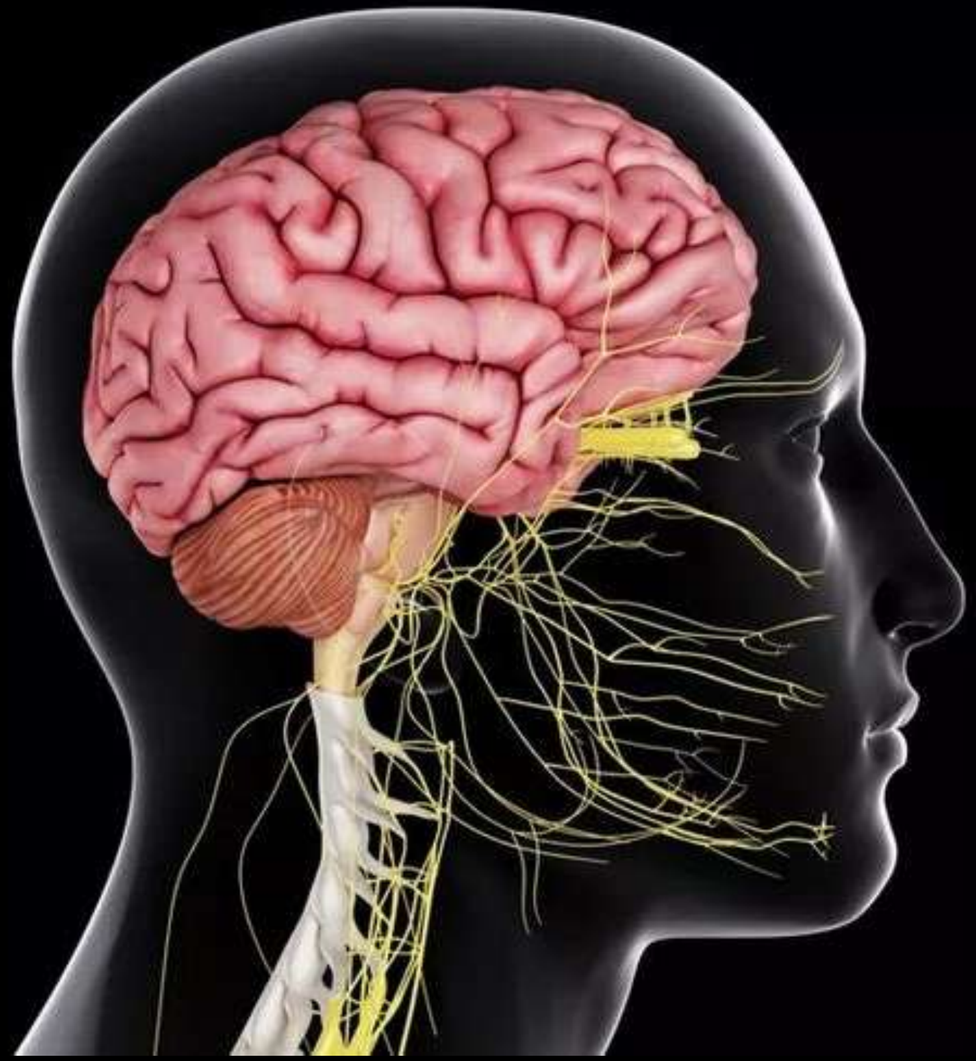
وَقُل رَّبِّ زِدْنِي عِلْمًا



CENTRAL NERVOUS SYSTEM

SUBJECT :PHYSIOLOGY

LEC NO. : TWO

DONE BY : JOHAINAH TAHA

بسم الله الرحمن الرحيم

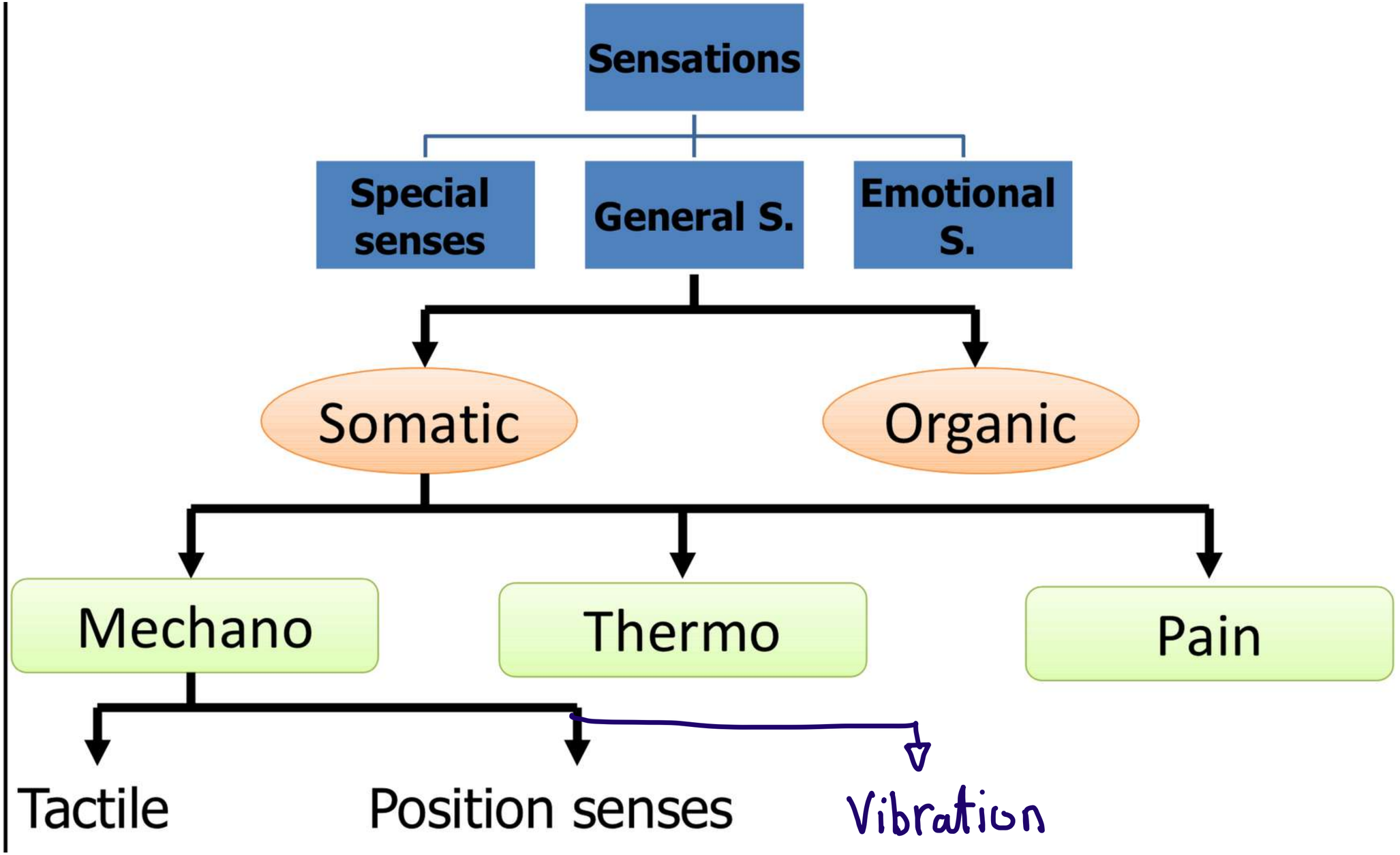
Spinal Cord & Somatic Sensations

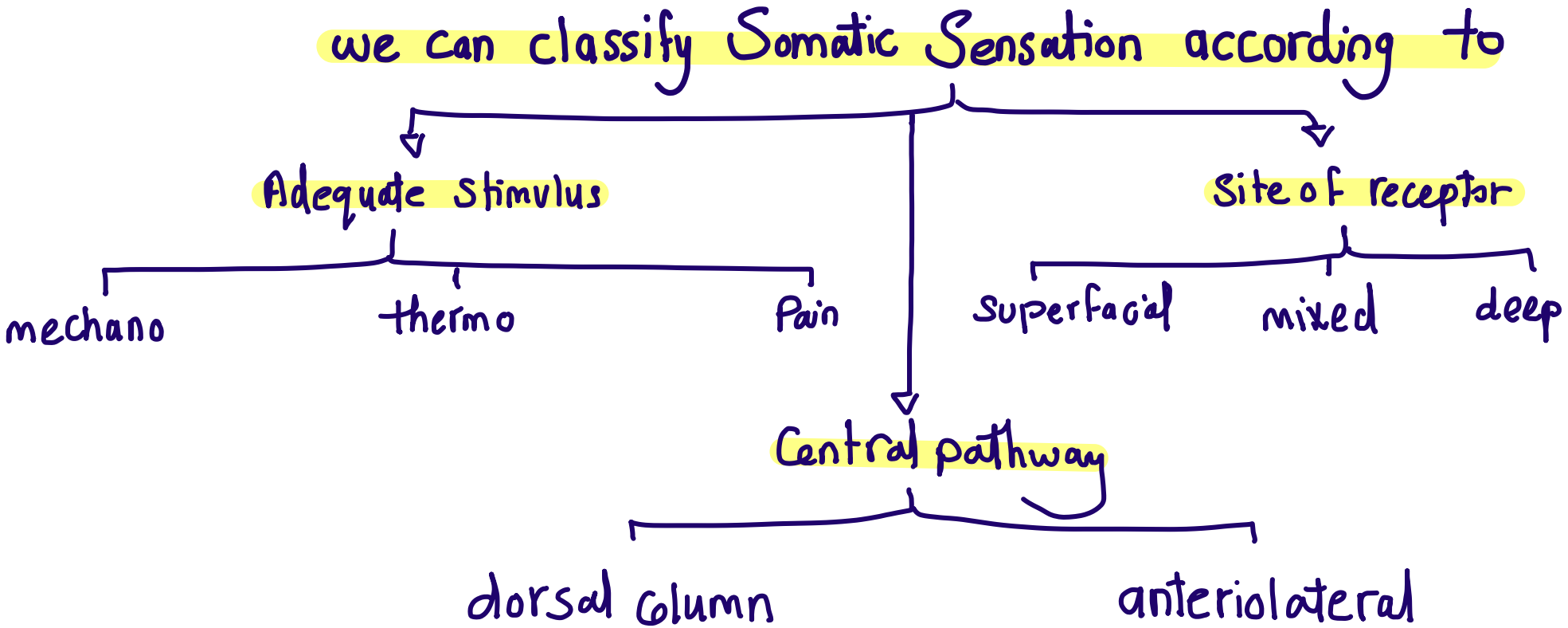
Lecture 2

* قبل مانبدأ المحاضرة ، نصيحة كونوا دارسين أناتومي 2 على الأقل

* عملت إعادة ترتيب للصور و المواضيع حسب شرح الدكتورة ، وضفت انتم ملاحظات خارجية لتغرهوا المحاضرة كويس.

لا تخافوا من عدد السلايدات وبسم الله نبدأ...


Sensations
Special senses
General S.
Emotional S.
Somatic
Organic
Mechano
Thermo
Pain
Tactile
Position senses
Vibration


we can classify Somatic Sensation according to
Adequate Stimulus
mechano
thermo
Pain
Site of receptor
superfacial
mixed
deep
Central pathway
dorsal column
anteriolateral

THE SOMATIC SENSATIONS

The various sensations in the body include :

(1) Somatic sensations (from the skin and deep tissues, e.g., muscles,joints, and bones)

(2) Visceral sensations

(3) Special sensations (vision. hearing, smell, taste and equilibrium)

(4) Organic sensations (e.g., hunger, thirst, and sexual sensations).

The sensory pathway or axis

—The perception of a certain sensation requires that its pathway (or axis) should be intact.

