اللهم صل على محمد وآل محمد

السلام عليكم ورحمة الله وبركاته

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Physiology of Pain

Dr. Hayam Gad
Associate Professor of Physiology

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Learning Objectives

- *Pain receptors (nociceptors)*
- *Effects associated with pain sensation*
- *Mechanism of stimulation of pain receptors*
- *Qualities of pain*
- *Types of pain*
  - *Somatic pain (superficial & deep pain).*
  - *Visceral pain.*
- *Referred pain*
- *Pathway of pain*
  - *The neospinothalamic pathway*
  - *The paleospinothalamic pathway*
- *Role of cerebral cortex in pain perception*

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Pain

Pain is unpleasant sensation and emotional experience associated with actual or potential tissue damage.

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Pain 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.***

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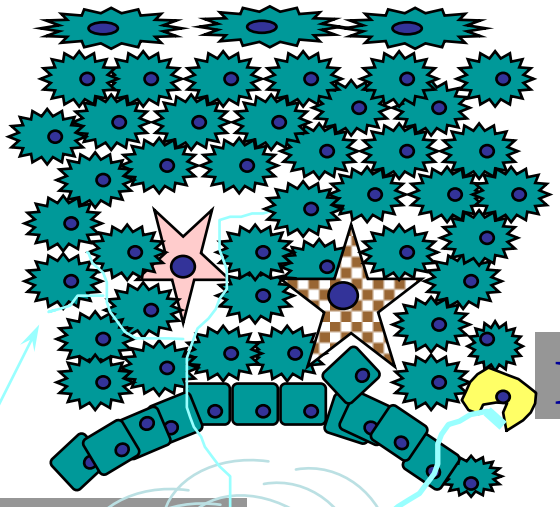

Merkel cell

TOUCH

Free endings

PAIN

TOUCH & COLD

Meissner's corpuscle

TOUCH

Pacinian corpuscle

Pressure

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Classification of Nerve Fibers

Roman Numeral	Letter	Size (μm)	Conduction Velocity	Myelination
Ia	-	12-20	70-120	√√√√√
Ib	-	12-20	70-120	√√√√√
-	Aα	12-20	70-120	√√√√√
II	Aβ	6-12	30-70	√√√√
-	Aγ	2-20	10-50	√√√
III	Aδ	1-6	5-30	√√
-	B	< 3	3-15	√
IV	C	< 1.5	0.5-2	None

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- *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.*

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- *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.*

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Effects associated with pain sensation

1- Motor reactions

These may take the form of:-

* *Reflexes e.g. withdrawal reflex.*

* *Muscle rigidity (stiffness).*

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2- Autonomic reactions

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

** Sever pain stimulates ant. hypothalamic N⟶ parasympathetic changes e.g. bradycardia.*

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

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Mechanism of stimulation of pain receptors (nociceptors)

- *Pain receptors are depolarized either directly or through the production of pain producing substances, 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.*

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Qualities of pain

I. 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.*

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- *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.*

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II. 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.*

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

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Types of pain

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

1. ***Somatic pain*** *(superficial & deep pain).*
2. ***Visceral pain.***

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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.*

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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).*

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- *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.*

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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**.

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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.*

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Causes of visceral pain

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

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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.*

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- ***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.*

