Physiology of Pain

Color index

- Important
- Further Explanation

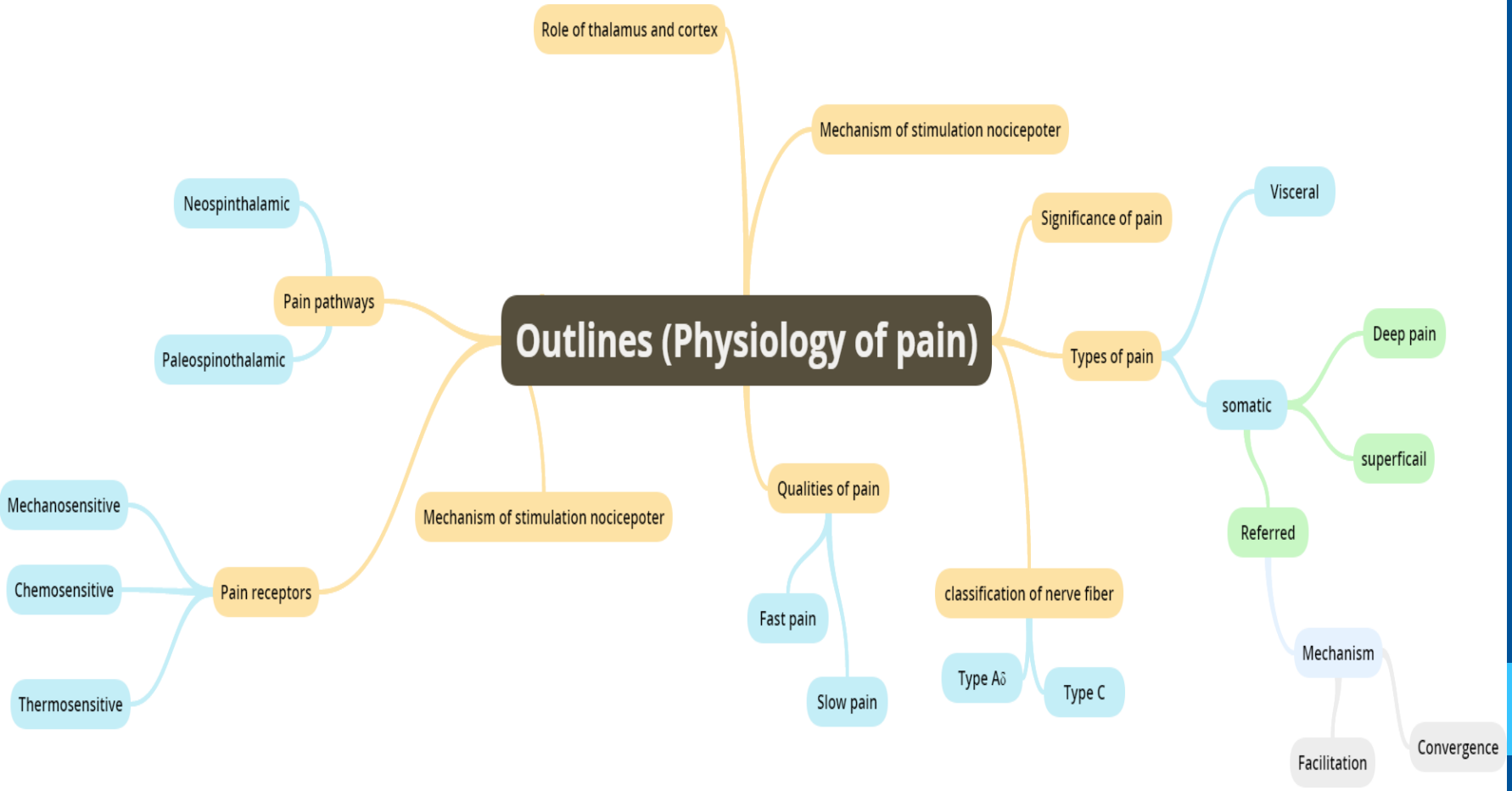
Guyton ch.48 p583
Dr.Najeeb's videos are recommended "Ascending tracts"

Physiology Team 434
contact us : physiology434@gmail.com

Contents

Recommended Videos!

