

# PHYSIOLOGY

**SHEET NO. 2**

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### This lecture we will:

- List the types of mechanoreceptive sensations and its receptors.
- Describe the two pathways for its transmission (dorsal column medial lemniscal tracts and anterolateral spinothalamic tracts).
- Follow these pathways to the cortex.
- Differentiate the two pathways.

### ✚ Classification of Somatic Sensations

- According to the type:
  - 1- **Mechanoreceptive**: they are stimulated by mechanical displacement.
    - **tactile**: touch, pressure, vibration, tickle and itch.
    - **position or proprioception**: static position and rate of change(dynamic).
  - 2- **Thermoreceptive**: detect heat and cold (they detect the changes in the stimulus).
  - 3- **Nociceptive (pain receptors)**: detect pain and they are activated by any factor that damages tissue.

### ✚ Tactile Receptors

- ✓ Free nerve endings
  - They are connected to A $\delta$  and C fibers.
- ❖ **Note**: A is myelinated fiber, C is unmyelinated fiber.
  - detect touch and pressure.
  - they're found everywhere in the skin and other tissues.
- ✓ Meissner's corpuscles
  - They are connected to A $\beta$  (large myelinated fiber).
  - rapidly adapting (within a fraction of a second) because they're encapsulated receptors.
  - detect movement of light objects over skin, sensitive to low frequency vibrations.
  - They are found on nonhairy skin (glabrous skin), fingertips and lips down in the epidermis.
- ✓ Merkel's discs
  - They are connected to A $\beta$ .
  - respond rapidly at first and then slowly adapt, detect the "steady state".
  - found on hairy as well as glabrous (non hairy) skin.
  - They detect touch.
- ✓ Hair end organ
  - found around hair shaft to detect the movement of hair.
  - adapts rapidly and detects movement over the body.

