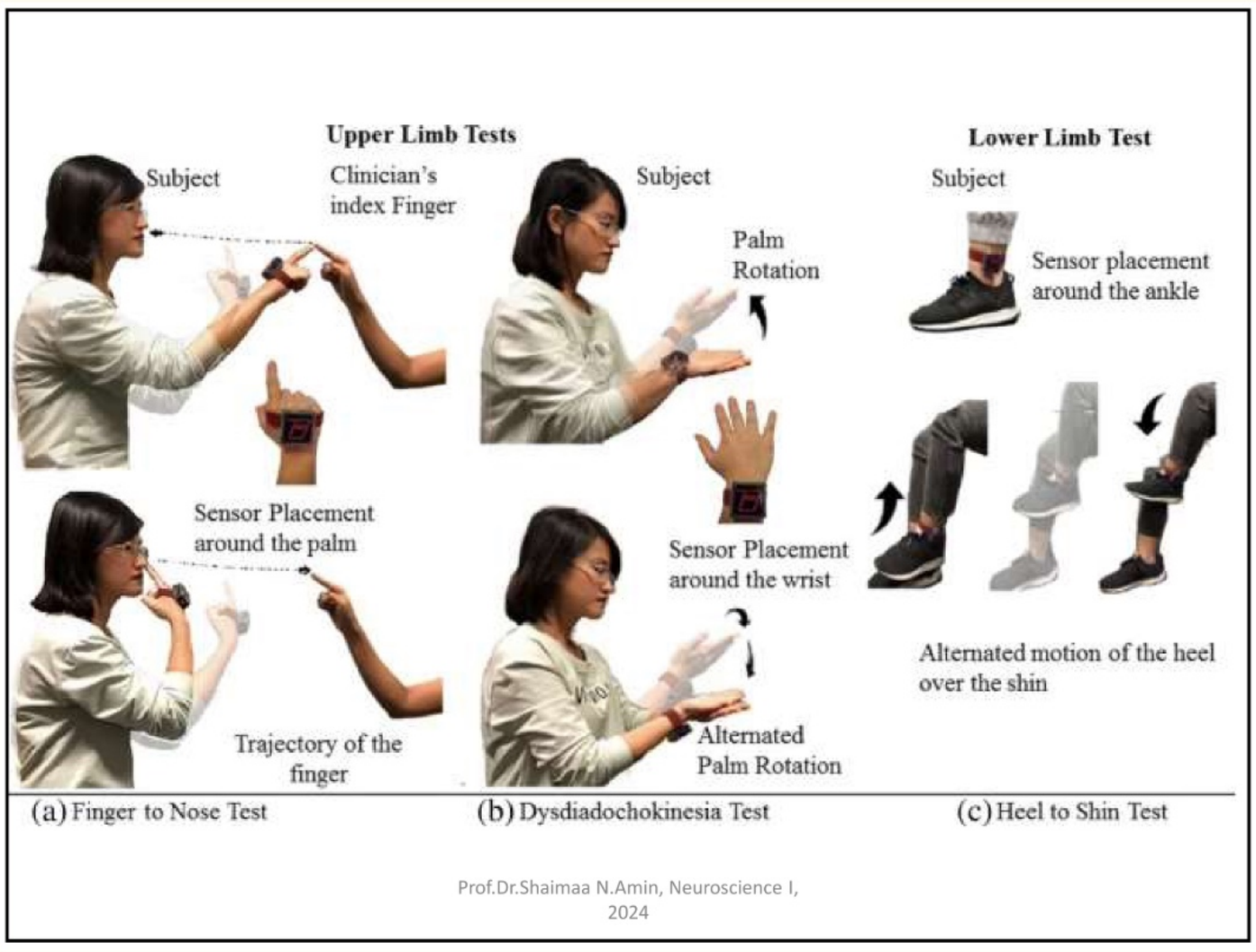
(4) Tests for rebound: (a) The arm pulling test (b) The wrist-slapping test: The hand of the patient is suddenly tapped downward. An exaggerated displacement of the arm occurs in motor ataxia.

