Revised By
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MED437

Proprioceptive pathway

Objectives:

- to know about proprioceptors its definition and its role in body balance.
- The muscle spindles and their role in stretch reflex.
- Organization of spinal cord
- Sensory receptor types
- Identify the major sensory pathways to the cerebral - with consciousness- components, processes and functions & its damage(appreciate the dorsal column system in conscious proprioception)
- Identify the major sensory pathways to the cerebellum - unconscious & its damage (describe the pathway of spinocerebellar tract in unconscious proprioception from muscles,tendons,and joints)
- differentiate between sensory and motor ataxia

Done by:

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Colour index:
important
Numbers
Extra

Editing file

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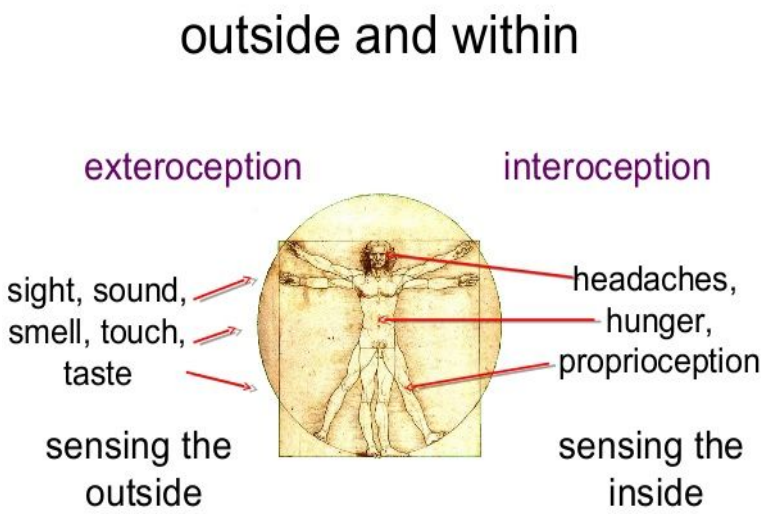
❖ Terminology

Terminology	Definition
Proprioception	Proprioception in Latin means proprius which means "one's own" or "individual". Perception is the sense of the relative position of neighbouring parts of the body and strength of effort being employed in movement. **Proprioception** is defined as our body's ability to know where it is in space.
Exteroception	By which one perceives the outside world. **Exteroception** is the sensitivity to stimuli originating outside of the body.
Interoception	By which one perceives pain, hunger, etc., and the movement of internal organs. **Interoception** is a lesser-known sense that helps you understand and feel what's going on inside your body.



Receptors

Meaning of Receptors:

Certain specialized structures are present at the interface of stimulus and afferent nerve fibers. These specialized structures convert any type of energy into electrical energy or action potential in afferent fiber. This action is known as transduction. Hence receptors act as biologic transducers.

Somatic receptors:
Somatic receptors are specialized structure present at the peripheral terminations of afferent fibers..
▪Receptors are detectors and transducers which transduce different form of energy into action potential
▪They are found in many parts of the body including the skin (cutaneous receptors), skeletal muscles, bones and joints (proprioceptors)
▪They differ from specific receptors that mediate the special senses of vision, hearing, smell, taste and equilibrium.

Classification of sensory receptors

A/Based on their location (Sherrington 1906)
1-Exteroceptors
2-interceptors
3-propriceptors

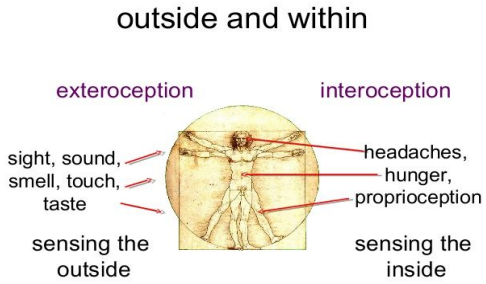
B/Based on their speed of adaptation
1-Slowly adapting (SA) or tonic receptors
2-Rabidly adapting (RA) or phasic receptors
3-Non adapting receptors: eg Free nerve endings for pain sensation

C/Based on their adequate stimulus
1-Mechanoreceptors
2-Thermoreceptors
3-Chemoreceptors
4-Electomangetic receptors
5-nociceptors

❖ Classification of sensory receptor

A/Based on their location

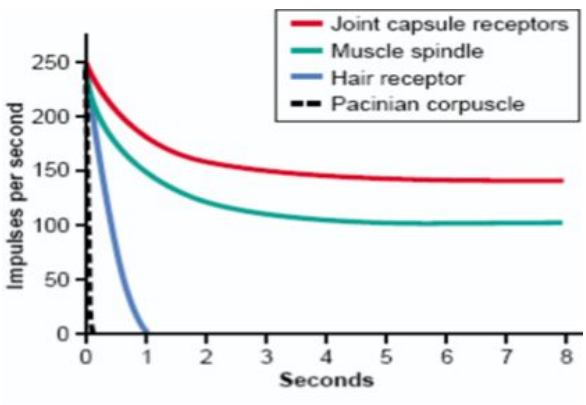
1-Exteroceptors: concerned with the external environment
▪ Found on the surface of the body ▪ E.g. touch and temperature receptors
2-Interoceptors: concerned with the internal environment
e.g. chemoreceptors ,osmoreceptors.
3-Proprioceptors: concerned with position of the body in the space.
▪ Are found in joint, tendons and muscles.



B/Sensory receptor based on their speed of Adaptation

1-Slowly adapting (SA) or tonic receptors:
Eg Muscle spindle, joint receptors, baroreceptor.
2-Rapidly adapting (RA) or phasic receptors:
Eg meissner's corpuscles(touch), pacinian corpuscles(vibration)
3-Non adapting receptors: eg Free nerve endings for pain sensation

- When a continuous sensory stimulus is applied, the receptor responds at a high impulse rate at first and then at a progressively slower rate until finally the rate of action potentials decreases to very few or often to none at all.

