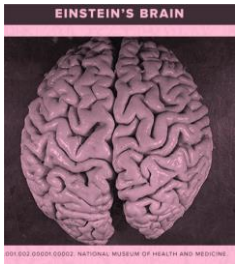
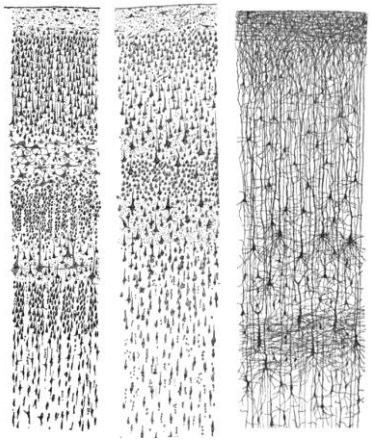
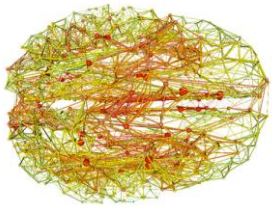
Welcome to Clinical anatomy of the head, neck and neuronal pathways

Lecture #9







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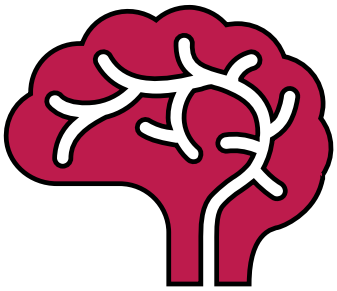
MUNI, MED

Spring 2023

Today's lecture will cover:

1- Somatosensory and Viscerosensory Pathways

2- Pain Pathways and Stress-Induced Analgesia



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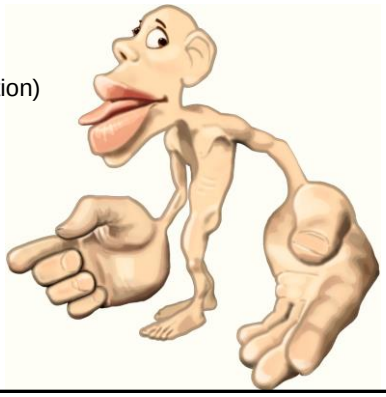
Somatosensory Pathways

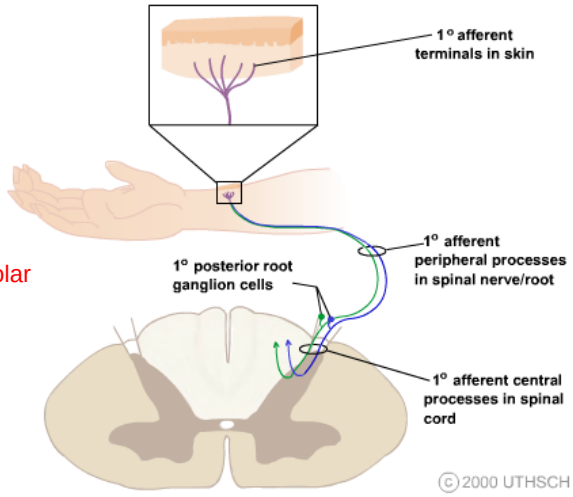
- Inform about objects around us through touch
- Inform about position and movements of our body parts (proprioception)
- Monitor the temperature
- Inform about painful, itchy and tickling stimuli



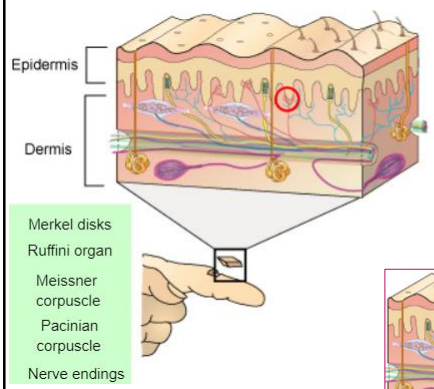
Somathosensory Pathway

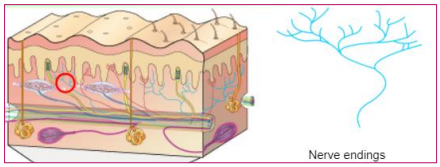
- Most somatosensory receptors are not specialized receptor cells and are formed by the terminal endings of the somatosensory 1st afferents.