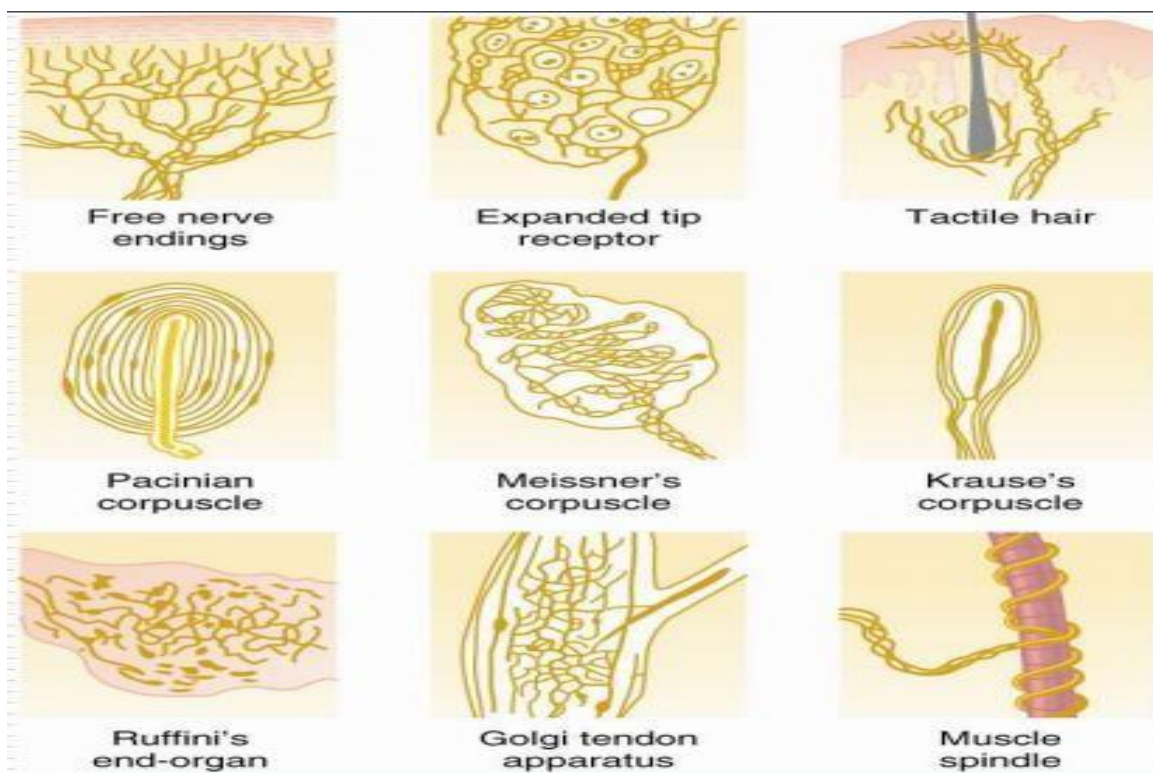
✓ **Ruffini's end organ**

- They are found deep in the dermis and detect the changes in pressure and joints formation.
- slowly adapting and respond to continual deformation of the skin and joint rotation.

✓ **Pacinian corpuscle**

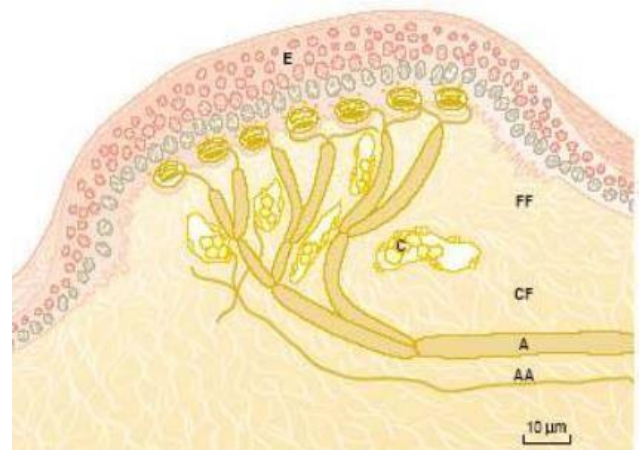
- They are found down in the dermis and connected to A $\beta$  fibers.
- very rapidly adapting because they're corpuscular and stimulated only by rapid movement.
- Detects [high frequency] vibration, pressure and other rapid changes in the skin.
- they are like onion rings.

✓ **Golgi tendon apparatus** and **muscle spindles**, they are found in the skeletal muscles.



✓ **Iggo dome receptors**

- ❖ Note the multiple numbers of Merkel's discs, they're connected to a single large myelinated fiber under epithelium.
- ❖ Detect touch.
- ❖ They are found under the hairy skin.



- Meissner's corpuscles, hair receptors, Pacinian corpuscles and Ruffini's end organs transmit signals in type **A $\beta$**  nerve fibers at 30- 70 m/sec (very fast).
- Free nerve endings transmit signals in type **A $\delta$**  nerve fibers at 5- 30 m/sec, some by type **C** unmyelinated fibers at 0.5-2 m/sec.
- The faster the rate of transmission the more critical the information so fine touch is transmitted very fast through **A $\beta$**  or **A $\alpha$** .

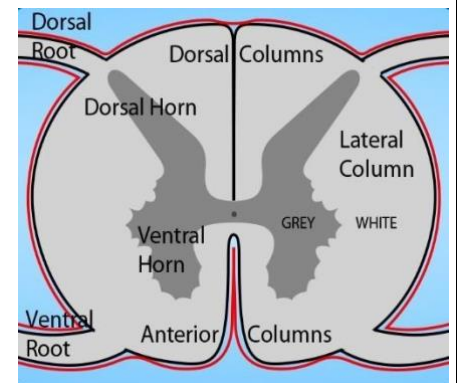
## ❖ Pathways for the Transmission of Sensory Information

- Almost all **sensory** information enter the spinal cord through the dorsal roots of the spinal nerves. Two pathways:

