
بسم الله الرحمن الرحيم
السلام عليكم ورحمة الله وبركاته

# Physiology of Pain



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# *Pain*

**Pain is unpleasant sensation and emotional experience associated with actual or potential tissue damage or described in terms of such damage. It is characterized by the following:-**

- **It has a protective function.**
- **All pain receptors are free nerve endings of unmyelinated C fibers & small diameter myelinated Aδ fibers.**
- **Pain receptors are the most widely distributed.**


Merkel cell
TOUCH
Free endings
TOUCH
COLD PAIN
Meissner's corpuscle
TOUCH
Pacinian corpuscle
Pressure

- Pain sensation can be produced by various types of stimuli i.e. mechanical, thermal & chemical, hence the existence of mechanoceptors, thermoceptors, & polymodal pain receptors (nociceptors).
- Pain receptors adapt very little, if not at all.

- Localization of pain stimuli is less exact than that of other modalities.
- Pain receptors are high threshold receptors i.e. painful stimuli must be strong & noxious to produce tissue damage.
- Pain is perceived at both the cortical & thalamic levels.

# *Effects associated with pain sensation*

**1- Motor reactions, these may take the form of:-**

*** Reflexes e.g. withdrawal reflex.**

*** Muscle rigidity ( stiffness).**

## 2- Autonomic reactions

* Mild pain stimulates post. hypothalamic N→ sympathetic changes e.g. tachycardia.

* Sever pain stimulates anter. hypothalamic N→ parasympathetic changes e.g. bradycardia.

**3- Emotional reactions** as anxiety, crying……..etc.

# Mechanism of stimulation of pain receptors (nociceptors)

- **Pain receptors are depolarized either directly or through the production of pain producing substances that are produced from damaged tissues as a result of inflammation ( also called inflammatory mediators e.g. bradykinin, serotonin, histamine, interleukins, substance P, $K^+$, Ach, proteolytic enzymes.**
- **Prostaglandins & interleukins lower threshold of pain receptors.**

# Qualities of pain

## *Fast pain (immediate, first)*

- **It is also called pricking, acute, sharp or electric pain.**
- **It occurs mainly in skin by mechanical or thermal stimuli.**
- **It is transmitted via type Aδ fibers, conduction velocity 3-30m/s, account for 20% of nociceptors primary afferents, arise from all types of nociceptors.**

# *Fast pain (immediate, first) (cont.)*

- It appears very rapidly within 0.1 sec., and lasts for short time.
- It is usually well localized.
- The neurotransmitter is glutamate.
- e.g. The type of sensation felt when skin is cut with a knife.

## *2- Slow pain (delayed or second)*

- * It is also called burning, aching or chronic pain.
- * It occurs in skin, deep tissues & viscera.
- * It is transmitted via type C fibers, conduction velocity < 2m/s, account for 80% of nociceptors primary afferents, arise from polymodal nociceptors.

## *2- Slow pain (delayed or second) (cont.)*

- **It appears slowly, after one sec. or more, and lasts for longer duration.**
- **The neurotransmitter is substance P.**
- **It is diffused (poorly localized).**

# Types of pain

- **Pain can be classified according to the site of stimulation into:-**

**1- Somatic pain ( superficial & deep pain).**

**2- Visceral pain.**

## *Superficial pain*

- **It arises from skin or other superficial structures.**
- **It occurs in 2 phase of fast pricking followed by slow burning pain.**
- **It can be well localized.**
- **It may be associated with motor, autonomic, emotional reactions.**

# Deep pain

- It originates from muscles, joints, periosteum, tendons & ligaments
- It is slow prolonged conducted by type C fibers.
- It is diffuse (i.e. poorly localized).

# Deep pain (cont.)

- It can initiate reflex contraction of nearby muscles.
- It may be referred to other sites.
- It is caused by, trauma, bone fracture & inflammation, arthritis, muscle spasm & ischemia.