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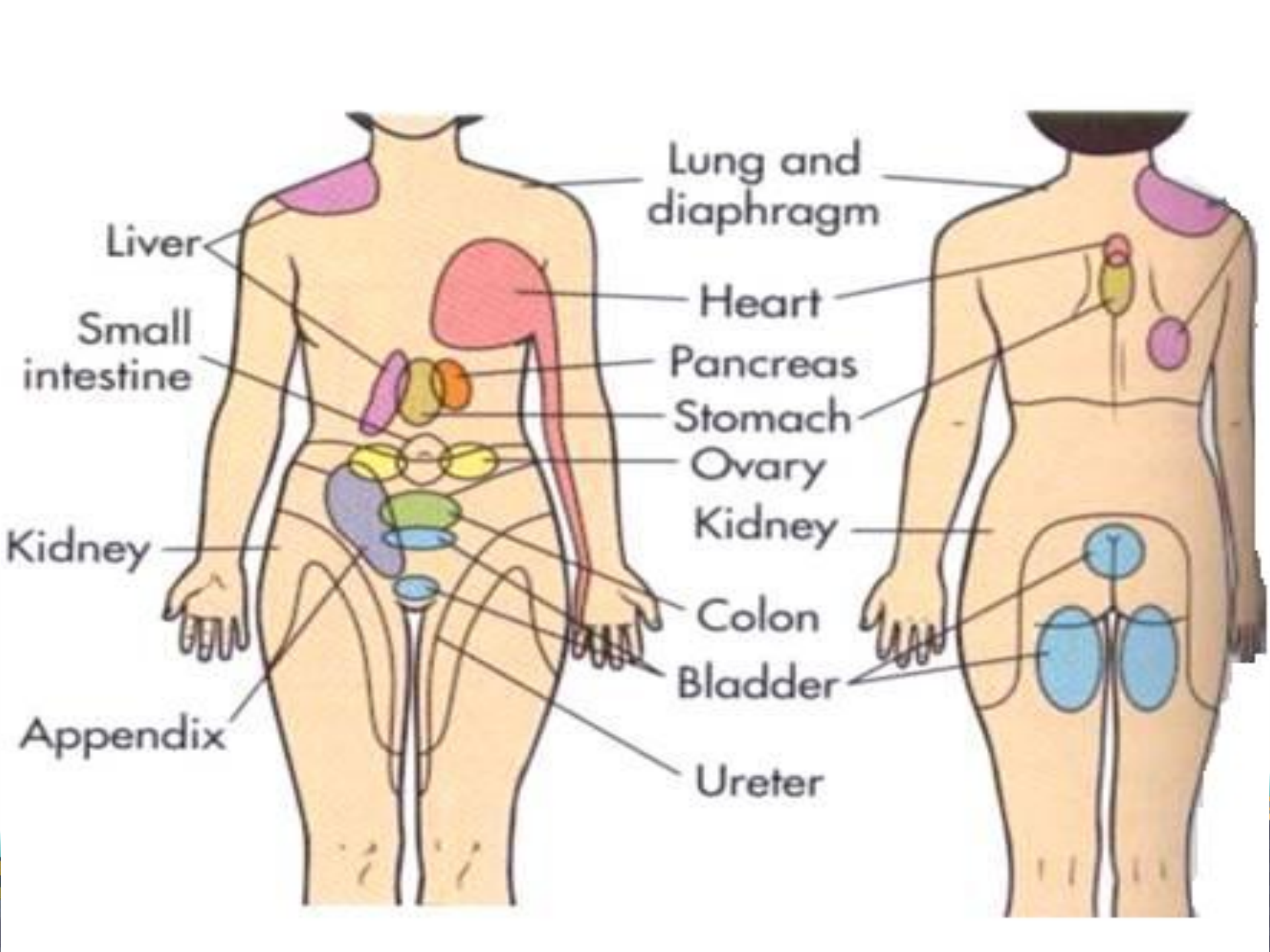
Lung and diaphragm
Liver
Heart
Small intestine
Pancreas
Stomach
Ovary
Kidney
Kidney
Colon
Bladder
Appendix
Ureter