1. Dorsal column-medial lemniscal system
2. Anterolateral [spinothalamic] system

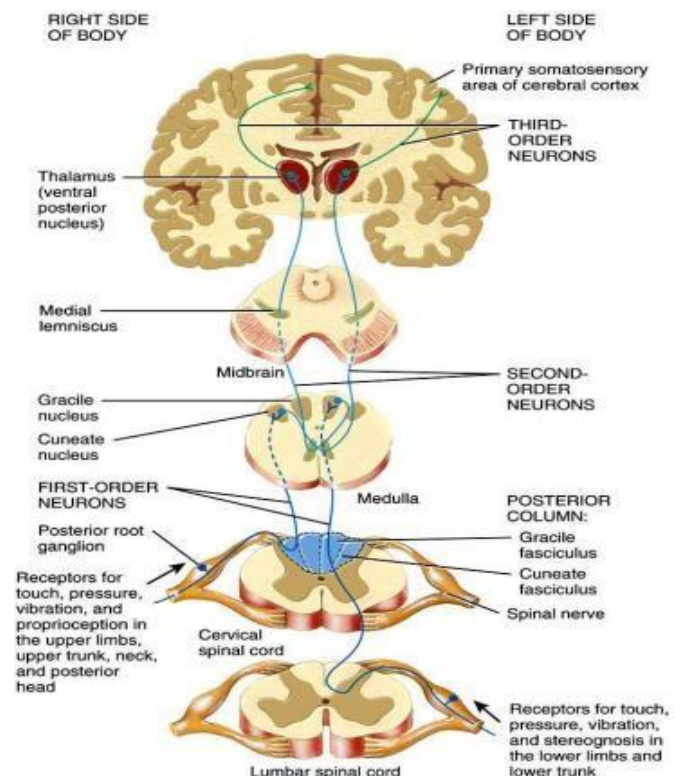
### ❖ Dorsal column-medial lemniscal system

- ✓ This tract ascends in the **dorsal column** of spinal cord and forms medial lemniscus.
- ✓ Contains large myelinated nerve fibers for **fast transmission** (30-110 m/sec), usually A $\beta$  fibers .
- ✓ High degree of **spatial orientation** that is maintained throughout the tract; the fibers come from each part in the body and arranged in highly organized way(**spatial fidelity**) .
- ✓ Transmits information rapidly with a high degree of spatial and **temporal fidelity** (**faithfulness**) (i.e., discrete types of mechanoreceptor information).
- ✓ **Spatial**>>position/space
- ✓ **Temporal**>>time
- ✓ **Modalities**: Fine touch, vibration, position, fine pressure and stereognosis.



### ➤ Pathway of the dorsal tract:

-The **afferent neurons** (1<sup>st</sup> order neurons) enter the spinal cord to the posterior horn, their cell bodies are found in dorsal root ganglia and they ascend until they reach their respective nuclei.



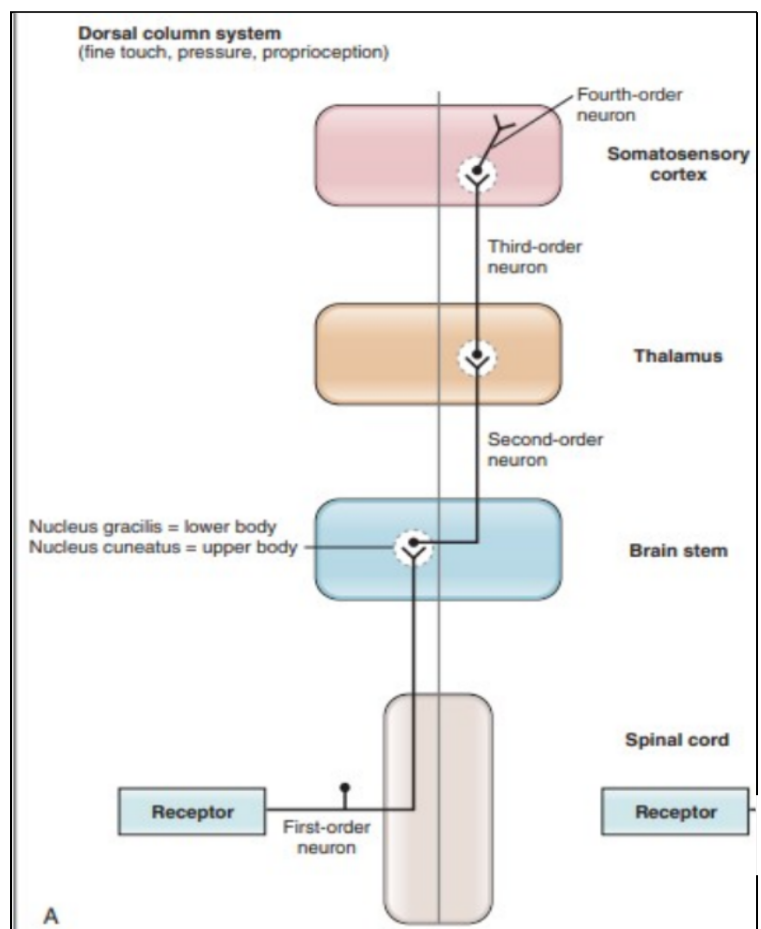


- **This tract consists of two parts:**

- ii. **Fasciculus gracilis** (medial): transmits information from the **lower** part of the body.
- iii. **Fasciculus cuneatus** (lateral): transmits information from the **upper** part of the body.

