



PHYSIOLOGY

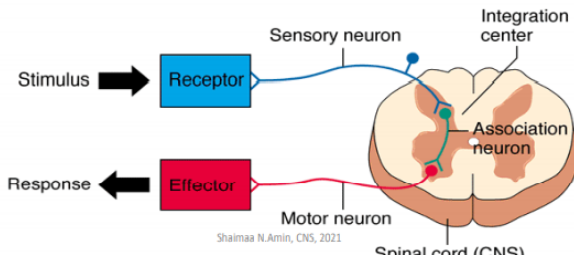
Lecture : 2#

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Lecture 2: spinal cord and somatic sensations

Sensations and perception:

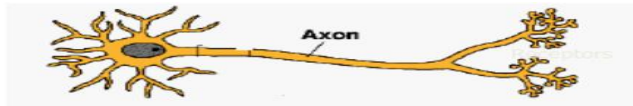
Sensation :is awareness of sensory stimuli in brain



عن طريق sensory pathway يتوصل الى specific part of the brain وبالتالي يتم ادراك هذا الاحساس وبيوصل لل cortex بس مش كل sensations يتوصل لل cortex فيه منها بيوصل ل sub cortex زي pain sensations

هاي sensory receptors عبارة عن detectors and transducers بحيث انها بتعمل detect وبتحس بأي تغيير والها specific sensation وممكن كمان يستجيبوا ل sensations ثانية ولكن ما بيوصلوا threshold قد sensation الرئيسي و transducers يعني انه بحول هاي sensation ل impulses يقدر CNS يفهمها

Sensory receptors are specialized structures or modified nerve endings at the peripheral termination of afferent fibers



So the receptors are excitable structures ((responding to change in surrounding environment))

فمثلا هلا muscle تستجيب عن طريق contractions وgland تستجيب عن طريق secretions و nerves تستجيب عن طريق action potential

FUNCTIONS OF THE SENSORY RECEPTORS

(1) They act as detectors and transducers : They detect energy changes in both the external and internal environments and transform such changes into action potentials (i.e. nerve impulses).

(2) They inform the CNS about changes occurring inside and outside the body : The nerve impulses generated at the receptors are transmitted to the CNS via *afferent neurons* where they give rise to various sensations and initiate appropriate reflex actions that *maintain homeostasis*. Accordingly, *the CNS becomes almost useless without receptors.*

-classification of receptors (depend on the stimulus type)

1-mechanoreceptors

(pressure, stretch)

2-thermoreceptors

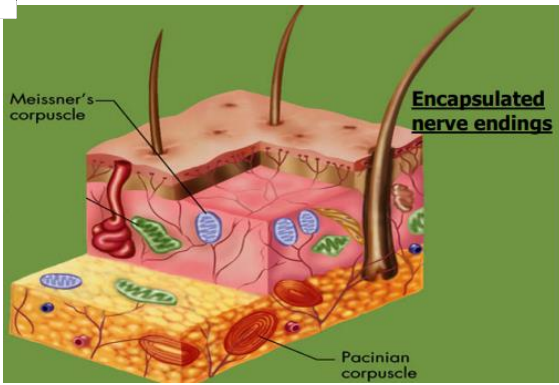
(warm,cold)

3-pain receptors

((extreme mechanic pain, extreme thermal stimulation, chemical stimulation e.g: peptic ulcer))

4-chemoreceptors

((chemical ,taste,smell))



Corpuscles which are sensory receptors in the skin

Excitability of the sensory receptors :

This is the property of responding to stimuli by generating action potentials. It has been studied in certain mechanoreceptors called *Pacini corpuscles*. Each corpuscle consists of a sensory nerve ending surrounded by multiple concentric lamellae of connective tissue, and the *terminal part of the nerve ending is unmyelinated* while its remaining part is myelinated, and the *first node of Ranvier is present inside the corpuscle* (figure 1).

When the corpuscle is not stimulated, the sensory nerve ending is in the polarized state (with a resting membrane potential about -70 mV). However, if it is stimulated (by applying pressure), the *unmyelinated part* is partially depolarized due to *increased Na^+ influx secondary to Na^+ channel activation*. This state of partial depolarization of the sensory nerve ending is called the **receptor or generator potential**, and its magnitude is *proportionate to the intensity of the stimulus* (a, b, c and d in figure 1).

