ANATOMY

SHEET NO. 3

WRITER : Doctor 018

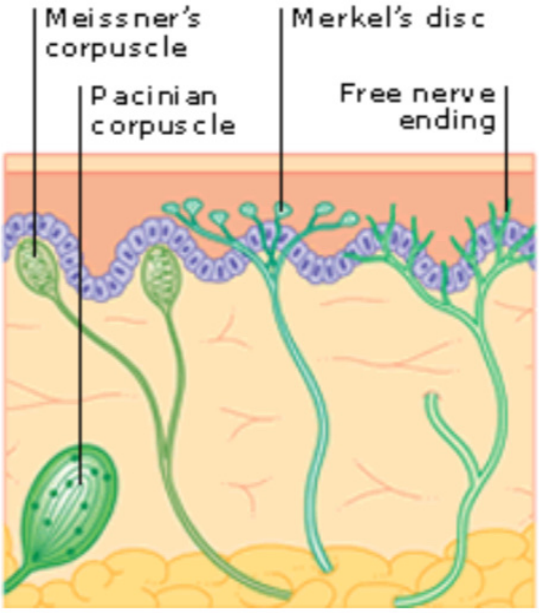
CORRECTOR : Shahed Hasanat

DOCTOR : Mohammad Alsalem

For the few next lectures, we'll talk about specific part of each tract like receptors, modality/type of sensation, anatomical location and organization for 1st, 2nd and 3rd order neurons in the CNS

Receptors

Sensation is basically converting one type of energy into a signal, and this is not possible without our dear receptors to receive this energy in the first place.



1. **Mechanoreceptors**

a. Meissner's corpuscle

They respond to touch, pressure, and low frequency vibration. Also, they are rapidly adapting (signals fade away after stimulus exposure).

b. Merkel's disc (Tactile Disc)

Respond to discriminative touch, and they are slowly adapting (signal is transmitted as long as the stimulus is present).

c. End organ of Ruffini

They are sensitive to skin stretch and slowly adapting.

d. Pacinian corpuscles

They respond to high frequency vibrations, and they are rapidly adapting.

2. **Thermoreceptors**

A type of free nerve endings, and they detect changes in temperature. TRP channels are an example of thermoreceptors .

Processes existing on the skin/ Bare.They have receptors called TRP (TRPV1, TRPC, TRPM …etc) each one of them is specialized for specific range of temperature , for example,TRPV2 IS ACTIVATED after 52, TRPV1 is activated after 45.

3. **Nociceptors**

A type of free nerve endings, and they detect damage (pain receptors).

They are multimodal; since there is no such thing as "pain" energy. Pain is considered as an exaggeration of a certain type of energy, e.g. too much heat, too much pressure.

→ After the signal is received by receptors, it is conducted through peripheral nerve fibers to reach the CNS

Adaptation of receptors occurs when a receptor is continuously stimulated. Many receptors become less sensitive with continued stimuli. Rapidly adapting receptors are best at detecting rapidly changing signals and signal fades away when the stimulus exposures , while slowly adapting receptors are capable of detecting a long, continuous signal, and signal is transmitted as long as the stimulus present

Here is all about these fibers:

ELECTROPHYSIOLOGIC CLASSIFICATION OF PERIPHERAL NERVES	CLASSIFICATION OF AFFERENT FIBERS ONLY (CLASS/GROUP)	FIBER DIAMETER (µm)	CONDUCTION VELOCITY (m/s)	RECEPTOR SUPPLIED
Sensory Fiber Type				
Aα	Ia and Ib	13-20	80-120	Primary muscle spindles, Golgi tendon organ
Aβ	II	6-12	35-75	Secondary muscle spindles, Skin mechanoreceptors
Aδ	III	1-5	5-30	Skin mechanoreceptors, thermal receptors, and nociceptors (fast pain)
C	IV	0.2-1.5	0.5-2	Skin mechanoreceptors, thermal receptors, and nociceptors (slow pain)
Motor Fiber Type				
Aα	N/A	12-20	72-120	Extrafusal skeletal muscle fibers
Aγ	N/A	2-8	12-48	Intrafusal muscle fibers
B	N/A	1-3	6-18	Preganglionic autonomic fibers
C	N/A	0.2-2	0.5-2	Postganglionic autonomic fibers

Notes about this table:

1. We are starting with the sensory part, so we are only concerned with sensory fibers here.

2. The difference between these fibers is the myelination (C aren't myelinated), and the diameter with Aα being the largest and C the smallest.

