Dorsal Columns Medial Lemniscus

Spinal Cord:

- primary afferent fibers w/ cell bodies in dorsal root ganglia receive input from meisner's discs, etc.
- enter spinal cord via dorsal roots and then forms the dorsal columns
- no synapse or crossing in spinal cord

Medulla

- ipsilateral synapse in nucleus gracilus or cuneatus
- secondary afferents from nucleus gracilus or cuneatus cross in internal arcuate fibers and then form medial lemniscus

Thalamus

- synapse on thalamus neurons (ipsilateral)
- the third order thalamus fibers project to cortex via internal capsule and corona radiata

Cerebral Cortex

- Synapse in primary somatosensory cerebral cortex

Dorsal Columns

- Fasiculus Gracilis ⟶ contains primary afferent fibers (axon) from lower body (lower thoracic-T6, Lumbar, and Sacral) and synapses in nucleus gracilis (in medulla)
- Fasiculus cuneatis ⟶ contains primary afferent fibers from upper body (above T6 and cervical) that synapse in nucleus cuneatus (in medulla)

Sensory Decussation Level

- secondary fibers cross at sensory decussation level of closed medulla
- crossing fibers are called internal arcuate fibers
- once fiber reaches the midline, they become the medial lemniscus
- final destination of medial lemniscus is the thalamus

Ventral Posterior Thalamus

- fibers from the DCML synapse in ventral posterior lateral (VPL) nucleus of the thalamus ⟶ sensation of body
- trigeminal system ends medially to ventral posterior medial nucleus (VPM) ⟶ sensation of face

Primary Somatosensory Cortex

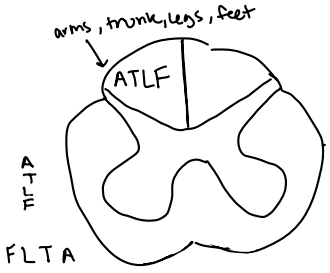
- projects to post central gyrus of cortex in Brodman's Areas 1,2,3
- damage to primary somatosensory cortex results in contralateral loss of fine touch + proprioception

DCML Lesions ⟶ complete unilateral DCML lesions

- Peripheral nerve damage ⟶ ipsilateral loss of Fine touch + proprioception distal to nerve damage

- spinal cord ⟶ ipsilateral loss of fine touch + proprioception at and below lesion
- lower medulla (below internal arcuate fibers) ⟶ ipsilateral loss of fine touch + proprioception at and below lesion (entire body)
- upper medulla and above ⟶ contralateral loss of fine touch + proprioception

Somatotopic Organization of DC/ML



- Spinal Cord / Caudal Medulla ⟶ sensation from feet is medial, arms is lateral
- Rostral Medulla ⟶ in the medial lemniscus, arms ventral feet dorsal
- Pons ⟶ arms medial, feet lateral
- Midbrain and thalamus ⟶ feet dorsal, arms lateral
- Cortex ⟶ feet medial, arms lateral

Anterior Lateral Fasiculus – Classic/lateral Somatosensory Pain Pathway

Primary Afferent Fibers

- type C (IV) or Aδ (delta) fibers w/ cell bodies in the dorsal root ganglia

Synapse:

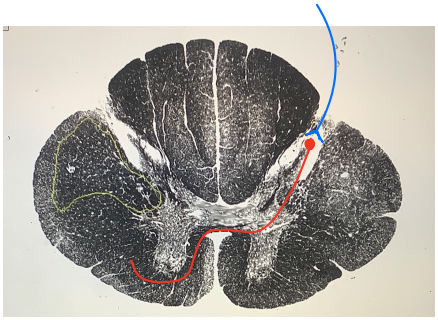
- synapse at dorsal horn at spinal nerve level onto 2nd order neurons in posteromarginal nucleus and substantia gelatinosa and lamina 5 and 6. primary afferents release substance P for neurotransmitter
- or they travel via lissauer's tract and synapse in dorsal horn of another level

Lissauer's Tract ⟶ ascending or descending primary afferent fibers (prior to synapse).