# Visceral pain

- **There are few pain receptors in most viscera, some viscera are pain insensitive e.g. liver parenchyma, lung alveoli, brain tissue, visceral layer of peritoneum, pleura and pericardium.**

# Characters of visceral pain

- It is **slow** pain conducted by **C fibers** ( pain arising from parietal peritoneum, pleura and pericardium is sharp, pricking type).
- It is **diffuse**, the patient feels pain arising from inside but he cannot pinpoint it exactly.
- It is often associated with **autonomic reactions**.
- It can be associated with **rigidity** of nearby muscles.
- It may be **referred** to other sites.

# Causes of visceral pain:-

- **Distension** of a hollow organs
- **Inflammation** of an organ.
- **Ischemia** e.g. pain due to myocardial ischemia.

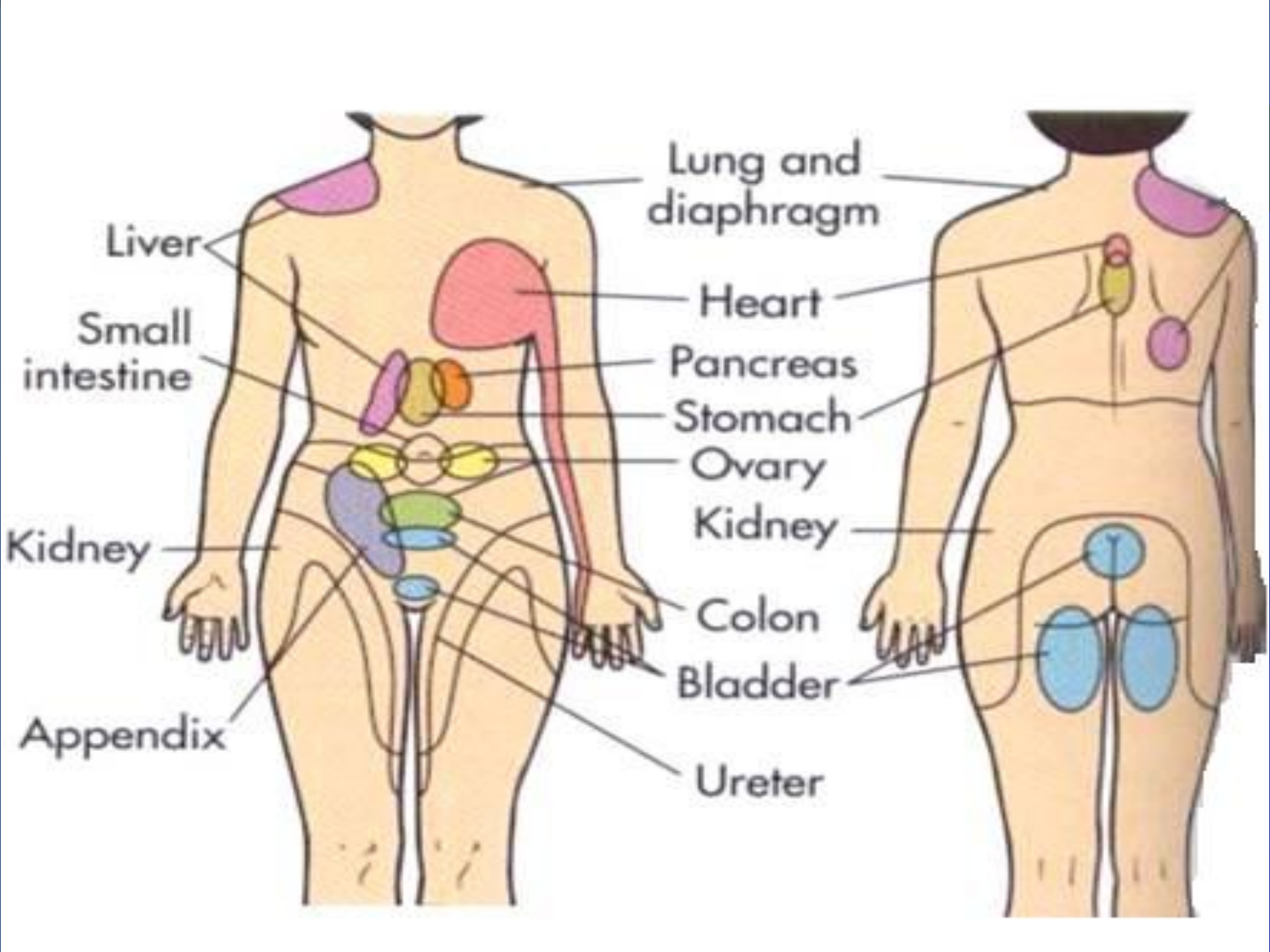
# *Referred pain*

- **This is pain that is felt away from its original site.**
- **It is most frequent with visceral pain & deep somatic pain but cutaneous pain is not referred.**
- **Pain is referred according to dermatomal rule.**

# *Referred pain*

**Examples of referred pain:-**

- **Cardiac pain is referred to left shoulder & inner side of left arm.**
- **Pain of appendicitis is referred to umbilical region.**
- **Pain from the ureter is referred to testicular region.**