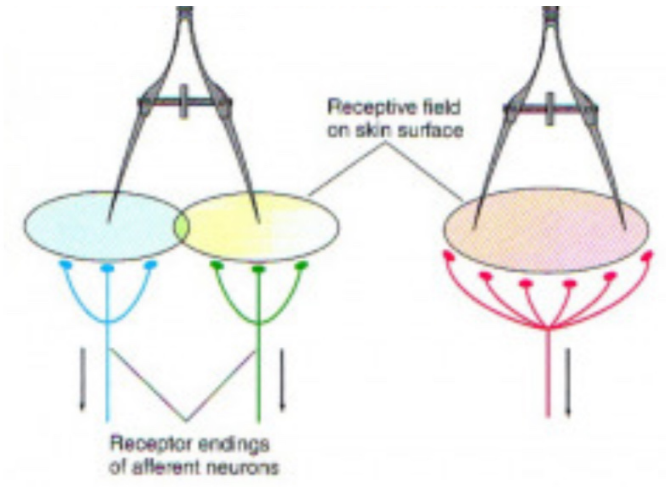
3. The greater the diameter, the greater the conduction velocity (directly proportional). (Aα > Aβ > Aδ > C) in terms of diameter as well as velocity.

4. Muscle spindles are stretch receptors that detect the length of the muscle.

5. Golgi tendon organ are receptors that detect the tension in the tendons.

Receptive field

An area of skin that receives sensation from a single nerve fiber (receptor).

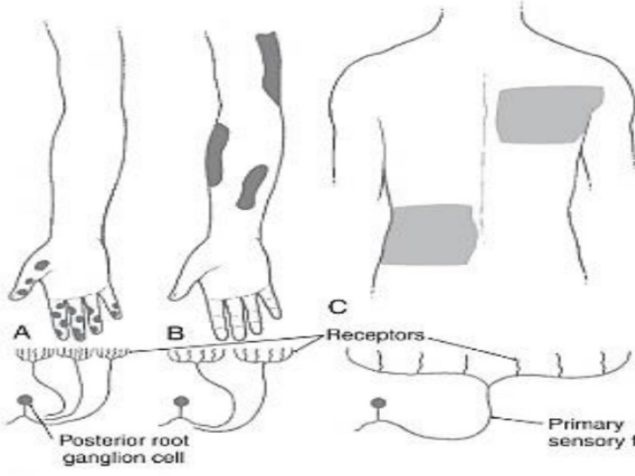


If we apply the concept of receptive fields here, we'll conclude that each circle represents a single receptive field (as each receives sensation from a single fiber). The importance of this lies in the fact that the brain can discriminate a receptive field as an individual area; no matter how big or small the area is as long as it has its own fiber. Here, the brain can distinguish the two points of the compass as two distinct points in the case of the yellow and blue receptive fields. But it'll only feel as one point in the case of the pink one.

And as a result:

a. The greater the density of receptors (e.g.in the hand), the smaller the receptive fields of individual afferent fibers.

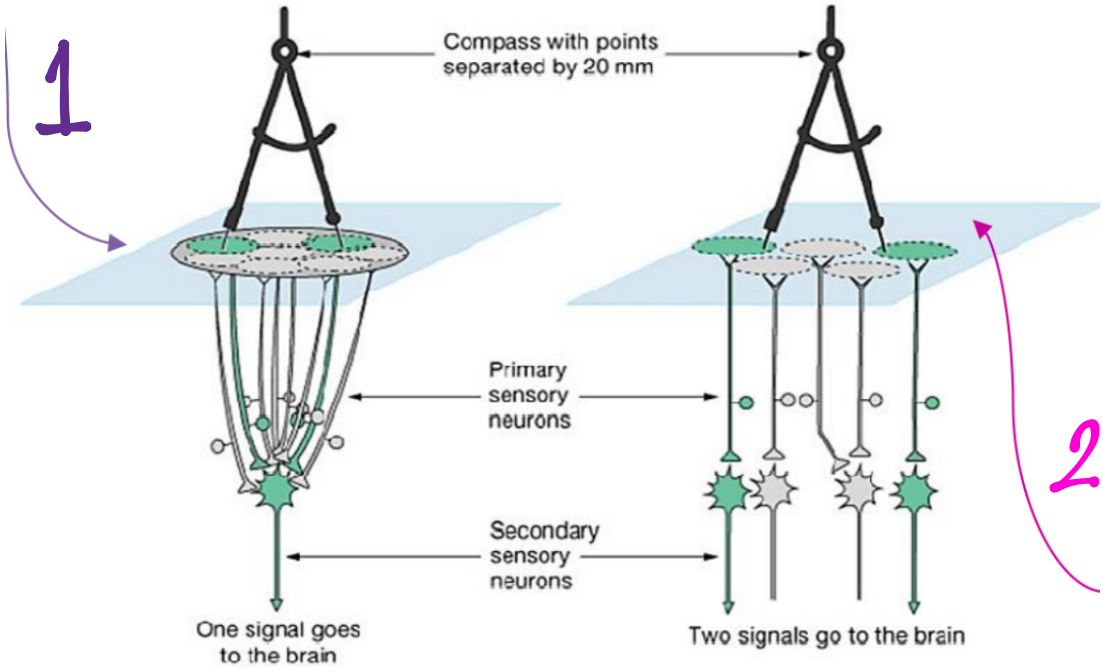
b. The smaller the receptive field, the greater is the acuity or the discriminative touch.