The receptor potential is *passively conducted to the first node of Ranvier* (by local circuits of current flow) causing its depolarization, and if this reaches the firing level, it initiates an action potential (e in figure 1) that is propagated along the afferent nerve to the nervous system.

The *threshold receptor potential that discharges an action potential is about 10 mV* , and if its magnitude rises above that level (depending on the intensity of the stimulus), the frequency of discharge increases proportionately (figure 2).

هنا بداية response يكون عبارة عن

all or non receptor وما يتبع graded potential(local response) ويكون action potential وبالتالي ما بصيرله propagation وبالتالي بما انه local response وانا زودت degree of pressure يتبع على receptor هيك action response ورح يوصل ل threshold ويتحول من local الى action potential ولو زودت ((pressure)) degree of stimulation حتى بعد action potential ما رح يتغير عندي amplitude رح تتغير frequency of discharge ليش طيب؟لانه action potential يتبع نظام all or non law and it is not graded زي بالرسمه ضل $\text{AP} = -30$ وما تتغير مع كل stimulation بس زادت frequency

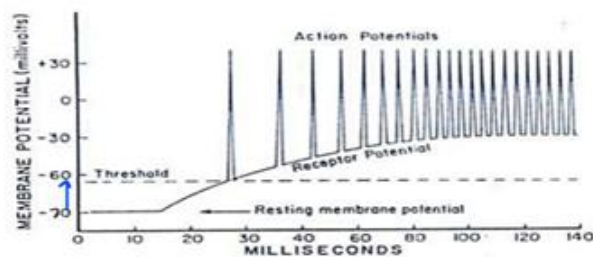
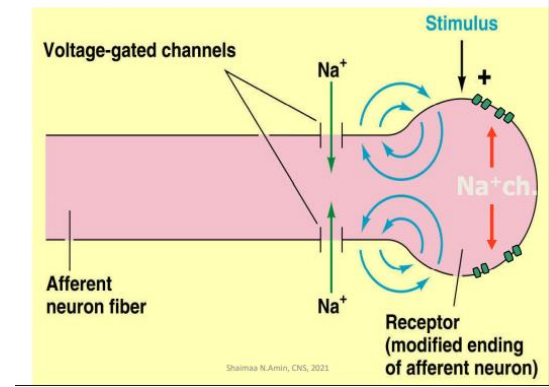


Figure 2 : Relation between the receptor potential (RP) & action potentials (APs). As the (RP) rises above threshold, the frequency of (APs) increases.

This is the property of responding to stimuli by generating action potentials. It has been studied in certain mechanoreceptors called *Pacinian corpuscles*. Each corpuscle consists of a sensory nerve ending surrounded by multiple concentric lamellae of connective tissue, and the *terminal part of the nerve ending is unmyelinated* while its remaining part is myelinated, and the *first node of Ranvier is present inside the corpuscle* (figure 1).



Adaptation of the sensory receptors :

Figure A :

عبارة عن slowly adapting response يعني
 مهما stimulation طول حيفضل طول الوقت
 شغال ويرسل AP الى CNS
 e.g: pain sensation
 وذلك لانه يدل على انه فيه tissue injury فلازم
 يضل CNS شغال ويدرك الوضع

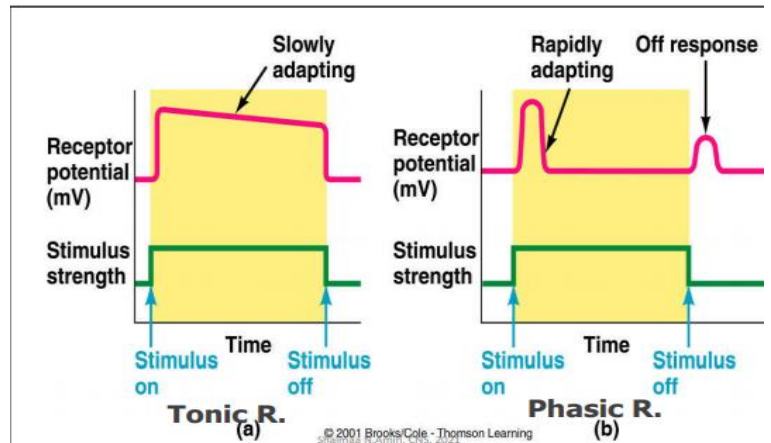


Figure B:

عبارة عن مستقبلات بصيرلها بصيرلها
 وبحيث اول ما يصيرلها stimulation ببيلش AP
 وبعدين ببيلش يختفي فمثلا pressure, touch
 وانت لابس ساعة اولها بتحس بدغدغة وبعدين
 خلص زي كأنه بتنسى انها موجودة لانه صارله
 receptor adapting وبطل يبعث impulses
 لل CNS

وفيه نوع ثالث:

Moderately adapting response.

e.g: warm and cold receptors

Coding of sensory information :

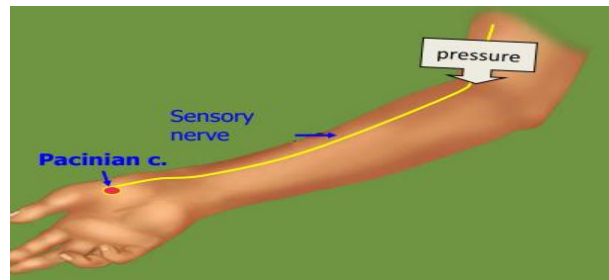
هنا عرفنا انه receptors هي transducers بحيث اول ما يصير لها sensation بيحولوا للغة مفهومة لل CNS عن طريق الشحنات كهربائية يلي هي propagated AP طيب هلا كيف CNS بد يفك هاي الشيفرة تاعت AP يلي وصلته لازم يفك 3 حاجات يلي هي :

1-type of sensation ((modality))

Muller's law ,labeled line principle

مثلا Pacinian corpuscles وبالتالي pressure sensation وموصول بال sensory pathway as a sensory pathway وبالتالي لو عملت stimulation على منطقة بعيدة عن receptor رح توصل لل CNS ويترجمها على انها من receptor

بهاي الصورة منلاقي انه sensation هو
Pacinian receptors و locality رح تكون



2-law of projection (locality)

يحدد sensation واصل من وين من periphery يعني لو عملت stimulation على طول axis رح يوصل على كانه من receptor

مثال : phantom limb phenomenon بحيث لو صار amputation for the leg المريض رح يحس باصبع رجله تنميل وهو اصلا مش موجود لانه الغرز بتكون شادة على axis نفسه يلي يكون فيو receptor

3-intensity ((strength))

(recruitment of the receptors ,frequency of impulses)

وبالتالي هل هو light or deep pressure فلو زاد stimulation رح تزيد عدد stimulating receptors فرح يوصل ل CNS انه stimulation عالي ولو زودت intensity حسب weber-Fechner principle رح يوصل ل CNS انه intensity عالية طيب شو هي weber-Fechner principle ?

Weber-Fechner principle:

This is a logarithmic function which states that: **the perceived sensation is proportional to log intensity of the stimulus.**

$$R = \log S \times K$$

R: perceived sensation .

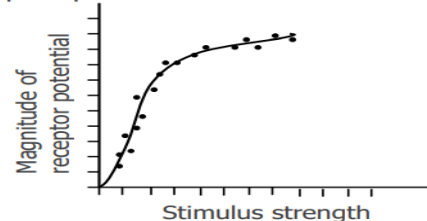
S: stimulus intensity.

K : constant.

This means that 100 fold increase in stimulus intensity, will increase the perceived sensation by 2 times, 1000 fold increase will increase sensation by 3 times and so forth.

مش مهم القانون بس لازم نعرف كلما زودت intensity كلما زاد frequency of discharge وهاي العلاقة مش linear بحيث لازم يكون على اقل حصل 10% تغيير في degree of stimulation

Relation of strength of the stimulus to receptor potential



Shaimaa N.Amin, CNS, 2021

To sum up :

CODING OF SENSORY INFORMATION

This is the ability of the nervous system to discriminate (or identify) the *modality (= type), locality and intensity of various sensations, although all sensations are transmitted from the receptors to the higher centres in the same form (i.e. as action potentials).*

(1) MODALITY DISCRIMINATION

The various sensory pathways are discrete (i.e. separate from each other), and the modality of a certain sensation is *discriminated at the specific brain area where its pathway terminates.* This agrees with Muller's law.