Please check out this link before viewing the file to know if there are any additions/changes or corrections. The same link will be used for all of our work Physiology Edit


Outlines (Physiology of pain)
Role of thalamus and cortex
Mechanism of stimulation nocicepoter
Significance of pain
Types of pain
Visceral
somatic
Deep pain
superficail
Referred
Mechanism
Facilitation
Convergence
Qualities of pain
Fast pain
Slow pain
classification of nerve fiber
Type Aδ
Type C
Mechanism of stimulation nocicepoter
Pain receptors
Mechanosensitive
Chemosensitive
Thermosensitive
Pain pathways
Neospinthalamic
Paleospinothalamic

Mind Map

Pain

Free nerve endings receptors sense only pain and temperature

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

- <u>Pain is Characterized By:</u>
- It has a protective function
- Accompanied by behavioral responses (withdrawal, defense) as well emotional responses (crying , fear)
- All pain receptors are free nerve endings of **unmyelinated C fibers** & small diameter **myelinated Aδ fibers**.
- Pain receptors are the most widely distributed.
- Pain receptor widespread in the superficial layer of the skin ,fewer in the deep tissues and absent in brain tissue.

Pain receptors are present in skull and meninges of the brain

Classification of Nerve Fibers

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

Pain Receptors “ Nociceptors”

- Nociceptors : are special receptors that respond only to noxious stimuli and generate nerve impulses which the brain interprets as “pain”
- Pain sensation can be produced by various types of stimuli i.e. mechanical, thermal & chemical (noxious stimuli)
- 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.

Pain Reception and Perception

- Reception: Response of nerve receptors in the skin and tissues to stimuli resulting from actual or potential tissue damage.

- Perception: The point at which a person experiences pain.

Reactions Associated With Pain Sensation

Motor Reactions

- may take the form of:
- Reflexes e.g. withdrawal reflex.
- Muscle rigidity (stiffness)

Autonomic Reactions

- Mild pain stimulates post. hypothalamic N→ sympathetic changes e.g. tachycardia.
- * Sever pain stimulates ant. hypothalamic N→ parasympathetic changes e.g. bradycardia

Emotional Reactions

- as anxiety, crying……..etc.

Mechanism of Stimulation of 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.**

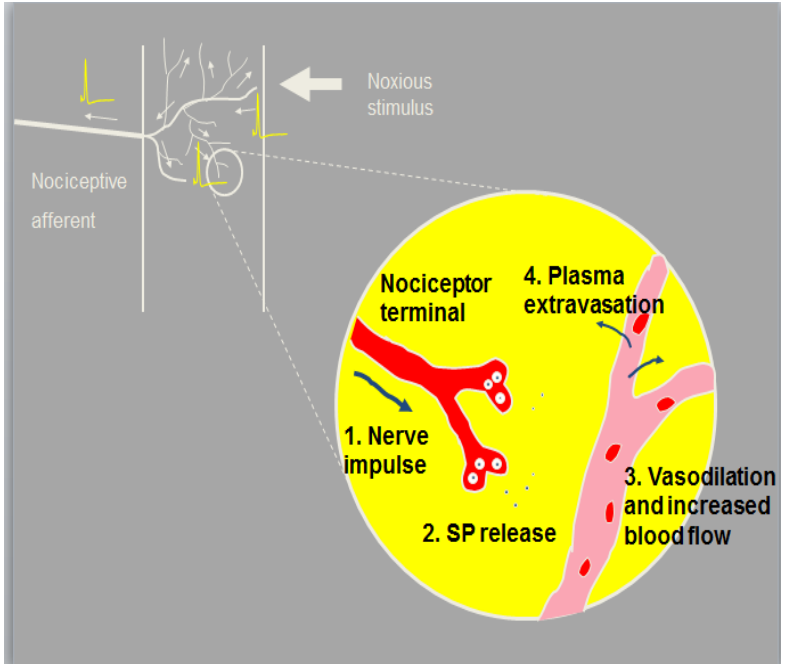
Substance	Source
Potassium	Damaged cells
Serotonin	Platelets
Bradykinin	Plasma
Histamine	Mast cells
Prostaglandins	Damaged cells
Leukotrienes	Damaged cells
Substance P	Primary nerve afferents