- damage to dorsal horn at level primarily reduces pain/temp at that level, in addition to multisegmental sensory loss/loss of reflexes. loss of pain isn't as significant at levels above/below level of damage

Secondary Fibers

- fibers that synapse in dorsal horn ⟶ secondary fibers then cross in ventral white commissure



- Secondary spinal cord fibers of the pain and temp system ascend spinal cord in the ALF

The ALF contains:

- the spinothalamic tract
- spinoreticular tract (brainstem)

tract vs. fasiculus

- tract – fibers have a common origin and termination
- fasiculus – can contain multiple tracts

- spinomesencephalic tract
- propriospinal tract (to spinal cord)

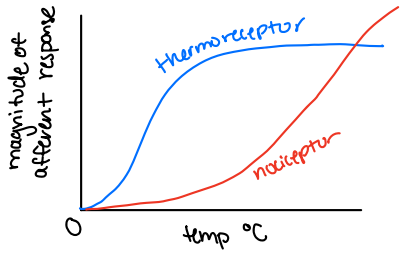
Somatotopic organization

spinal cord → cervical is medial, sacral is lateral

For discriminative Pain

- nerve synapses in dorsal root of spinal cord
- secondary afferent cross midline via ventral white commissure and ascends spinal cord via spinothalamic tract (part of ALF)
- synapses at VPL nucleus of thalamus (responsible for touch localization)

Thermal Detection



- non-nociceptive thermoreceptor have much lower threshold for action potentials
- nociceptors much higher threshold for pain

pathway:

- specialized free nerve endings have low threshold response to temperature (seperate receptors for warm/cold)
- similar pathway to discriminative pain → if you lose pain, you lose temp sensation
- they have the same tracts, but different axons → so not a violation of labeled line theory

Lesions to ALF pathway

spinal nerves → ipsilateral loss of pain distal to lesion

Spinal cord:

- dorsal root → ipsilateral loss at level of lesion
- dorsal horn → ipsilateral at level of lesion
- Dorsolateral fasiculus (Lissauer's tract) → pain + temp near level of lesion (up or down a level)
- ALF (also in brainstem) → contralateral and below level of lesion

Thalamus (VPL) → contralateral entire body (not face)

Somatosensory Cortex → pain persists even if there is damage to cortex

Functional Components of Pain

Discriminitive Pain

- involved in pain localization and intensity
- transmitted via A-delta fibers

- lateral pain pathway to VPL and S1 of somatosensory cortex
- also known as "epicritic" pain, fast pain, neospinothalamic pain