Muller's law of specific nerve energies

This law states that *stimulation of a certain sensory pathway no matter how or where produces the sensation to which its receptors are specialized.* Such effect is also called the *labeled line principle* i.e. each sensory pathway (from the receptors till the termination at the higher centres) is labeled for a specific sensation (so stimulation of the retinal receptors whether by light or mechanically by pressure always produces a light sensation, page 1).

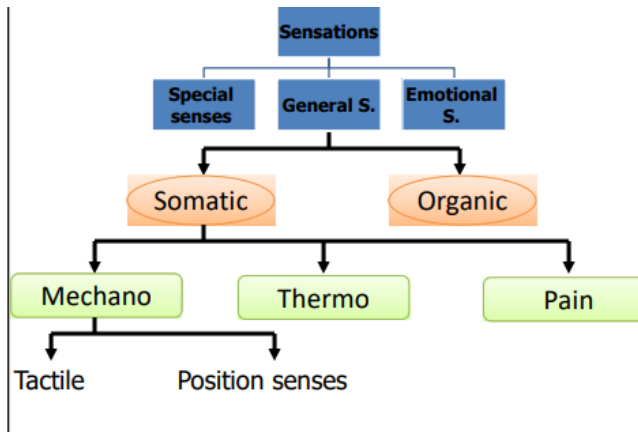
(2) LOCALITY DISCRIMINATION

The discrimination of the locality of a certain sensation also depends on the specific pathway of that sensation. When this pathway is stimulated anywhere along its course, the evoked sensation is projected to (i.e. referred to) the location of its receptors. This effect is called "*law of projection*", and it is evident in patients whose limbs are amputated, who *may feel severe pain in the phantom limb (i.e. the non-existing limb) due to irritation of the sensory nerves at the site of amputation.*

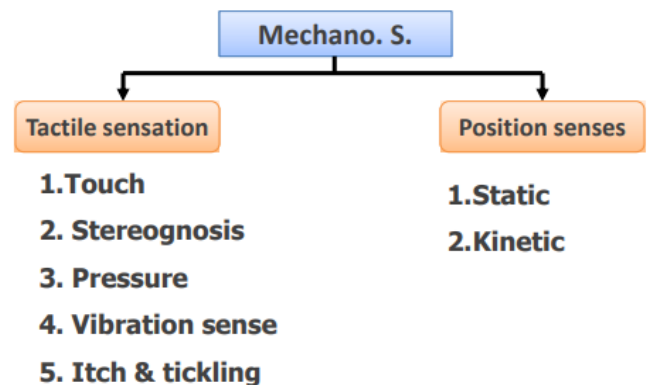
(3) INTENSITY DISCRIMINATION

The discrimination of the intensity of a certain sensation depends on the number of *activated receptors and their frequency of discharge* as well as on the *state of nerve centres* (if they are depressed e.g. due to O₂ lack or hypoglycemia, the sensations become dull and their intensity is decreased).

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).



1- Touch

يمكن المس ايشي املس بس مش مثلا يعني سكيئة لانه سكيئة بتشغل pain sensations وبالتالي فيه نوعين يلي هما
Fine sensation انه نحدد مكان اللمس without vision ولكن crude sensation يعني ما بنقدر حدد مكان اللمس ويكون non-localized without vision
Stereogonosis مثلا اميز وانا عم بطلع من الشنطة مفتاح ولا عطر فمنحس الاغراض من غير ما نشوفها وهي جواتها وهو sensation لا يعتمد فقط على fine touch بيعتمد على familiar learning sensation

There are 2 types of touch (tactile) sensation :

[A] **Crude touch** : This is a poorly-localized gross tactile sensation.