But frankly, it's not that simple. Remember when we said that in the sensory system we have 1st order neuron, 2nd, and a 3rd?

1- If many primary sensory neurons converge onto a single secondary neuron, this creates a very large receptive field. The two stimuli will be perceived as a single point because both stimuli fall within the same receptive field.

2- However, if fewer neurons converge, secondary receptive fields are much smaller, and the two stimuli activate separate pathways and are perceived as distinct stimuli.



Labelled line theory

This theory says that

- individual primary afferent fibers carry information from a single type of receptor.

i.e. an afferent fiber has only one type of receptors (mechano, thermo, or nociceptors). In this way, the brain can tell the signals apart, since each fiber is "labelled" with a certain type of receptor that ONLY responds to a certain type of energy, e.g. pressure cannot stimulate thermal receptors.
-Therefore, pathways carrying sensory information centrally are also specific, forming a "labelled line" regarding a particular stimulus

- Individual receptors preferentially transduce information about an adequate stimulus. An adequate stimulus is the amount and type of energy required to stimulate a specific sensory organ. (e.g. thermoreceptors only respond to heat, and specific channels only respond to heat above a certain degree).

So, when we talk about **sensation**, there are three things to consider:
a. Modality (type)
b. Locality (remember the homunculus of the brain)
c. Intensity

Ascending sensory tracts

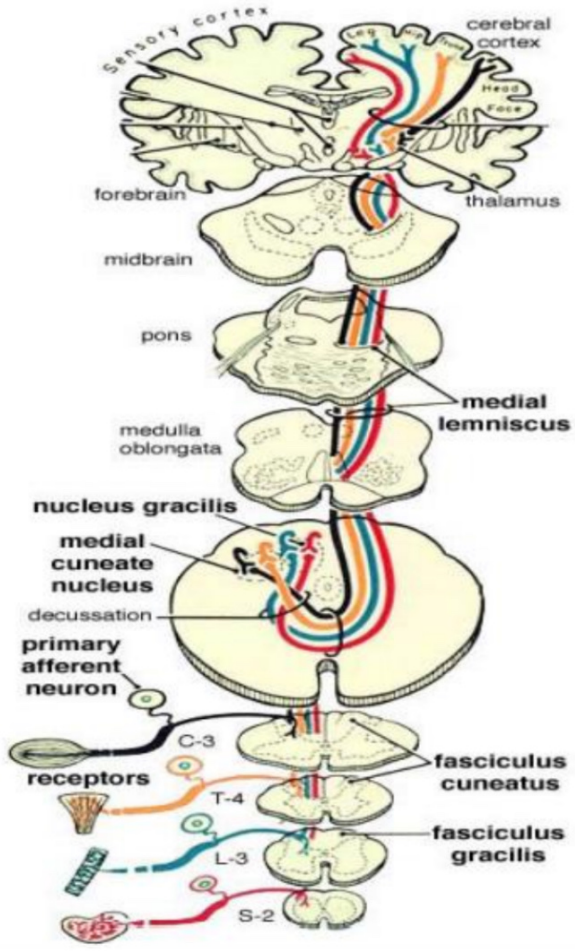
The Posterior Column – Medial Lemniscal Pathway

› Located in the posterior white column of the spinal cord (hence the name!).
› The posterior white column is divided into two fasciculi on each side, fasciculus gracilis (medially) and fasciculus cuneatus (laterally).

Modality:

Discriminative Touch Sensation (the ability to discriminate when touched in two different points) ,including Vibration and Conscious Proprioception
➔ Proprioception is a muscle joint sense, by which the CNS knows how every muscle and
joint of the body is positioned in space. It is very important for motor coordination, in order for me to make a move I need to know my initial position, the position I want to achieve with the move, and how each muscle should change to achieve it.
➔ Conscious proprioception: the proprioception that reaches the cortex (unconscious only reaches cerebellum).