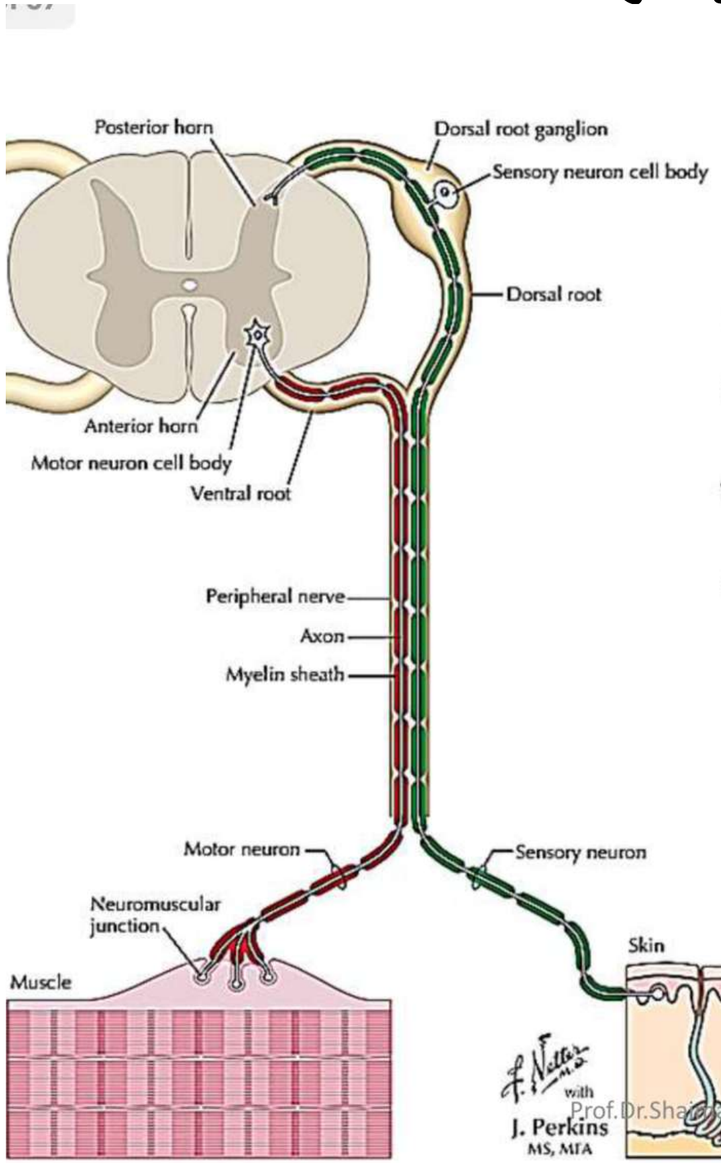
—A sensory axis includes:

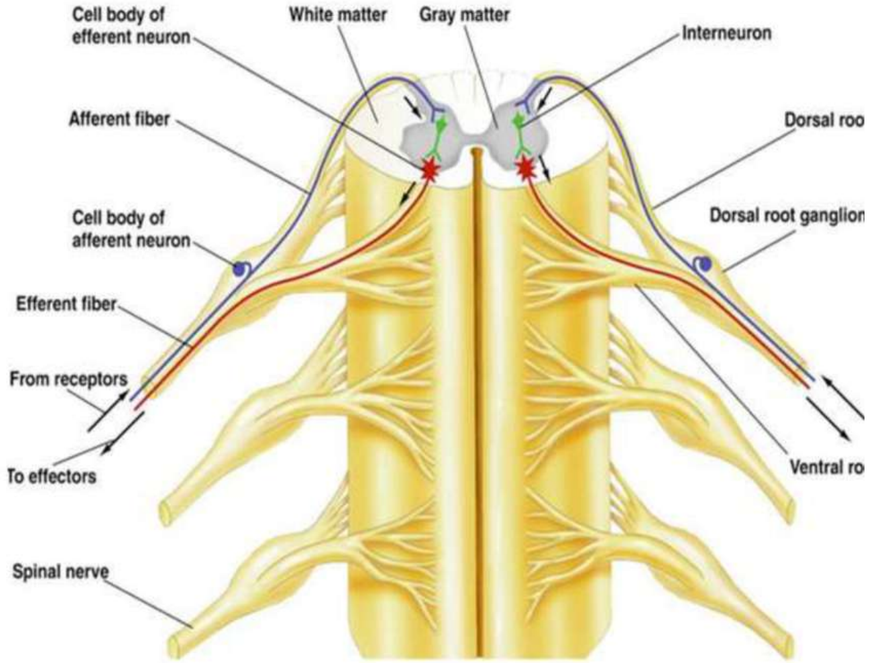
(I) A receptor

(2) An afferent (or sensory) nerve that transmits the signals to the nervous system

(3) A transmitting tract to the higher centres and cortical sensory areas.

The sensory pathway or axis

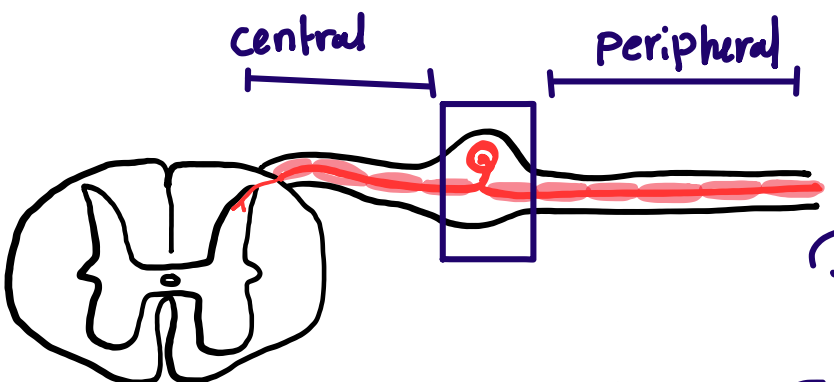




* الطريق من البداية وحتى النهاية بنوصفه بشي اسمه order neurons .

وبراد الطريق عنا Stations كالتالي ← first order neurons
2nd order neurons
3rd order neurons

* الـ first-order-neuron الـ cell body بتجرا موجود في dorsal route ganglion و نوع الخلية هو pseudounipolar



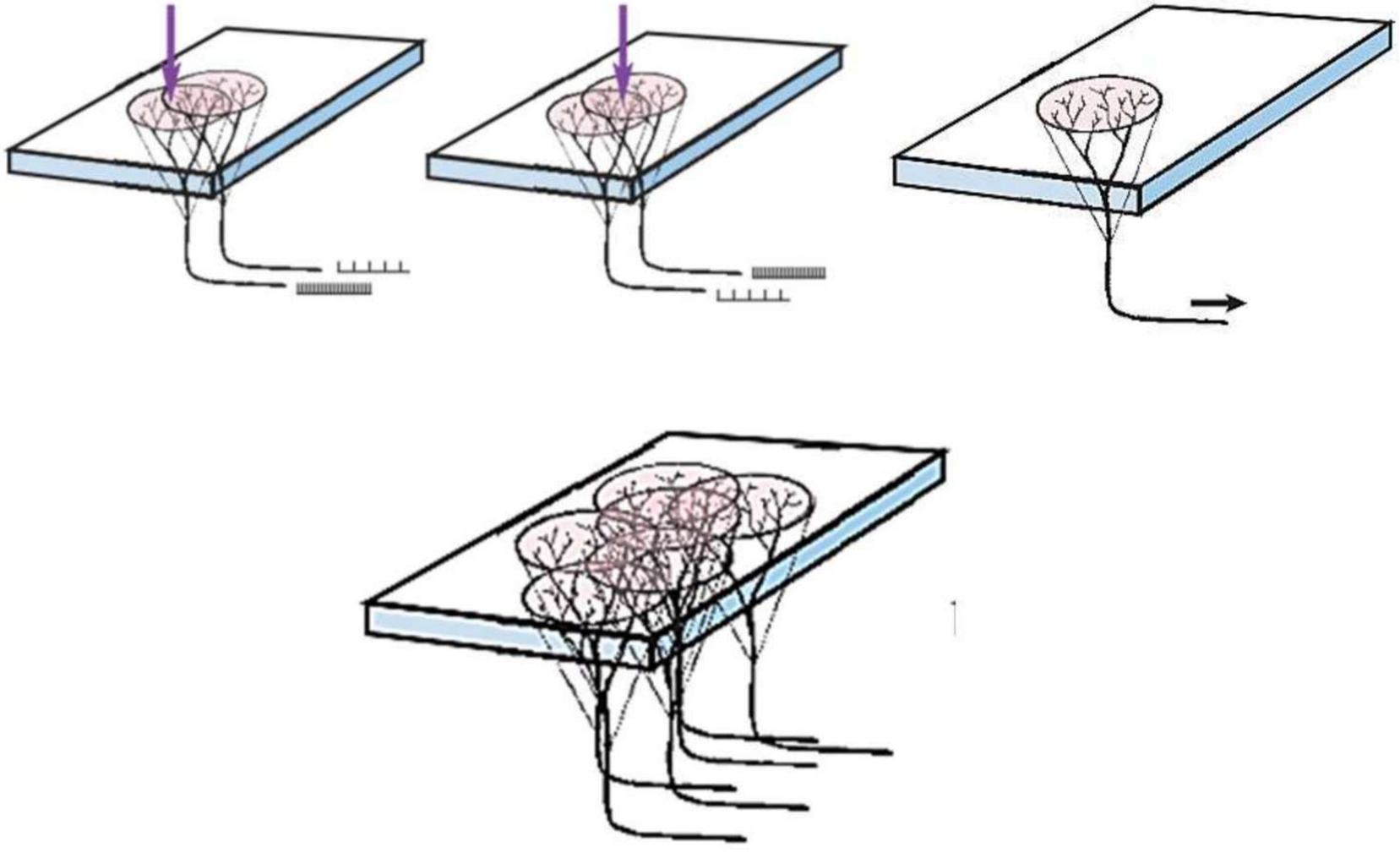
* في عنا 2 processes براد الـ neuron ← Central
Peripheral ← حيكمل ليوصل الـ receptor

The sensory unit and the receptive field

-The sensory unit consists of a single afferent nerve and all its peripheral branches, while the receptive field is the area supplied by a certain unit.

-There is a considerable overlap of the receptive fields of neighbouring sensory units.

-This is evident in the skin in which each spinal nerve innervates a definite area called a dermatome, and that shows marked overlapping.



The sensory unit and the receptive field

Recruitment of receptors and sensory units

-Threshold (or minimal) stimuli activate only the highly sensitive receptors, leading to a little discharge of impulses.

-However, as the intensity of stimulation increases, more receptors become activated (= recruitment of receptors), and the higher centers interpret more sensory unit discharge (recruitment of sensory units), which increases the intensity of the sensation.

CLASSIFICATION OF THE SOMATIC SENSATIONS

The somatic sensations can be classified in 2 ways:

** الدكتورة مرت على هاد الموضوع سريعًا

(A) ACCORDING TO THE SITE OF THE SENSATION

(1) Superficial (or exteroceptive) sensations

(2) Deep sensations

(3) Combined or synthetic senses

(B) ACCORDING TO THE MODALITY OF THE SENSATION

(1) Mechanoreceptive sensations

(2) Thermoreceptive sensations (heat and cold sensations).

(3) Pain sensation.

CLASSIFICATION OF THE SOMATIC SENSATIONS

(A) ACCORDING TO THE SITE OF THE SENSATION

(1) Superficial (or exteroceptive) sensations

These are the skin sensations (pain, touch, and temperature).

(2) Deep sensations

These are the sensations from skeletal muscles, tendons, joints, bones, and ligaments, and they include the following types

(a) Proprioceptive sensations

These include the sense of position and the sense of the rate of movement kinaesthetic sensation

(B) Pressure sense

(c) Muscle tension sense

(d) Muscle sense

(= pain elicited by a firm squeeze of skeletal muscles). Sometimes the vibration sense is included in this group.

CLASSIFICATION OF THE SOMATIC SENSATIONS

(A) ACCORDING TO THE SITE OF THE SENSATION

(3) Combined or synthetic senses

These include stereognosis and the vibration sense (and sometimes tactile discrimination).

CLASSIFICATION OF THE SOMATIC SENSATIONS

(B) ACCORDING TO THE MODALITY OF THE SENSATION

(1) Mechanoreceptive sensations

These include the touch, pressure, vibration, itch, and tickle sensations, as well as muscle tension and proprioceptive sensations.