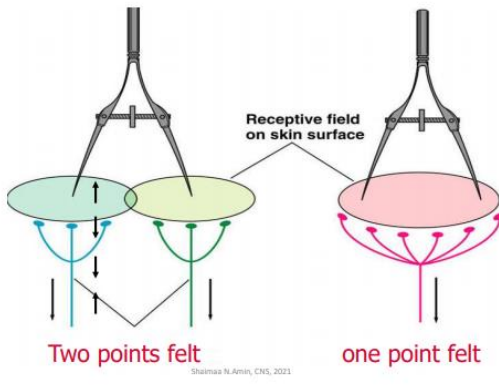
- *Receptors* : Free nerve endings and hair end organs.
- *Afferent nerves* : A-delta nerve fibres.
- *Central pathway* : Ventral spinothalamic tract (page 22) and also partly in the gracile and cuneate tracts (page 24).
- *Testing* : By stroking the skin lightly with a piece of cotton.

[B] **Fine touch** : This includes tactile localization and discrimination, stereogonosis and the sense of texture of material (see below).

- *Receptors* : Meissner's corpuscles and Merkel's disks.
- *Afferent nerves* : A-beta nerve fibres.
- *Central pathway* : The gracile and cuneate tracts (page 24).

وفي texture يلي هي احس مادة معين قماش /قطن..

وعنا tactile localization فيه عنا الة اسمها weber compass لو سويت sensation على 2 points لنفس sensory unit رح يطلع لنفس efferent nerve واحس انه اللمس صار بنقطة وحدة بينما tactile discrimination بسوي sensation بنفس الة على 2 different points وبالتالي كل sensory unit حتكمل بال pathway تاعتها واحس انه اللمس صار بنقطتين



2-pressure

This sensation is perceived mainly by the *Pacian corpuscles and Ruffini's endings* in the skin (for light pressure) and subcutaneous tissues (for deep pressure). 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*). Like touch, there are 2 types of pressure sensation : **fine** (which is transmitted by the gracile and cuneate tracts) and **crude** (which is also transmitted by the ventral spinothalamic tract).

3-sense of vibration

loss of vibration **زي مثلا شوكة رنانة على اماكن معينة عشان بعض الامراض زي diabetes بيحصله sensation**

This is the sense of buzzing (or thrill) that is 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*. 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. Both are transmitted by the *gracile and cuneate tracts*, and both are impaired if these tracts degenerate e.g. in cases of pernicious anemia, tabes dorsalis and diabetes mellitus.

4- Itch /tickling

removal of the **عشان يصير safe insect bite زي itching و دغدغة يعني زي Tickling irritating**

Tickle is a pleasurable sensation (often causing laugh) that results from mild tactile stimulation of the skin, while 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 fibres.
- *Central pathway* : Ventral spinothalamic tract.

Itch often initiates the *scratch reflex* which helps removal of the stimulus, and also *initiates pain signals* which help suppression of this sensation.

5-static

orientation of **يعني ادراك (يعني ادراك) Sense of position different of the body)**

This is the *conscious perception of the position of different parts of the*

body 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 in the other side at a similar position

6-kinetic

يعني يعرف مثلا كيف بقدر اتحرك وطريقة الحركة وكيف بتمشي

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, as well as its rate and direction.

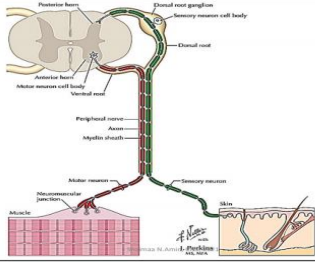
** Both types of proprioception are frequently called **kinesthetic sensations** (although only the dynamic type is kinetic).

**هاد الجدول حكيت الدكتوراه مهم بيحكى عن specific sensation لكل receptor وبالإضافة لل نوع nerve fiber يلي بوصل sensation

Sensations carried by dorsal column

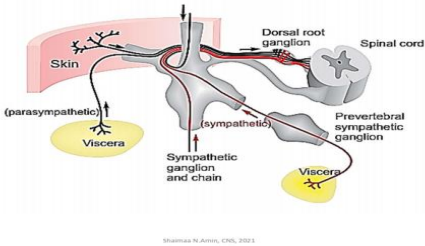
Sensation	Receptor	Afferent fiber
Fine touch	M & M	A β
Stereognosis	mixture	A β
Pressure	Pacinian & spray	A β
Vibration S.	Pacinian & Me.	A β
Position S.	Pacinian R & S	A α