1st order somatosensory afferent neurons: pseudounipolar neuron located in DRG

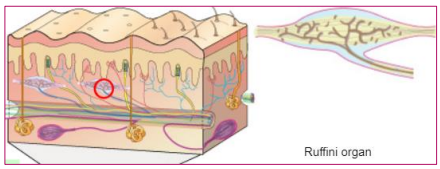


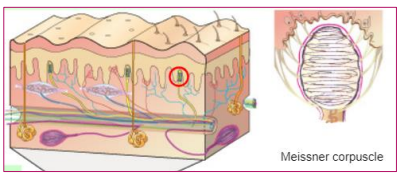
Somatosensory Receptor Types

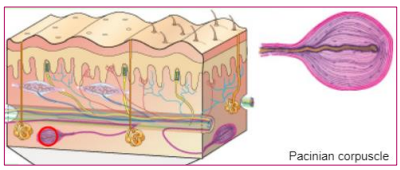




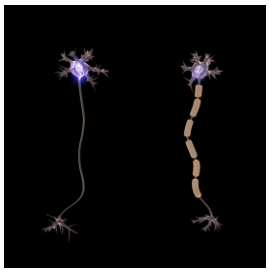
pain, temperature and crude touch



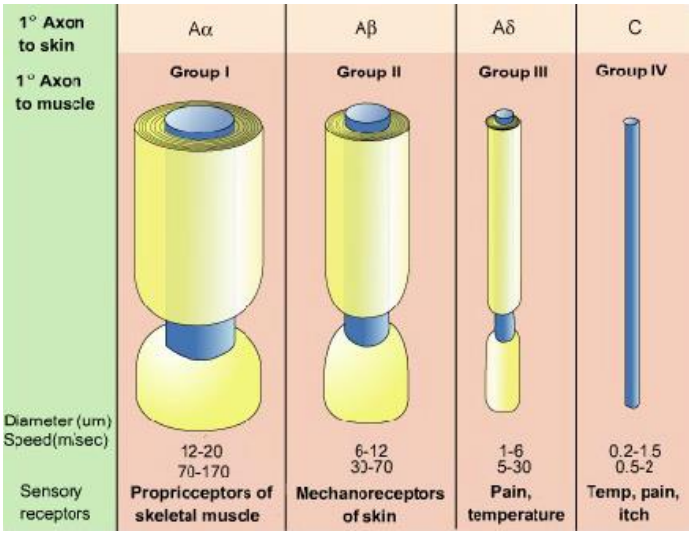




Peripheral Somatosensory Axons



- Faster propagation of an action potential in myelinated neurons than that of unmyelinated neurons.



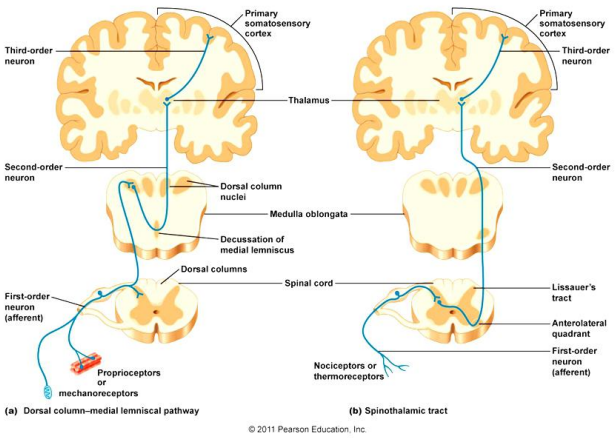
Somatosensory Pathways

Lemniscal system
Medial Lemniscal Pathway

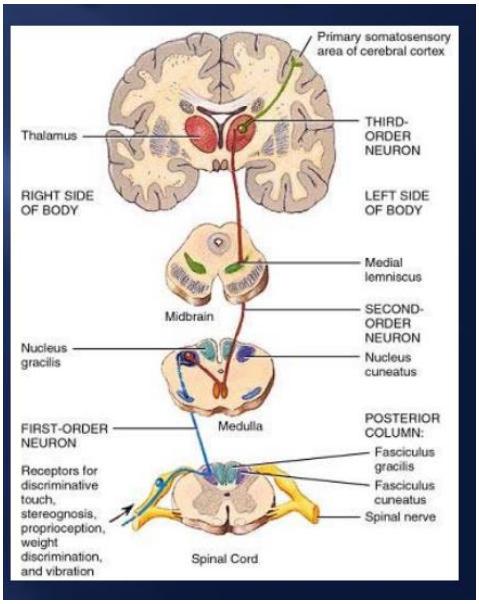
- perception with high discrimination ability
- discriminative touch, proprioception