- keep in mind-> The posterior column is a sensation pro. It specializes in high velocity and precise signals.



Receptor: Most types of receptors (like spindles and GTO) except free nerve endings.

1st order Neuron:

Cell bodies lie in the Dorsal Root Ganglion (Cell bodies of the 1st neurons are pseudo-unipolar. They have a single stalk that divides into two processes: one that goes peripherally and one that ascends centrally).
-Journey:

1. Mechanoreceptors enter the posterior white column, their fibers ascend upwards ipsilaterally (on the same side they came from), they go up till they reach the lower part of medulla oblongata, and there they synapse with the bodies of second order neurons.

2. 2nd neurons' bodies collect in two nuclei; one that is more medial called **nucleus gracilis** (fasciculus gracilis fibers synapse in it) and one that is more lateral called **nucleus cuneatus** (fasciculus cuneatus fibers).
—Fasciculus: is a bundle of ascending white matter from 1st order neuron.

2nd Neuron:

-Journey summary :

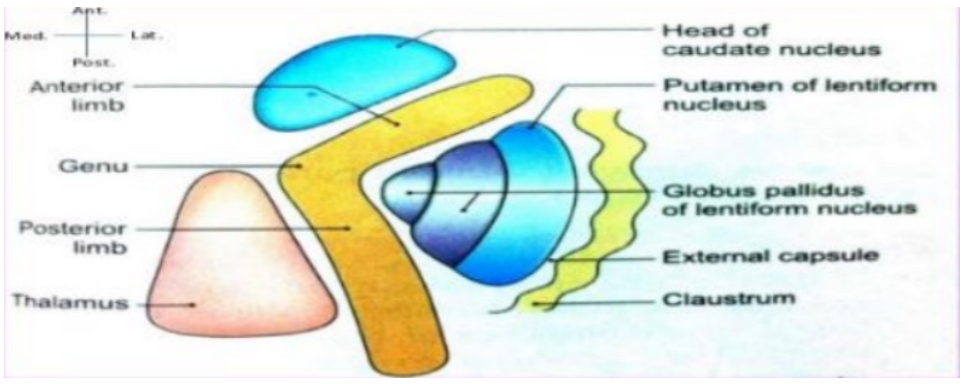
Dorsal Column Nuclei (Nucleus Gracilis and Cuneatus) —>Internal Arcuate Fiber—>Lemniscal Decussation —>Medial Lemniscus
-Details:
The processes of the second order neurons in the lower part of medulla oblongata cross over to the other side (performing primary sensory decussation) creating an arch, which is why we call them 'internal arcuate fibers', then ascend contralaterally.

➔ As they go up, these fibers gather and lie close to the midline, forming a lemniscus (an elongated shape) called medial lemniscus. They keep ascending through the medulla oblongata, pons, and midbrain until they reach the thalamus where they synapse with the third order neurons.
—Medial lemniscus: Elongated bundle of white matter
— keep in mind: At this level, the sensation is carried contralaterally.

3rd Neuron:

— Journey summary: Thalamus (VPL) (Internal Capsule ----- Corona Radiata)
— Details:
Ventral posterolateral nucleus (VPL) is the thalamic nucleus related to the posterior white column. It receives the medial lemniscus where the synapse between the second and third order neurons takes place. 3rd neurons project from the thalamus towards the cortex (the outer aspect of the cerebrum (telencephalon)).

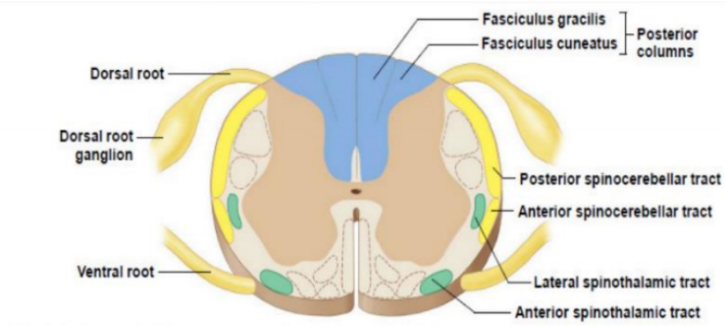
➔ As the fibers head towards the cortex, they pass through a critical narrow area between multiple nuclei (caudate nucleus, the thalamus medially and the lentiform nucleus laterally) and this area is called **internal capsule.**
-It's Called projecting centre because it connects upper centre with lower centre.