(2) Thermoreceptive sensations

heat and cold sensations

(3) Pain sensation

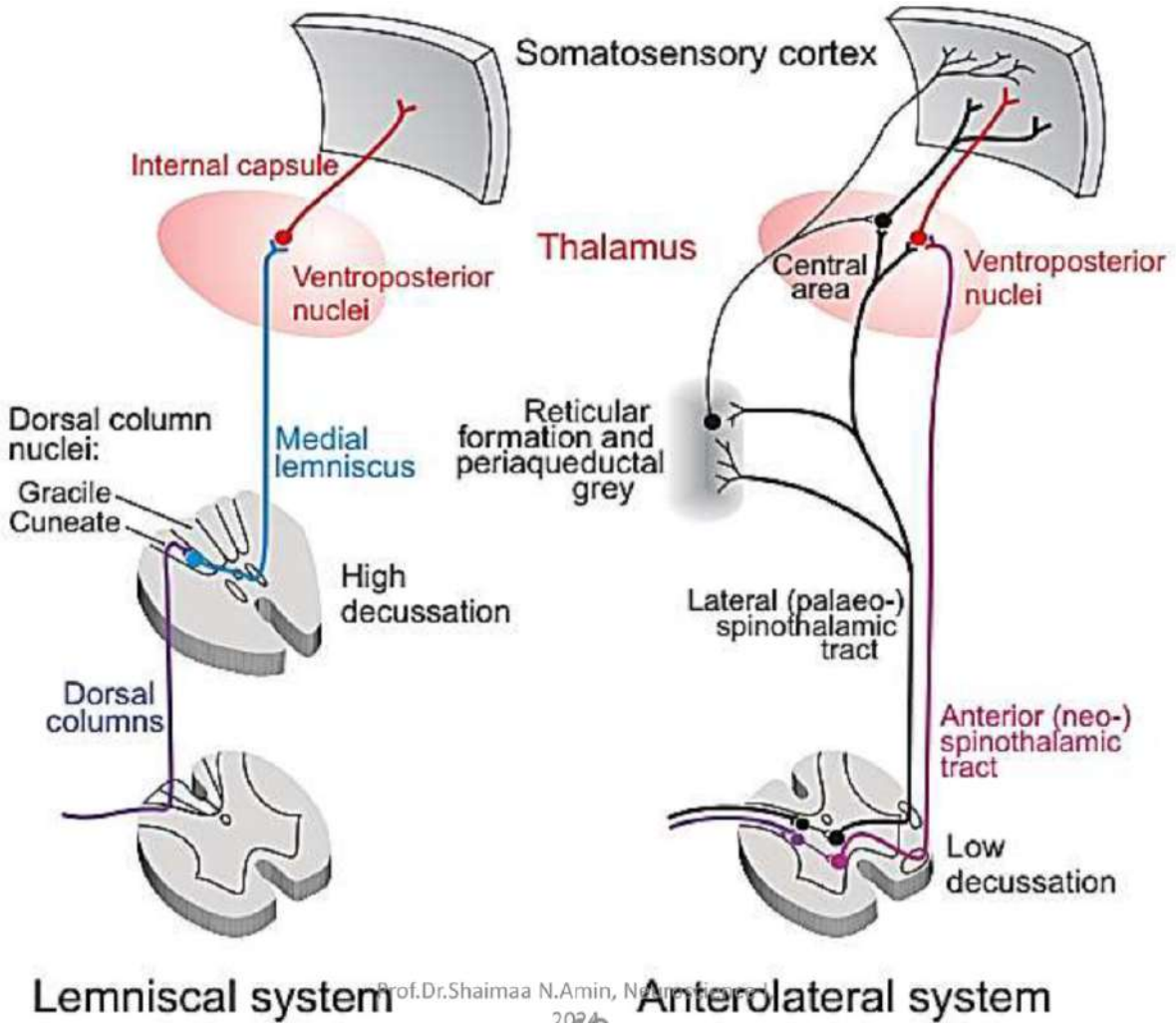
Dermatomes

* are specific areas of skin supplied by a single spinal nerve.
* There are 30 dermatomes in total
* each corresponding to a particular spinal nerve.
* They are important clinically for diagnosing conditions like nerve injuries.

THE SENSORY PATHWAYS (ASCENDING TRACTS)

Depending on the position in the spinal cord, there are 2 systems of the ascending tracts called :

1. **THE DORSAL COLUMN SYSTEM** ⇒lemniscal tract
2. **THE ANTEROLATERAL SYSTEM**


Somatosensory cortex
Internal capsule
Thalamus
Ventroposterior nuclei
Central area
Ventroposterior nuclei
Dorsal column nuclei:
Medial lemniscus
Reticular formation and periaqueductal grey
Gracile
Cuneate
High decussation
Lateral (palaeo-) spinothalamic tract
Dorsal columns
Anterior (neo-) spinothalamic tract
Low decussation
Lemniscal system
Anterolateral system

THE SENSORY PATHWAYS (ASCENDING TRACTS)

Each sensory pathway consists of

(1) The afferent nerves (first-order-neuron), which have their cell bodies in the dorsal root ganglia and terminate at the various laminae of the dorsal horn of the grey matter.

(2) Second-order neurons that start at the dorsal horns and form bundles called the ascending tracts which terminate at subcortical centers.

**Some sensations require third-order neurons that transmit signals to centers in the cerebral cortex.

Each pathway consists of three populations of neurons :–

First-order, Second-order and Third-order.

Unipolar, with its cell body in a sensory ganglion

Its axon
- decussates.
- ends in the thalamus.

Cell body in thalamus. Axon ends in cortex.

THE DORSAL COLUMN SYSTEM

The gracile and cuneate tracts

These tracts transport :

(1) **Fine tactile sensations** (tactile Localization and tactile discrimination)

↳ the ability to distinguish between dif. tactile stimuli based on their characteristic

↳ ability to identify the location or point of contact of a tactile stimulus applied on the skin.

(2) **Stereognosis** and texture of material sensation

↳ to identify the objects based on their size, shape*, texture.

(3) **Fine pressure** and muscle tension sensations

(4) **vibration sense**

(5) **proprioceptive and kinaesthetic sensations.**

السلايدات القادمة فيها تفصيل كل نقطة...

Sensations carried by dorsal column

Sensation	Receptor	Afferent fiber
Fine touch	M & M (meissner's corpuscle, markel's disk)	Aβ
Stereognosis	mixture	Aβ
Pressure	Pacinian & spray	Aβ
Vibration S.	Pacinian & Me.	Aβ
Position S.	Pacinian R & S (Ruffini)	Aα

THE MECHANORECEPTIVE SENSATIONS

(1) TOUCH (TACTILE) SENSATION

There are 2 types of touch (tactile) sensation:

1- Crude touch

-This is a poorly localized gross tactile sensation

-Receptors: Free nerve endings and hair end organs.

-Afferent nerves: A-delta nerve fibers

-Central pathway: Ventral spinothalamic tract.

-Testing: By stroking the skin lightly with a piece Of cotton..

THE MECHANORECEPTIVE SENSATIONS

(1) TOUCH (TACTILE) SENSATION

There are 2 types of touch (tactile) sensation:

2- Fine touch

-This includes tactile Localization and discrimination, stereognosis, and the sense of the texture of the material.

-Receptors: Meissner's corpuscles and Merkel's disks.

-Afferent nerves: A-beta nerve fibers.

-Central pathway: The gracile and cuneate tracts.

Tactile Localization (topognosis)

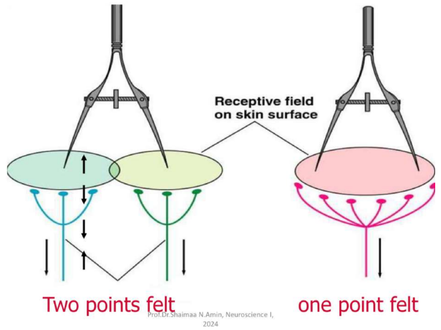
-The ability to localize a touched skin point while the eyes are closed.

-It is tested by touching the skin lightly with a marker pencil (e.g., a charcoal pencil), and the subject is asked to touch the stimulated point with another pencil.

-The closer the 2 touch points are to each other, the more accurate the localization is.

الدكتورة ركزت عليه

Tactile Discrimination (T.D. or 2-point discrimination)



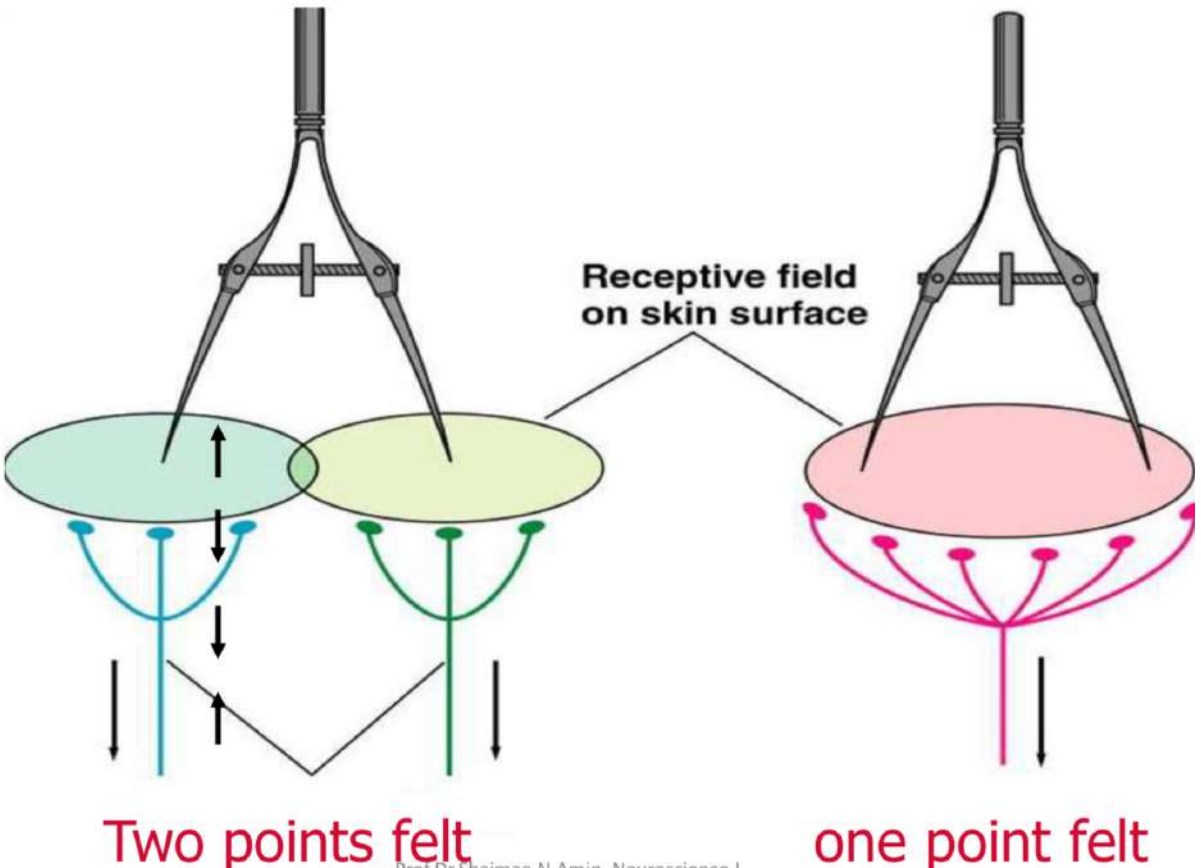
-T.D. is the ability to distinguish 2 touch stimuli applied simultaneously to the skin as 2 separate points of touch.

-It is tested by repeated touching the skin with the 2 blunt points of a Weber compass, starting with a closed compass, then increasing the distance between its limbs gradually till finding the 2-point threshold (i.e., the minimal distance at which the 2 points are separately perceived).

-It is a highly educated cortical sensation that requires the excitation of 2 separate receptors and 2 separate areas in the sensory cortex.

Tactile Discrimination
(T.D. or 2-point discrimination)

-Accordingly, it is more accurate (i.e., the 2-point threshold is small) in areas that are rich in receptors and their representation in the sensory cortex is wide such as the lips and fingers (e.g., it is only about 2 mm in the fingers) while it is less acute (i.e., the 2-point threshold is large) in areas lacking these characteristics such as the shoulders, thighs, and back (e.g., it is 65 mm or more in the back).



- باختصار هاي الـ test مثل الفرجار بضل أكبر فيه لغاية ما اعريف بخبرني انه حاسس بنقطتين طبعاً هاد الاحساس دليل انه عقلنا stimulation لـ 2 cortical areas.

- طبعاً في عنا أكثر من عامل بأثر على مقدار الـ distance منهم عدد الـ receptors.

* مهم نعرف انه من آهم التطبيقات على الـ discrimination هو برايل (طريقة القراءة عند المكفوفين)

لها بحيث بتكون المسافة بين كل dot والثانية هي 3mm.

Threshold distance for tactile discrimination

Important

Two-point Discrimination:

- 1 mm on the fingertips of young adults; by the sixth or seventh decade of life it declines on average to ~ 2 mm.
  - **Receptor: *Merkel cell*>>*Meissner's* corpuscle** (as Merkel cell has the smallest receptive field).
- Braille Reading: For blind person, **Braille** dots (spaced ~ 3 mm apart) are perceived as separate dot because of **Merkel cell**. Meissner's corpuscle also contributes to detection of Braille patterns because they sense motion.

Stereognosis

-This is the ability to recognize the nature of objects by handling them without using vision (from their shapes, sizes, weights, etc.).

-It is tested by giving the subject a familiar object (e.g., a key, pen, or coin), and with closed eyes, he is asked to recognize its nature.

-It is a highly educated cortical sensation that depends mainly on the tactile and pressure sensations and the integrity of the high cortical sensory centers.

-The sense of the texture of the material is a type of stereognosis.

Stereognosis

-It is the sensation evoked by touching materials and is concerned with identifying their natures.

-It is tested by asking the subject to differentiate between various materials, e.g., pieces made of silk, wool, or cotton.

THE MECHANORECEPTIVE SENSATIONS

(2) THE PRESSURE SENSATION

-This sensation is perceived mainly by the Pacinian corpuscles and Ruffini's endings in the skin (for light pressure) and subcutaneous tissues.

-It is tested by asking the subject to differentiate between various weights without lifting them (by placing them in his hand while it is supported on a table).

-There are 2 types of pressure sensation like touch: fine (which is transmitted by the gracile and cuneate tracts) and crude (which is also transmitted by the ventral spinothalamic tract).

THE MECHANORECEPTIVE SENSATIONS

(2) THE PRESSURE SENSATION

-The muscle tension sensation is evoked by traction on the tendons and is concerned with discrimination or weights while lifting them.