(B) COORDINATION TESTS IN THE LOWER LIMBS

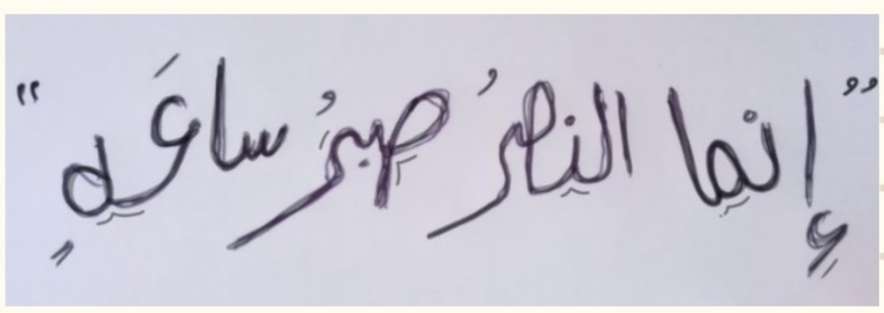
(I) Heel-knee test: At recumbency, the patient is asked to place his heel on the opposite knee, then run it down the shin of the tibia to the foot.

(2)Test the gait while walking along a straight line.

(3)Test for Romberg's sign by closing the eyes.



Prof.Dr.Shaimaa N.Amin, Neuroscience I, 2024



THE HYPOTHALAMUS AND LIMBIC SYSTEM

The hypothalamus is a part of the diencephalon located below and anterior to the thalamus. It is the main component and the major output pathway of the limbic system, so their functions are closely interrelated. It contains the following groups of nuclei :

(I) Anterior group (supraoptic, suprachiasmatic, preoptic and paraventricular nuclei).
(2)Lateral group (mainly a large lateral nucleus).
(3)Medial group (dorsomedial and ventromedial nuclei and the arcuate nucleus).
(4)Posterior group (posterior nucleus and the mamillary bodies).
(5) Periventricular nuclei (refer to the analgesia system).