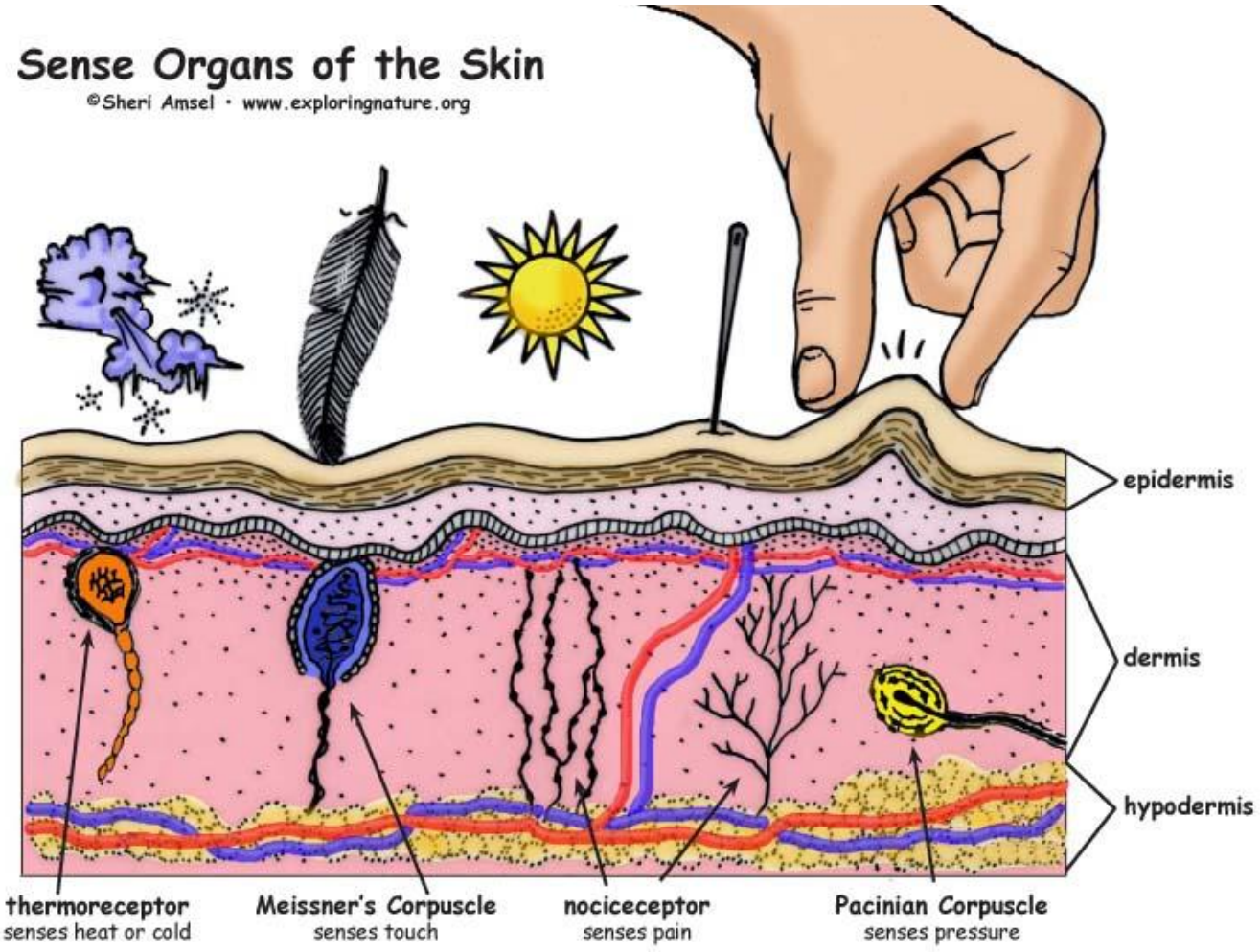


Mechanisms by which Receptors Adapt

- First, the pacinian corpuscle is a viscoelastic structure so that after stimulation within few hundredths of a second, the fluid within the corpuscle redistributes, so that the receptor potential is no longer elicited.
- The second mechanism of adaptation of the pacinian corpuscle, but a much slower one, results from accommodation, which occurs in the nerve fiber itself. This probably results from progressive "inactivation" of the sodium channels in the nerve fiber membrane

C/Sensory Receptors Types Based on their adequate stimulus

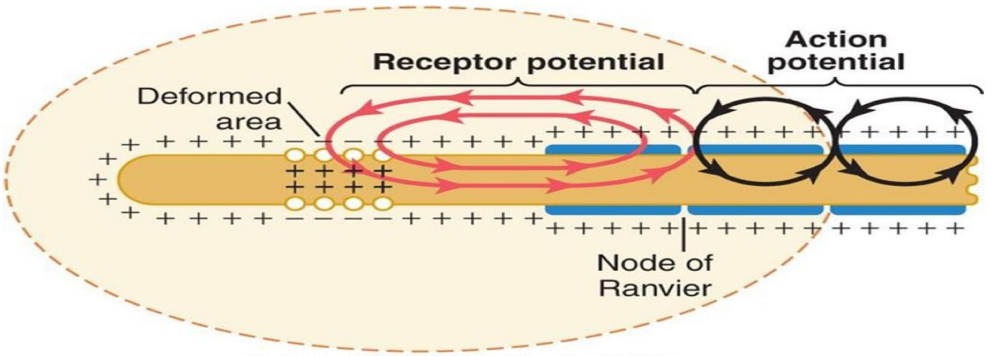
- **MECHANORECEPTORS**: which detect mechanical compression or stretching of the receptor or of tissues adjacent to the receptor eg proprioceptors
- **THERMORECEPTORS**: which detect changes in temperature, some receptors detecting cold and others warmth.
- **NOCICEPTORS** (pain receptors): which detect damage occurring in the tissues, whether physical damage or chemical damage eg free nerve endings
- **ELECTROMAGNETIC** RECEPTORS: which detect light on the retina of the eye eg rods and cones
- **CHEMORECEPTORS**: which detect taste in the mouth, smell in the nose, oxygen level in the arterial blood, osmolality of the body fluids, carbon dioxide concentration, and perhaps other factors that make up the chemistry of the body. Eg chemo R in carotid bodies