-Its receptors are the Golgi tendon organs transmitted by the gracile and cuneate tracts.

-It is tested by asking the subject to differentiate between various weights placed in his unsupported hand.

THE MECHANORECEPTIVE SENSATIONS

(3) THE VIBRATION SENSE

-This is the sense of buzzing (or thrill) felt when the base of a vibrating tuning fork is placed on the skin.

-During testing, it is better to place the tuning fork on a bony prominence, e.g., the lower end of the radius bone or one of the malleoli, because bone magnifies the sense of vibration.

- this bony prominence is going to amplify the signals.
  So the receptor can detect it easily.

THE MECHANORECEPTIVE SENSATIONS

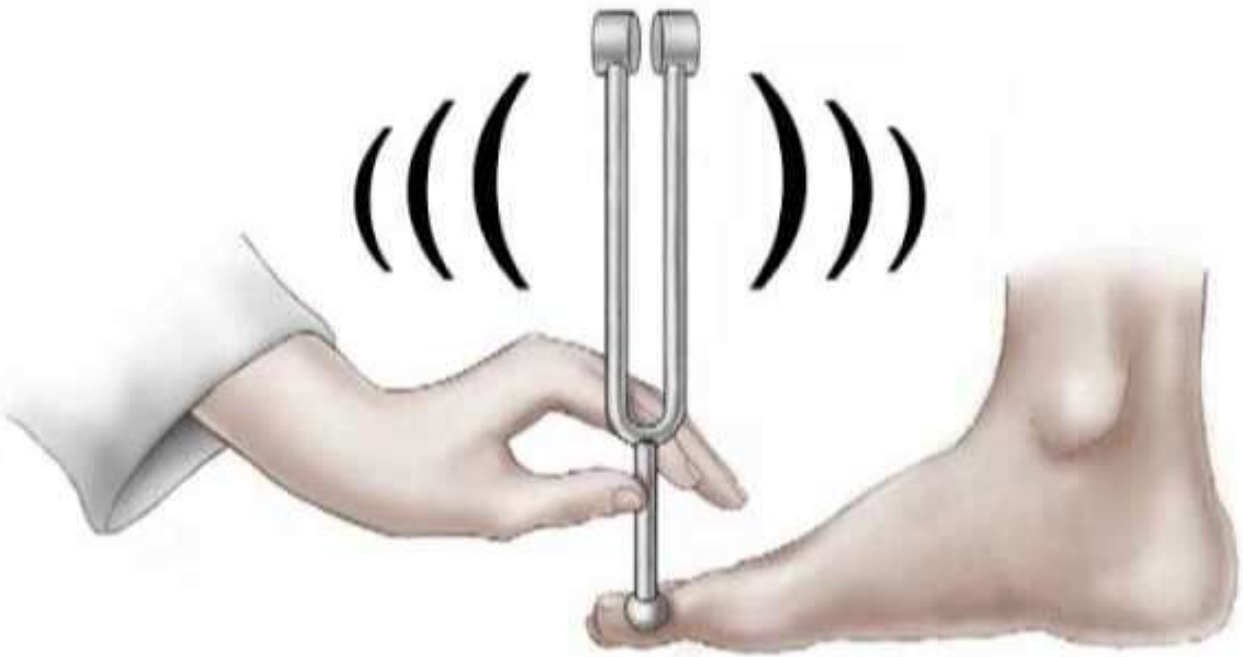
(3) THE VIBRATION SENSE

-It is produced as a result of rhythmic pressure stimuli (which is interpreted as vibration) that stimulate 2 types of rapidly adapting mechanoreceptors

(a) Meissner's corpuscles, which respond to vibrations up to 80 Hertz
(b) Pacinian corpuscles, which respond to vibrations up to 800 Hertz

-Vibration is closely related to proprioception. The gracile and cuneate tracts transmit both, and both are impaired if these tracts degenerate.

Physical Exam:Vibration



- Keep in mind that vibration sense can be diminished even in healthy older patients, but they still should be able to detect the vibration for at least 8 seconds
- If patient cannot detect vibration for ≥ 8 seconds at the toe, that may be the earliest sign of peripheral neuropathy

صورة خارجية ، توضح
vibration test
بلعي ماحضن لاب
Clinical Skills

THE MECHANORECEPTIVE SENSATIONS

ماجبناسيرتك بالمحاضرة ت

(4) THE TICKLE AND ITCH SENSATIONS

-A tickle is a pleasurable sensation (often causing laughing) that results from mild tactile stimulation of the skin, while an itch is an annoying sensation that results from skin irritation by moving tactile stimuli (e.g., a crawling flea).

-Receptors: Rapidly adapting free nerve endings. Afferent nerves: Unmyelinated type C nerve fibers.
-Central pathway: Ventral spinothalamic tract.
-Itch often initiates the scratch reflex, which helps remove the stimulus and initiates pain signals that help suppress this sensation.

THE MECHANORECEPTIVE SENSATIONS

(5) THE PROPRIOCEPTIVE SENSATIONS

-These sensations arise mainly from receptors in the deep structures, especially the muscles & joints) including the muscle spindles and Golgi tendon organ-like receptors.

-They are transmitted to the high centers by the gracile and cuneate tracts and include 2 types:

(a) Sense of position (static proprioception)

* في اله نوعين ومرام نقارن بينهم

(b) Sense of movement (dynamic proprioception):

THE MECHANORECEPTIVE SENSATIONS

(5) THE PROPRIOCEPTIVE SENSATIONS

(a) Sense of position (static proprioception):

-This is the conscious perception of the position of different body parts with respect to each other.

-It is tested by placing one of the patient's limbs, toes, or fingers in an unusual position (with his eyes closed) and asking him to place the corresponding part on the other side in a similar position.

مثال: غمض عينك ، واعمل اي مثل ما بعمل الك بإيدك اليسار ، لو ثنيت الكوع لازم مخه يفهم شو صار بإيده حتى لو موشايفها

THE MECHANORECEPTIVE SENSATIONS

(5) THE PROPRIOCEPTIVE SENSATIONS

(b) Sense of movement (dynamic proprioception):

-This is the sensation of movement of joints.

-It is tested by moving one of the patient's fingers or toes passively (i.e., by the examiner) while his eyes are closed and asking him to determine the start and end of the movement and its rate and direction.

مثال: غمض عينك وأوصف الحركة اللي عم أعملها بأصبعك.

THE MECHANORECEPTIVE SENSATIONS

(5) THE PROPRIOCEPTIVE SENSATIONS

** Both types of proprioception are frequently called kinaesthetic sensations (although only the dynamic type is kinetic).

- الآن حنبدأ نحكي عن الـ Roots والـ Systems ، ونصيحة اقرأوا نوتات نينجا يزد الي حطتها المعلم قبل كل موضوع ♡

- الي عليه هايلايت بنوتات نينجا يزد فهو معنا ، الباقي شرح اضافي.

- بعد شرح نينجا يزد حننتقل حالسلايدات وصور الدكتورة لـ ضروري نركز حالامور الي حايط هايلايت.

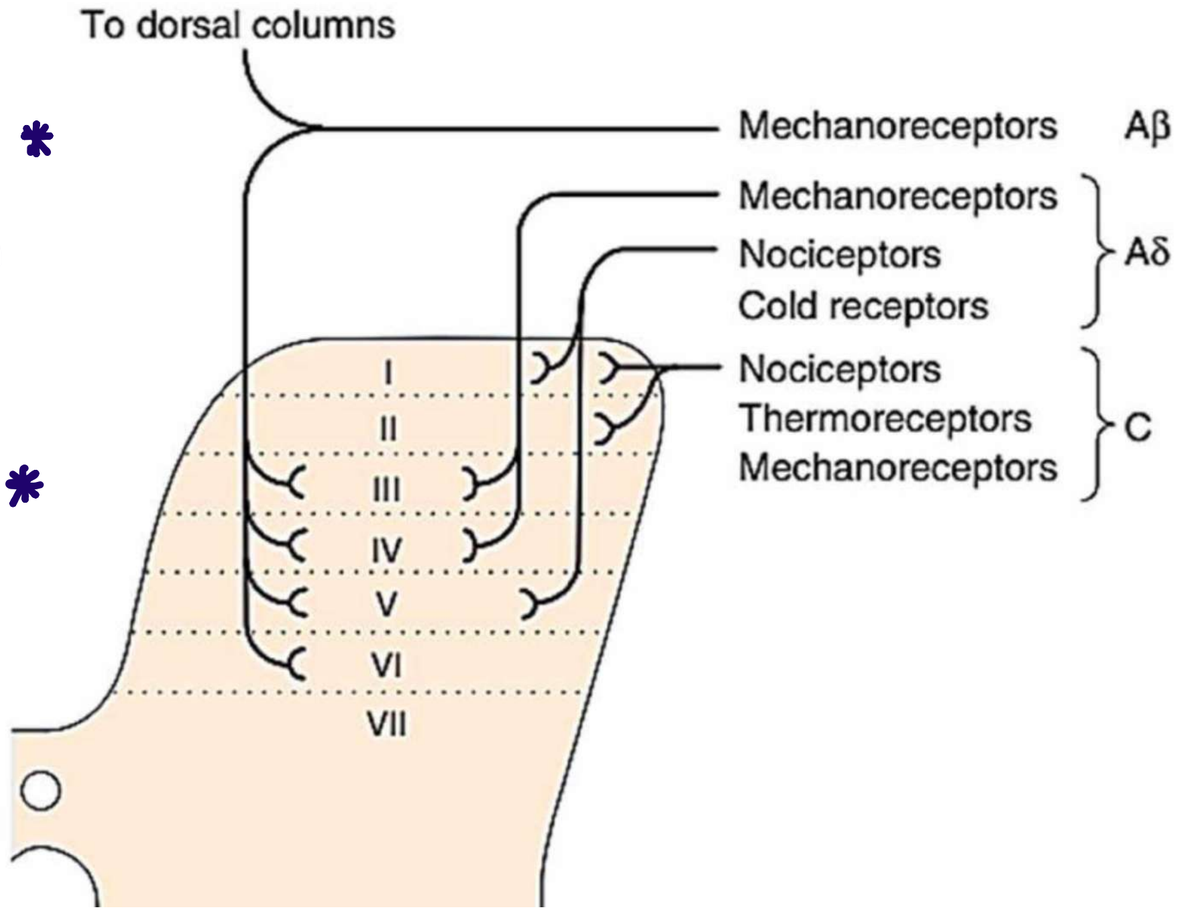
* بدأنا مع هاي الصورة ؛ الـ dorsal column system

مسؤول عن استقبال ونقل Sensation .

وهو مقسم الى 7 طبقات .

* الاختلاف بين الـ dorsal والـ anteriolateral

بكون عبر من اي طبقة حتستقبل الـ 1st neuron



ASCENDING TRACTS | DORSAL COLUMN: MEDIAL LEMNISCUS PATHWAY

OUTLINE

I) FUNCTION OF THE DCML PATHWAY

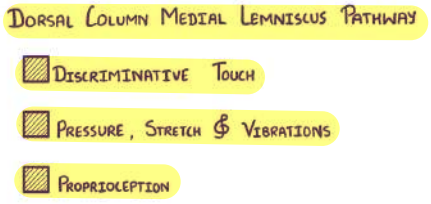


Figure 1: Function of DCML pathway

- **Discriminative touch** = two-point touch
  - Performed by touching surface of the skin at two different points of contact
- **Proprioception** = knowing position of body in space

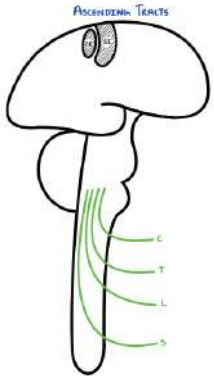


Figure 2: Ascending tract in the CNS

- DCML = an *ascending tract*
  - Tract – bundle of axons in the CNS
- Peripheral process receives stimulus and projects it into the spinal cord → stimulus ascends the spinal cord
- Stimuli can be received at any level of the spinal cord including cervical, thoracic, lumbar, and sacral regions
- The axons send the stimulus up the tract to the cerebral cortex

II) SKIN & MUSCLE RECEPTORS

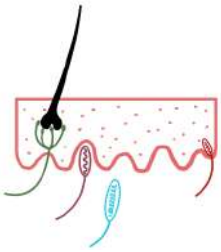


Figure 3: Receptors in the skin

- Several receptors within the skin and muscles help to transmit signals that are relayed through the DCML

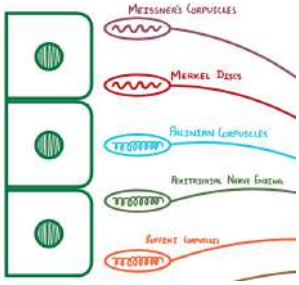


Figure 4: Receptors in the skin cont.