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

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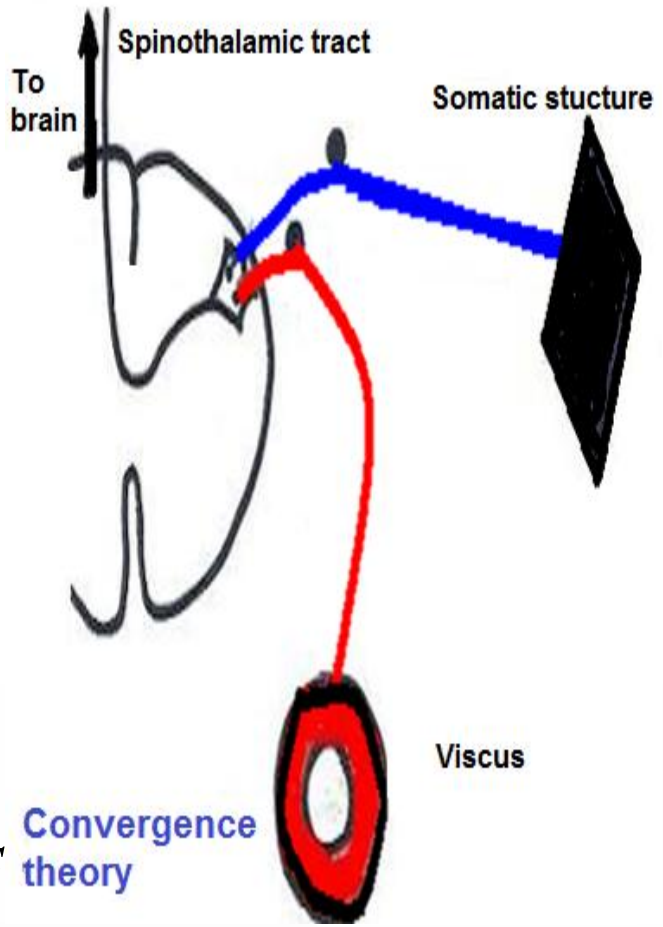
Mechanism of referred pain

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.*



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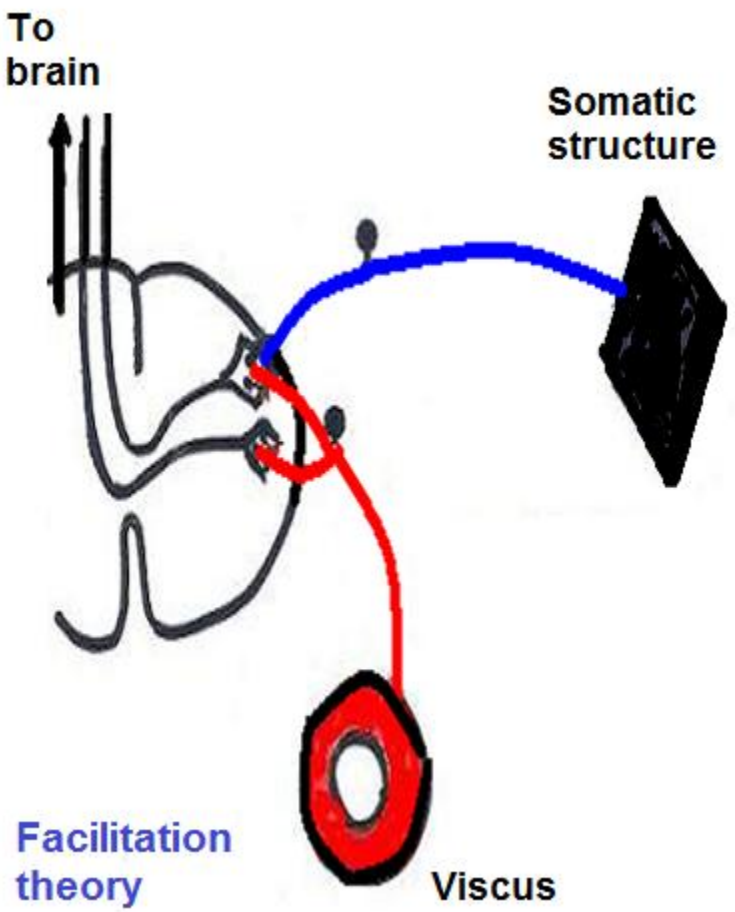
Facilitation theory

Pain fibers from skin are always carrying impulses, 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



