6
Somatosensitivity, viscerosensititvity, proprioception and pain II

Viscerosensitivity

- An information from visceral and cardiovascular system
- Linked to the autonomic nervous system
- The most of information does not reach higher structures than hypothalamus
- The most of information does not reach consciousness
- Parasympathetic nervous system (IX., **X.**)
  - „ Operational information“ (blood pressure, pO2, pCO2)
- Sympathetic nervous system
  - „Potential danger“ (pressure, pain, cold)

Proprioception

- Information from muscles, tendons and joints
- Important for precise coordination of movements
- Overload protection
- More will be discused in lecture about motor

Somatosensory pathways

- Three systems

- (Archispinothalamic)
  - Interconnection of adjacent segments (tr. Spinospinalis)
- Paleospinothalamic
  - tr. Spinoreticularis, tr. Spinotectalis…
- Neospinothalamic
  - tr. Spinothalamicus
- Dorsal column system
  - tr. Spinobulbaris

Somatosensory pathways

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  - tr. Spinoret
- Neospinothala
  - tr. Spinothalar
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EVOLUTION….

Evolutionary old structures have not been replaced by new ones during evolution, but the old has been kept and the new added

Somatosensory pathways

- Paleospinothalamic
  - Low resolution – dull, diffuse pain („slow pain“)
- Neospinothalamic
  - High resolution – sharp, localized pain („fast pain“), temperature
  - Low resolution – touch
- Dorsal column system
  - High resolution – touch, proprioception

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Immediate survival

Long-term survival

Paleospinothalamic system

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- Evolved before neocortex

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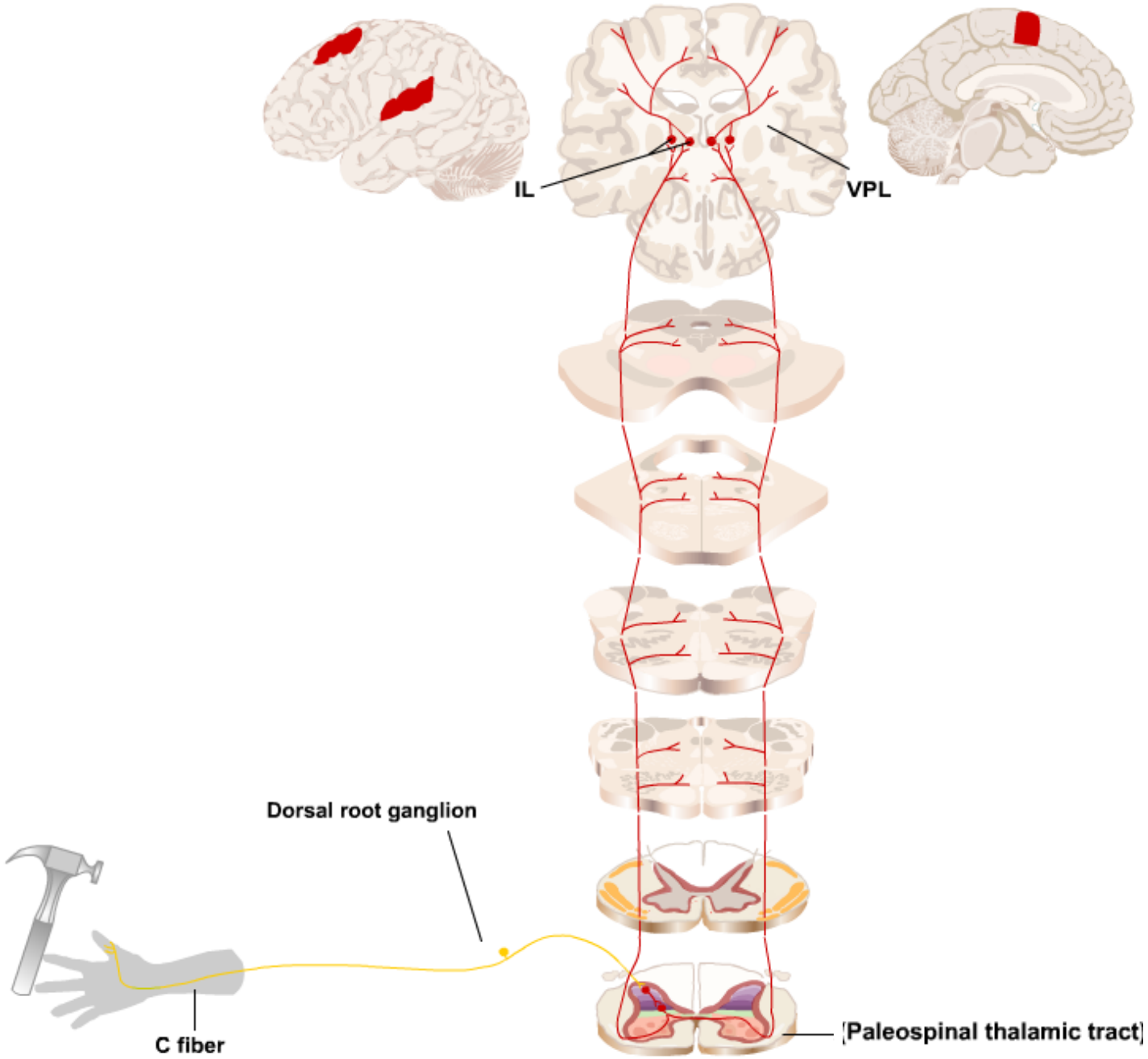
- This tract is not designed for „such a powerful processor as neocortex“
- Approximately half of the fibers cross the midline