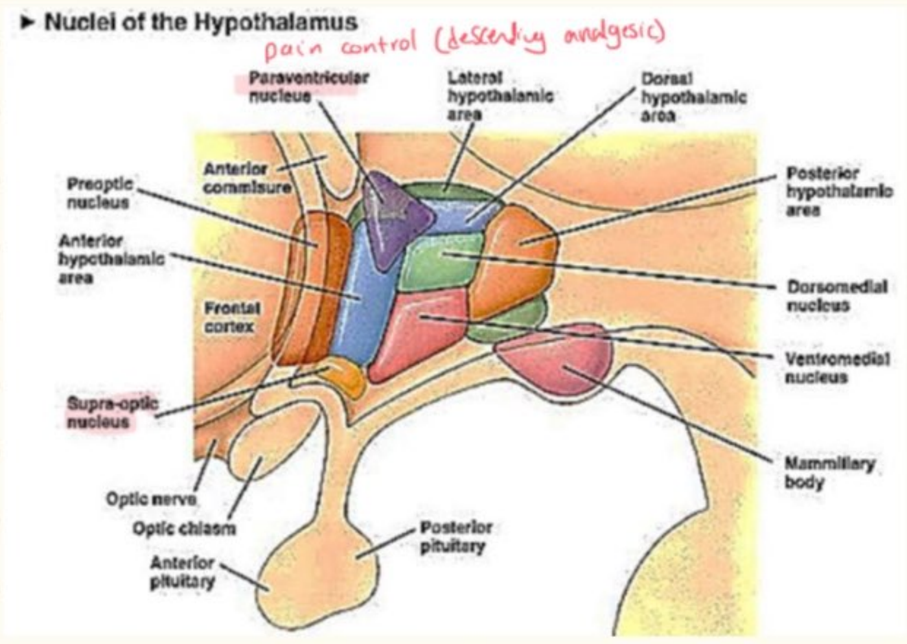
FUNCTIONS OF THE HYPOTHALAMUS

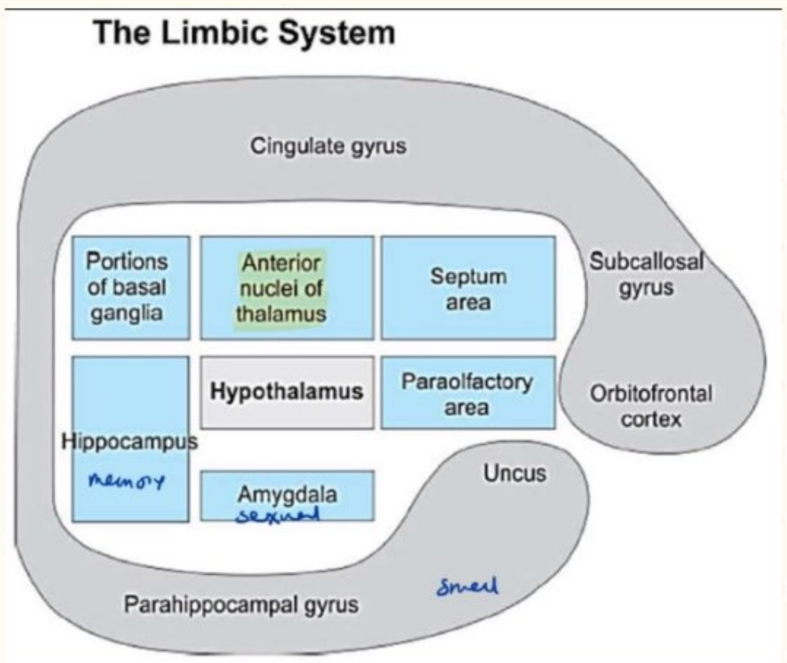
The hypothalamus is essential for homeostasis through the following:
(1) Control of autonomic functions (sympathetic and parasympathetic).
(2) Control of the endocrine system: This occurs in 2 ways :

A-Nervous control: The hypothalamus controls 2 endocrine glands by sending nerve signals to (a) The adrenal medulla (through affecting the vasomotor centre) (b) The posterior pituitary gland (through the hypothalamohypophysial tract). This gland's hormones (ADH and oxytocin) are also synthesized in the hypothalamus.

B-Hormonal control: The hypothalamus controls the anterior pituitary gland (and consequently most endocrine glands) by releasing the hypophysiotropic hormones from its median eminence (refer to endocrines).

(3) body temperature regulation: The hypothalamus contains sensitive thermoreceptors and the thermoregulatory center.
(4) Control of water balance: Hypothalamic osmoreceptors regulate water intake and loss.
(5) Control of food intake: This occurs by activity of the hypothalamic appestat center, subdivided into 2 parts: a feeding center and a satiety center.
(6) Control of circadian (=diurnal or 24-hour) rhythms: This occurs by the suprachiasmatic nuclei, which are the pacemakers for the circadian rhythms in the body.
(7) Regulation of sexual functions: The hypothalamus regulates the release of gonadotropins which controls spermatogenesis and ovulation and the secretion of sex hormones from the gonads.
(9) Control of motivation by the reward-punishment systems. In addition, the hypothalamus shares in the control of memory & learning.
(10) Emotional expression (reactions).