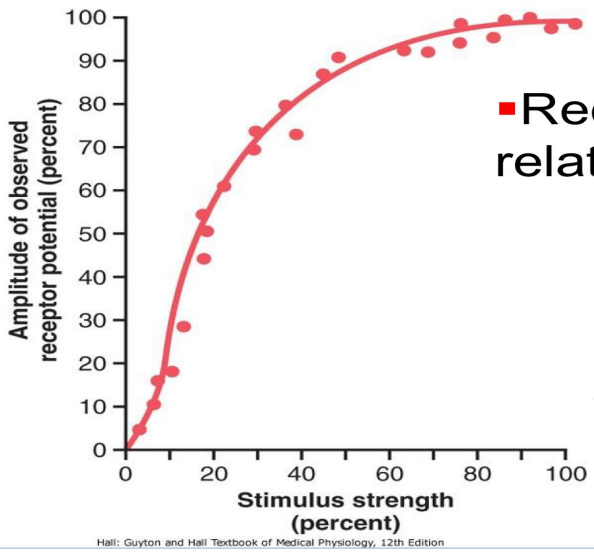
Activation of Sensory Receptors: Generation of Receptor Potential (RP)

Generation of Action Potential:

- Stimuli (mechanical, thermal, chemical) cause deformation in the sensory receptors
- This causes influx of positive ions and generation of RP
- RP induces a local circuit of current flow that spreads along nerve fiber and generates APs when threshold is reached



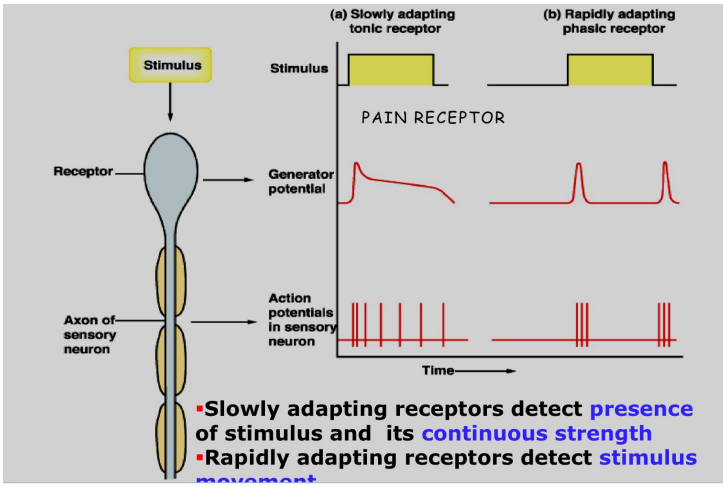
Relation Between Stimulus Strength & Receptor Potential Amplitude:



Hall: Guyton and Hall Textbook of Medical Physiology, 12th Edition

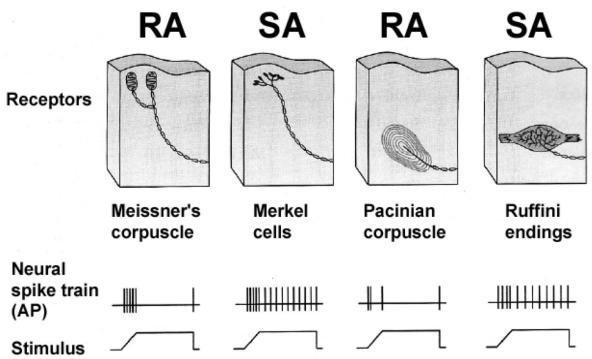
- Receptor potential is directly related to stimulus strength

Dr's note:
-Increase stimulus lead to increase amplitude of action potential generation.
-Increase stimulus lead to increase rate of frequency of generated action potential



- Slowly adapting receptors detect presence of stimulus and its continuous strength
- Rapidly adapting receptors detect stimulus movement

Examples of RA and SA Receptors



Muscle spindles & nociceptors are other examples of SA receptors

Classification of Nerve fibers

A/ General Classification

1-Myelinated (A- fiber)
- Aα (thickly myelinated)
- Aβ (intermediate m.)
- Aδ (thinly myelinated)

2-Unmyelinated (C-fiber)

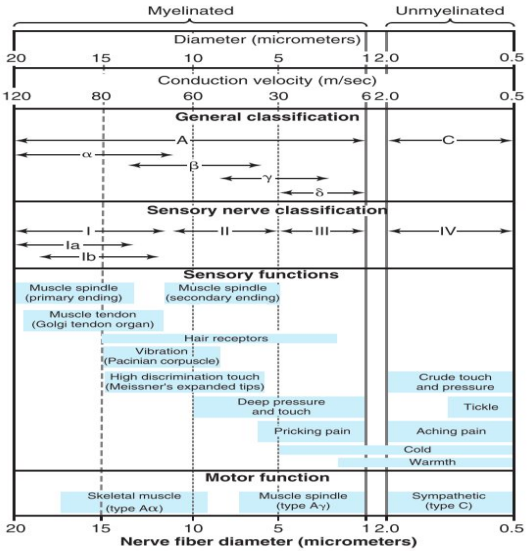


Figure 47-6. Physiological classifications and functions of nerve fibers.

B/ Numerical Classification

TABLE 4-1 Types of mammalian nerve fibers.