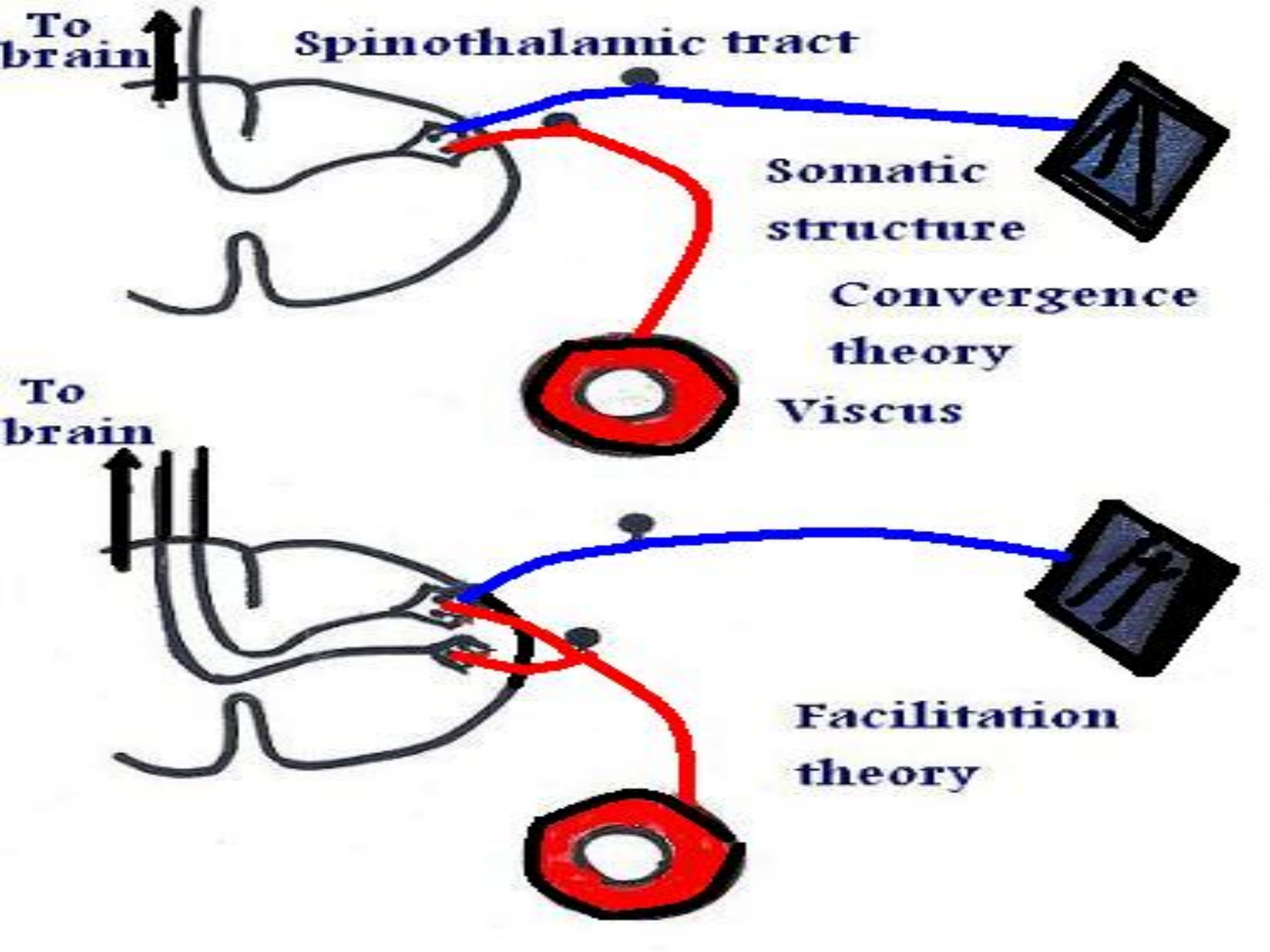

Lung and diaphragm
Liver
Heart
Small intestine
Pancreas
Stomach
Ovary
Kidney
Kidney
Colon
Bladder
Appendix
Ureter

| Organ | Site of referred pain |
| --- | --- |
| Meninges | Back of head &neck |
| Heart | Central chest, left arm |
| Diaphragm | Shoulder tip |
| Esophagus | Behind sternum |
| Stomach,duodenum | Epigastrium |
| Kidney | Loin |
| Ureter | Testicles |
| Trigone of bladder | Tip of penis |
| Hip | Knee |
| Appendix | Umbilicus |
| Uterus | Low back |

# Mechanism of referred pain

## Convergence theory

- **Afferent nerves from somatic structure & viscera that develop from same embryonic segment converge on same spinothalamic tract.**