IL
VPL
Dorsal root ganglion
C fiber
Paleospinal thalamic tract

Neospinothalamic system

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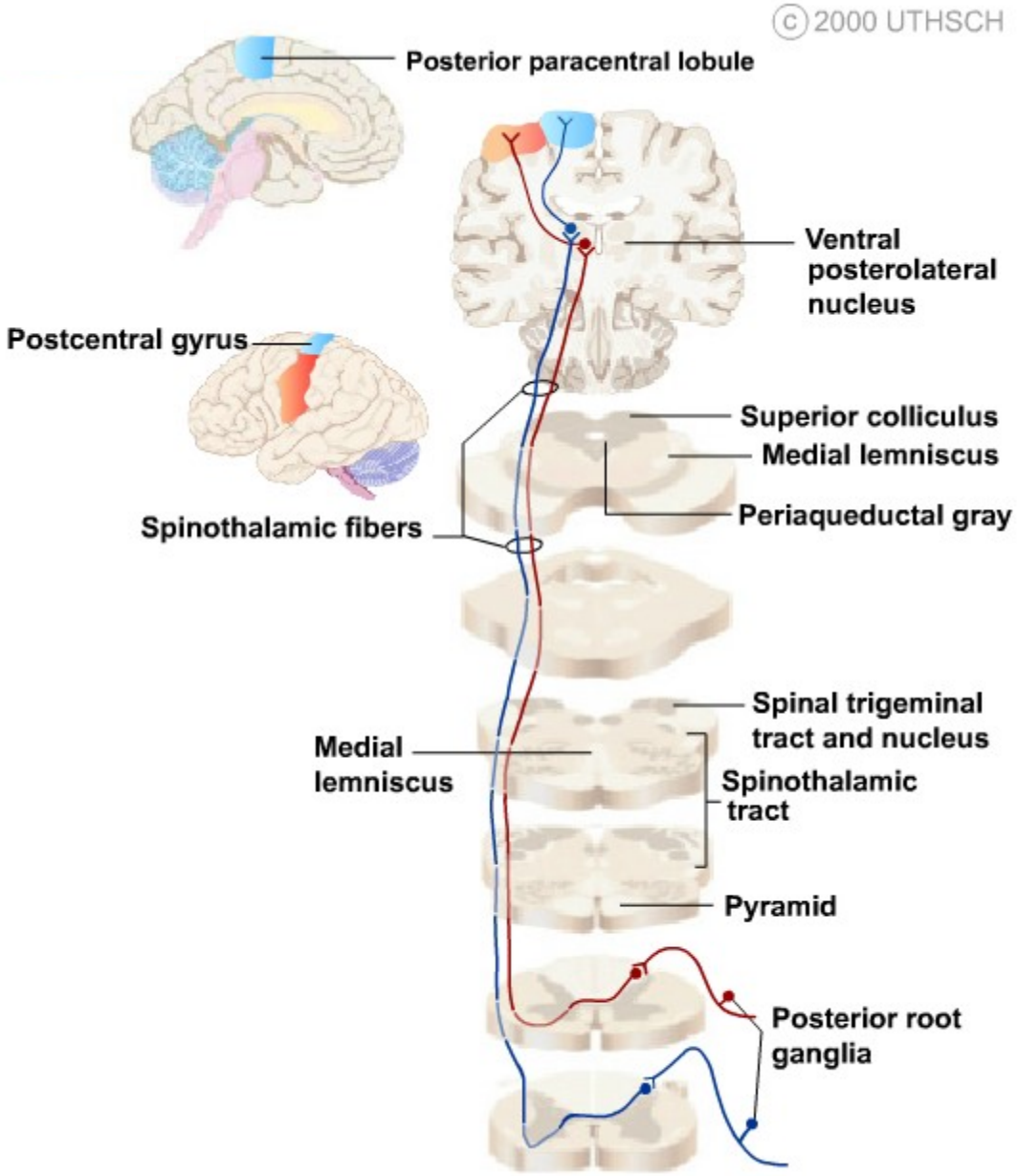

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Dorsal column system

- Tr. Spinobulbaris

Dorsal column system

- Tr. Spinobulbaris
- The youngest system
- High capacity

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- Vibration
- Proprioception

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- Better object recognition
- Adaptive value