- Remember these two tracts are found in both sides in spinal cord and the crossing occurs in both sides.
- The information that comes from right side of the body are going to the left side of the cortex and vice versa (decussation).
- The left and right brain cannot work by themselves; they have to work together.

- i. They ascend until they reach their respective nuclei in the **medulla**, it contains **cuneatus nucleus** and **gracilis nucleus**, each of these tracts synapse in its nucleus with the **2<sup>nd</sup> order neuron**.
- ii. The **2<sup>nd</sup> order neuron** crosses the midline (decussates) in the medulla oblongata and ascends as **medial lemniscus** to the thalamus.
- iii. In the **thalamus** it goes to ventrobasal complex to synapse in VPL with the 3<sup>rd</sup> order neuron, the **3<sup>rd</sup> order neuron** ascends to **primary somatosensory cortex**.
- iv. Ventrobasal complex consists of two parts; ventral posterolateral (VPL) and ventral posteromedial (VPM).

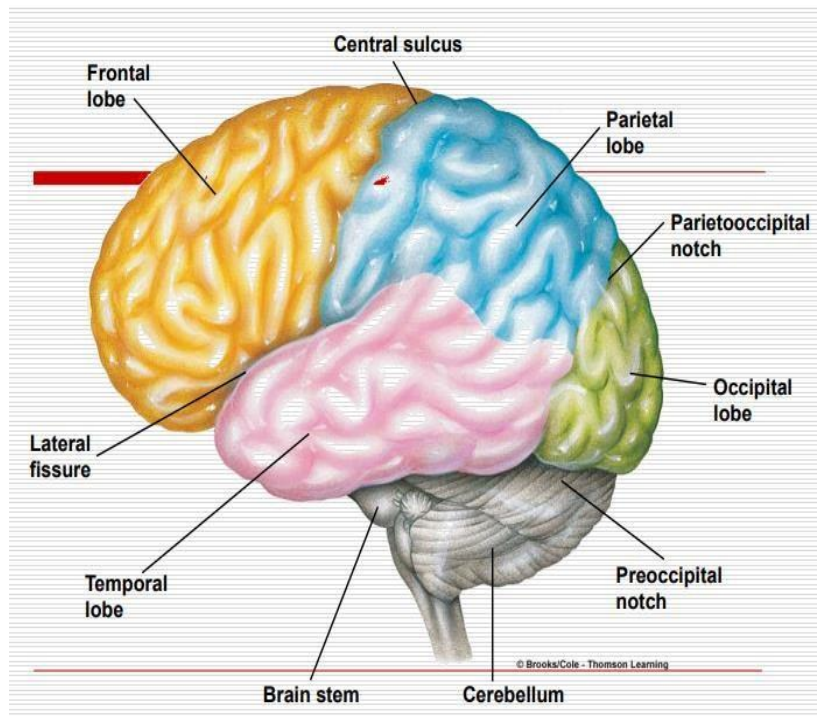


- ✓ **Dorsal column-medial lemniscal system** conveys nerve impulses for:
  - **Fine** touch (well localized) and **fine** pressure because it transmits its information through rapidly transmitting neurons.
  - Vibration and **weight discrimination** (to discriminate which object is heavier or lighter than the other one).
  - **Two points discrimination** to see if the stimulus at one or two points.