Table 1: Skin receptors and their functions

RECEPTOR	FUNCTION
Meissner's Corpuscles	Fine & discriminative touch
Merkel Discs	Fine touch, superficial pressure
Pacinian Corpuscles	Pressure change & vibrations
Peritrichial Nerve Endings	Hair bending & touch
Ruffini Corpuscles	Skin stretch & vibrations

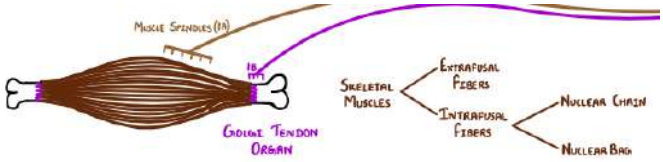


Figure 5: Receptors in the muscles

- Skeletal muscles are made up of:
  - **Extrafusal fibers** – these are the ones that are contracting
  - **Intrafusal fibers** – 2 types that respond to stretch in the muscle
    - Nuclear chain – stretch onset
    - Nuclear bag – progressive stretch of muscle
- Muscle spindles (Type 1A fibers) come from the nuclear chain and bag fibers (respond to muscle stretch)
- Golgi tendon organs (GTO) (Type 1B fibers) respond to tendon

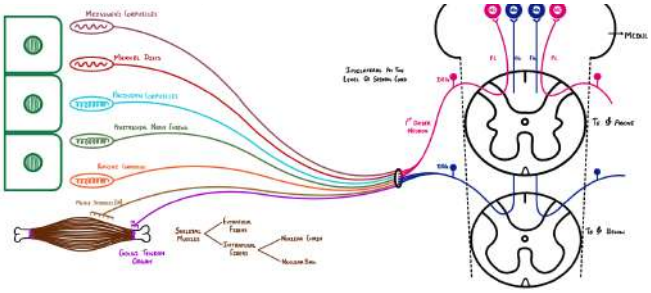


Figure 6: Overview of fibers entering the CNS

III) TYPES OF NERVE FIBERS

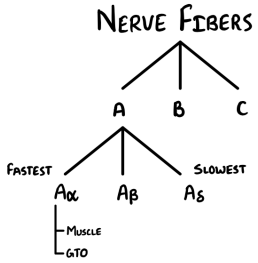


Figure 7: Types of nerve fibers

Table 2: Types of nerve fibers

NERVE FIBER	DESCRIPTION
TYPE A	• **Aα** - (fastest; 120m/s) muscle spindles/GTOs • **Aβ** - (all skin receptors • **Aδ** - (slowest; 30 m/s) fast, prick pain, crude touch/pressure • Most myelinated • Very fast
TYPE B	• Moderately myelinated • Medium speed
TYPE C	• Least/unmyelinated • Pain, temperature, itch • Slow

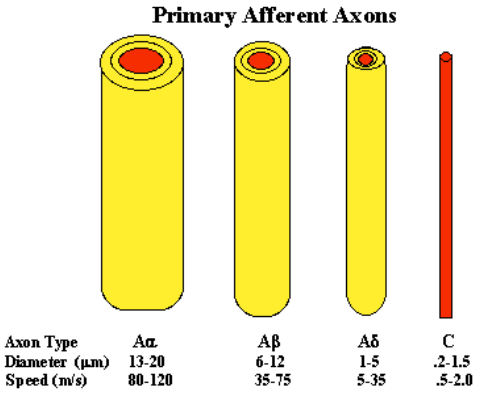


Figure 8: Types of nerve fibers cont.[1]

IV) INSIDE THE CNS

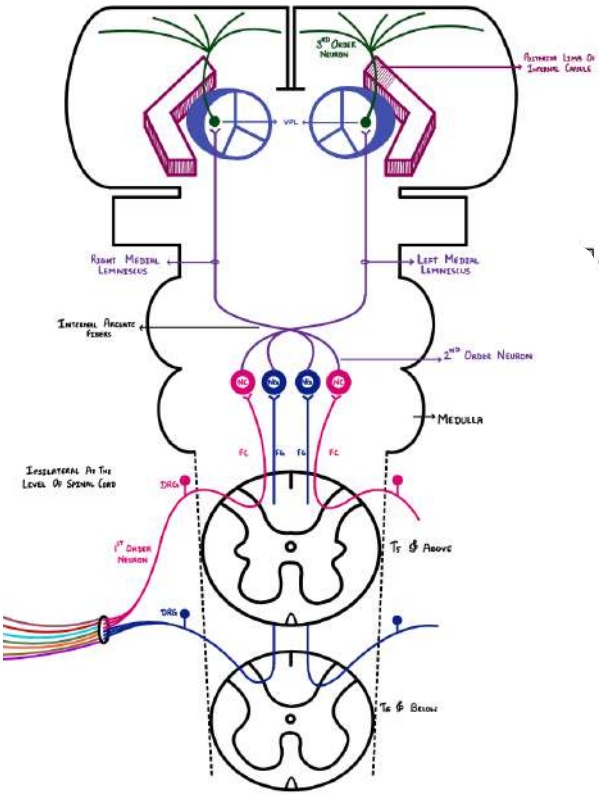


Figure 9: Overview of DCML pathway in the CNS

- Fibers from the skin and muscle receptors enter the spinal column below T6 via the 1st order neuron – dorsal root ganglion (DRG)
  - Central processes projecting into the posterior/dorsal gray horn
  - The fibers will then funnel into the *fasciculus gracilis* (below T6) without synapsing
  - **Fasciculus Gracilis** picks up information from below T6 form the legs and lower body trunk
- Fibers from the skin and muscle receptors also enter the CNS above T6 via the dorsal root ganglion
  - Central processes project into the dorsal white column (lateral to fasciculus gracilis)
  - The fibers will funnel into the *fasciculus cuneatus* (above T6) without synapsing
    - **Fasciculus cuneatus** picks up information from above T6 the upper limbs and upper body trunk

TIP: To remember that the fasciculus Gracilis carries fibers from the lower extremity/trunk, think that the Gracilis muscle is found in the leg

- Both the fasciculus grascilis and fasciculus cuneatus travel up the spinal cord within the dorsal column

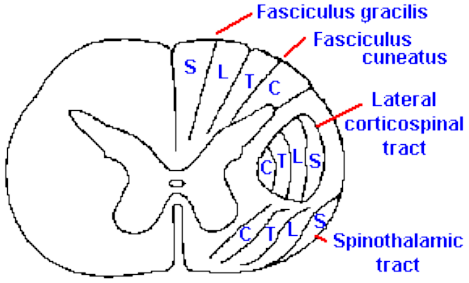


Figure 10: Somatotopic arrangement of spinal cord[2]

The DCML pathway is ipsilateral at level of spinal cord

- The fibers from both fasciculi ascend into the medulla to the 2nd order neurons

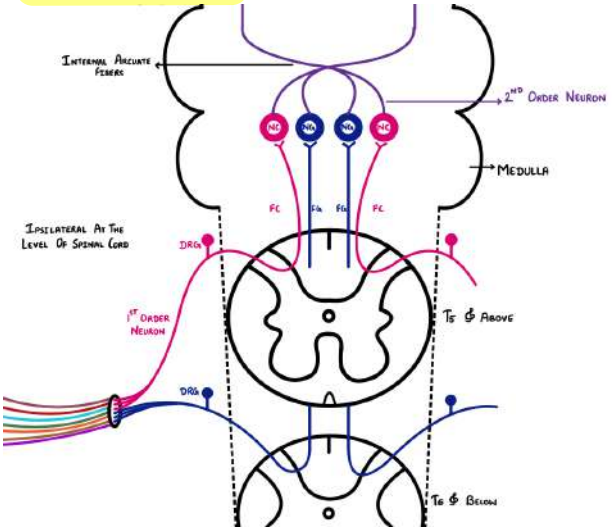


Figure 11: Pathway to the 2nd order neurons

- There are 4 nuclei in the medulla that receive fibers from the ascending fasciculi
  - Two lateral nuclei: **Nucleus cuneatus**
    - Receive fibers from the *fasciculus cuneatus* on their respective ipsilateral side from above T6
      - Ex) R fasciculus cuneatus fibers will ascend and synapse on the R nucleus cuneatus
  - Two medial nuclei: **Nucleus gracilis**
    - Receive fibers from the *fasciculus gracilis* on their respective ipsilateral side from below T6
      - Ex) R fasciculus gracilis fibers will ascend and synapse on the R nucleus gracilis

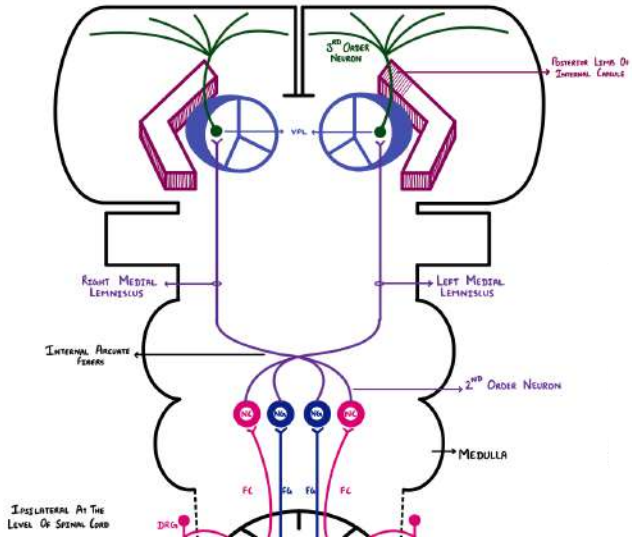


Figure 12: Pathway to the 3rd order neurons

- The R nucleus cuneatus and R nucleus gracilis fibers come together and cross over to the L side of the medulla and form the *left medial lemniscus*
- The L nucleus cuneatus and L nucleus gracilis fibers come together and cross over to the R side of the medulla and form the *right medial lemniscus*
- The center where both fibers cross in the posterior aspect of the medulla behind the pyramids is called the *internal arcuate fibers*
- The right and left medial lemnisci fibers ascend ipsilaterally into the brainstem and synapse on a special nucleus in the thalamus
  - The nucleus is called the *ventroposterior lateral (VPL) nucleus*
  - This is the 3rd order neuron
- The posterior 1/3 limb of the internal capsule receives axons from the VPL
  - The posterior 1/3 limb of the internal capsule are supplied by the lenticulostriate arteries (branches from the middle cerebral artery)
  - An infarct here will affect the sensory fibers ascending from the internal capsule
- Fibers extend out into the cortex and form the *corona radiata*

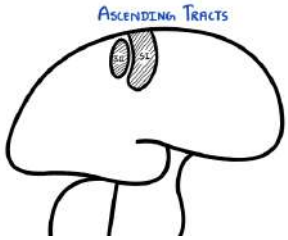


Figure 13: Inside the cerebral cortex

- The postcentral gyrus, AKA the *primary somatosensory cortex – S1*, is located just posterior to the central sulcus
  - There is another gyrus just posterior to that called the *secondary somatosensory cortex – S2*

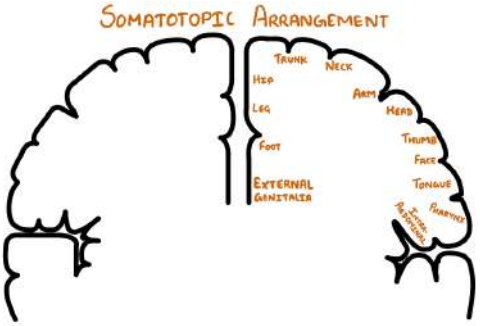


Figure 14: Somatotopic arrangement in the cerebral cortex

- Any fibers that come from the thalamus and extend to certain parts of the cerebral cortex will be associated with different parts of the body
  - External genitalia and the lower extremity can be found at the medial section of the cortex
  - The trunk and neck can be found superiorly
  - The arm, head, thumb, face, tongue, pharynx, and intraabdominal sections can be found laterally and inferiorly extending respectively

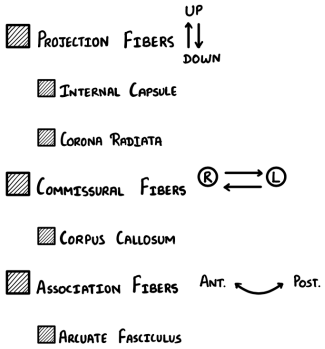


Figure 15: Fiber pathways in the CNS

- **Projection fibers** allow information to travel up and down
- **Commissural fibers** allow information to travel from left ↔ right cerebral hemispheres
- **Association fibers** allow information to travel from anterior ↔ posterior

QUESTIONS	ANSWERS
1) **Which of the follow is not a function of the DCML pathway?** a. Proprioception b. Discriminative touch c. Vibrations, pressure, stretch d. Temperature	D – Temperature (temperature is a function of the anterolateral spinothalamic (ALS) tract
2) **T/F 2nd order neuron fibers cross in the spinal cord and ascend to the 3rd order neurons in the thalamus** a. True b. False	B – False – The 2nd order neuron fibers won't cross midline until in the medulla
3) **T/F There are 4 nuclei located in the medulla that receive fibers from the ipsilateral and corresponding fasciculi: gracilis and cuneatus** a. True b. False	A – True
4) **Which of the following is not true regarding Type A nerve fibers** a. Made up of 3 types b. Unmyelinated c. Fast d. Most myelinated	B – Unmyelinated (Type C nerve fibers are unmyelinated)
5) **The fasciculus cuneatus receives information from above T6 and this area of the body** a. Lower trunk and extremity b. Only the head c. Upper extremity and upper trunk d. All of the skin	C – Upper extremity and upper trunk

THE DORSAL COLUMN SYSTEM

-This system includes the gracile and cuneate tracts and the spinocervical tract, consisting mainly of types A-alpha and A-beta nerve fibers. → شفناهم بالجدول

-It transmits mainly fine sensations from the same side.