Anterolateral system
Spinothalamic pathway

- perception with low discrimination ability
- crude touch, pain and temperature



Medial Lemniscal Pathway

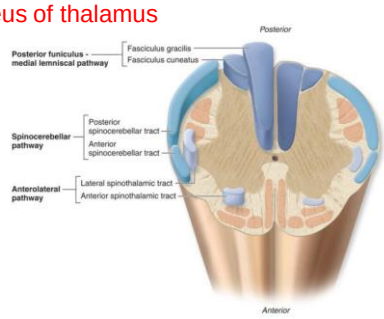


2nd order neurons:

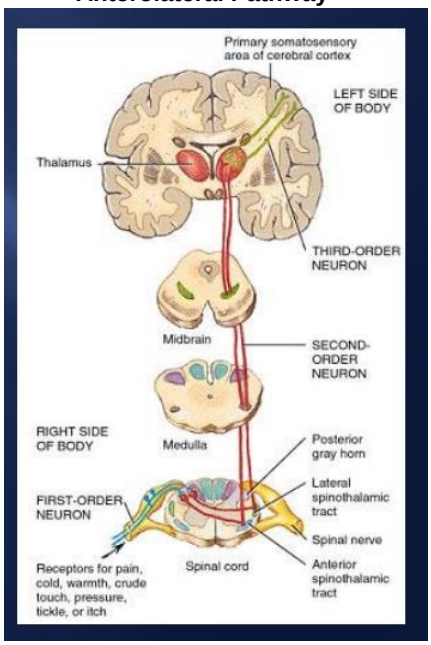
- Nucleus Gracilis (below T6)
- Nulleus Cuneatus (above T6)

3rd order neurons:

Ventroposterior lateral nucleus of thalamus



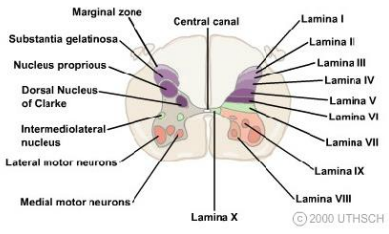
Anterolateral Pathway



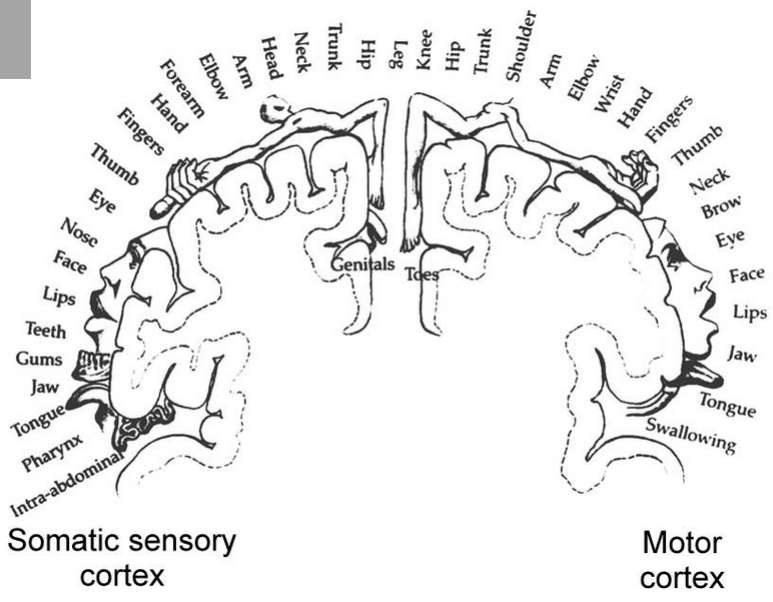
- Anterior spinothalamic tract
- Lateral spinothalamic tract
- Spinotectal tract
- Spinohypothalamic tract

2nd order neuron: Lamina I to V

3rd order neurons: Ventroposterior lateral nucleus of thalamus



Sensory Homunculus



Somatic sensory cortex

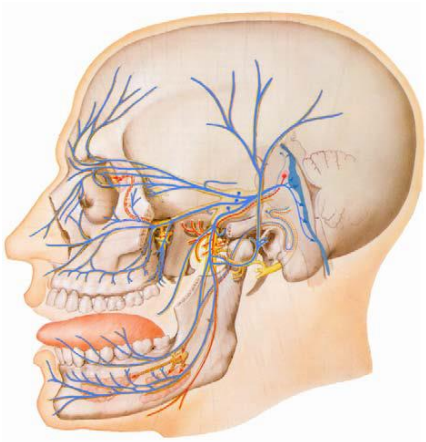
Motor cortex

Trigeminal Systems

Somatic sensory representation for most of head and all of face

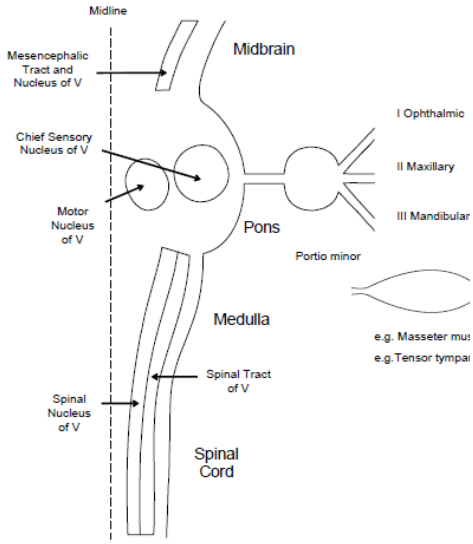
Somatic sensory pathways:

- Lemniscal system
- Antrolaterlal system
- Trigeminal system



Trigeminal Nerve (CN V)

Sensory Inputs to Trigeminal Nuclei:
Somatic sensory, tactile, pain and temperature



Trigeminal Pathways

1st order neurons:

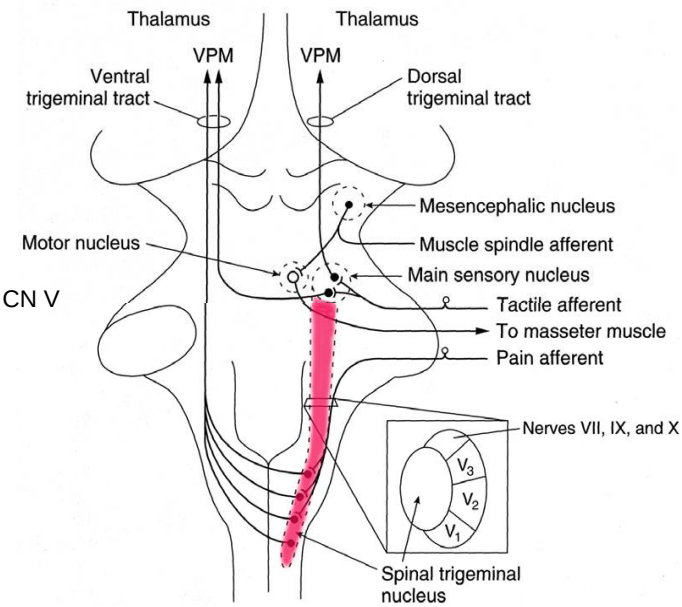
Trigeminal Ganglion cell

2nd order neurons:

Spinal nucleus of CN V & central sensory nucleus of CN V

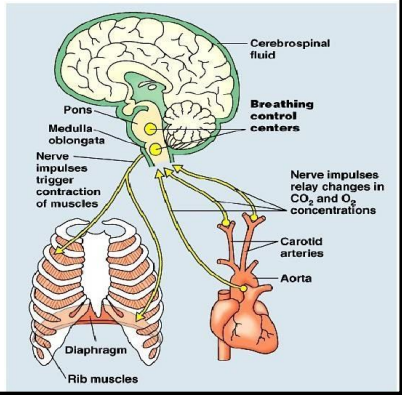
3rd order neurons:

Ventral posterior medial nucleus of thalamus (VPM)



Viscerosensory Pathways

- Carry information from the thoracic, abdominal and pelvic cavities, and from the cardiovascular system
- Utilize autonomic pathways to reach the CNS
- Participate in important reflexes
- Mostly end in the hypothalamus

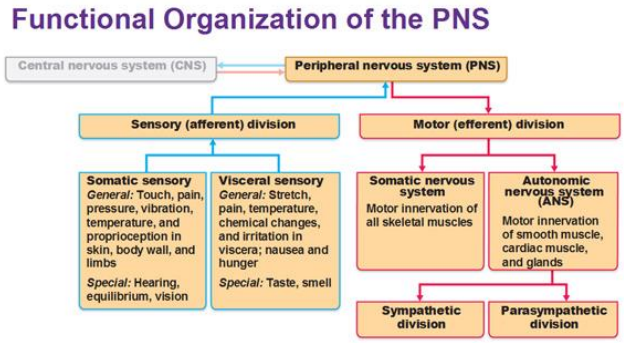


Viscerosensory fibres go together with sympathetic and parasympathetic nerves.

visceral organ

pseudounipolar neurons in ganglia

dorsal horn or brain stem sensory nuclei (the solitary nucleus)