Axon Reflex

- It is a reflex that occurs when an AP in one branch of nociceptor conducts centrally through the main axon, but in addition it spreads antidromically into other branches of the axon in the skin leading to SP and CGRP (Calcitonin gene related peptide) release from the peripheral branches of the nociceptor.

- The released SP has several effects including:-Vasodilation: resulting in reddening (erythema) and warming of the skin.
- plasma extravasation which is flow of water and electrolytes out of the capillaries into the extracellular space.

pain causes vasoconstriction for few Seconds then vasodilation



Pain Mechanism

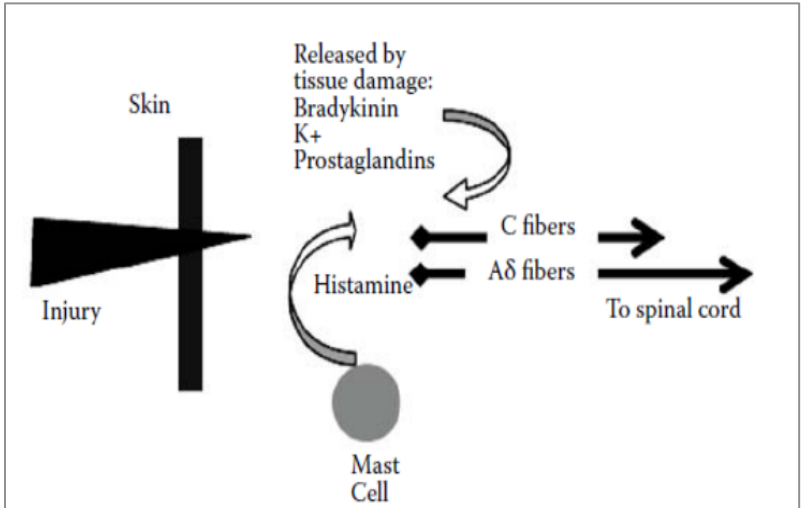
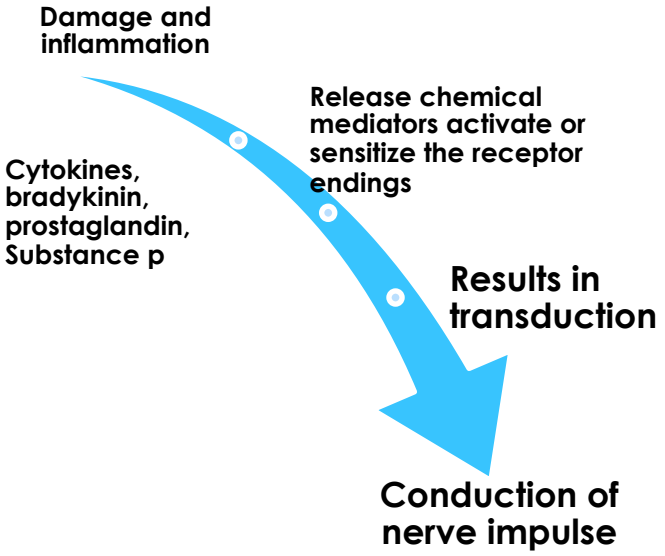


Fig. 1. Some chemicals released by tissue damage that stimulates nociceptors. In addition release of substance-P, along with histamine, produce vasodilation and swelling.