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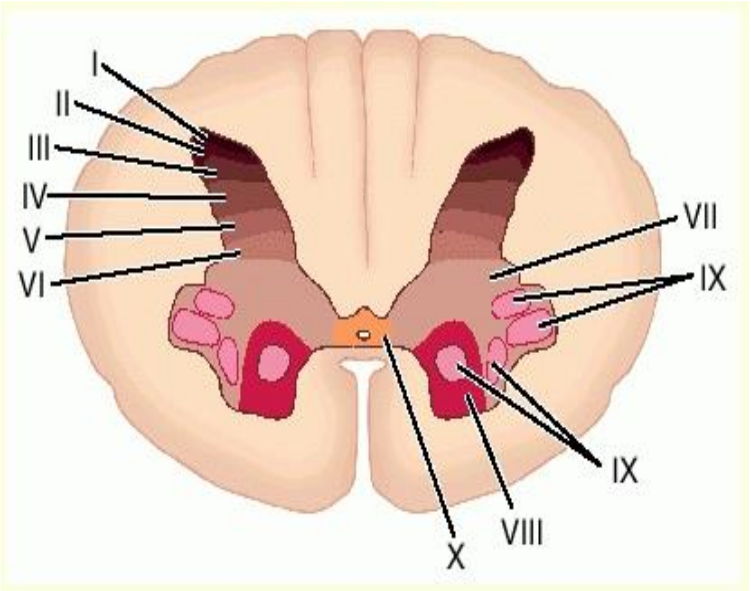
Pathway of Pain

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



A) 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.