Visceral Pathways

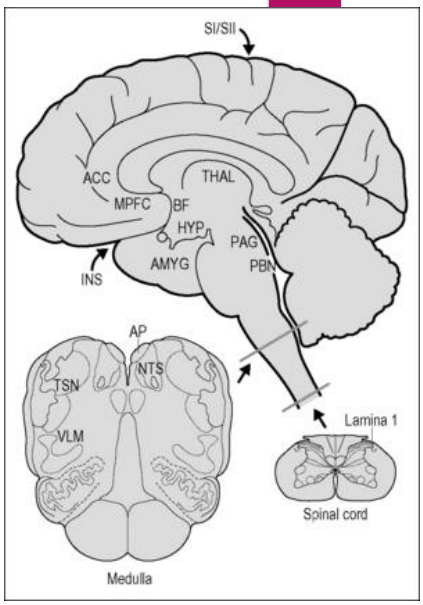
1st order neurons:

Ganglion cell of spinal cord or inferior ganglion of CN IX or CN X

2nd order neurons:

Lamina I of dorsal horn or solitary nucleus in medulla

Signals are transmitted to reticular formation, hypothalamus and thalamus.



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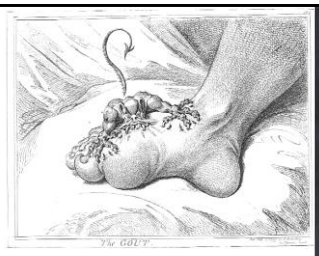
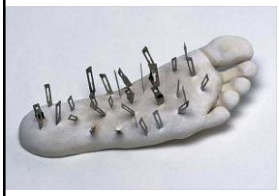
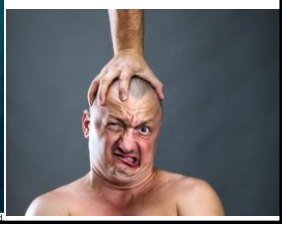




Pain is very personal and individualized



International Association for the Study of Pain (IASP):

"Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage".

Nociceptors

Noxious, adj.

from classical Latin noxius harmful, injurious, guilty (from noxa; harm, injury + -ius)

Noxious stimulus: A stimulus which is damaging to normal tissues

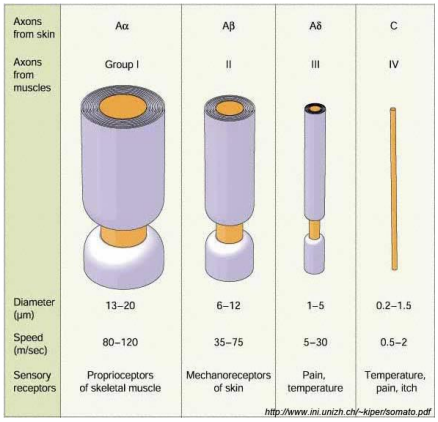
Nociceptor:

A sensory receptor neuron preferentially sensitive to a noxious stimulus or to a stimulus which would become noxious if prolonged.

Nociceptors

- nociceptors of Aδ fibres (5-30 meters/sec)
  - Aδ mechanical nociceptors
  - Aδ thermal nociceptors
- nociceptors of C fibres (0.2-2.0 meters/sec)
  - C polymodal nociceptors – react to thermal, mechanical and chemical stimuli
- silent nociceptors (MIA = mechanically insensitive afferents)

  - responsive after inflammation and tissue injury



Nociception

Nociception: all events following damage, or threat of damage to tissue

1. Begins with detection of noxious event by nociceptors
   - influenced by non-neuronal cells (e.g. inflammatory and immune cells, keratinocytes)
2. Subsequent activity in CNS neurons and pathways

a. reflex and withdrawal behaviors

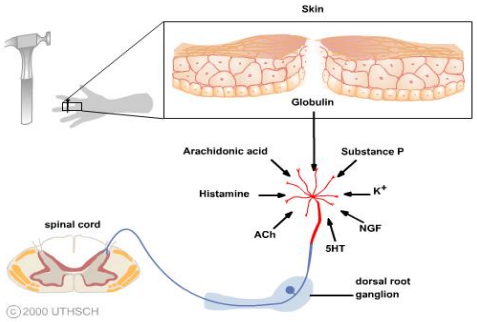
b. autonomic responses

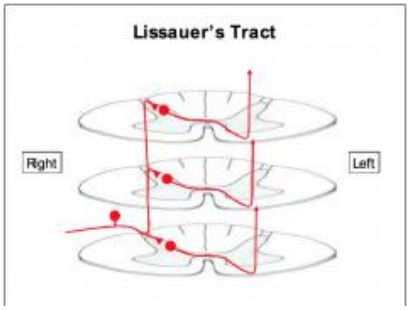
c. activity of neurons in “pain” pathways and systems