- **Since brain is accustomed to receiving impulses from skin than viscera, so pain impulses carried to cortex along spinothalamic neurons shared by afferents from skin & other from diseased viscus are misinterprited by the brain as coming from skin.**


To brain
Spinothalamic tract
Somatic structure
Convergence theory
Viscus
To brain
Facilitation theory

# Facilitation theory

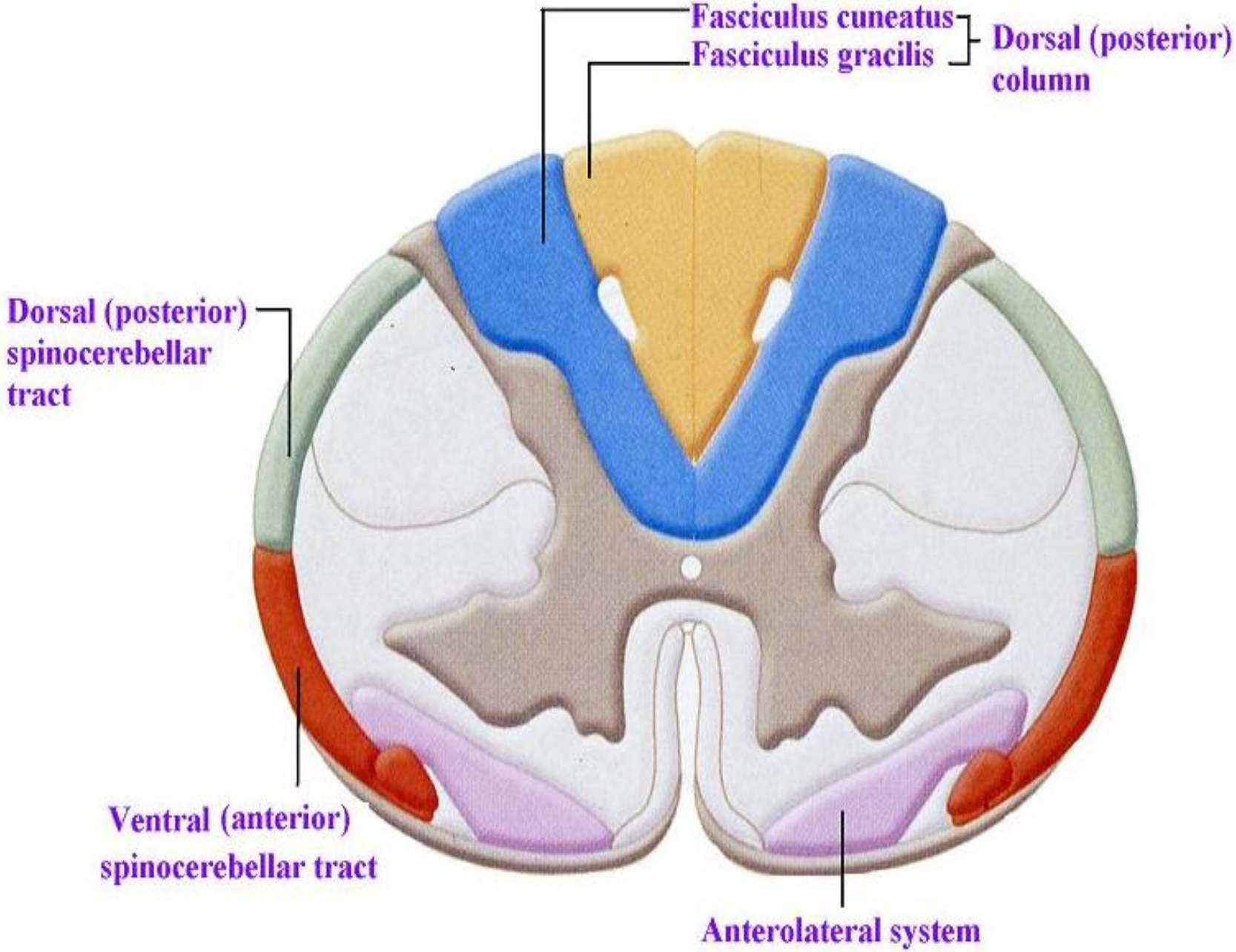
- **Pain fibers from skin are always carrying impulses, but they are not enough to produce pain. Impulses from diseased viscus pass through afferents which give collaterals to ST neurons receiving pain fibers from skin. As a result, ST neurons' excitability is raised (they are facilitated) to reach a threshold level. The signals reaching the brain are projected to skin area and pain is felt in skin dermatome**