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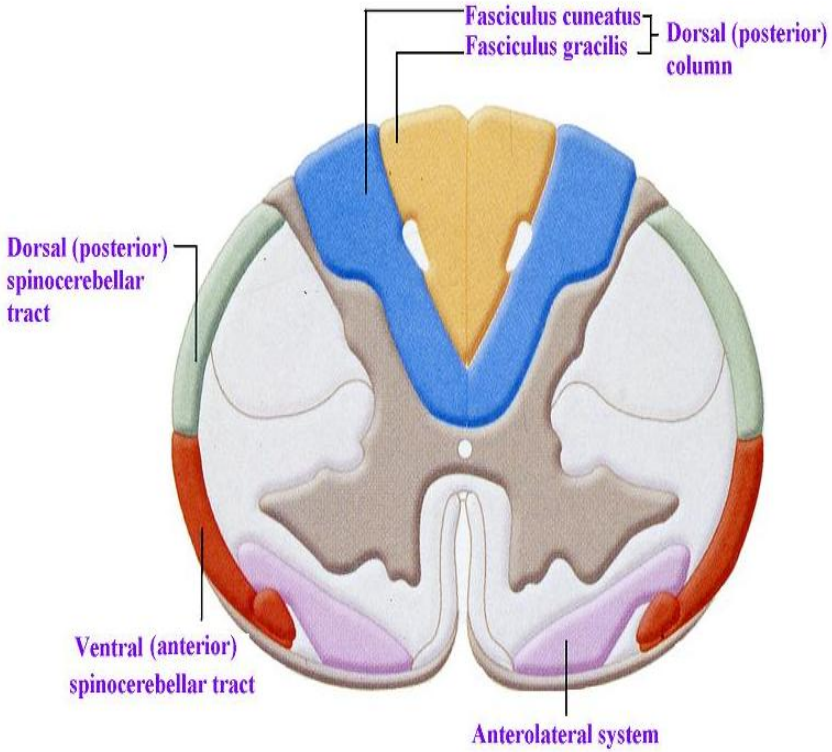
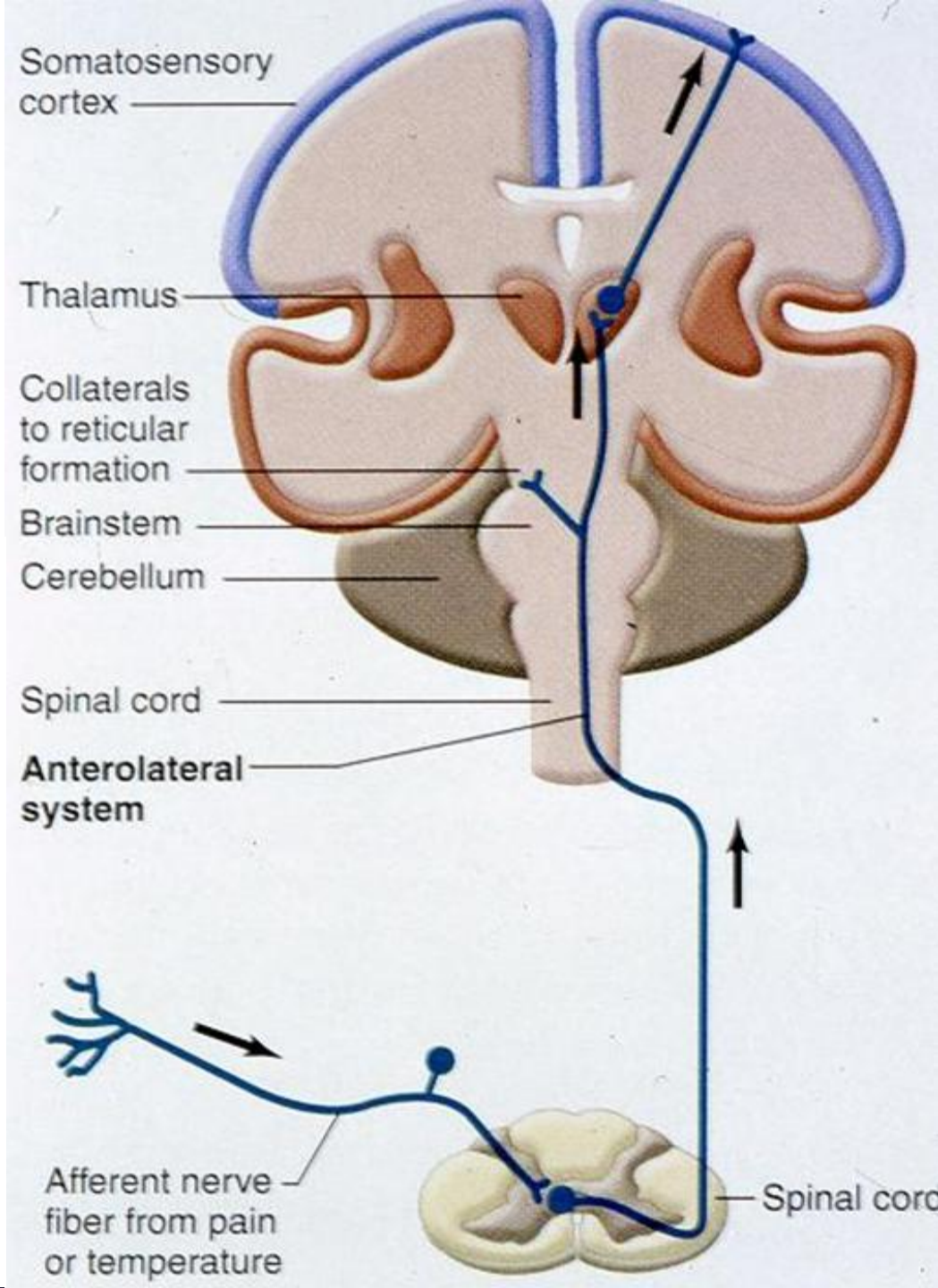

Fasciculus cuneatus
Fasciculus gracilis
Dorsal (posterior) column
Dorsal (posterior) spinocerebellar tract
Ventral (anterior) spinocerebellar tract
Anterolateral system


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

- ***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.

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B) 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.*

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○ ***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.

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- ***Third order neurons***

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

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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.*

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