➔ As they approach the cortex, the fibers spread out forming **corona radiata,** here they show localization as each body part is represented by these fibers on a specific area.

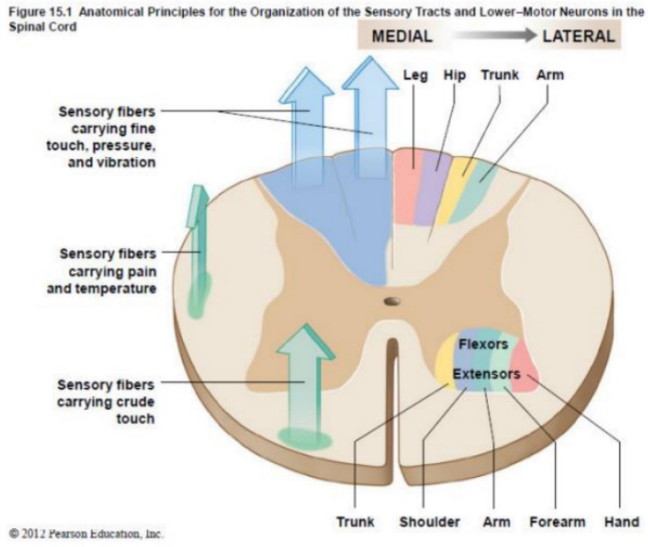
• Termination: the part of the cortex they terminate into is known as primary somatosensory (Somesthetic) Area (SI), a part of the parietal lobe.

—What is the difference between fasciculus gracilis and cuneatus?
They hold the same function, but fasciculus gracilis transmits information coming from areas inferior to T6 (lower parts of the body) while Cuneatus transmits above it (upper part of the body).

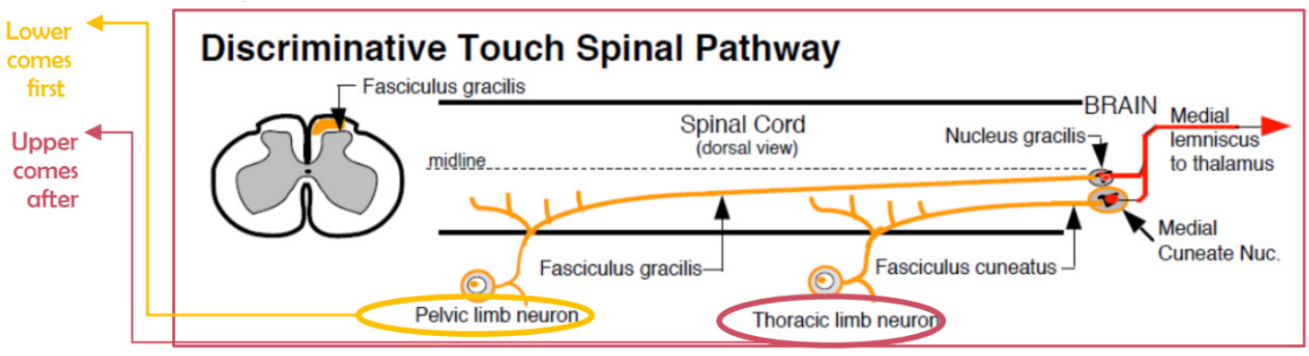


Discriminative touch, vibratory sense, and conscious muscle-joint sense
•**Posterior Column tract consists of:**
•**Fasciculus gracilis**
•Transmits information coming from areas inferior to T6
•**Fasciculus cuneatus**
•Transmits information coming from areas superior to T6

Figure 15.1 Anatomical Principles for the Organization of the Sensory Tracts and Lower-Motor Neurons in the Spinal Cord



explanation:
In the posterior WC-ML pathway, the fibers come ipsilaterally. Now, let's take a look at the lowest part of the body 'THE FOOT'. A fiber coming from the foot would be the first to enter, taking place in the first-row seats which happen to be the most medial part of the column. The fibers that come afterwards would then sit next to them and more laterally. Thus, the lower part is most medial, and the upper part is most lateral.
-Somatotopic principle exists here too. Just like the representational order on the cortex, there is also order in the spinal cord.
-modulation doesn't exist before T6
Here's an example:



- The thalamus is the secretary of the cortex.It's made of two egg?shaped collections of gray matter, and it consists of multiple nuclei (VPL, VPM, etc).
- The body is represented as a map/ homunculus(a tiny human representation) on the cortex which helps our CNS localize the body parts.