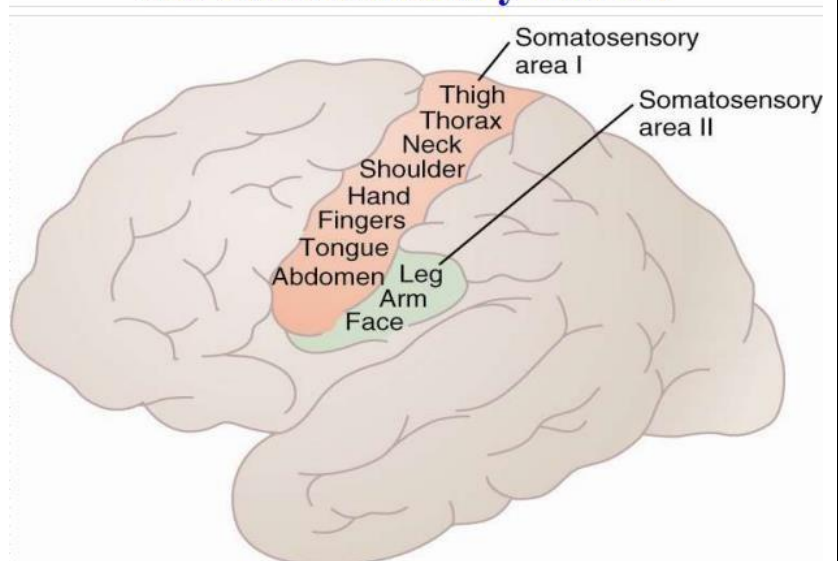
- **Stereognosis**; by moving your hand over the object you can determine the form, shape and smoothness of the object. (Braille language in case of **blindness** by moving the fingers over dots so you can determine the letters by highly developed sensation because it is used very much). **Astereognosis** -> inability to identify objects by feeling only [without the visual system].
- **Conscious proprioception** (sensation of position) from the limbs, trunk, neck, and posterior head to the **postcentral gyrus of the cerebral cortex**.

### ❖ Lateral view of the cerebral cortex.

- ✓ The cerebral cortex is divided into lobes by sulci; **frontal lobe** anterior to the central sulcus, **parietal lobe** posterior to the central sulcus, **temporal lobe** inferior to lateral fissure and finally the parietooccipital notch separates the parietal lobe from the **occipital lobe**.
- ✓ Posterior to the central sulcus in the parietal lobe we have **postcentral gyrus**.
- ✓ Postcentral gyrus is the **primary somatosensory area** which has a very high level of organization.
- ✓ **Gyrus** is the area between two sulci.
- ✓ There is another area posterior to area 1 which has a gross representation of our body.