Qualities of Pain

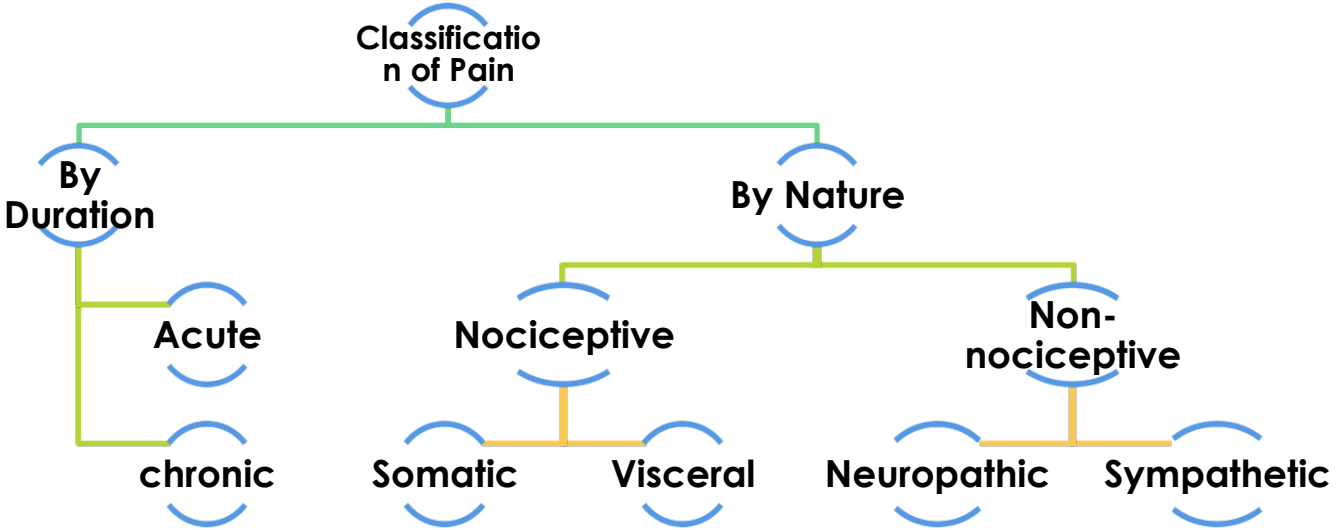
Fast pain (immediate, first)

- e.g. The type of sensation felt when skin is cut with a knife
- It is also called pricking, acute, sharp or electric pain.
- It occurs mainly in **skin by mechanical or thermal stimuli.**
- It appears **very rapidly** within 0.1 sec., and lasts for short time.
- It is usually **well localized**.
- **It is transmitted via <u>type A δ fibers</u>:**
  - Myelinated.
  - Diameter fine 1 - 6 µm
  - 5 - 30 m/sec conduction velocity.
  - Terminated in neurons at I and V laminas.
  - 20% pain conduction and its neurotransmitter is **glutamate**.
- Responsive to common analgesics

Slow pain (delayed or second)

- It is also called burning, aching or chronic pain.
- It occurs in **skin, deep tissues & viscera.**
- It appears **slowly**, after one sec. or more, and lasts for longer duration
- It is diffused **(poorly localized).**
- **It is transmitted via <u>type C fibers</u>**:
  - Non-Myelinated.
  - 0.4-1.2 µm in diameter.
  - 0.5 to 2 m/s conduction velocity.
  - Terminate in neurons at II and III laminas.
  - Neurotransmitter is **Substance- P**
  - 80% of pain conduction.
- Often refractory to common analgesics.