Non-discriminative Pain

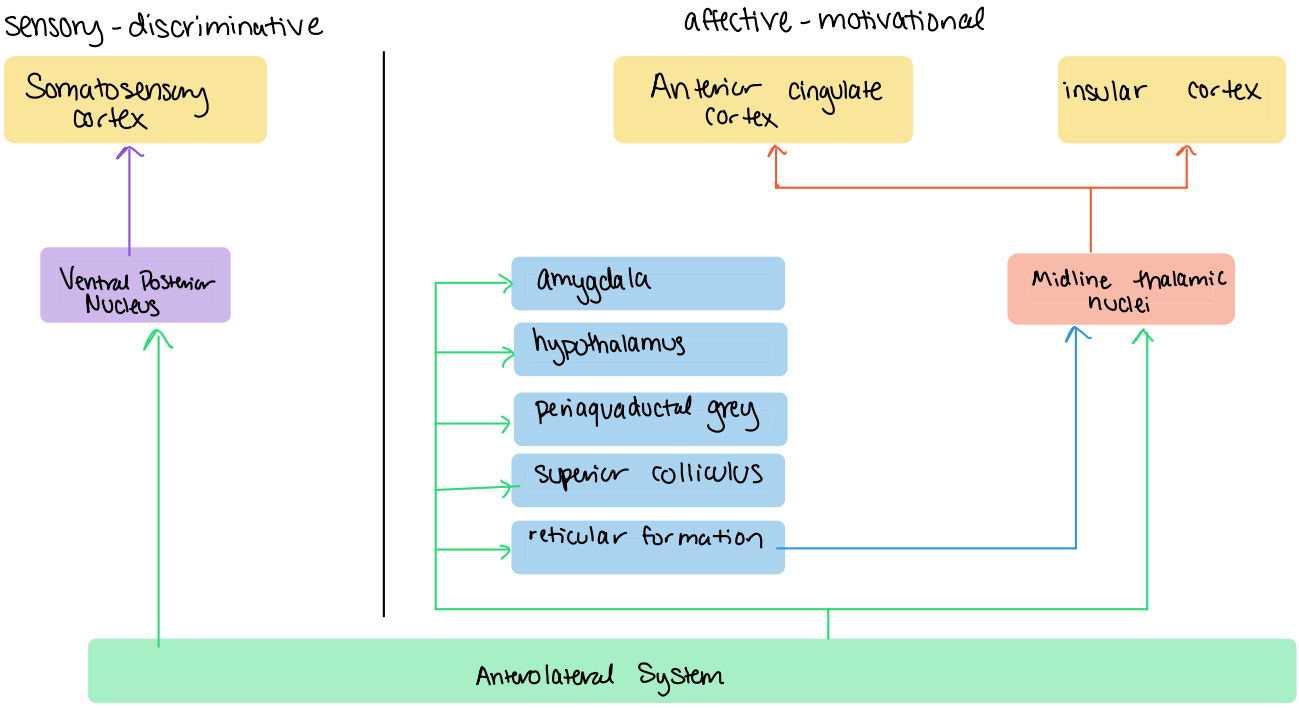
- involved in the unpleasantness and affective (emotional) components of pain
- transmitted via C-fibers
- also known as "protopathic" pain, slow pain, and paleospinothalamic pain
- medial pain pathway of the cingulate cortex, insula

Medial Pain Pathway → non-discriminative

- secondary afferents cross in ventral white commissure
- fibers travel to thalamus in two ways:
  - spinothalamic → directly to thalamus
  - spinoreticular → synapse in reticular nuclei in brainstem and then reticulothalamic

- synapse in midline and intralaminar thalamic nuclei (MITN)
- project from thalamus through internal capsule to the cingulate cortex and insula

Discriminitive vs Affective Pain



- damage to somatosensory cortex (S1, S2) → have pain, but don't know where
- damage to anterior cingulate cortex (bilaterally) → you know you have pain/where you have pain/how much

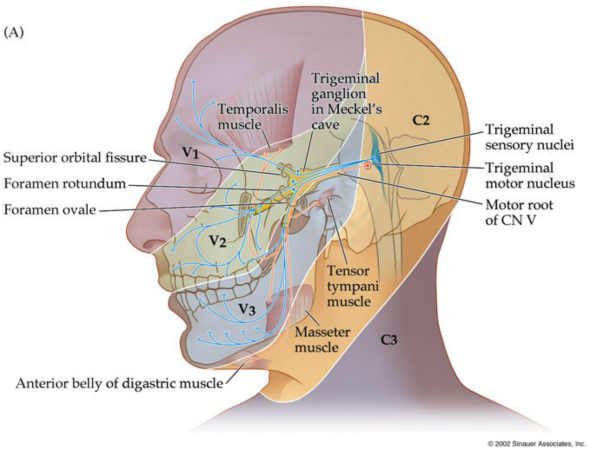
but you don't care if you have pain → removes unpleasantness

- damage to VPL → have pain, don't know where
- damage to entire thalamus → no pain sensation