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- Tactile sensation
- Vibration
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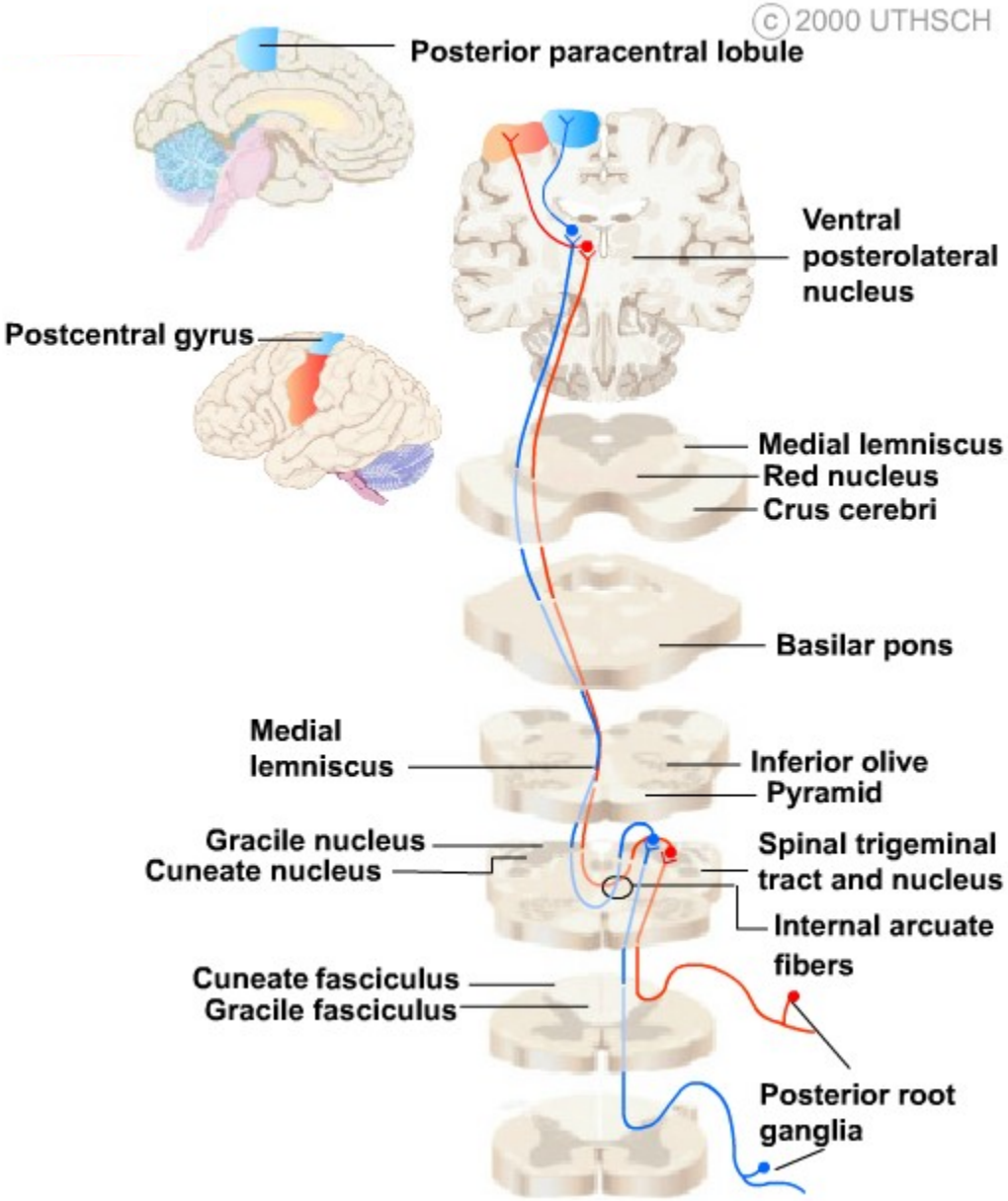
- Fine motor control
- Better object recognition
- Adaptive value
- The fibers cross midline at the level of medulla oblongata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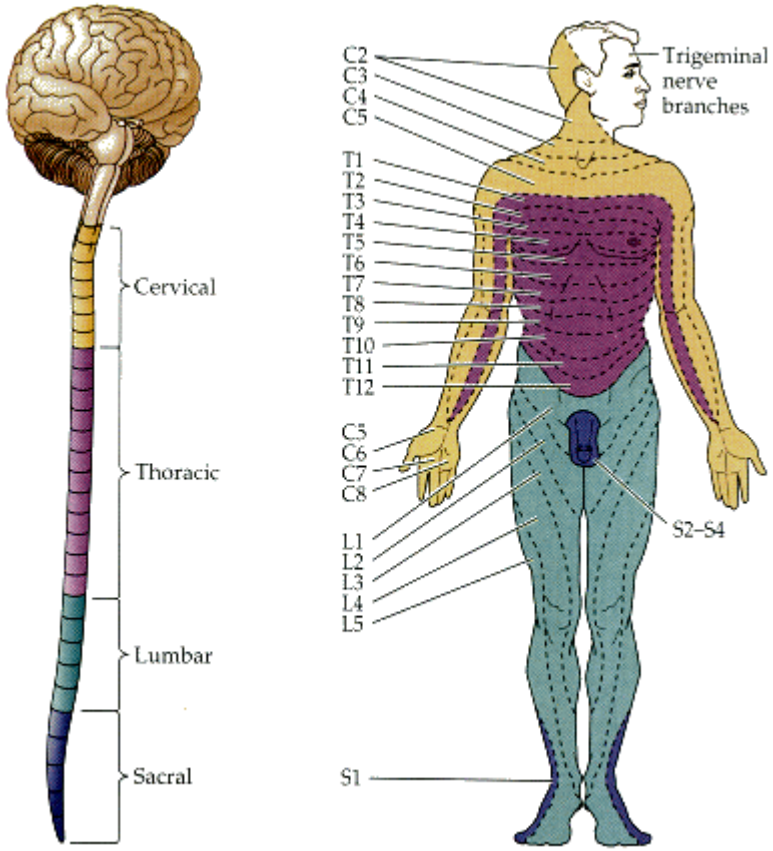
Posterior paracentral lobule
Ventral posterolateral nucleus
Postcentral gyrus
Medial lemniscus
Red nucleus
Crus cerebri
Basilar pons
Medial lemniscus
Inferior olive
Pyramid
Gracile nucleus
Cuneate nucleus
Spinal trigeminal tract and nucleus
Internal arcuate fibers
Cuneate fasciculus
Gracile fasciculus
Posterior root ganglia