THE LIMBIC SYSTEM

The word "limbic" means "border." Originally, the term "limbic" was used to describe the border structures around the basal regions of the cerebrum, but according to the functions of the limbic system, the term limbic system has been expanded to mean the entire neuronal circuitry that controls emotional behavior and motivational drives. This system consists of 2 components:

(l) The limbic lobe of the cerebral cortex is a rim of primitive cortical tissue around the hilum of the cerebral hemispheres. It is also called the rhinencephalon, and it contains mainly the cingulate and hippocampal gyri and the uncus. the piriform and entorhinal cortex.
(2) Certain subcortical structures: These include the amygdaloid nuclei, hippocampus, hypothalamus, fornix, anterior thalamic nucleus, septal nuclei, and upper part of the midbrain area.

Connections of the limbic system

(1)Between its different parts, especially between the hypothalamus and the amygdaloid nucleus via the stri terminalis.

(2)A few connections with the neocortex.

(3)***The Papez circuit***: The hippocampus is connected via the fornix to the mamillary bodies, and these ar connected via the mamillothalamic tract to the anterior thalamic nucleus, which projects to the cingulate gyrus and this finally discharges to the hippocampus again.

FUNCTIONS OF THE LIMBIC SYSTEM (1) Perception of olfactory (smell) sensation.

(2) Control of the feeding behavior (3) Control of autonomic functions.

(4)Control of sexual behavior: The behavior that accompanies the sexual act is regulated in the limbic syste particularly the amygdaloid nuclei, since bilateral damage of these nuclei in males leads to abnormal sexu behavior together with hypersexuality. (5) Memory and learning.

(6)Control of emotions: The limbic system controls emotional reactions with the hypothalamus.

(7) Control of motivation: Motivation is controlled by reward and punishment systems. ↑↑ = عقاب = صح ؟

Types of Memory

Two major types:

- ***Implicit or non-declarative memory:*** ضمني
  - ➢ Does not require conscious or, awareness
  - ➢ Does not usually involve the hippocampus.
  - ➢ Example: remembering how to brush your teeth
- ***Explicit or Declarative memory***: Memory of words, rules, and language مفسر
  - ➢ Associated with consciousness or, at least awareness
  - ➢ Dependent on the hippocampus ⇒ short قصيرة / long طويلة term memory → ؟ تتخزن → medium temporal lobes
  - ➢ Example recalling the first day in college

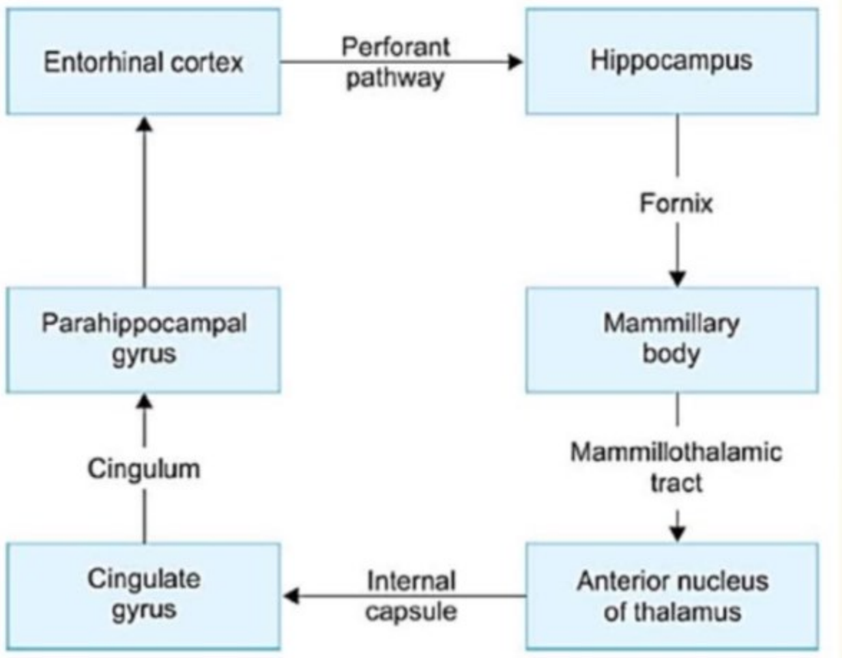
Implicit memory is subdivided into four types:

1. Procedural memory includes skills and habits, which, once acquired, become unconscious and automatic.
2. Priming is the facilitation of recognition of words or objects by prior exposure to them. An example is improved recall of a word when presented with the first few letters of it (Name a fruit with GR.. GRAPE). of recall مثلا تكملة الاغنية او الكلام
3. Associative learning is related to classical and operant conditioning in which the organism learns about the relation of one stimulus to another (check below).
4. Non-associative learning includes habituation and sensitization and is dependent on various reflex pathways. Here the organism learns about a single stimulus.

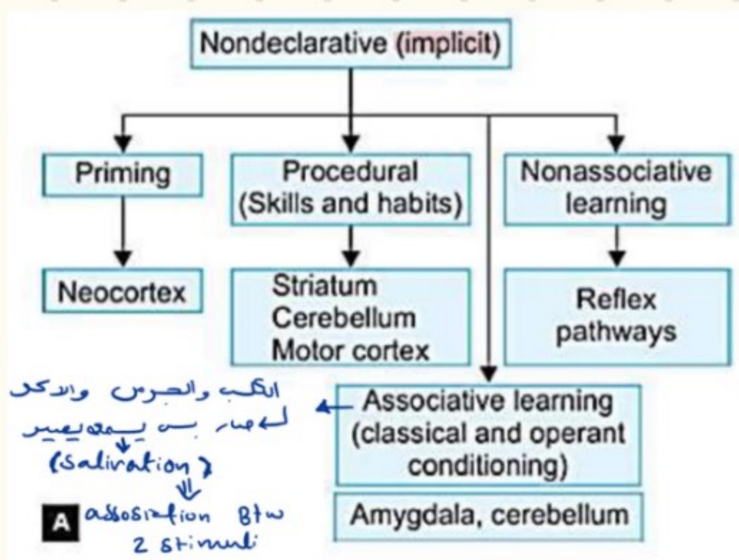
Explicit memory is subdivided into two types:

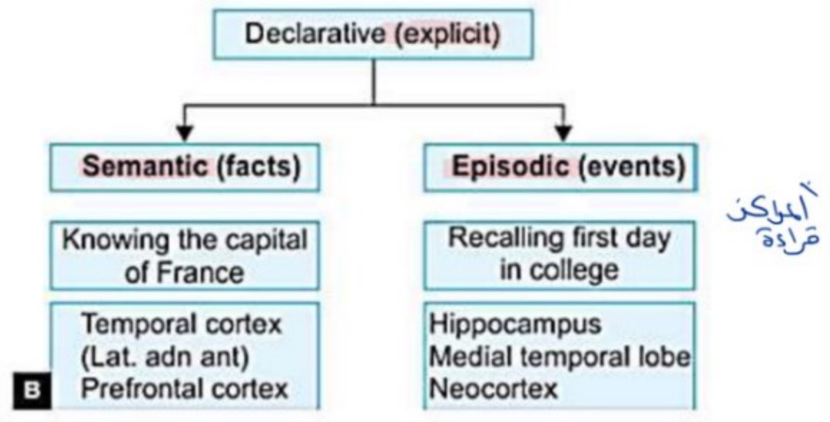
1. Episodic memory for events
2. Semantic memory for facts (e.g. words, rules, and language). معلومات عامة

The different parts of brain areas involve in processing and formation of implicit and explicit memory memory is given in the Flowchart:



Component of papez circuit. ← emotion learning





Explicit Memory and Many Forms of Implicit Memory Involve

1. ***Working memory (recent memory):*** It is a form of short-term memory that keeps information available, usually for very short periods, while the individual plans action based on it. Capacity is 7 ± 2 'chunks' of information and duration of storage is 18–20 secs only. الاقصى

Small amounts
لـ رقم تلفون مثلا حافظه كد ما سجله

عملية التحول consilidation ("Sleep" Diet ...)