Somatosensory Systems of the face

Trigeminal Functional Areas

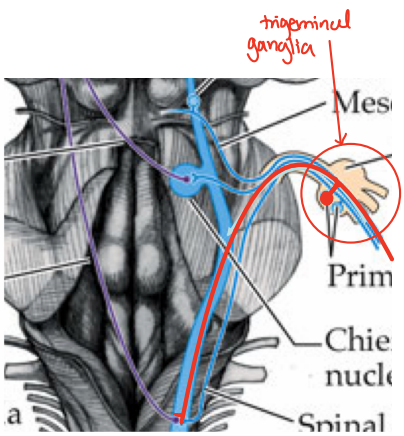
- traditional dermatomes are unique based on somite they derived from
- real dermatome of the face is C2 (some of external ear)
- facial "dermatomes" → derived from mesodermal branchial arches, not somites, so not technically dermatomes
  - V1 (opthalmic) → cornea, part of nose, forehead
  - V2 (maxillary) → part of nose, temple, cheek
  - V3 (mandibular) → lower jaw, anterior ear
  - as you go down closer to eardrum, innervation is by CN 7, 9, and 10



Trigeminal Nuclei

- Spinal trigeminal nucleus/tract (descending fibers) → medulla + caudal pons
  - pain + temperature (above C2)
  - nucleus and tract analogous to lamina 1 and 2 and DLF in spinal cord
- Chief sensory trigeminal nucleus → middle pons
  - fine touch + proprioception
- trigeminal motor nucleus → middle pons
  - branchial motor control of muscles of mastication
- mesencephalic nucleus → rostral pons + midbrain
  - face proprioception

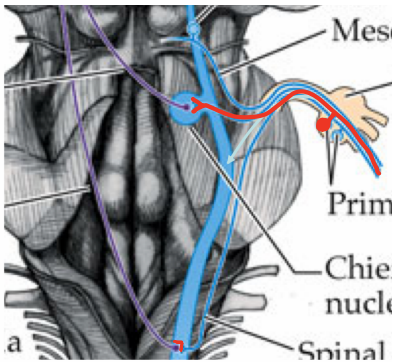
Pain + temperature pathways of face



- Primary nociceptors in face in external ear (5, 7, 9, 10), teeth, tongue, cornea, dura
- cell bodies are in sensory ganglia
  - trigeminal ganglia (also known as gasserian or semilunar ganglia)
  - located outside the dura at the base of the skull
- primary afferent synapses in spinal trigeminal nucleus. Can travel up or down via spinal trigeminal tract before synapsing (same as Lissauer's tract) in spinal

trigeminal nucleus.

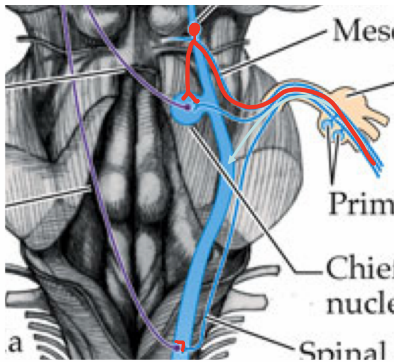
Touch + Proprioception pathway



- touch receptors in face, external ear (CN 5, 7, 9, 10), and tongue (CN 9)
- cell bodies of primary afferents in trigeminal sensory ganglia
- Synapses chief sensory nucleus in the middle pons

Proprioceptive Pathway

- proprioception receptors in muscles → muscle spindles in muscles of mastication, tongue, and eye muscles
- primary afferent cell bodies are in mesencephalic nucleus or trigeminal ganglia
  - mesencephalic "nucleus" → these neurons are derived from neural crest cells
- Synapse in chief sensory nucleus



Discriminative Trigeminal Pathways

- axons of secondary fibers cross immediately (at level of synapse)
- ascend after crossing via trigeminothalamic tract (trigeminal lemniscus)
- Secondary afferents synapse in Ventral Posterior Medial Nucleus (VPM)
- project to cortex through corona radiata, posterior limb of internal capsule
- Synapse in lateral part of somatosensory cortex

Medial Painpathway

- secondary fibers cross and project to midline + intralaminar nuclei
- tertiary fibers project to cingulate cortex

★ look into labelled line theory