Fiber Type	Function	Fiber Diameter (μm)	Conduction Velocity (m/s)	Spike Duration (ms)	Absolute Refractory Period (ms)
Aα	Proprioception; somatic motor	12–20	70–120		
Aβ	Touch, pressure	5–12	30–70	0.4–0.5	0.4–1
Aγ	Motor to muscle spindles	3–6	15–30		
Aδ	Pain, temperature	2–5	12–30		
B	Preganglionic autonomic	<3	3–15	1.2	1.2
C, Dorsal root	Pain, temperature	0.4–1.2	0.5–2	2	2
C, Sympathetic	Postganglionic sympathetic	0.3–1.3	0.7–2.3	2	2

TABLE 4–2 Numerical classification of sensory nerve fibers.

Number	Origin	Fiber Type
Ia	Muscle spindle, annulo-spiral ending	Aα
Ib	Golgi tendon organ	Aα
II	Muscle spindle, flower-spray ending; touch, pressure	Aβ
III	Pain and cold receptors; some touch receptors	Aδ
IV	Pain, temperature, and other receptors	Dorsal root C

What Are the Stimulus Features That Are Mediated by Sensory Receptors?

Sensory receptors mediate 4 features of a stimulus:

1-Modality: is what we perceive after a stimulus.
-Examples of sensory modalities: vision, hearing, smell, taste, touch and temperature
-Each modality has many sub-modalities (e.g. taste can be sweet, bitter, sour, salty), Temperature sub-modalities: cold and heat

2-Intensity: depends on the stimulus strength and is encoded by action potential frequency.

3-Location: the site on the body or space where the stimulus originated.

4-Duration: time from onset to offset of a stimulus.
-If persists for long time, the perceived intensity diminishes (adaptation)

❖ To know about proprioceptors its definition and its role in body balance.

PROPRIOCEPTION

- Perception about the relative positions of different body parts and strength of effort being employed in movements.

It can be divided into:

1. Static position sense: which means conscious perception of the orientation of the different parts of the body with respect to one another

   هذا يعني اذا طلبت من المريض يغلق عيونه ورفعت اصبعه لأعلى او لأسفل وتسأله وين تحس اصبعك فيه فوق ولا تحت

2. Dynamic proprioception: rate of movement sense: also called kinesthesia or dynamic proprioception

   وهذا يعني انك تمسك اصبع من اليد مثلاً وتحركه لأعلى واسفل بسرعة معينه وتسوي مره ثانية بسرعة مختلفة وتسأل المريض هل فرق في السرعة او نفس بعض

Structures concerned with proprioception:

1. Proprioceptors (spatial orientation, four inputs).
2. Brain Stem (Cortico, Rubro, Vestibulo, Reticulo, Olivo, Tectospinal).
3. vestibular system (apparatus, nuclei).
4. Ascending Tracts.
5. Visual system.
6. Cerebellum (flocculonodular lobe → dynamic equilibrium, Uvula → Static equilibrium).
7. Cerebral cortex (primary cortical center for equilibrium located in the parietal lobe deep in the sylvian fissure).

Types of Proprioception:

1. Conscious proprioception: reach the level of cerebral cortex sensory area via dorsal column tract.
2. Subconscious proprioception: reach the level of cerebellum via spinocerebellar tracts (Ventral & Dorsal) ,these are main ascending sensory pathways for proprioception

Role of Proprioception

Proprioception informs us about:
- The location of a body part in relation to other parts
- The rate of movement of a body part when it is moving
- The degree to which our muscle are being contracted or stretched
- The amount of tension created in our tendons
- The head orientation in relation to the ground and in response to movement

Proprioceptive information is carried from periphery to the CNS by proprioceptors and other somatic receptors

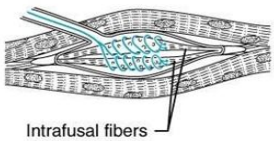
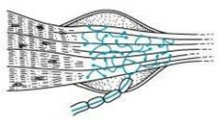
❖ To know about proprioceptors its definition and its role in body balance.

Three Types of Proprioceptors:

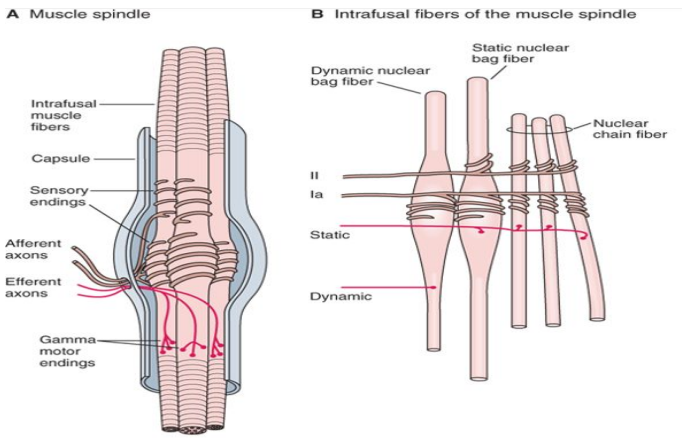
Proprioceptors include the muscle spindles, Golgi tendon organs, and joint receptors. These provide a sense of body position and allow fine control of skeletal movements

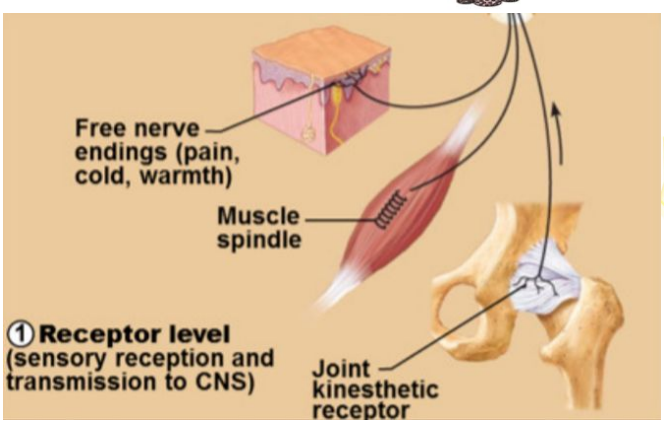
- 1)Muscle spindles:
  - measure the changing length of a muscle
  - Imbedded in the perimysium between muscle fascicles
- 2)Golgi tendon organs:
  - located near the muscle-tendon junction
  - Monitor tension within tendons (locomotory organs)
- 3)Joint kinesthetic receptors:
  - Sensory nerve endings within the joint capsules