2. ***Short-term memory:*** This lasts seconds to hours, during which processing in the hippocampus and elsewhere lays down long-term changes in synaptic strength.

3. ***Long-term memory:*** This stores memories for years and sometimes for life. During short-term memory, the memory traces are subject to disruption by trauma and various drugs, whereas long-term memory traces are remarkably resistant to disruption.

electrical / chemical
Brain changes = recall experience

The neural mechanisms of memory depend on the following forms of synaptic plasticity:

Synaptic plasticity means changes in the strength of synaptic transmission (which represent forms of learning memory). Such changes are presynaptic and postsynaptic, and they include potentiation, depression & sensitization.

SYNAPTIC POTENTIATION (OR FACILITATION)

This is the production of high-amplitude EPSPs in response to stimulation. It occurs after a brief period of rapidly repeated stimulation of the presynaptic neuron (= tetanizing train of stimuli), and is 2 types :

1-Short-term potentiation (= post-tetanic potentiation): This lasts up to one minute and is due to excess Ca- in the presynaptic knobs due to the repeated stimulation (which increases the release of the neurotransmitter and, in turn, increases the EPSP).

2-Long-term potentiation (LTP): This especially occurs in the hippocampus, where the excitatory transmitter is glutamate. It lasts a few hours or days, and both the pre and postsynaptic neurons participate in its production. The presynaptic neuron releases glutamate, increasing the Ca^{+2} influx in the postsynaptic neuron, thus increasing the EPSP. In turn, the postsynaptic neuron releases a chemical signal (NO) that causes more glutamate secretion from the presynaptic neuron.

SYNAPTIC DEPRESSION

This is a decrease in the response of postsynaptic neurons, and is 2 types:

1 - Habituation: This is a gradual decrease of the postsynaptic response when a stimulus to the presynaptic neuron is repeated over and over. It is due to less release of the neurotransmitters from the presynaptic terminals secondary to the reduction of the intracellular Ca+2 (which occurs due to the closure of the Ca+2 channels by an unknown mechanism).

2- Long-term depression (LTD): This is the opposite of LTP, produced by slower stimulation of the presynaptic neurons (Occurs if presynaptic neuron stimulation→ depolarization of postsynaptic neuron less than 20mv (the threshold for NMDA receptors to open)).