Dermatoms



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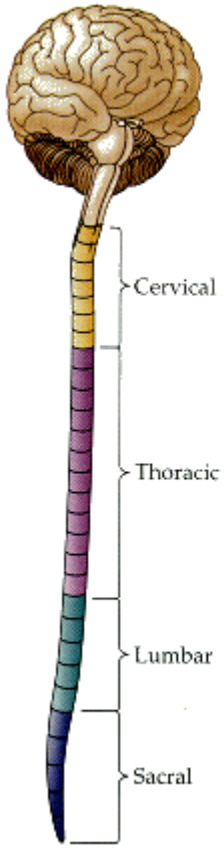
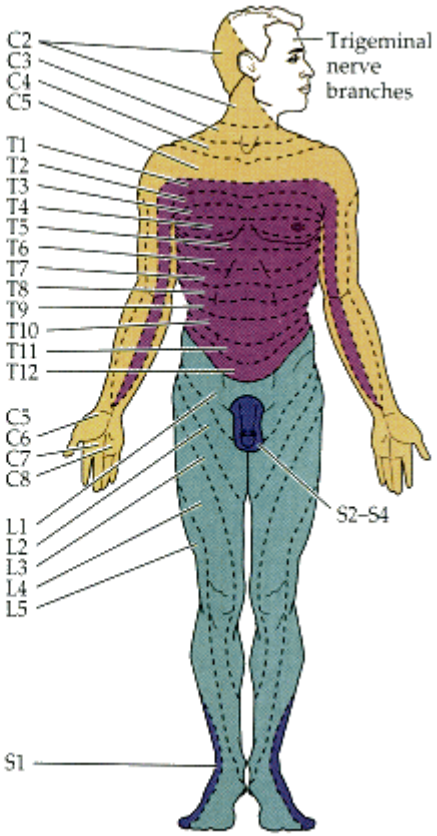
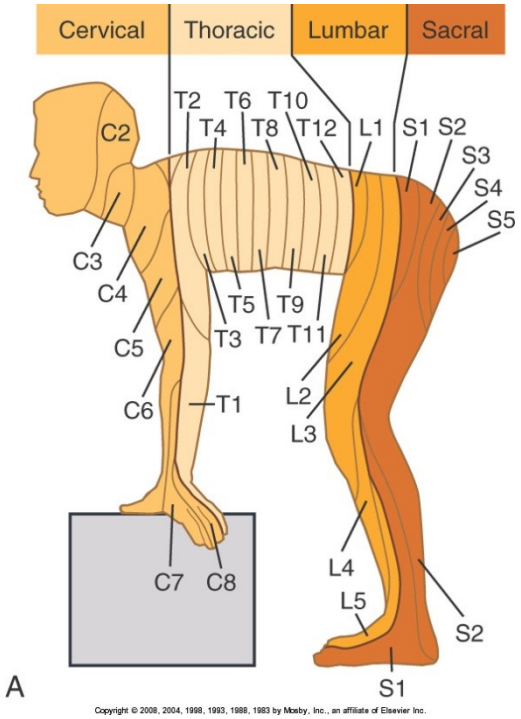
Dermatoms







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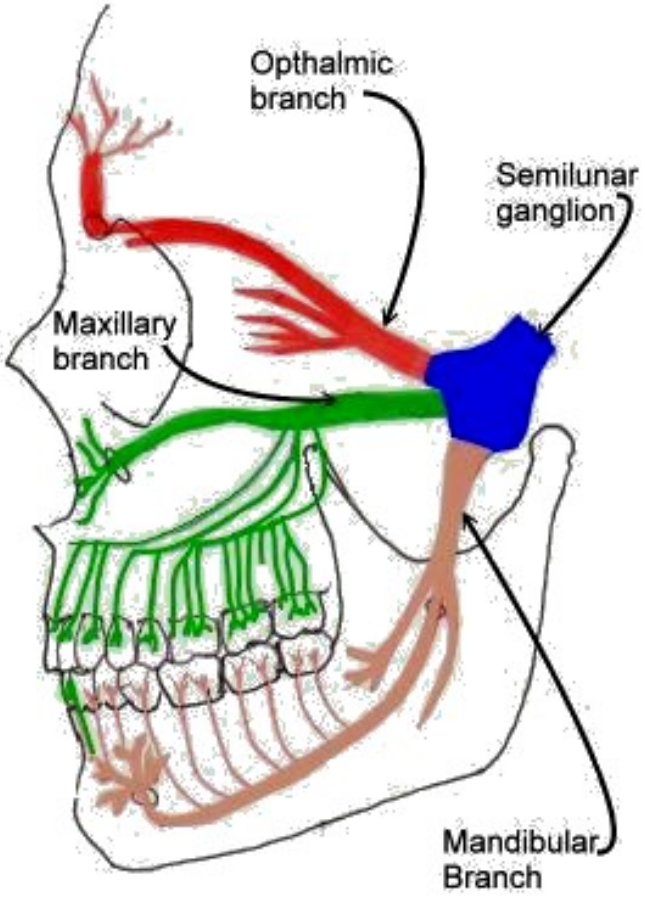
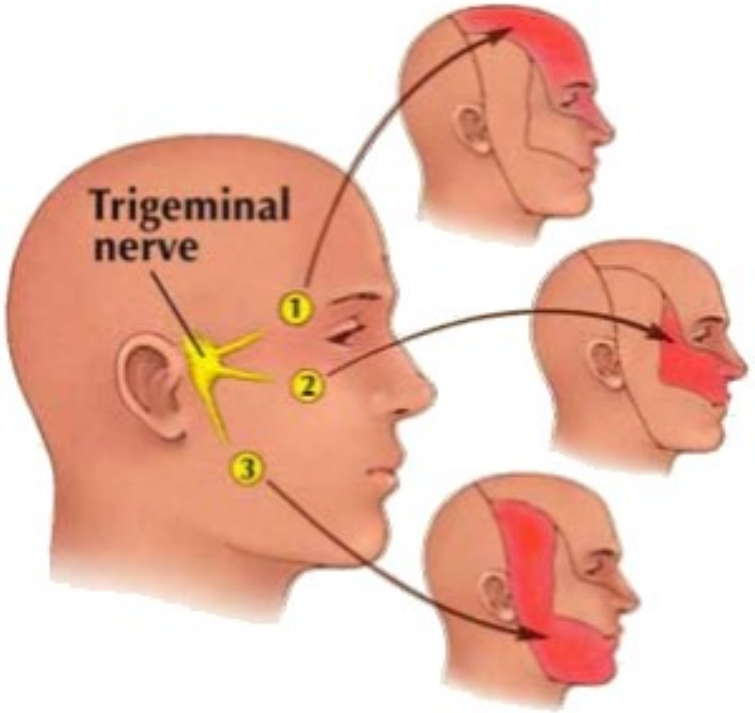
Trigeminal system