14.1 General Sensory Receptors Classified by Structure and Function *(continued)*

Structural Class	Illustration	Functional Class According to Location (L) and Stimulus Type (S)	Body Location
PROPRIOCEPTORS			
Muscle spindles		L: Proprioceptors S: Mechanoreceptors (muscle stretch)	Skeletal muscles, particularly those of the extremities
Golgi tendon organs		L: Proprioceptors S: Mechanoreceptors (tendon stretch)	Tendons
Joint kinesthetic receptors (Pacinian and Ruffini endings, free nerve endings, and receptors resembling Golgi tendon organs)		L: Proprioceptors S: Mechanoreceptors and nociceptors	Joint capsules of synovial joints

1





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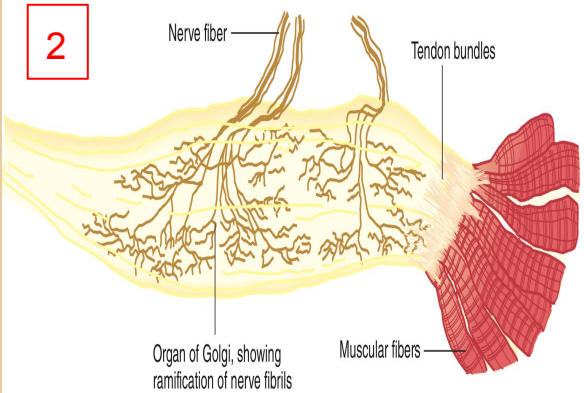


❖ Identify the major sensory pathways to the cerebral - with consciousness-

SENSORY TRACTS

- DORSAL COLUMN SYSTEM
- ANTEROLATERAL SYSTEM

Each system carries different types of sensations which are known as MODALITIES like pain,temperature,finetouch,crude touch, vibration, proprioception etc

1. Dorsal column pathway
carries signal of fine touch(two point discrimination), pressure, vibration, stereognosis and proprioception,
2. Spinothalamic pathway
carries signals of pain, temperature, deep pressure, and crude touch.
3,4-Posterior and anterior spinocerebellar pathways
carry subconscious proprioception.Dorsal gray horn-to lateral column-to medulla oblongata-to pons–to cerebellum.

DORSAL COLUMN MEDIAL LEMNISCAL SYSTEM "Advanced types of sensations"

1.Touch sensations requiring a high degree of localization of the stimulus
2.Touch sensations requiring transmission of fine gradations of intensity
3.Phasic sensations like vibratory sensations
4.Sensations that signal movement against skin
5.Joints Position sensations (Proprioception)
6.Pressure sensations requiring fine degrees of judgment of intensity
7.Strereognosis

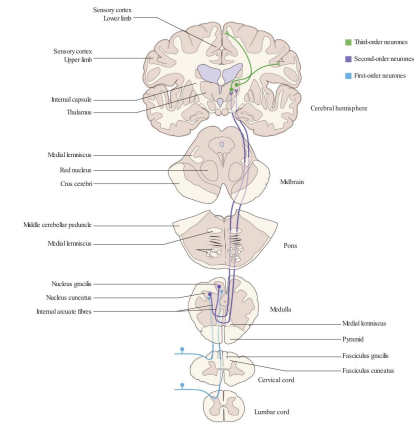


Figure 8.16 **Dorsal columns.** The central pathways carrying conscious proprioception and discriminative touch are illustrated.

-Fine Touch
-Fine Pressure
-Vibration
-Position

ANTEROLATERAL SYSTEM (Ventral & lateral spinothalamic tracts)

1.Pain
2.Thermal sensations, (warmth & cold)
3.Crude touch and pressure sensations capable only of crude localizing ability on the surface of the body
4.Tickle and itch sensations
5.Sexual sensations

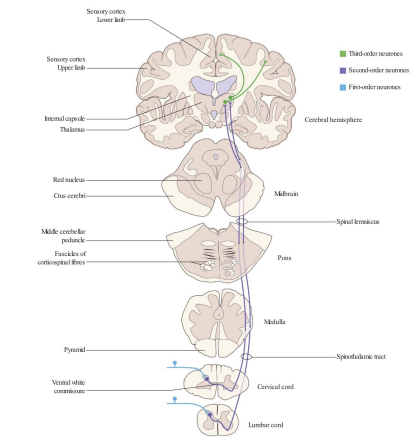
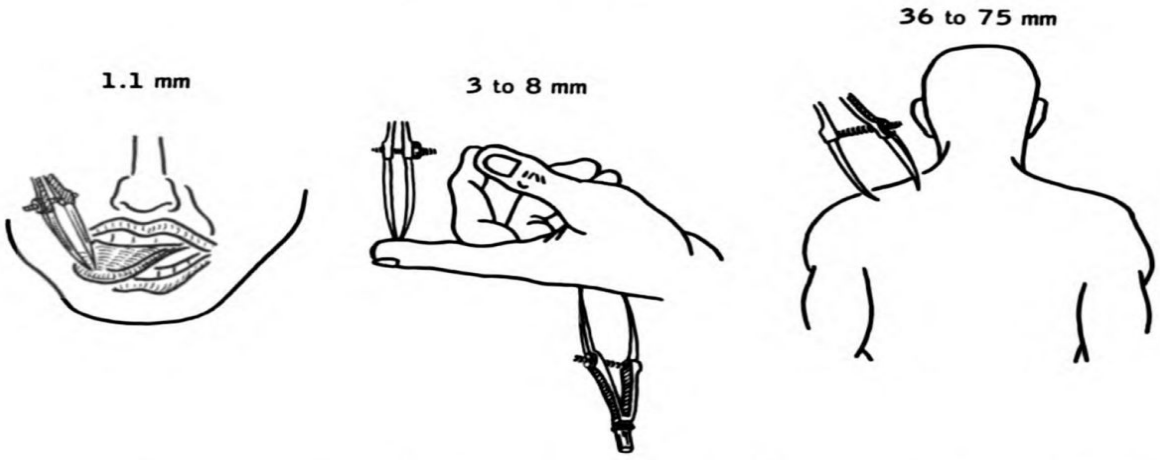