Classification of Pain:



Nociceptive & Neuropathic Pain:

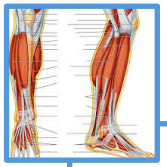
Types Of Pain

Pain can be classified according to the site of stimulation into

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

Superficial

- 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**).
- 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

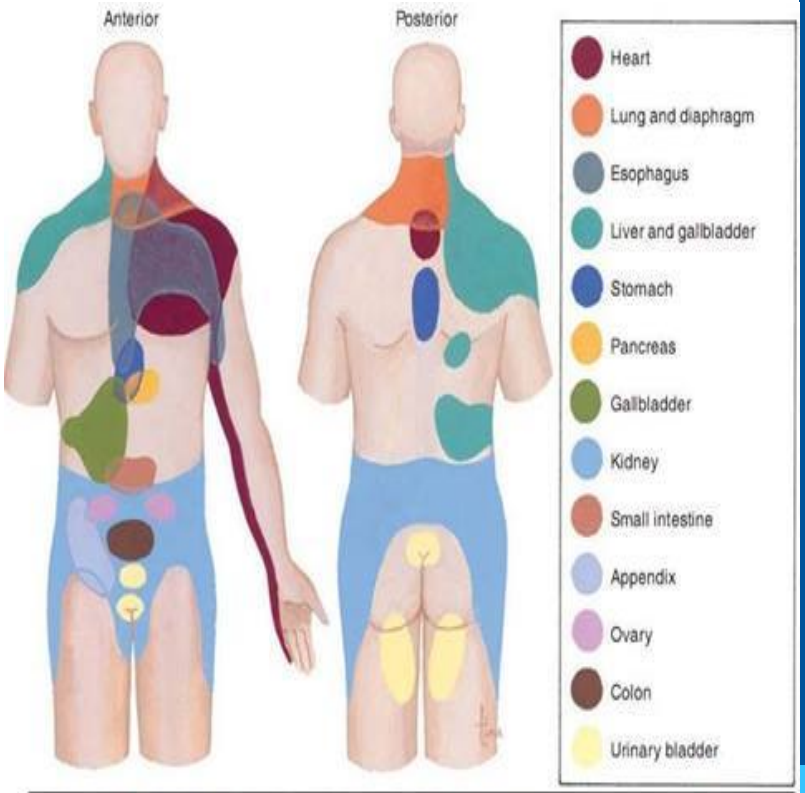
- It is **slow** pain conducted by **C fibers** (pain arising from parietal peritoneum, pleura and pericardium is sharp, pricking type).
- It is **diffuse, poorly localized** the patient feels pain arising from inside but he cannot pinpoint it exactly.
- It is often associated with nausea and **autonomic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