Somatosensory pathways

Table I
The Sensory Modalities Represented by the Somatosensory Systems

Modality	Sub Modality	Sub-Sub Modality	Somatosensory Pathway (Body)	Somatosensory Pathway (Face)
Pain	sharp cutting pain		Neospinothalamic	Spinal Trigeminal
	dull burning pain		Paleospinothalamic	
	deep aching pain		Archispinothalamic	
Temperature	warm/hot		Paleospinothalamic	
	cool/cold		Neospinothalamic	
Touch	itch/tickle & crude touch		Paleospinothalamic	
	discriminative touch	touch	Medial Lemniscal	Main Sensory Trigeminal
		pressure		
		flutter		
		vibration		
Proprioception	Position: Static Forces	muscle length		
		muscle tension		
		joint pressure		
	Movement: Dynamic Forces	muscle length		
		muscle tension		
		joint pressure		
		joint angle		

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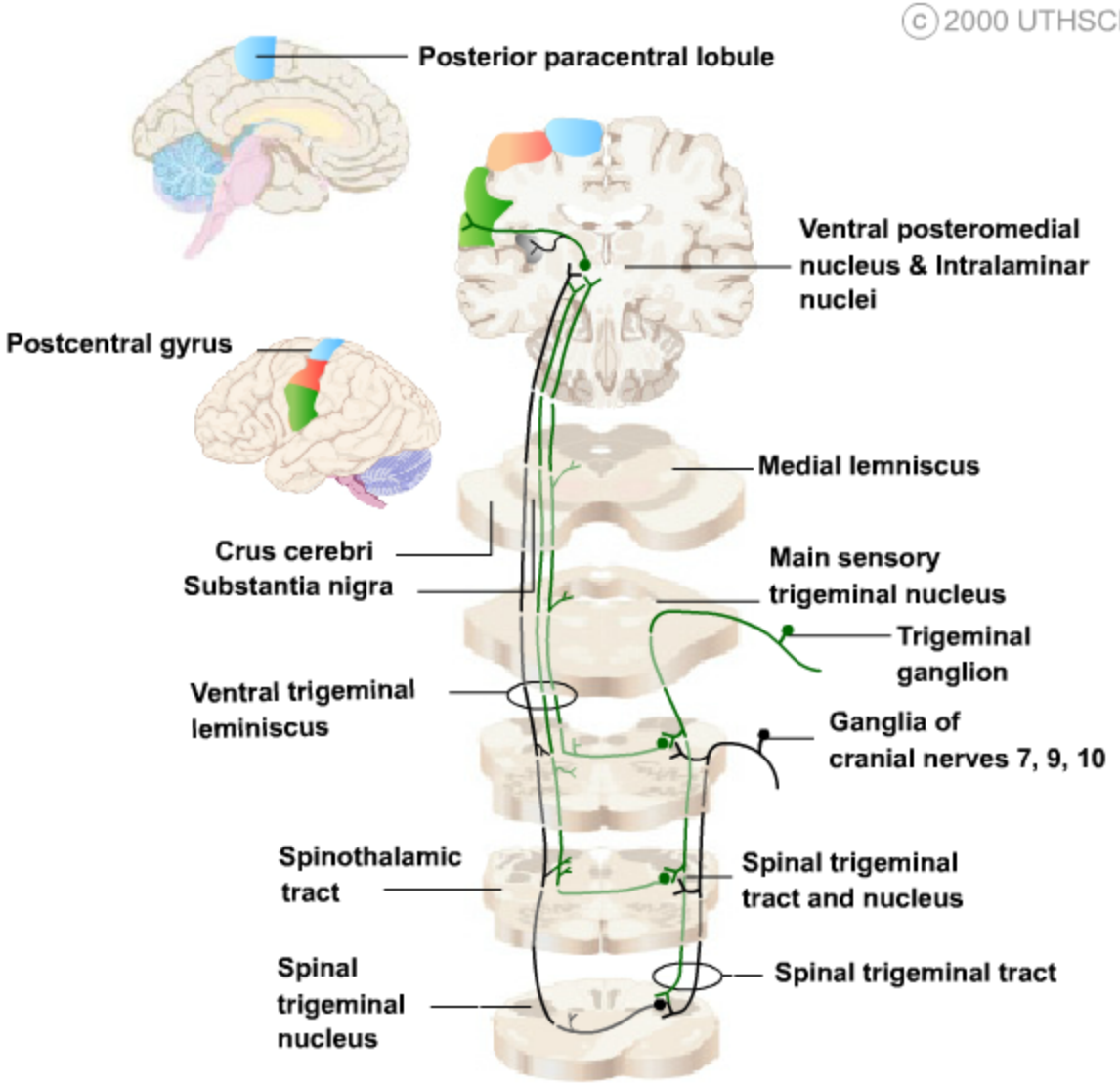