Figure 8.17 **Spinothalamic tract.** The central pathways for pain, temperature, touch and pressure are illustrated.

If you want Dr.Najeeb explanations for tracts click here

Mid term part

Two point discrimination in the dorsal column



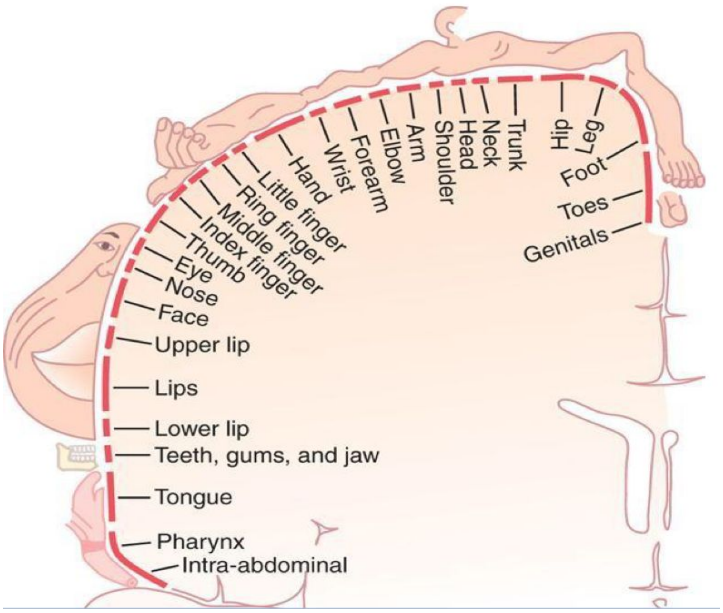
معناها قدرة الجسم على الاحساس بان هناك جسمين يلامسانه وليس 1- جسم واحد
في الكتف لو كان المسافة بين الجسمين ٣ مل متر الاحساس عندنا بيصير كأن جسم واحد يلامسنا
لكن في اليد لو كان بين الجسمين ٣مل متر راح يجينا احساس انها جسمين بعكس الكتف ليه ؟

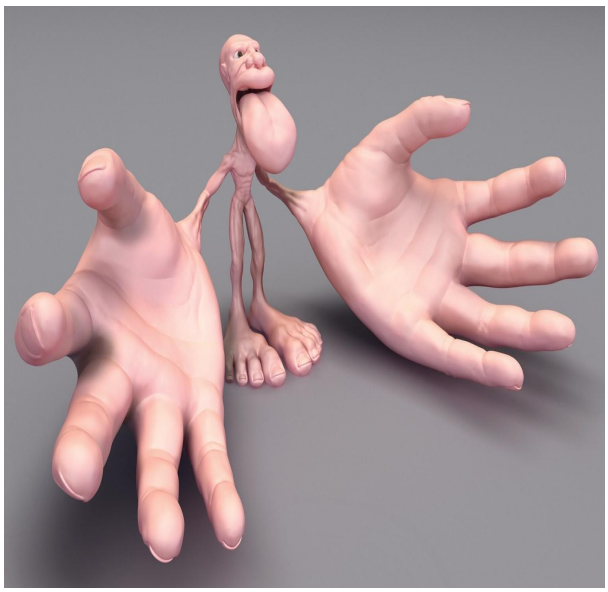
Number of receptors
Area of representation

الدكتورة ركزت عليها

Sensory Homunculus (Little Man)

- Body is represented upside-down, with large representation of hands & lips
- The extent of representation is proportional to the density of sensory receptors





❖ Identify the major sensory pathways to the cerebellum - unconscious & its damage