THE DORSAL COLUMN SYSTEM

The gracile and cuneate tracts

قاعدة لما احكي كلمة Crossing يليط synapse

The pathways of these tracts consist of 3 neurons:

-First-order neurons:

-These are mostly type A-beta afferent nerve fibers.

dividing يعني بين synapse ياخد عندي

-They enter the spinal cord and divide into ① medial and ② lateral branches.

-The medial branch turns upwards in the ipsilateral dorsal column and ascends without relay as the gracile and cuneate tracts till relaying at the gracile and cuneate nuclei medulla oblongata.

THE DORSAL COLUMN SYSTEM

The gracile and cuneate tracts

** The gracile tract carries sensations from the lower part of the body and lies medially in the dorsal column. In contrast, the cuneate tract carries sensations from the upper part of the body lies laterally.

** The neurons that form the lateral branch synapse with neurons in laminae lll, IV, V, and VI of the dorsal horn from which some fibers reenter the dorsal column and some form the spinocervical and spinocerebellar tracts, while other fibers elicit certain spinal reflexes.

- معلش لازم احطلكم صورة تصف اللي قرأتوه ♡

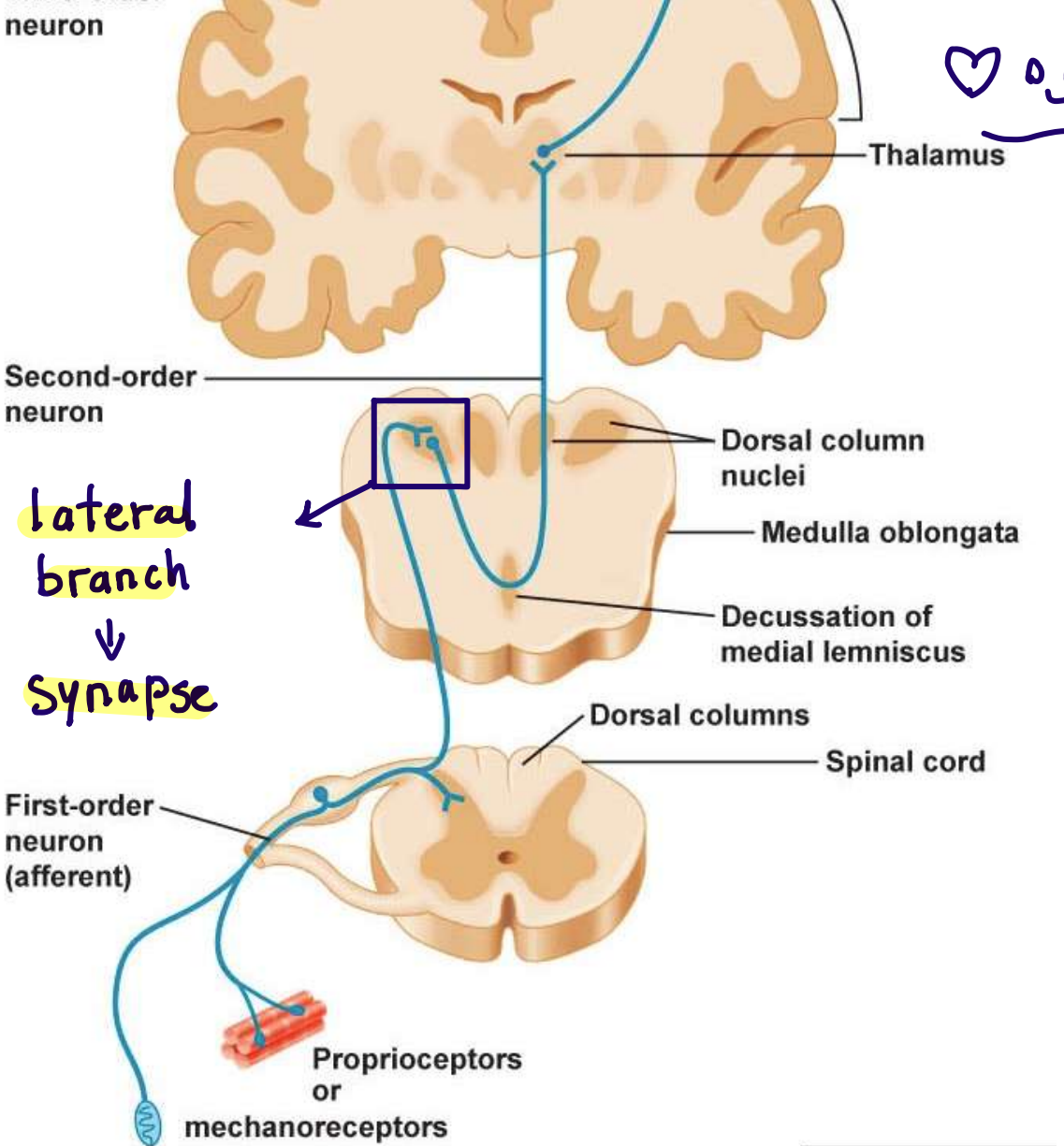


Image from: Pearson Education

THE DORSAL COLUMN SYSTEM

The gracile and cuneate tracts

-Second-order neurons:

These start at the gracile and cuneate nuclei in the medulla, cross in the sensory decussation to the opposite side (in which the fibers are called the internal arcuate fibers), then ascend as the medial lemniscus, and finally, they terminate at the thalamus in the VPLN.

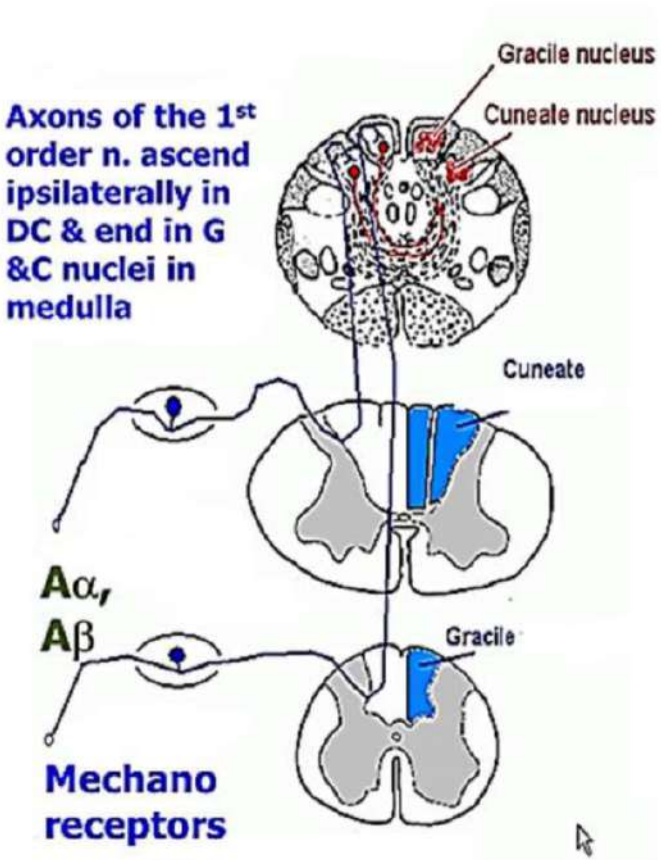
مجرد ماحصار في Synapse بين 1st و 2nd ماحيتحل على نفس الـ side وحيعمل Crossing.

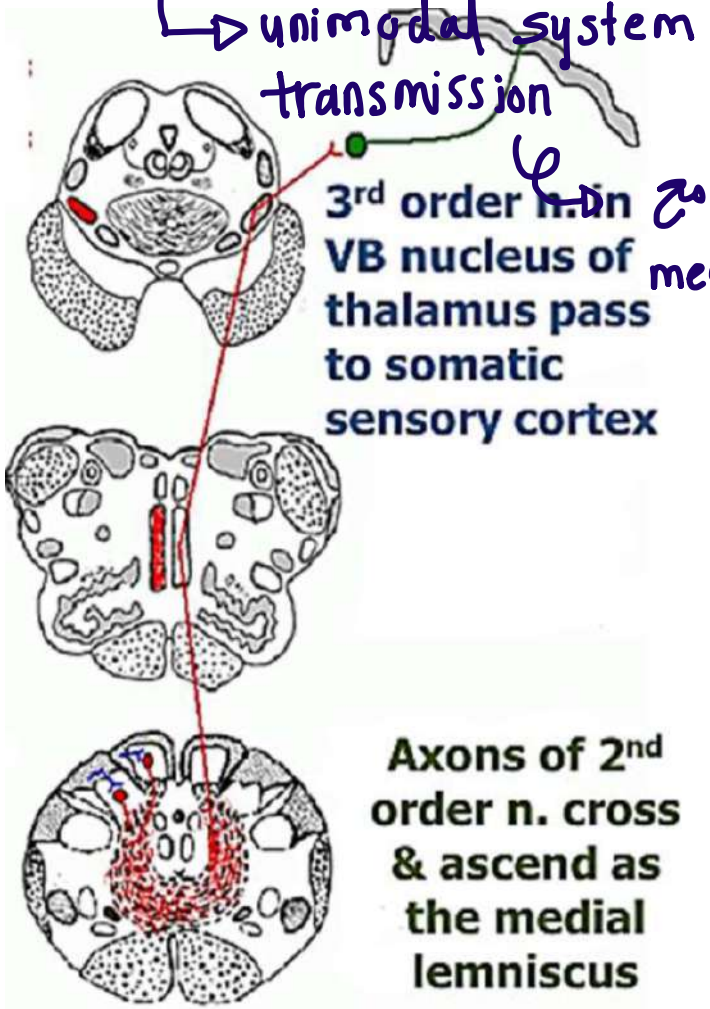
-Third-order neurons:

start at the thalamic VPLN and terminate at the cortical sensory areas in the postcentral gyrus.

Dorsal Column

- Fine sensations.
- unimodal system of transmission
  - يتعامل فقط مع mechano stimuli



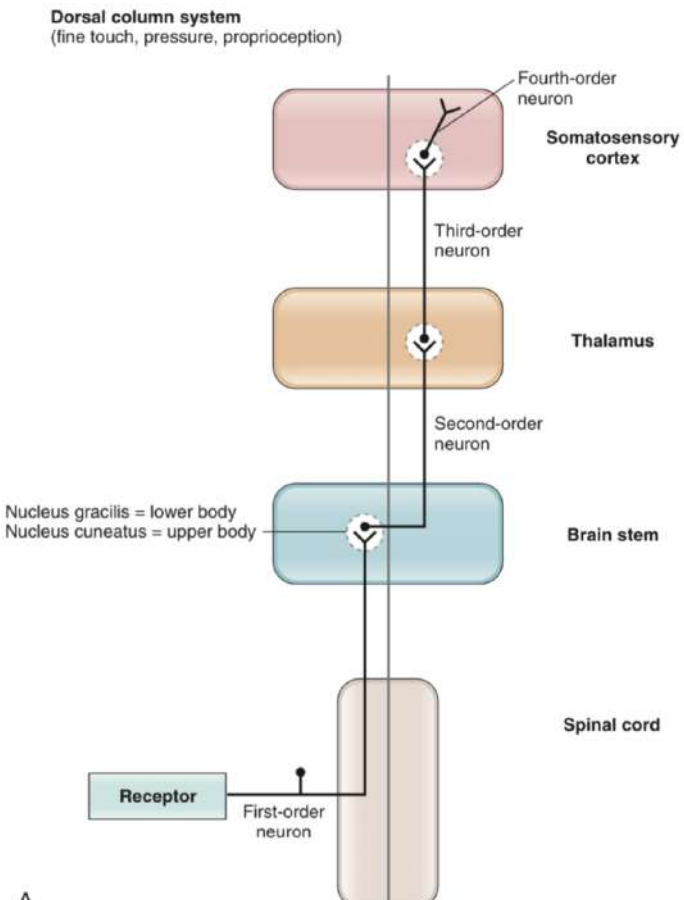


Costazo من خلاصة

Dorsal Column System

The dorsal column system is used for transmitting somatosensory information about **discriminative touch, pressure, vibration, two-point discrimination,** and **proprioception.** The dorsal column system consists mainly of group I and II nerve fibers. The first-order neurons have their cell bodies in the dorsal root ganglion cells or in cranial nerve ganglion cells and ascend ipsilaterally to the **nucleus gracilis** (lower body) or **nucleus cuneatus** (upper body) in the medulla of the brain stem. In the medulla, first-order neurons synapse on second-order neurons, which *cross the midline.* The second-order neurons ascend to the contralateral thalamus, where they synapse on third-order neurons, which ascend to the somatosensory cortex and synapse on fourth-order neurons.