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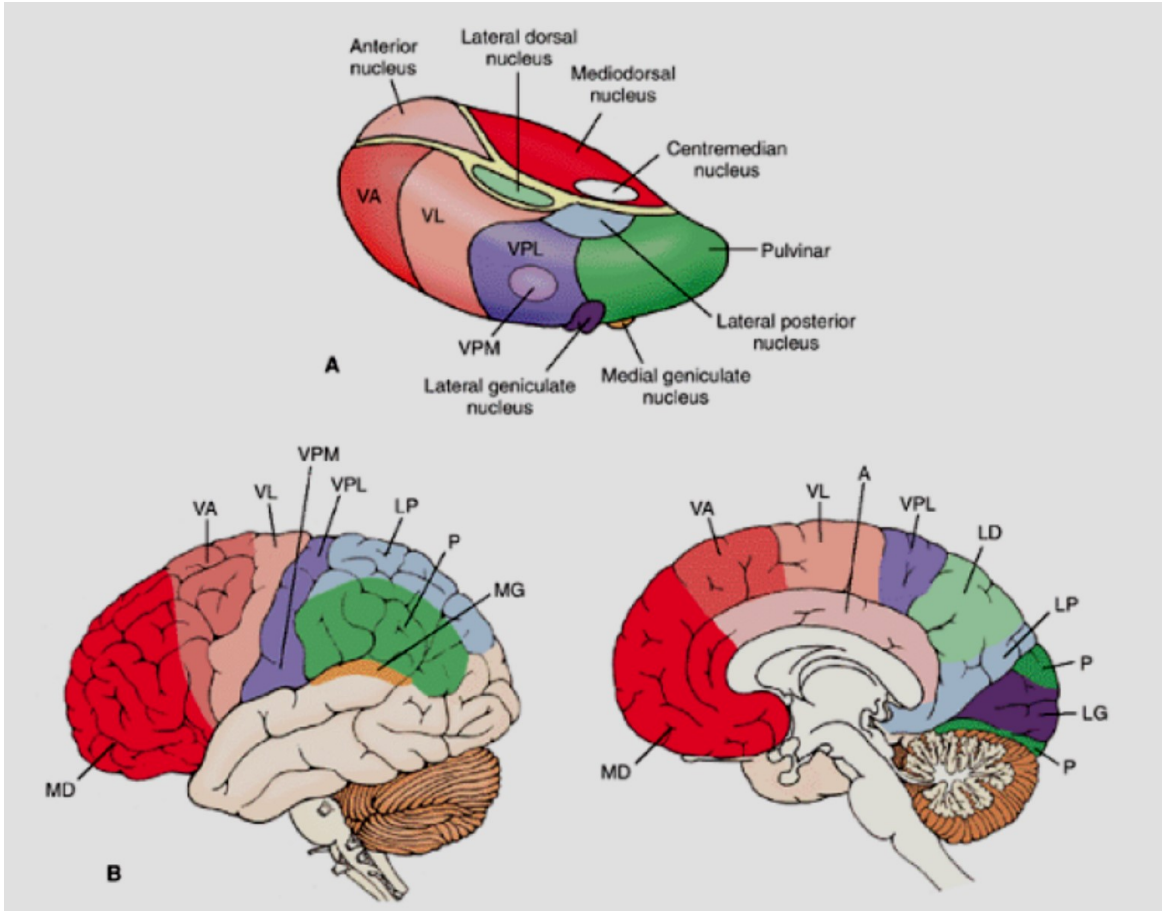
Thalamus a neocortex

- Almost all the afferent information gated in the thalamus
- Olfaction is an exception
- Bilateral connections between neocortex and thalamus