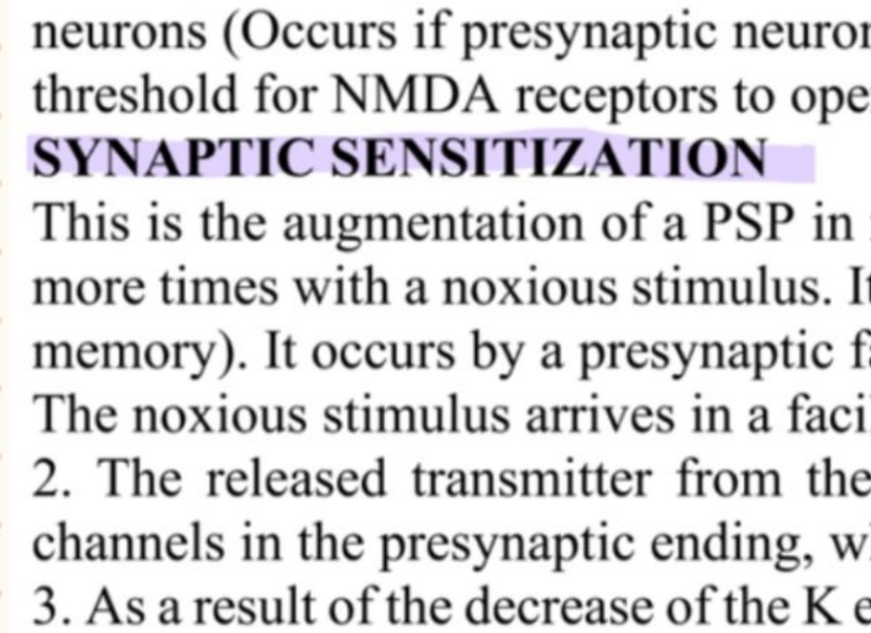
SYNAPTIC SENSITIZATION

This is the augmentation of a PSP in response to a habituated presynaptic stimulus if the latter is paired one or more times with a noxious stimulus. It may be transient or prolonged (becoming in the latter condition a form of memory). It occurs by a presynaptic facilitation mechanism as follows:

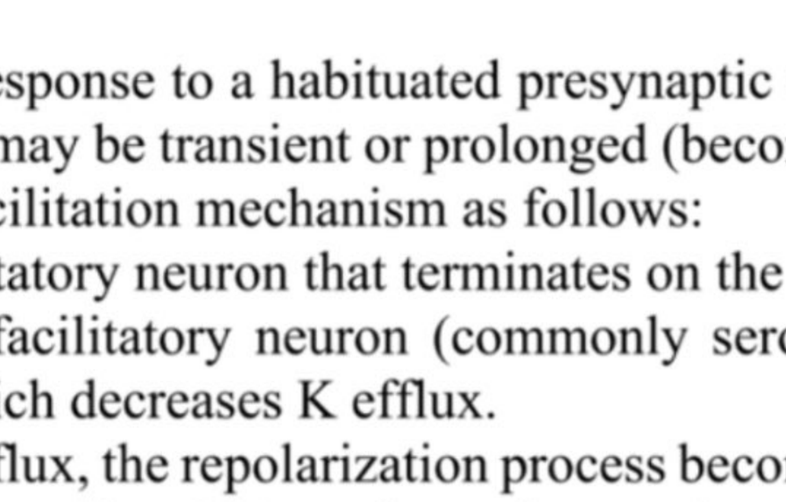
The noxious stimulus arrives in a facilitatory neuron that terminates on the presynaptic ending.

2. The released transmitter from the facilitatory neuron (commonly serotonin) causes the closure of the K channels in the presynaptic ending, which decreases K efflux.

3. As a result of the decrease of the K efflux, the repolarization process becomes slow, leading to the prolongation of the action potential in the presynaptic ending. This prolongs the opening of the Ca- channels in the presynaptic ending, which leads to more Ca influx and, consequently, more release of the neurotransmitter (resulting in an augmented PSP).



repeated exposure to benign stimulus = inactivates Ca^{+2} voltage on presynaptic = ↓ NT release



Type of S. plasticity	Stimuli	Ionic basis
Habituation	▪ Repeated ▪ Benign	**Inactivation of presy. Ca^{++} ch.**
PTP (immediate m.)	▪ Brief ▪ tetanizing	**Presy. Ca^{++} accumulation**
Sensitization (STM)	▪ Noxious + benign	**Presynaptic facilitation**
LTP	▪ as PTP (brief & repeated)	**Activation of NMDA**
LTD	Slower st. of presyn. n.	**Closure of NMDA**

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1) Short term inhibition
Habituation

- Repeated
- Benign st.

→ habituation

2) Short term Facilitation

1. Post tetanic potentiation
(basis of immediate memory)

- brief
- tetanizing

→ PTP

2. Sensitization (basis of short term memory)

- noxious st. + benign st.