و موطلوب منا



... anteriolateral system على يلا، خلصنا *

SPINOTHALAMIC TRACT

Last edited: 8/31/2021

Spinothalamic Tract

Medical Editor: Adara Garcia Maestu

OUTLINE

I) FUNCTION

- The Spinothalamic Tract (also known as the Anterolateral System) is an ascending pathway that carries sensory information from the periphery to the brain
  - Pain
  - Temperature
  - Crude touch
  - Pressure

It can be divided into:

- **Anterior Portion**→ Crude touch and Pressure
- **Lateral Portion**→ Pain and Temperature

Current research suggests that this division is not as clear-cut as previously thought and that all sensations can be carried by both the anterior and lateral pathways. However, this simplified model is still widely accepted.

II) PERIPHERAL RECEPTORS

- Sensory information is picked up by different receptors on the skin

Free nerve endings

- Dendrites of these nerves are found in the skin and react to various stimuli
- There are various types:

Nociceptors

- Most abundant free nerve endings
- Pick up **pain** and **temperature**
- Activated by:
  - Mechanical tissue damage
    - **DRASIC/mDEG** receptors
  - Extreme temperatures
    - **TRP** receptors
  - Inflammatory chemicals
    - H^+ and K^+ released from cells
    - Histamine
    - Bradykinin

Thermoreceptors

- Pick up temperatures
- Activated by:
  - Extreme temperatures
    - **TRP** receptors
  - Certain chemicals
    - This is why mint is “cold” and chilli is “hot”

Mechanoreceptors

- Respond to **mechanical damage**
  - Deformity of tissue

Merkel’s Discs

- Pick up **pressure sensations** or **indentation of the skin**
- Help pinpoint the location of **touch**

Peritracheal nerve endings

- Found around **hair bulbs**
- Detect changes in hair direction

III) TYPES OF SENSORY FIBERS

There are two main types of neurons/fibers in the spinothalamic pathway:

A-Δ Fibers/Neurons

- Transmit:
  - **Sharp, localized, immediate** pain
  - **Cold** temperatures
- **Myelinated** fibers→ Impulse travels **fast** to the brain
- Synapse in **layers I + V of the dorsal horn** directly onto 2^{nd} order neuron

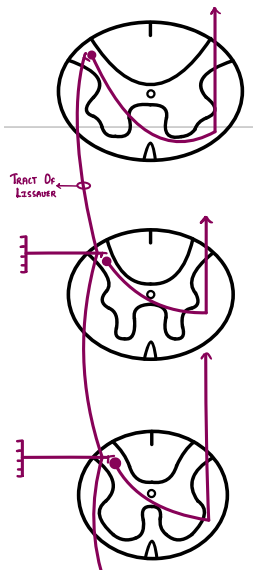
C Fibers/Neurons

- Transmit:
  - **Dull, diffuse, delayed** pain
  - **Hot** temperatures
- **Unmyelinated** fibers→ Impulse travels **slow** to the brain
- Synapse in **layer II + III of the dorsal horn** onto **interneuron**
- Interneuron then synapses on **layer V** onto 2^{nd} order neuron

The sensations of **crude touch** and **pressure** are transmitted by a mixture of A∂ and C fibers

Tract of Lissauer

- After C fibers and A∂ fibers enter the grey horn, they send axons that ascend and descend before synapsing with 2^{nd} order neurons
- This means if an injury occurs, pain and temperature sensations will be impaired from two to three spinal levels below the injury on the contralateral side



Rexed laminae of the dorsal grey horn

- The grey matter of the spinal cord can be divided into layers or laminae according to structure and function
- Each layer is associated with a spinal nucleus
  - **Lamina I** → Receives **noxious** (dangerous) stimuli
    - Mainly pain and temperature
    - Nucleus→ Marginal zone
  - **Lamina II** → Receives **all** sensory stimuli
    - Plays a part in pain modulation
    - Nucleus → Substantia Gelatinosa
  - **Lamina III** → Receives proprioception and light touch
    - Nucleus→ Nucleus Propius
  - **Lamina IV** → Receives non-noxious stimuli
    - Nucleus→ Nucleus Propius
  - **Lamina V** → Relays all sensory information to the brain

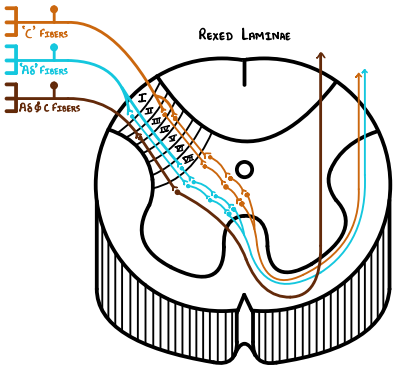


Figure 1 Cross-section of the spinal cord showing dorsal horn laminae

IV) SPINOTHALAMIC PATHWAYS

MAIN PATHWAYS

Crude touch and Pressure fibers

1) 1st order neurons synapse on **dorsal grey horn** (laminae III, IV, V)
2) 2nd order neurons **decussate** via the **anterior commissure**
3) Ascend to the brain as the **anterior (ventral) spinothalamic tract**
4) Synapse at the **thalamus**
   a. Mainly at **Ventroposterior Lateral Nucleus (VPL)**
   b. Some at **Ventroposterior Inferior Nucleus (VPI)**
5) 3rd order neuron brings sensations to the **somatosensory cortex**
   - Awareness of pain

Aδ fibers (fast pain and cold temperature)

1) 1st order neurons synapse on **dorsal grey horn** (laminae I, V)
2) 2nd order neurons **decussate** via the **anterior commissure**
3) Ascend to the brain as the **lateral spinothalamic tract**
   - Neospinothalamic (newer concept)
4) Synapse at the **thalamus**
   - Mainly at Ventroposterior Lateral Nucleus (VPL)
   - Some at Ventroposterior Inferior Nucleus (VPI)
5) 3rd order neuron brings sensation to the **somatosensory cortex**
   - Awareness of pain

C fibers (slow pain and hot temperature)

1) 1st order neurons synapse on **dorsal grey horn** (laminae II, III, V)
2) 2nd order neurons **decussate** via the **anterior commissure**
   - Some can stay on the **ipsilateral side** and ascend as the **spinoreticular tract**
3) Ascend to the brain as the **lateral spinothalamic tract**
   - Paleospinothalamic (older concept)
4) Synapse at:
   - **Reticular Formation (85%)**
   - **Thalamus (15%)**
     - **Intralaminar** nuclei (Centromedian + Parafasciculus)
5) 3rd order neuron brings sensation to:
   - Somatosensory cortex
     - Awareness of pain
   - **Cingulate gyrus + insular cortex**
     - Emotional aspects of pain

At the level of the medulla, the anterior and lateral spinothalamic tracts join together to form the **spinal lemniscus** which ascends all the way to the thalamus

COLLATERAL PATHWAYS

- As fibers move through the midbrain, they give off axons to surrounding structures which play a role in the perception of these sensations

Spinotectal Tract

- Spinal lemniscus gives off fibers to the **superior colliculus** in the tectum
  - Allows for a quick **response of the head and neck** towards the origin of the stimulus

Spino-mesencephalic Tract

- Spinal lemniscus gives off fibers to the **parabrachial nucleus**
  - Sends axons to the **amygdala**→ **Fear and anger** in response to pain
- Spinal lemniscus gives off fibers to the **Periaqueductal Grey Matter**
  - Sends descending axons that help with the **modulation of pain**

Spino-hypothalamic Tract

- Spinal lemniscus gives off fibers to the **hypothalamus**
  - Controls **physiological** response to pain (nausea, dizziness etc.)

Spinoreticular Tract

- Most C fibers and some Aδ fibers synapse at the **reticular formation** in the brain stem
- The reticular formation then sends axons to the itralaminal nuclei in the **thalamus** which sends the information to various cortical structures
  - Awareness and perception of pain

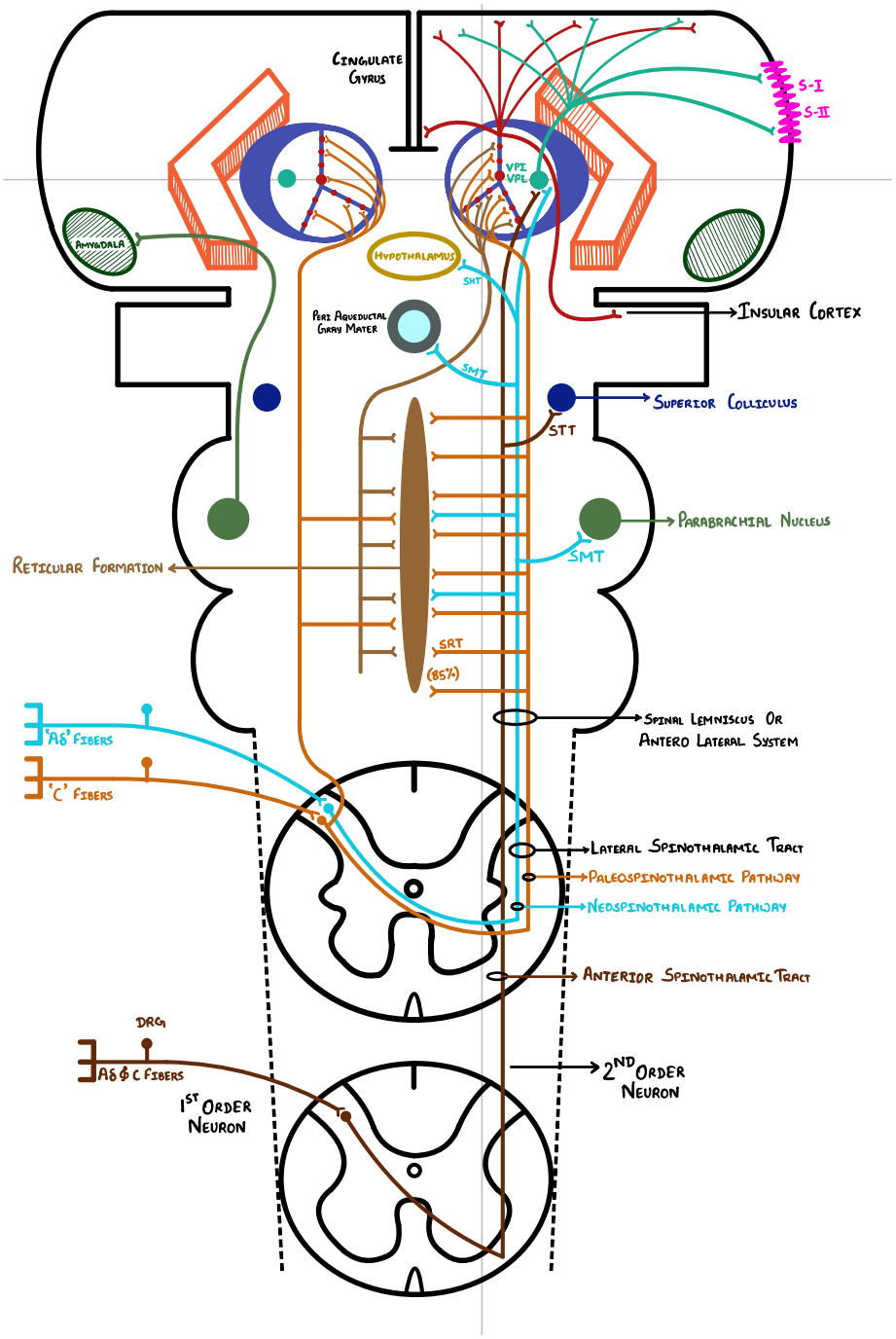


Figure 2 Diagram demonstrating all spinothalamic pathways

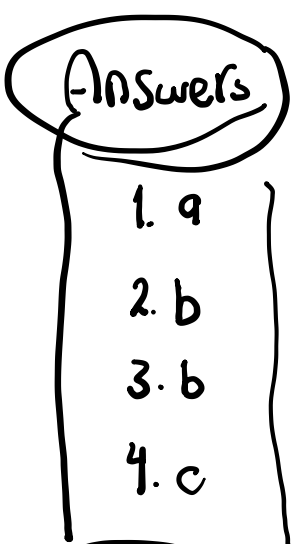
V) REVIEW QUESTIONS

1) **Which dorsal horn lamina do C fibers synapse at?**
   a. Lamina II
   b. Lamina I
   c. Lamina VI
   d. Lamina IV

2) **Which of the following is the tract of Lissauer?**
   a. Tract through which spinothalamic fibers decussate to the contralateral side
   b. Tract that connect spinothalamic messages of different spinal levels
   c. Tract that gives off fibers to the superior colliculus in the tectum
   d. Tract that brings impulses from the reticular formation to the thalamus

3) **Which of these sensations are transmitted by Aδ fibers?**
   a. Slow, dull pain
   b. Cold temperatures
   c. Vibration
   d. Hot temperatures

4) **What sensation do Merkel's discs pick up?**
   a. Extreme temperatures
   b. Fine touch
   c. Pressure
   d. Hair movement



THE ANTEROLATERAL SYSTEM

or Spinothalamic System.