Causes of visceral pain

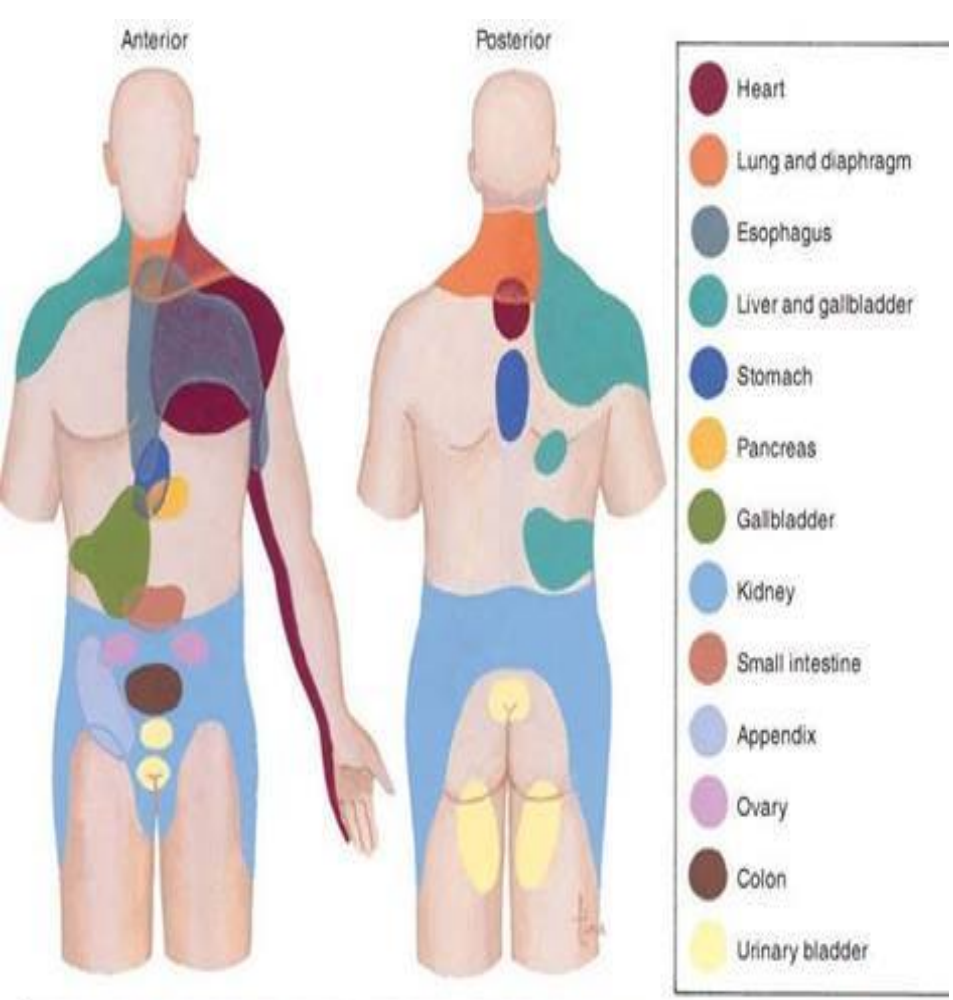
- **Distension of a hollow organs.**
- **Inflammation of an organ.**
- **Ischemia** e.g. pain due to myocardial ischemia.
- **Cutting, crushing *are not painful when applied to viscera*.**

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.
- **Poorly localized** and is not identical in all people
- Examples:
  - 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.



Referred pain. The sites for referred pain from various organs are shown.



Referred pain. The sites for referred pain from various organs are shown.

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 pain fibers from skin area & diseased viscera that develop from same embryonic segment converge on same 2nd order neuron and finally stimulate the same cortical neuron.
- ✧Sensory cortex is accustomed to receive pain from skin as the frequency of somatic pain is much more frequent than visceral pain.
- ✧The cortex would misinterpret the origin of visceral pain impulse and project (feel) pain as it is coming from the skin

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

Pathway of Pain

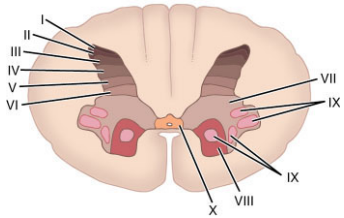
Pain sensation is carried by spinothalamic tracts which includes 2 separate pathways

A) The Neospinothalamic Pathway:

This transmits fast pain & thermoceptive sensation.

First order neurons

- Are mainly **A δ afferent** nerves. They ascend few segments in Lissauer' tract & terminate at lamina I & V of D. horn.



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

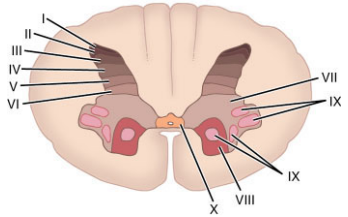
- These start at thalamus & project to somatosensory cortex.

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



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.
- Intensity of pain is encoded by rate of action potentials
- 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.