Shalmaa N. Ahmed, ChD, 2021



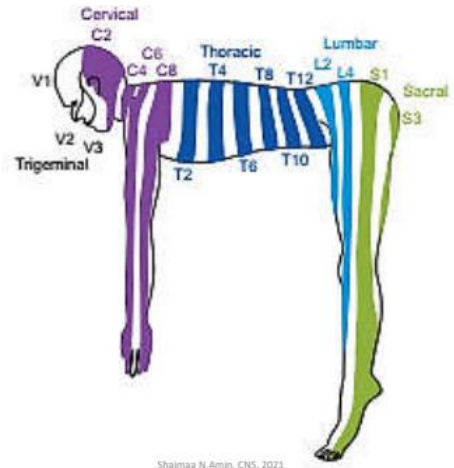
بيوصل cortex من خلال sensory pathway وبالتالي
 عشان توصل cortex لازم تعدي من spinal cord
 Sensory nerve جاي من عند periphery لل spinal
 cord ويتحرك upward الى target وبعدها ينزل بال
 muscle عند ventral root

L7

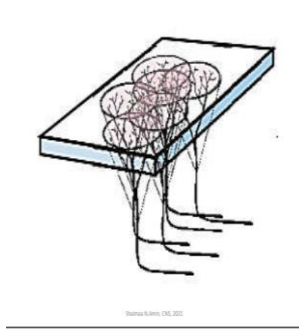
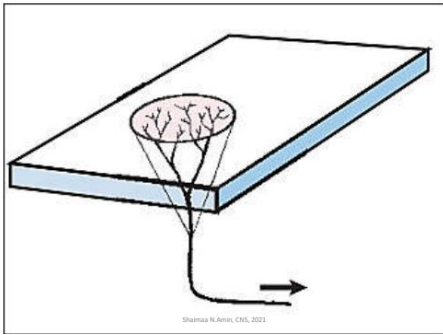


Shaimaa N.Amin, CNS, 2021

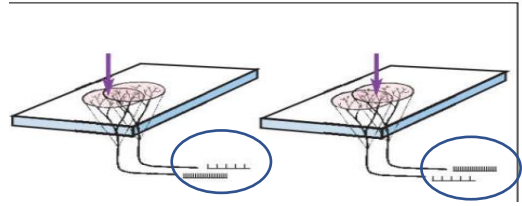
لو مثلا اجا مريض وعمل حادث وانت شاكك انه فيه مشكلة في
 احد spinal cord segments لازم اعمل examination
 واشك فيه certain levels.. فمثلا لما احكي انه فيه مشكلة
 في sensation عند level معين بعرف انه فيه injury في
 هاد nerve



Shaimaa N.Amin, CNS, 2021



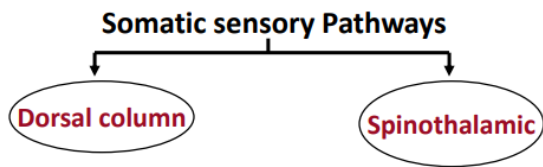
عنا هون sensory unit يلي بتكون فيها
 sensory nerves وممكن تكون overlap
 ووين ما صار sensation اكثر رح يوصل لل
 spinal cord اكثر زي الصورة هاي :



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* (figure 5) and these show *marked overlapping*

The sensory system ascending tracts :



انه كيف بتعدي من spinal cord لل ascending tracts ولل cortex
 2 pathways :

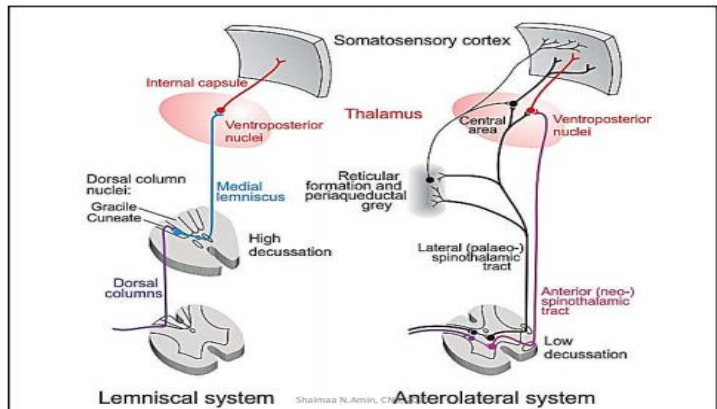
1-dorsal column

يولي بالعادة بتتعامل مع mechanical sensations
 ومنسميه lemniscal system يلي يكون with high decussation
 ((crossing of the midline يعني decussation))