-This system consists of the lateral and ventral spinothalamic tracts, mainly consisting of types A-delta and C nerve fibers.

-These tracts conduct signals from the opposite side, and their fibers are arranged in the spinal cord, with the fibres from the sacral region being the most superficial while those from the cervical region are the deepest.

#1 -The ventral (anterior) spinothalamic tract : This tract transports crude touch pressure as well as the itch-tickle sensations.

THE ANTEROLATERAL SYSTEM

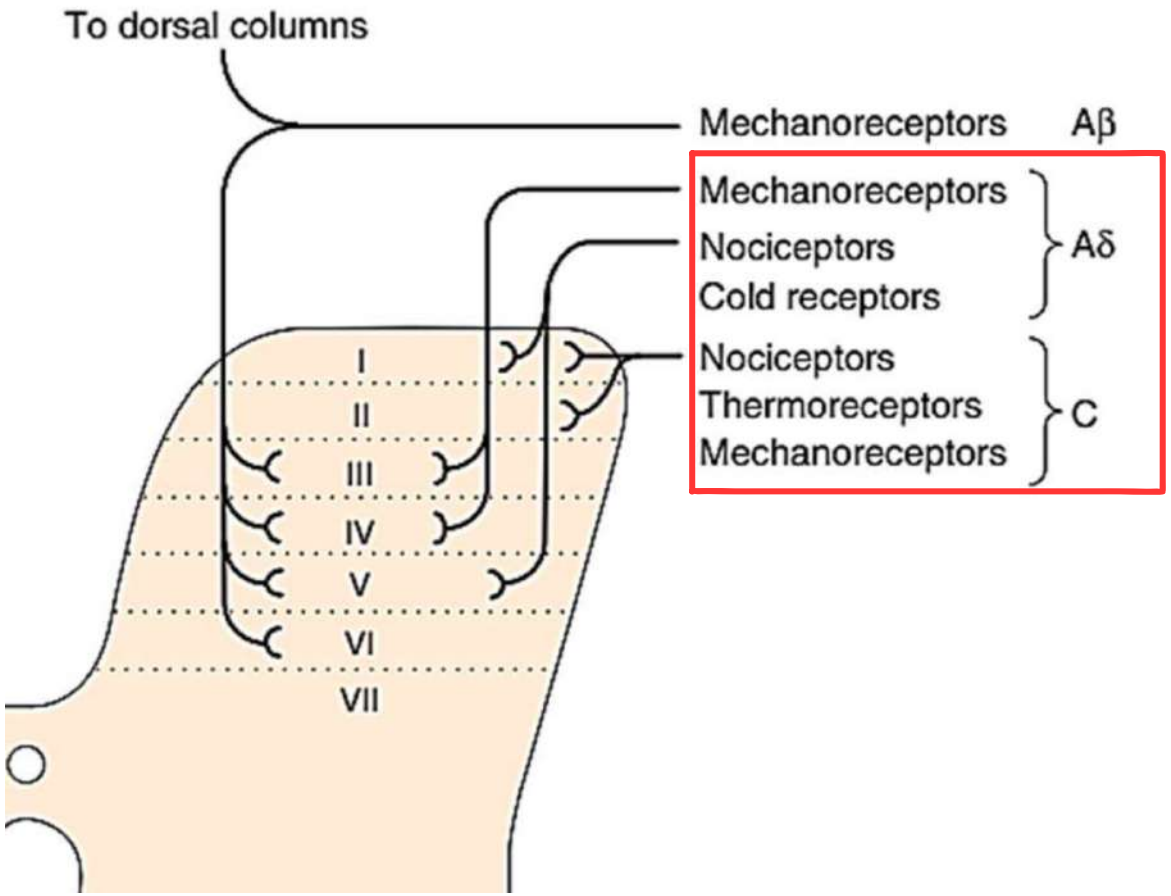
Its pathway consists of the following 3 neurons:

-First-order neurons: These are A-delta and C afferent nerve fibers. They enter the spinal cord via the dorsal roots and terminate in the dorsal horn's upper 4 laminae, especially at the main sensory nucleus.

-Second-order neurons: These constitute the tract. They start in the dorsal horn, cross to the opposite side, ascend in the anterior column of the spinal cord, and terminate in the ventrobasal thalamic complex, especially at the ventral posterolateral nucleus.

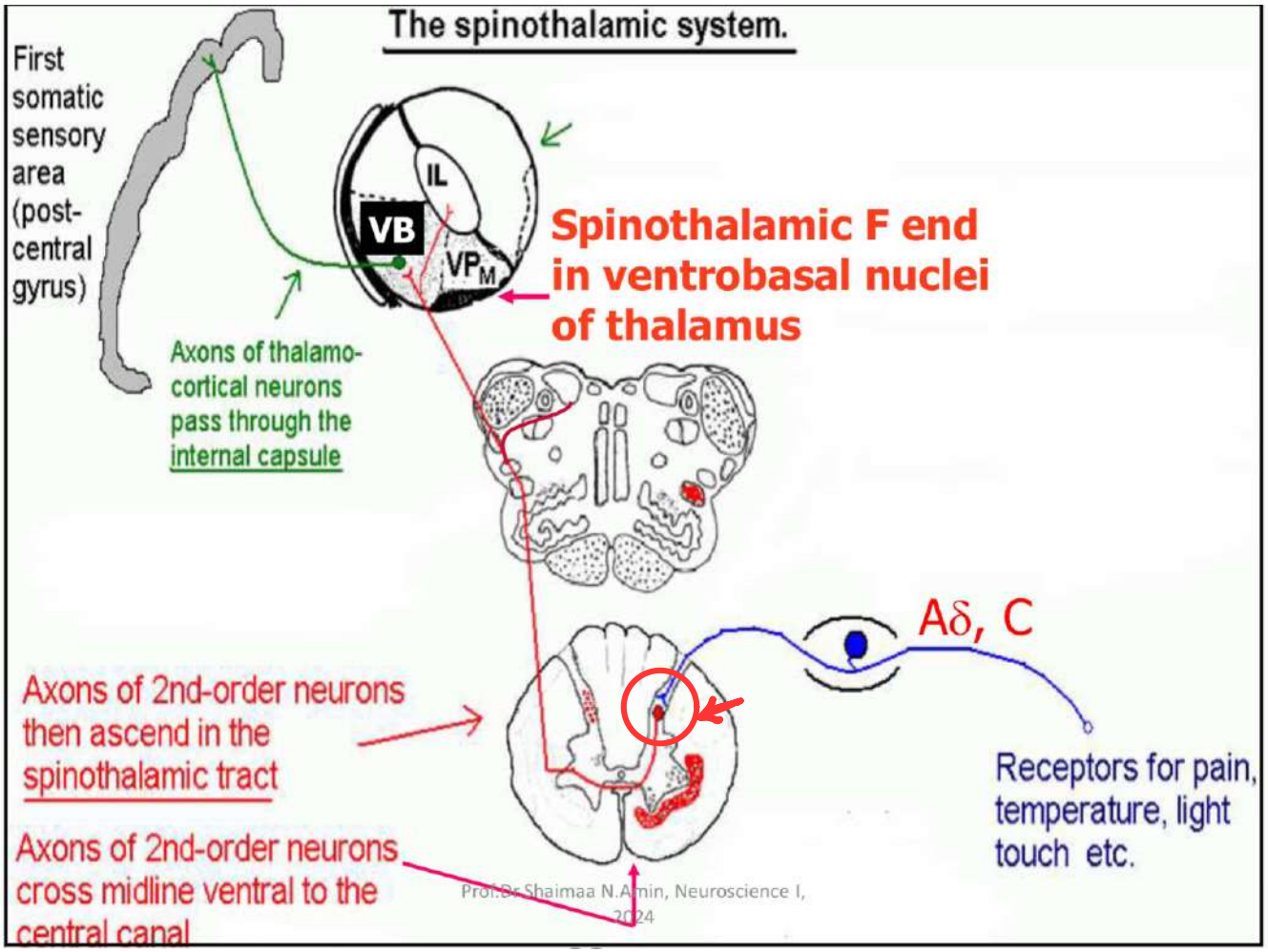
* not brain stem

-Third-order neurons: start in the thalamus, pass in the sensory (thalamic) radiation in the posterior limb of the internal capsule, and terminate at the cortical sensory areas in the postcentral gyrus.



مفصلين أكثر
نينجا نيرد فوق

The spinothalamic system.



#2 *THE LATERAL SPINOTHALAMIC TRACT*

This tract transmits pain, thermal and sexual sensations. It consists of 2 tracts which are the following:

(1) The paleo-spinothalamic tract

This tract transports slow (chronic) pain and crude thermoreceptive sensations. Its pathway consists of 2 neurons First-order neurons and Second-order neurons

(2) The neo-spinothalamic tract

This tract transports fast (acute) pain and fine thermoreceptive sensations. Its pathway consists of 3 neurons First-order neurons, Second-order neurons and Third-order neurons

لهيك لانه acute ؛ حيوصل Specific cortical area

وحيكون الله Specific nucleus

THE LATERAL SPINOTHALAMIC TRACT

This tract transmits pain, thermal and sexual sensations. It consists of 2 tracts which are the following:

(1) The paleo-spinothalamic tract

First order neurons

-These mainly type C afferent nerve fibers.

-They enter the spinal cord via the dorsal roots, ascend or descend a few segments in the Lissauer's tract, and then terminate in the upper 3 laminae of the dorsal horn, especially at the substantia gelatinosa of Rolandi (= SGR), which occupies lamina II and part of lamina III.

(2) The neo-spinothalamic tract

First order neurons

-These are mainly A-delta afferent nerve fibers.

-They ascend or descend in the Lissauer's tract and terminate mainly at laminae I and V of the dorsal horn.

THE LATERAL SPINOTHALAMIC TRACT

This tract transmits pain, thermal and sexual sensations. It consists of 2 tracts which are the following:

(1) The paleo-spinothalamic tract

second order neurons

-They start at the SGR, cross to the opposite side close to the central canal, ascend in the lateral column of the spinal cord, and terminate at the following sites (where the transported sensations are perceived): The reticular formation, the periaqueductal grey area in the midbrain and the nonspecific thalamic nuclei (especially the intralaminar nuclei) in addition to other subcortical centers.

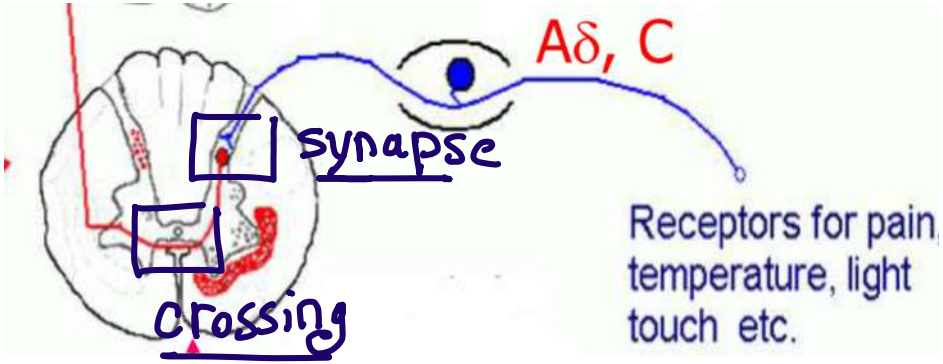
(2) The neo-spinothalamic tract

second order neurons

These constitute the tract. They start at the dorsal horns, cross to the opposite side and ascend in the lateral column of the spinal cord. In the brain stem, they combine with the palaeospinothalamic and ventral spinothalamic tracts forming the spinal lemniscus. These fibers finally terminate at the thalamus.

third order neurons

Third-order neurons are similar to those of the ventral spinothalamic tract (see above).



- هما بالنسبة للـ antereolateral ؛ انفقنا انو مكان الـ 1st / 2nd order neuron بين Synapse هو الـ Spinal cord وبين Brain Stem .

- هاد الـ System مقسم الى anterior و lateral ، الدكتورة نظرتنا لفرق بينهم مهم

← Lateral الـ Crossing بتعبر بكون جدًا قريب على Central Canal

← Ventral الـ Crossing بكونو بعيد شوي

سؤال: لو في Pathology معين في الـ Central Canal، مين متوقع انه يتأثر أولاً؟ هل الـ lateral أم الـ Ventral؟

الجواب: lateral يكون.

لهيك وطبعاً لو تطور حيوصل برضه للـ Ventral.