# Pathway of pain

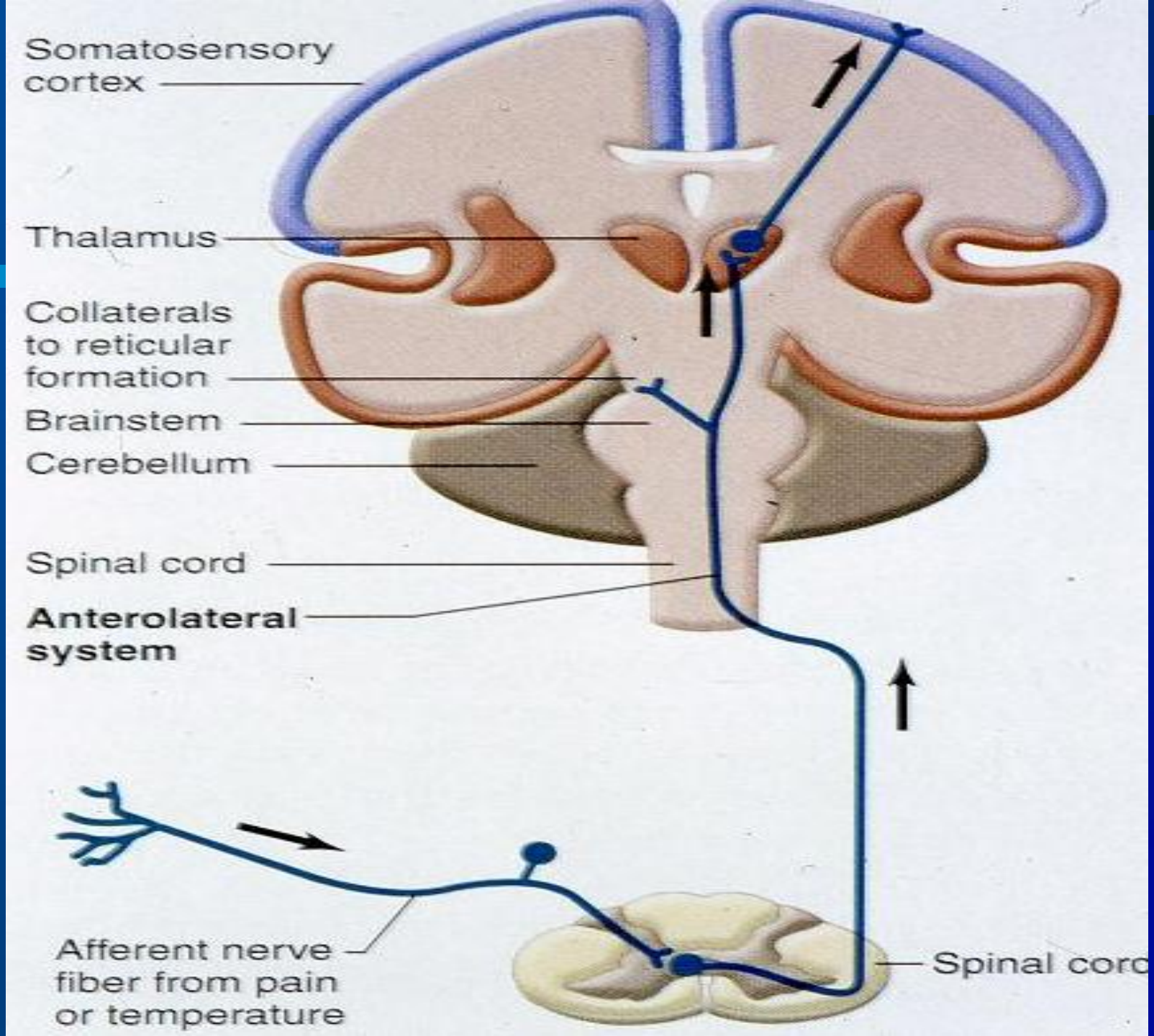
- Pain sensation is carried by **lateral spinothalamic tracts** which includes 2 separate pathways:-