2-spinothalamic

منسميه anterolateral system
 عشان بيعدى anterior and lateral columns

ولقدام رح ندرس عنهم ...



-هلا بأي pathway فيهم لازم يكون عنا : 3 stations حتي يوصل الموضوع لل CNS

1-first order

بكون pseudounipolar بحيث انه cell body بيطلع axon بينقسم لجهة peripheral وجهة ثانية central

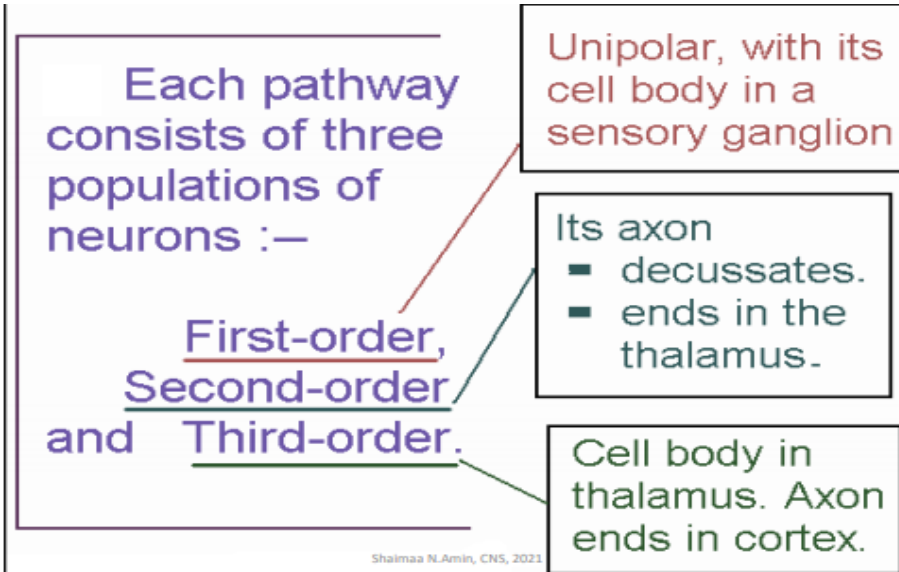
2-second order

هلا اول ما استقبل second neuron اشارة من first neuron by synapse لازم يصير decussation بحيث انه يعدي midline عشان زي ما منعرف قبل انه cortex اليمين بيستوعب من receptor يلي موجود على الشمال والعكس صحيح .

3-third order

وهلا بس توصله اشارة لازم يعمل synapse مع thalamus ((السكرتير ☺)) وبعدها thalamus بيودي اشارة لل cortex على حسب كل sensation

Each sensory pathway consists of (1) The afferent nerves which have their cell bodies in the dorsal root ganglia and terminate at the various laminae of the dorsal horn of the gray matter (figure 12 a) (2) Second order neurons that start at the dorsal horns and form bundles called the ascending tracts, which terminate at subcortical centres. Some sensations require third order neurons that transmit signals to centres in the cerebral cortex. Depending on position in the spinal cord, there are 2 systems of the ascending tracts called the anterolateral and the dorsal column (or lemniscal) systems.



**اخر صورتين موجودين بسلايدات الدكتورة ما حكت عنهم رح تحكي لقدام ..

**فيه فيديو من اسموسيز بيلخص كل المحاضرة: ((somatosensory receptor)) ☺

https://mega.nz/folder/LqB1yKCA#CJZx31S_CCub58X_7iE_5g/file/b6JWyAhS

**سامحونا على أي خطأ غير مقصود في التلخيص

GOOD LUCK ☺