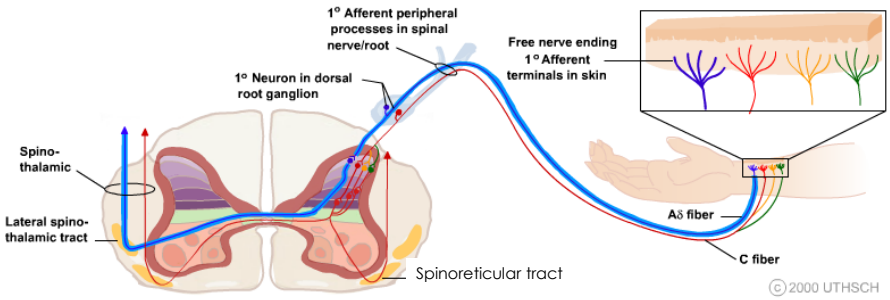
d. activation of endogenous modulatory systems

3. Perception of pain

Factors that activate nociceptors







A. Spinothalamic Tracts (STT)

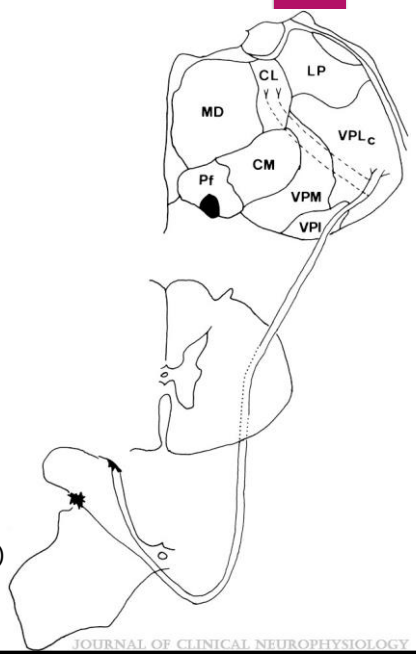
- neospinothalamic
- most cells of synapse in laminae I and V
- axons ascend contralateral
- thalamic terminations

a) VPL: somatotopic projection

b) Central Lateral (CL)

c) Posterior nuclei (PO)

- VPL projects primarily to primary somatosensory cortex
- Major role pain and temperature sensation (sharp, well localized pain)

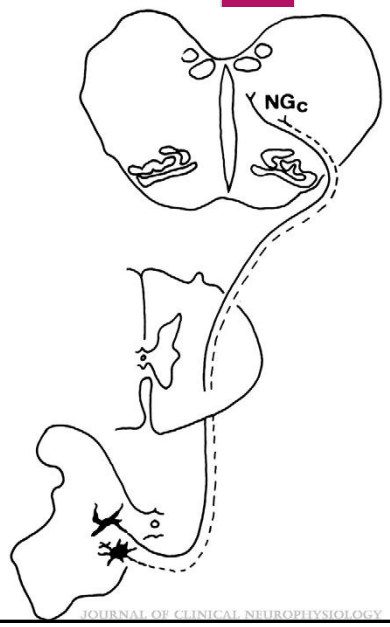


B. Spinoreticular Tract System (SRT)

- paleospinohalamic pathway
- many cells in lamina I and deep dorsal horn
- direct projections from spinal cord to reticular formation

a) medulla, pons, and midbrain (multiple levels)

- axons ascend contralateral (with STT)
- project to multiple thalamic and cortical regions
- Important in arousal and attention (diffuse, non-localized pain)

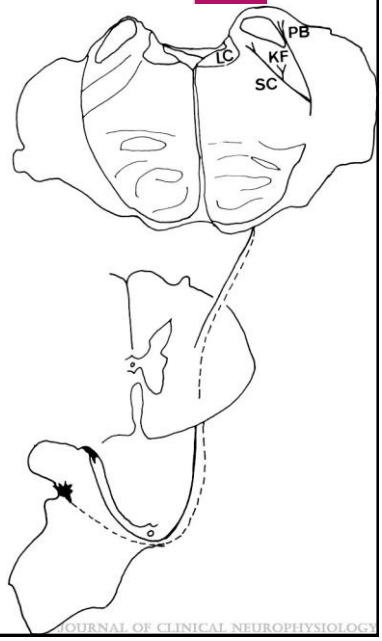


C. Spinoparabrachial Tract

- many cells in lamina I
- axons ascend through dorsal part of lateral funiculus
- axons terminate parabrachial nn. in pons
- parabrachial neurons project to thalamus