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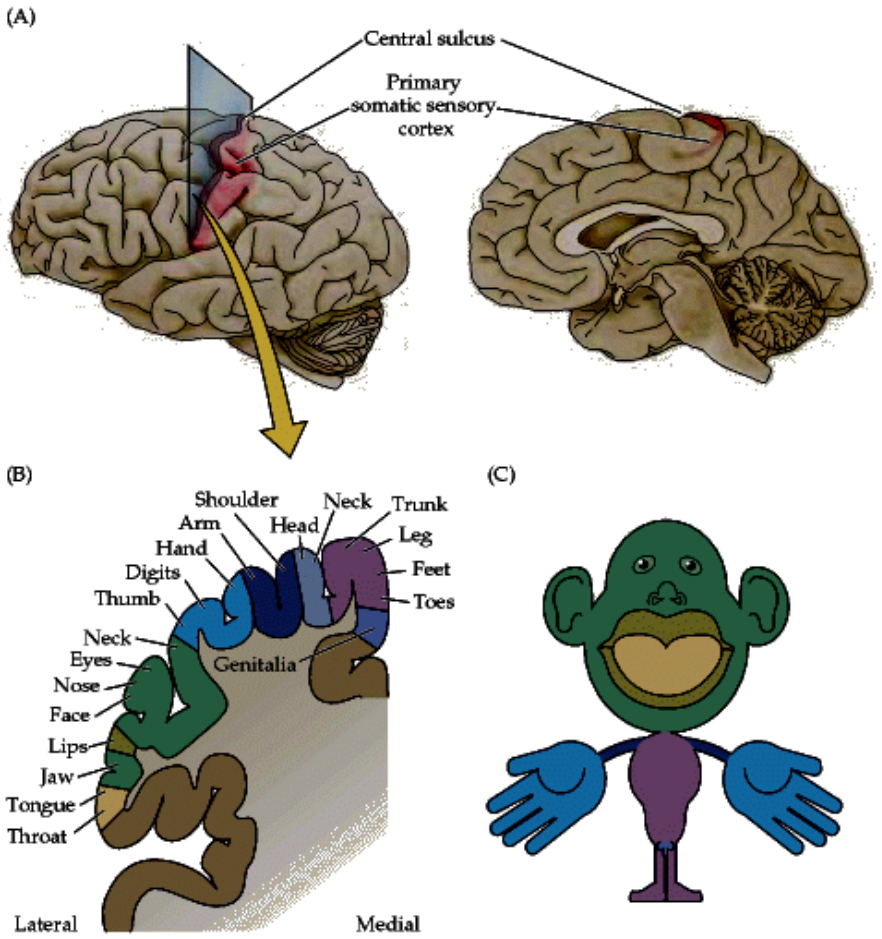
Neocortex



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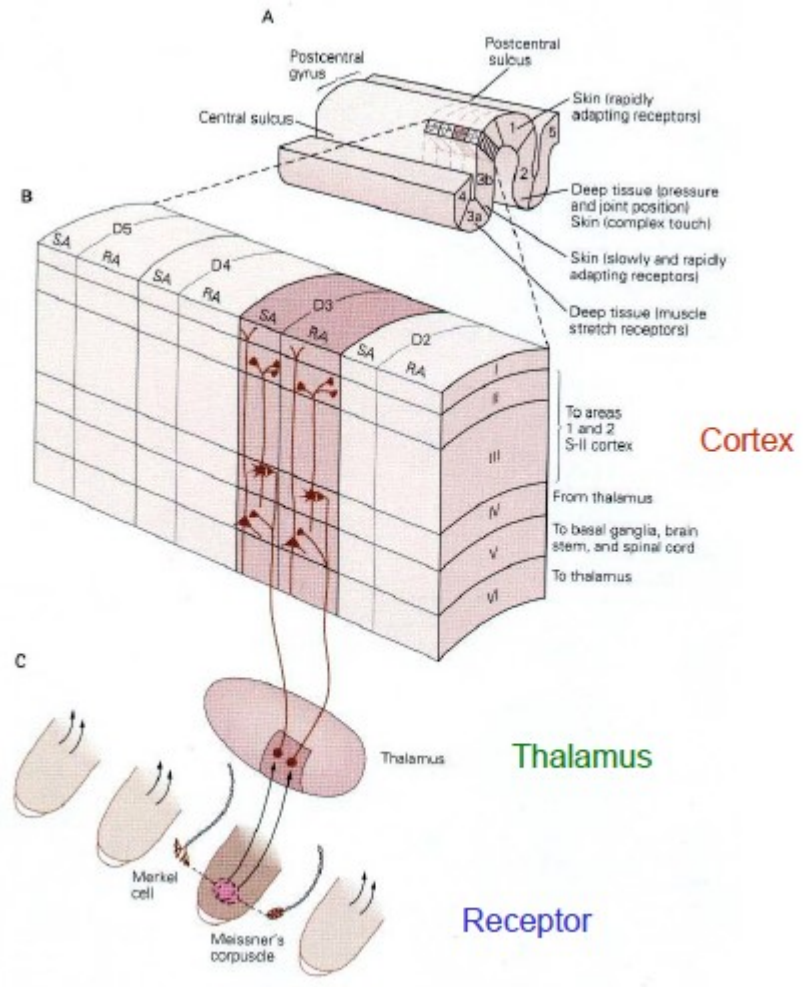
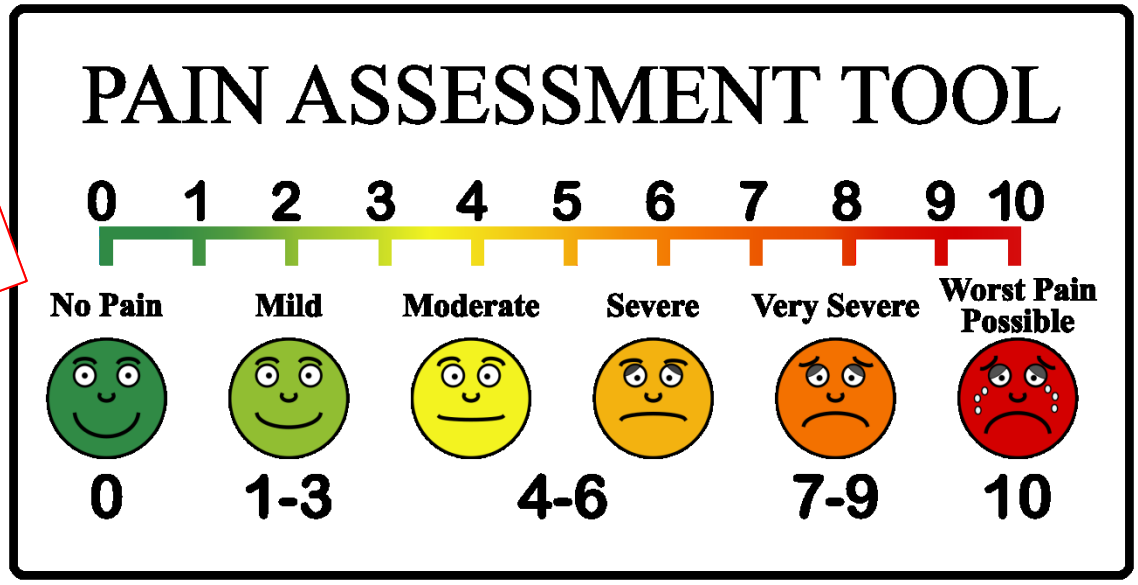