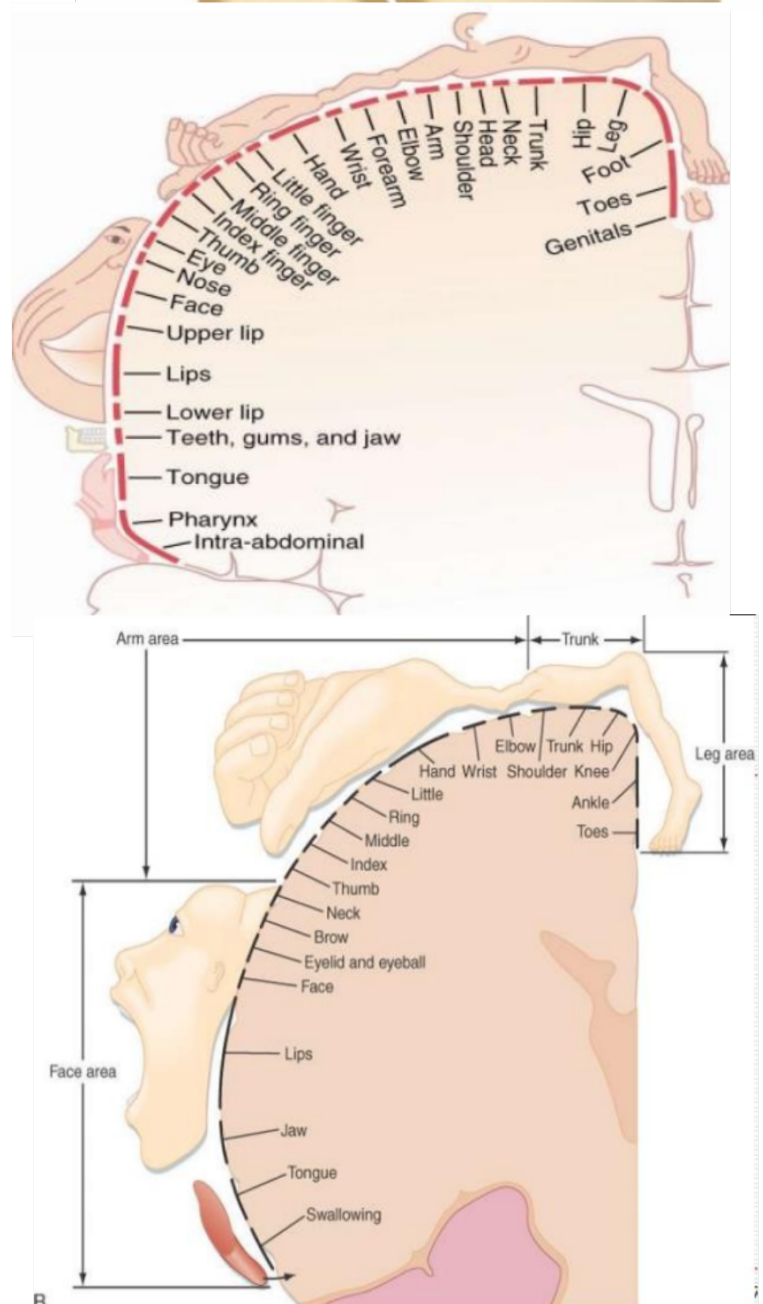
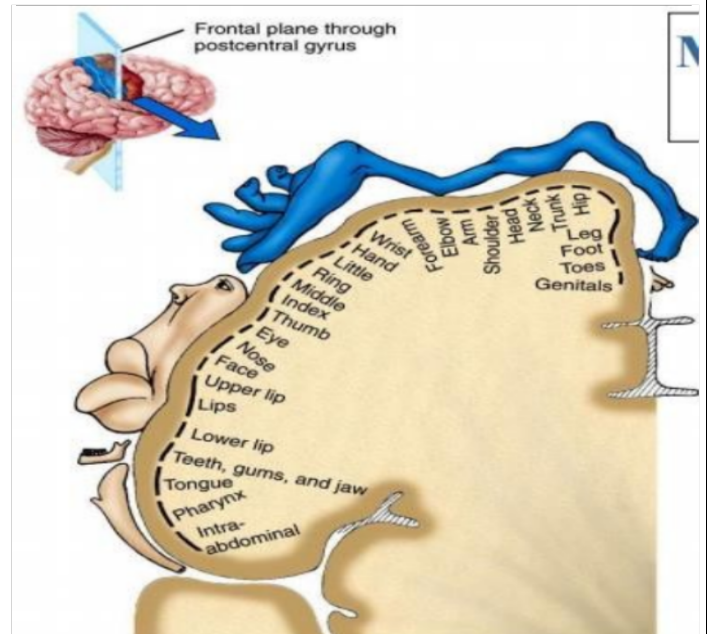


### The Somatosensory Cortex



## ✚ Mapping of the Primary Somatosensory Area(postcentral gyrus)

- This is a frontal section of primary somatosensory area (lateral aspect).
- The representation is **upside-down** and **contralateral**; the right side of the cortex represents the left side of the body and vice versa.
- The area of cerebral cortex that represents any part of our body isn't proportional to the size of that area in our body but it's proportional to the **number of the receptors in that area**.
- Look to the hand here, the area that represents the hand of the cerebral cortex is much larger than the area that represents the lower limbs because the number of receptors of the hand is much more than the number of receptors in the legs.
- Size of the cortical region representing a body part depends on the **density of the receptors** in that part and **sensory impulses** received from that part.
- In this picture, note how big is the area of the face and how small is the area of trunk and lower limb.



## Dermatomes

- ✓ A dermatome is an area of the skin of the human anatomy that is mainly supplied by branches of a single spinal sensory nerve root.
- ✓ As we all know the embryo started as a tube and this tube consists of segments, these segments consist of 3 layers; **endoderm**, **mesoderm** and **ectoderm**, from these layers the spinal cord segments develop; 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal.
- ✓ The nerves of nervous system develop from **ectoderm**, the soft tissue from **mesoderm** and the epithelium from **endoderm**.
- ✓ C8, T1, T2 supply the medial aspect of the hand and the heart comes from the same segments C8, T1, T2.
- ✓ This is important when we talk about pain; afferent sensory fibers from the appendix are carried on the sympathetic nerve fibers to enter the spinal cord at T10 which corresponds to **umbilical dermatome**.