- also hypothalamus and amygdala

- cognitive, emotional, affective responses to pain



D. Direct spino-limbic Access

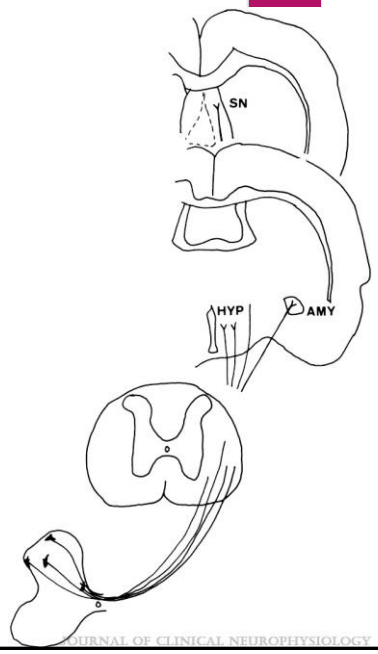
- spino-amygdaloid
- spino-hypothalamic
- spino-septal nuclei
  - cells of origin in dorsal and ventral horns
  - axons ascend through dorsal part of lateral funiculus
  - many bilateral projections to

a. hypothalamus

b. amygdala

c. septal nuclei and nucleus accumbens

- motivational aspects of pain

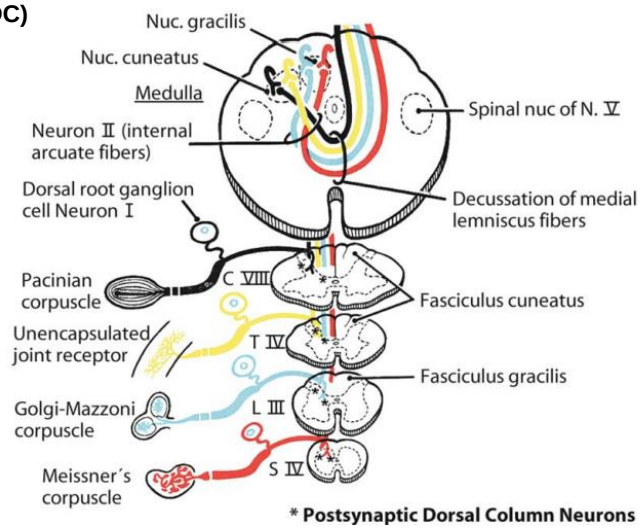


E. Postsynaptic Dorsal Column Tract System (PSDC)

- most cells in laminae III-IV
- many respond noxious visceral inputs
- PSDC axons ascend ipsilaterally
- axons terminate in dorsal column nuclei
- DCN cells project to contralateral thalamus

- ventrobasal complex of the thalamus
  - Important ascending visceral system

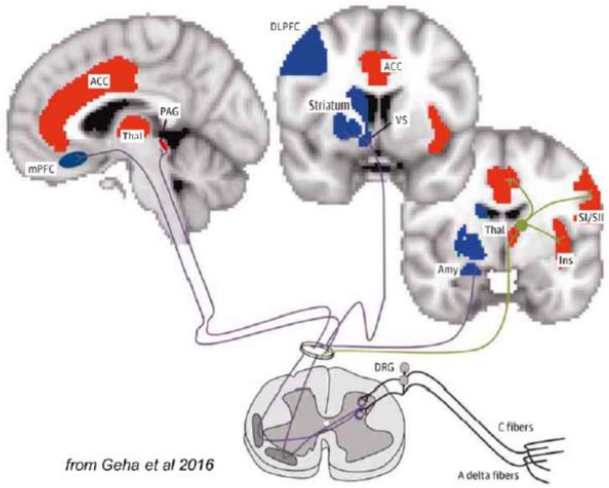
-effective for relief of extreme visceral pain



Westlund, *Springer* 2007

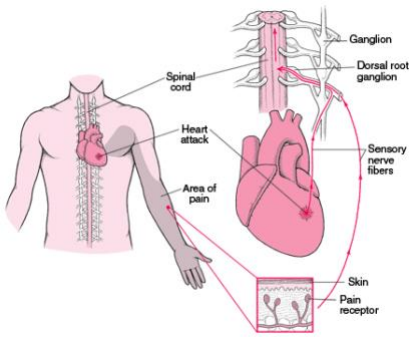
Forebrain Regions Related to Nociception (Nociception Matrix)

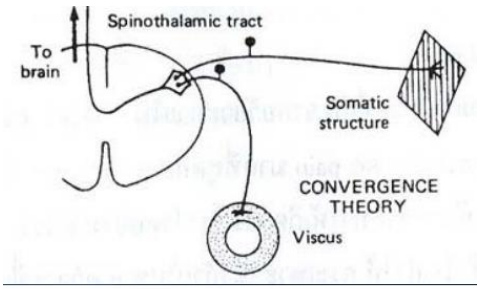
A. Primary Somatic Sensory Cortex (SI)
B. Secondary Somatic Sensory Cortex (SII)
C. Insular Cortex
D. Anterior Cingulate Gyrus
E. Pre-frontal cortex
F. Thalamus
H. Amygdala