**The neospinothalamic pathway:-**

- This transmits fast pain & thermoceptive sensation.
- **First order neurons**
- Are mainly Aδ afferent nerves. They ascend few segments in Lissauer' tract & terminate at lamina I & V of D. horn.


Fasciculus cuneatus
Fasciculus gracilis
Dorsal (posterior) column
Dorsal (posterior) spinocerebellar tract
Ventral (anterior) spinocerebellar tract
Anterolateral system

- **Second order neurons**
- **These constitute the tract. They start at dorsal horn, cross to opposite side and ascend in lateral column of spinal cord. The fibers ascend in brain stem to terminate in ventrobasal complex of thalamus.**
- **Third order neurons**
- **These start at thalamus & project to somatosensory cortex.**


Somatosensory cortex
Thalamus
Collaterals to reticular formation
Brainstem
Cerebellum
Spinal cord
Anterolateral system
Afferent nerve fiber from pain or temperature
Spinal cord

# The paleospinothalamic pathway:-

- This transmit slow pain sensation & thermoceptive sensation.

## First order neurons

- They are mainly type C fibers. They enter spinal cord via dorsal roots, ascend a few segments in Lissauer' tract & terminate at substantia gelatinosa in laminae II & III of dorsal horn.

# Second order neurons

- They start at SGR, cross to opposite side in front of central canal, ascend in lateral column of SC & terminate at:-
- Reticular formation of brain stem.
- Intralaminar nuclei of thalamus.
- Hypothalamus & adjacent region of basal brain.

Impulses arriving these regions have strong arousal effects and can be perceived.

# Third order neurons

- These start at thalamus,
- Project to all parts of cerebral cortex.

- ***Role of cerebral cortex in pain perception***
- **Full perception of pain occurs when signals enter RF of brain stem, thalamus & basal regions.**
- **Somatosensory cortex plays important role in topognosis i.e. localization & interpretation of pain quality.**
- **Fast pain is localized better than slow pain because signals carried in neospinothalamic tract reach somatosensory cortex, while a small propotion of paleospinothalamic pathway reach there.**


Thank You