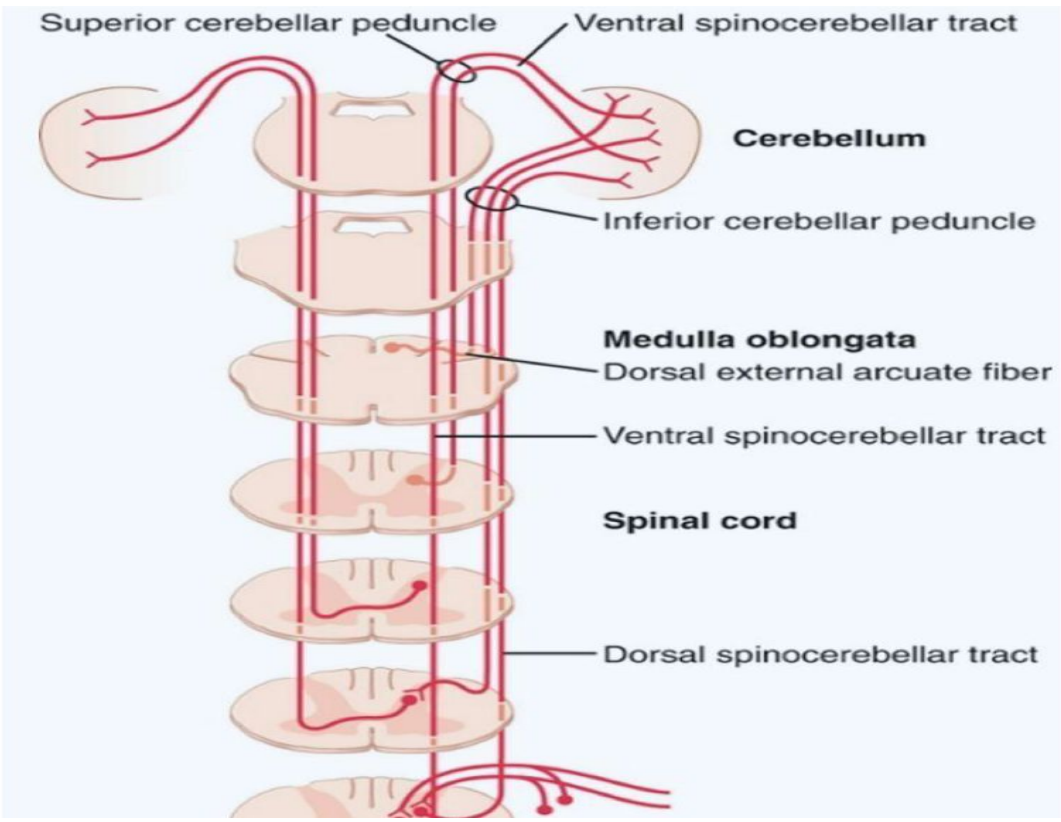
The Dorsal & Ventral Spinocerebellar Tracts

1-**The Dorsal Spinocerebellar tract (dSCT)**

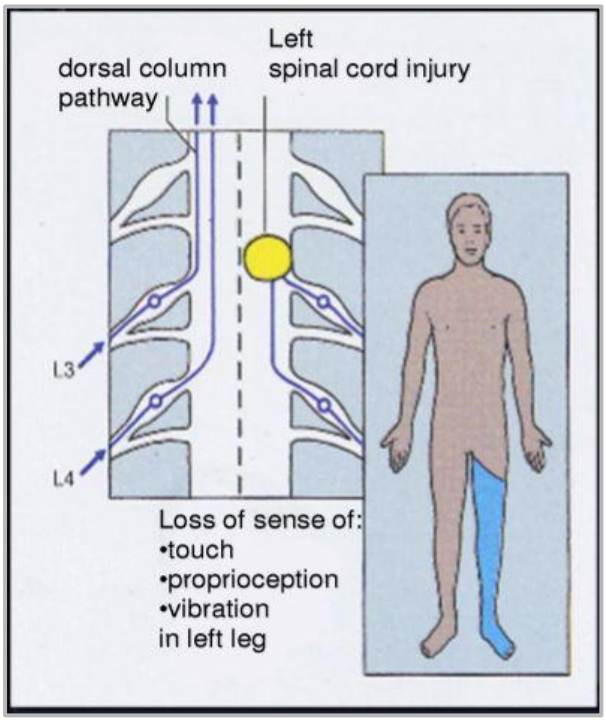
- Carry signals directly to cerebellum at a speed of up to 120 m/s mainly from muscle spindles, but also from GTO, skin receptors & joint receptors
- Enter cerebellum through inferior cerebellar peduncle
- Terminate in vermis & intermediate zone
- Functions of dSCT are to informs the cerebellum about:
- **Muscle length and contraction**
- **Degree of tension on tendons**
- **Position and rate movement of parts of body.**
- **Forces acting on the body surfaces**

2-**The Ventral Spinocerebellar tract (vSCT):**

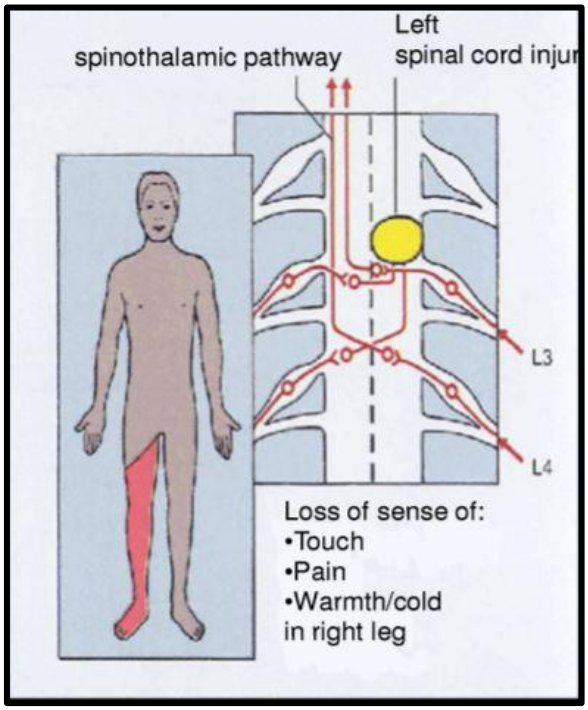
- Carry some signals from periphery (mainly from Golgi tendon organs) directly to cerebellum, but excited mainly by descending motor signals from brain (corticospinal & rubrospinal tracts) and from the spinal cord itself
- Enter cerebellum through superior cerebellar peduncle and terminate on both sides of cerebellum
- Functions of vSCT:
- informs the cerebellum about:
- **Which motor signals have arrived to the spinal cord.**



❖ Damage of major sensory pathways to the cerebral - with consciousness-



Dorsal column lesion



Spinothalamic lesion

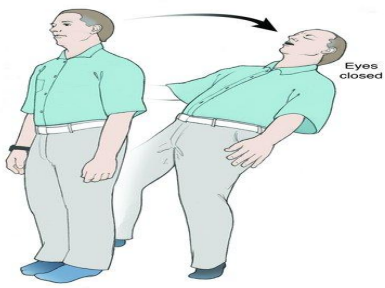
Dorsal column damage

- Sensory ataxia
- Patient staggers; cannot perceive position or movement of legs
- Visual clues help movement

Positive Romberg test (Ask the patient to close the eyes while standing: observe whether the patient becomes unstable)

The test depends on the integrity of proprioception from the joints of the legs.