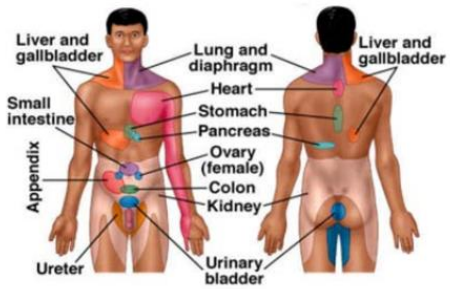


from Geha et al 2016

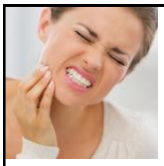
Referred Pain





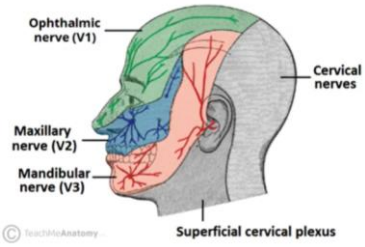


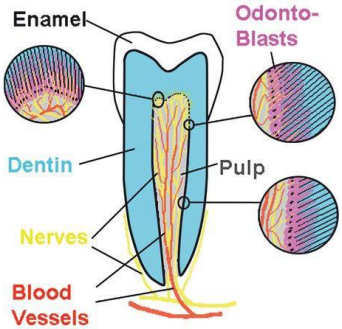
- Convergence theory
- Common dermatome hypothesis
- Facilitation or irritable focus
- Learned phenomenon



Dental Pain

- Aβ + Aδ fibres –first and sharp pain, easily stimulated by application of cold
- C fibres – dull ache, sensitive to inflammatory mediators, changes in blood flow
- pulp + dentin – enormous number of free nerve endings
- Somatic pain: musculoskletal pain and visceral pain
- Neuropathic pain: inflammed pulp or periapex – peripheral and central sensitization hyperalgesia, allodynia and spontaneous pain
- referred orofacial pain – both source and referral site

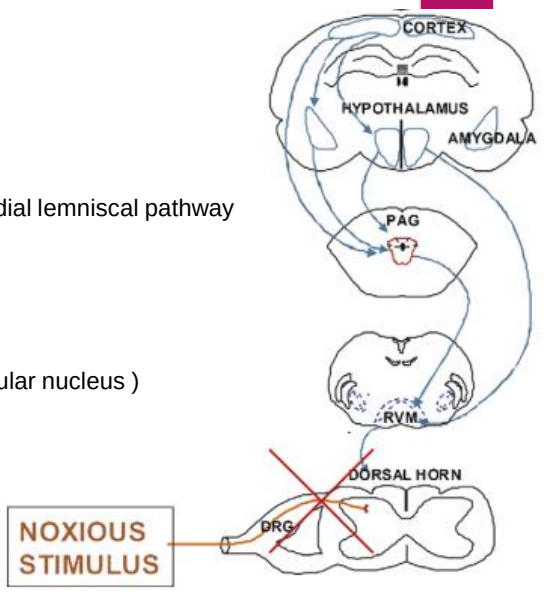




Modulating Systems of Nociceptive Pathway

Levels of modulation of nociceptive pathways

- spinal cord (“gate control theory”)- dorsal column medial lemniscal pathway
- peri-aquaeductal gray matter (PAG)
- locus coeruleus
- reticular formation of brain stem (gigantocellular reticular nucleus)
- raphe magnus nuclei



Ryan, *Neurobiology* 2009

Anterior limbic brain
Hypothalamus
(stress)

↓

Periaqueductal
gray matter

↓

other nuclei of RF
locus coeruleus
ncl. gigantocel.
ncl. raphae magnus

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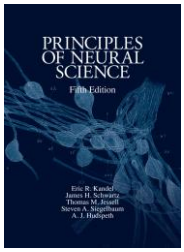
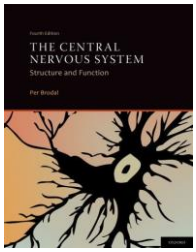
Dorsal spinal horns

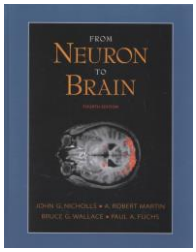
Stress-Induced Analgesia

Pain suppression upon exposure to unconditioned or conditioned stressful stimuli.

Reading List







Thank you very much for your attention