1- pain receptor is type of :-
A. Meissner corpuscles
B. Pacinian corpuscles
C. Free nerve endings
D. Merkel discs

2-Themal pain follows :-
A. Neospinothalamic pathway
B. Palespinothalamic pathway
C. Both of them
D. No one of them

3-type of pain when you injure yourself :-
A. Fast pain
B. Slow pain
C. Both of them
D. No one of them

4-location pf pain of angina :-
A. In the head
B. Chest and can be referred to the left arm
C. knee
D. Low baclkand can referred to testicular region

5- glutamate is a neurotransmitter produce in :
A. Burning pain
B. Fast pain
C. Slow pain
D. Chronic pain

6- First order in Neospinthalamic pathway terminate at which lamina in the dorsal horn of the spinal cord:
A. Lamina II
B. Lamina VI & V
C. Lamina VI &I
D. Lamina I&V

7- the pain that is felt away from its original site:
A. Deep pain
B. superficial pain
C. Referred pain

8- what is the source of Bradykinin?
A. Mast cell
B. Platelets
C. Primary nerve afferents
D. plasma

1.C
2. A
3.C
4. B
5.B
6.D
7.C
8.D

MCQs

1-what is the name of pain receptor ?
.nociceptor

2-what is the fastest type of afferent fiber and mention its velocity ?
.Aa afferent nerve fiber . 70-120 m/s

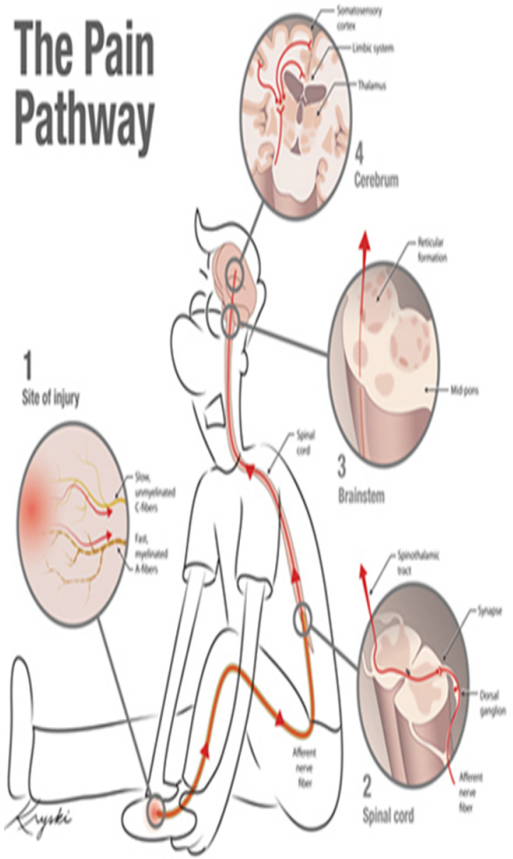
3- why does the Fast pain is localized better than the slow pain ?
because signals carried in neospinothalamic tract reach somatosensory cortex, while a small propotion of paleospinothalamic pathway reach there.

4- what is neuropathic pain and how does it differ from Nociceptive pain ?
. Neuropathic pain : the pain that occur due nerve fiber damage
While Nociceptive pain : the pain caused by painful stimulus or activation of nociceptors.

Qualities Of Pain

Fast Pain (Acute)	Slow Pain (chronic)
called Acute, pricking and sharp	called burning and aching
Apperears very rapidly within 0.1 ses	Apperears slowly within 1 sec
Well localized	Poorly localized
Associated with reflex and withdrawal	Associated with destruction of tissue
Transmitted via type Aδ fibers	Transmitted via type C fibers
Usually somatic (occurs in skin)	Occurs in skin , deep tissue and viscera
Neurotransmitter is glutamate	Neurotransmitter is substamce P

Tarfa Bin Maymoon



Neospinothalamic	Paleospinothalamic
Transmit fast pain	Transmit slow pain
Mainly Type **Aδ** fiber	Mainly type **C** fiber
project to somatosensory	Project to all parts of cerebral cortex

Summary

THANK YOU FOR CHECKING OUR WORK!

BEST OF LUCK

Done By:

- Ghaida almasaad
- Tarfa Bin maymoon
- Abdulrahman Alkaff
- Razan Alsubhi