If the damage above the decussation the abnormality will occur contralateral



Positive Romberg test

Ataxia and Gait Disturbances

Ataxia: inability to coordinate voluntary muscular movements that is due to nerve damage (CNS or PNS) and not due to muscle weakness (called also incoordination)

- Pathophysiology

– Result from any condition that affects the central and peripheral nervous systems
– Ataxia Types :
  ▪Motor ataxia
  ▪Sensory ataxia

▪Motor Ataxia

–Caused by **cerebellar** disorders
  ▪ Intact sensory receptors and afferent pathways
  ▪Integration of proprioception is faulty
  ▪Midline cerebellar lesions cause truncal ataxia
  ▪Lateral cerebellar lesions cause limb ataxia
  ▪Thalamic infarcts may cause contralateral ataxia with sensory loss

Features of Cerebellar ataxia

- Clumsy movements.
– Wide-based, reeling gait (ataxia)
–Incoordination of the limbs (intention tremor)
–Alcoholic intoxication produces similar effects!

SENSORY ATAXIA

▪Peripheral **sensory** lesions (e.g. polyneuropathy) cause ataxia because there is loss of the sense of joint position proprioception.
Broad-based, high-stepping, stamping gait develops.
▪This ataxia is made worse by removal of additional sensory input (e.g. **vision**) and is worse in the dark.
First described in sensory ataxia of tabes dorsalis, this is the basis of Romberg's test>>
Ask the patient to close the eyes while standing: observe whether the patient becomes unstable (and prevent falling).

❖ Quick review

★ **Proprioception:** Perception (sense) about the relative **positions** of different body parts and **strength** of effort being employed in movements.
Can divide into: Static position sense & Rate of movement (sense kinesthesia or dynamic proprioception)

★ **Types:**
1- Conscious proprioception: reach the level of **cerebral cortex** sensory area via **dorsal column tract**
2- Subconscious proprioception: reach the level of **cerebellum** via **spinocerebellar tracts**

★ **Proprioceptors:** provide a sense of **body position** and allow **fine control** of skeletal movements. **Types:**
1-Muscle spindles: Imbedded in the perimysium between muscle fascicles measure the changing **length of a muscle**
2- Golgi tendon organs: located near the muscle-tendon junction
Monitor **tension** within tendons
3- Joint kinesthetic receptors: Sensory nerve endings within the joint capsules

★ **Adaptation of receptor (Types)**
1- Rapid adapting or **phasic** receptors: eg meissner's corpuscles(**touch**), pacinian corpuscles (**vibration**)
2- Slowly adapting or **tonic** receptors: eg ruffini's (**pressure** ,**skin stretch**)

★ **3- Non adapting receptors:** eg Free nerve endings for pain sensation

★ **Activation of Sensory Receptors:**
Stimuli (mechanical, thermal, chemical) → cause **deformation** in the **sensory receptors** → causes **influx** of **+ve ions** & **generation** of **receptor potential** → **induces** a **local circuit** of current flow → **spreads** along nerve fiber & **generates action potentials** when threshold is **reached**

★ Receptor potential is directly related to stimulus strength

Dorsal column damage	Spinocerebellar tract damage
Sensory ataxia Patient **staggers**; cannot perceive **position** or **movement of legs** **Visual clues** help movement Positive Romberg test	**Cerebellar ataxia** **Clumsy** movements **Incoordination** of the **limbs (intention tremor)** Wide-based, reeling gait **(ataxia)** *Alcoholic intoxication produces similar effects!

Ataxia: result from any condition that **affects CNS & PNS**

Sensory Ataxia	**Motor** ataxia
Peripheral sensory lesions (e.g. polyneuropathy) **lesion in thalamus & sensory** Made **worse** in **the dark** or **no vision** Romberg's test	Caused by **cerebellar disorders** Intact sensory receptors & afferent pathways Integration of proprioception is faulty **Midline cerebellar lesions** cause **truncal ataxia** **Lateral cerebellar lesions** cause **limb ataxia**

❖ Questions

1) Which of these resembles encapsulated receptors?
A- Hair follicles receptors
B- Merkel disc
C- pacinian corpuscles
D- A&B

2) Tickle and itch sensation is carried by:
A- Dorsal column
B- Lateral spinothalamic tract
C- ventral spinothalamic tract
D- B&C

3) What type of receptors are located in carotid bodies?
A- Thermoreceptors
B- Mechanoreceptors
C- Chemoreceptors
D- Nociceptors

4) Thalamic infarcts may cause:
A- Contralateral ataxia
B- Contralateral ataxia with sensory loss
C- Ipsilateral ataxia with sensory loss
D- Ipsilateral ataxia

5) Which one is Rapid adapting receptor:
A- Merkel's disc
B- krause's end bulbs
C- Meissner's corpuscles(touch),
D- Non

SAQ

6) what are the three types of proprioceptors?

*Muscle spindles
*Golgi tendon organs
*Joint kinesthetic receptors

7) What are the structures that are concerned with proprioception ?

Proprioceptors
* Brain stem
* Vestibular system
* Ascending tracts

*Visual system
*Cerebellum
*Cerebral cortex

8) Mention the two types of proprioception

1-Conscious proprioception: reach the level of cerebral cortex sensory area via dorsal column tract.
2- Subconscious proprioception: reach the level of cerebellum via spinocerebellar tracts

9) Pacinian corpuscles' Ruffini's corpuscles are examples of ?

Joint kinesthetic receptors

10) two point discrimination depend on

*Number of receptors
*Area of representation

1. C
2. D
3. C
4. B
5. C