→ Sensitization

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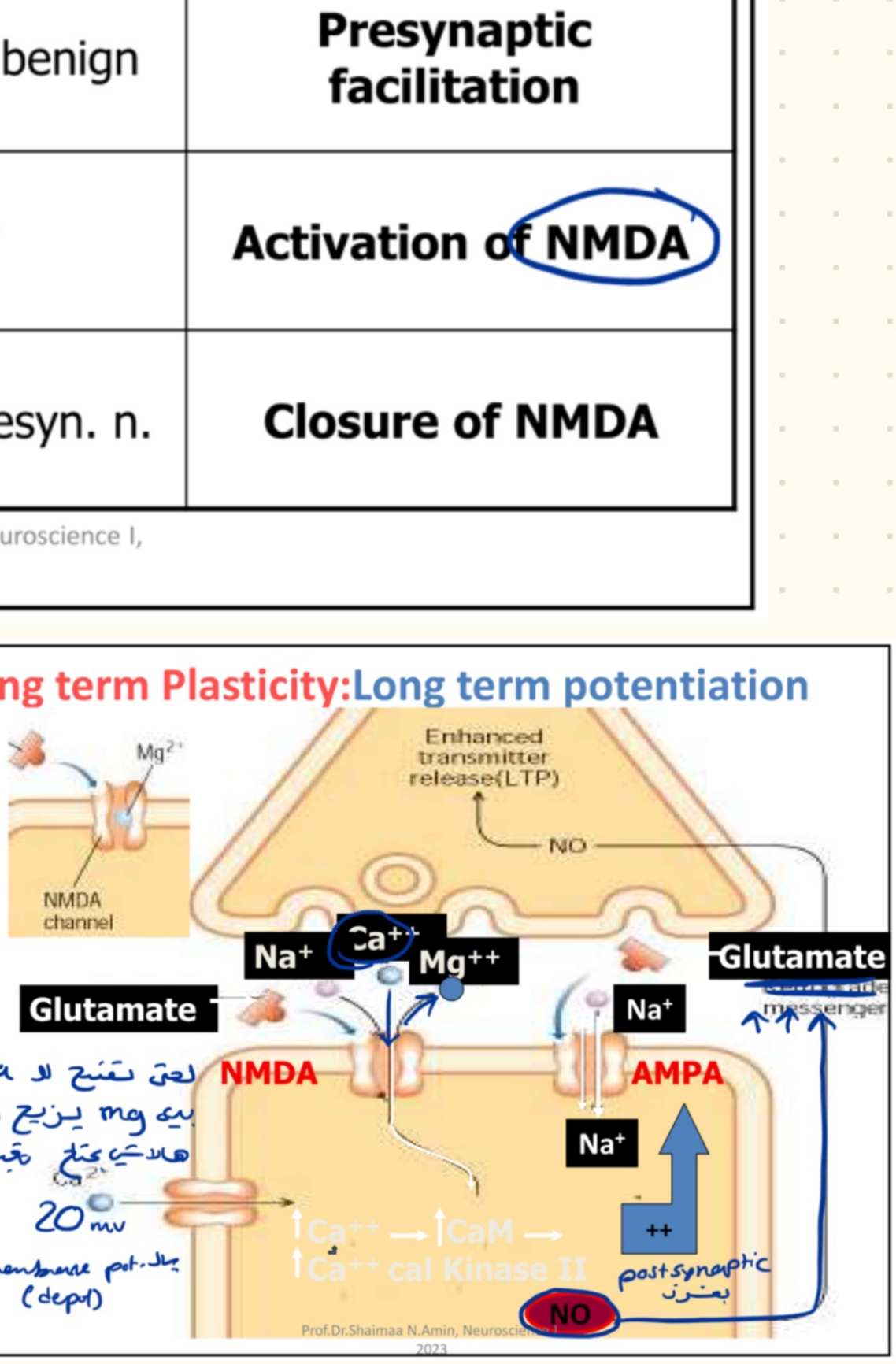
Long term Plasticity: Long term potentiation



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2. Long term Depression (LTD):

Presynaptic neuron stimulation ⟶ prolonged depression of postsynaptic neuron.

Ionic basis:

negative memory

Occurs if presynaptic neuron stimulation ⟶ depolarization of postsynaptic neuron less than 20mv (threshold for NMDA receptors to open).

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اللهم صل على سيدنا محمد