http://www.shadmehrlab.org/Courses/physfound_files/wang_5.pdf

Pain

- Distressing feeling associated with real or potential tissue damage
- Sensor x psychological component
- Physiological x pathological pain
- Acute (up to 6months) x chronic (more than 6 months)

Subjective character



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Limbic system

Navratilova E, Porreca F. Reward and motivation in pain and pain relief. *Nat Neurosci*. 2014;17:1304–1312.

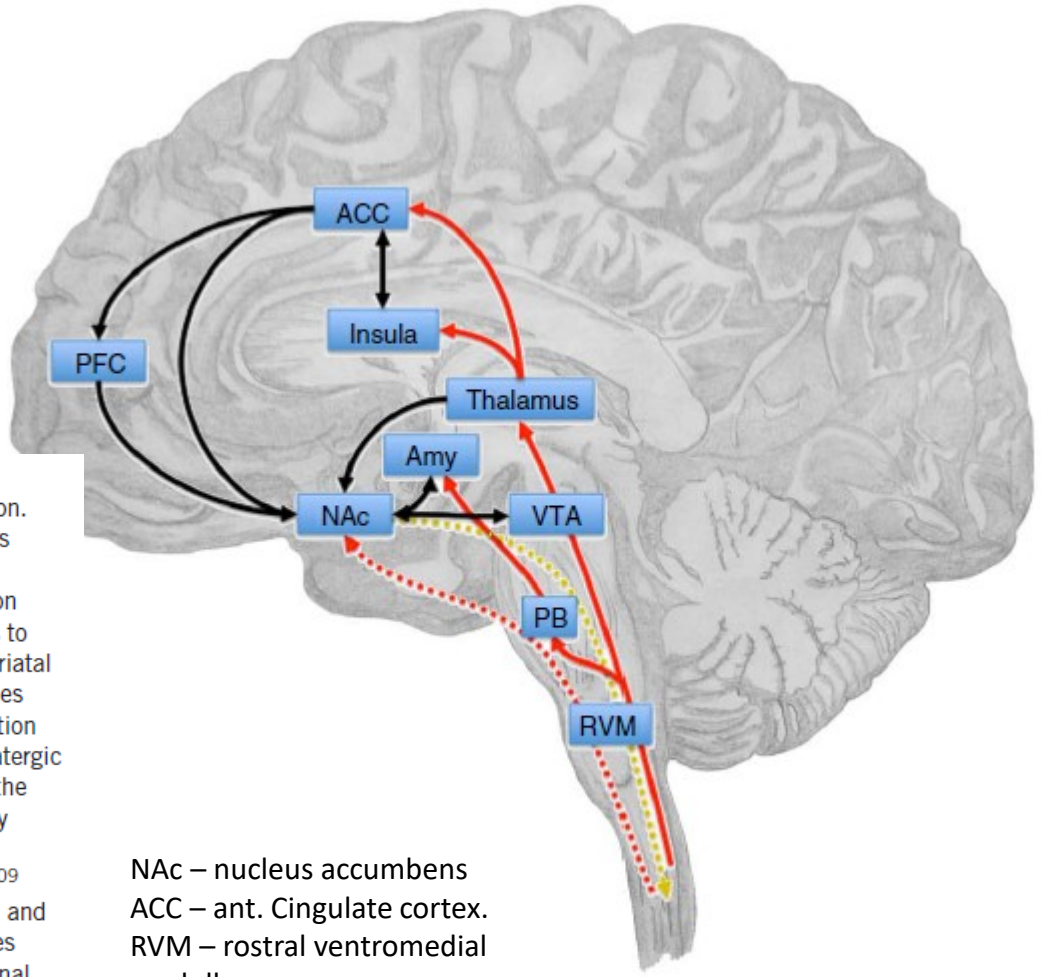
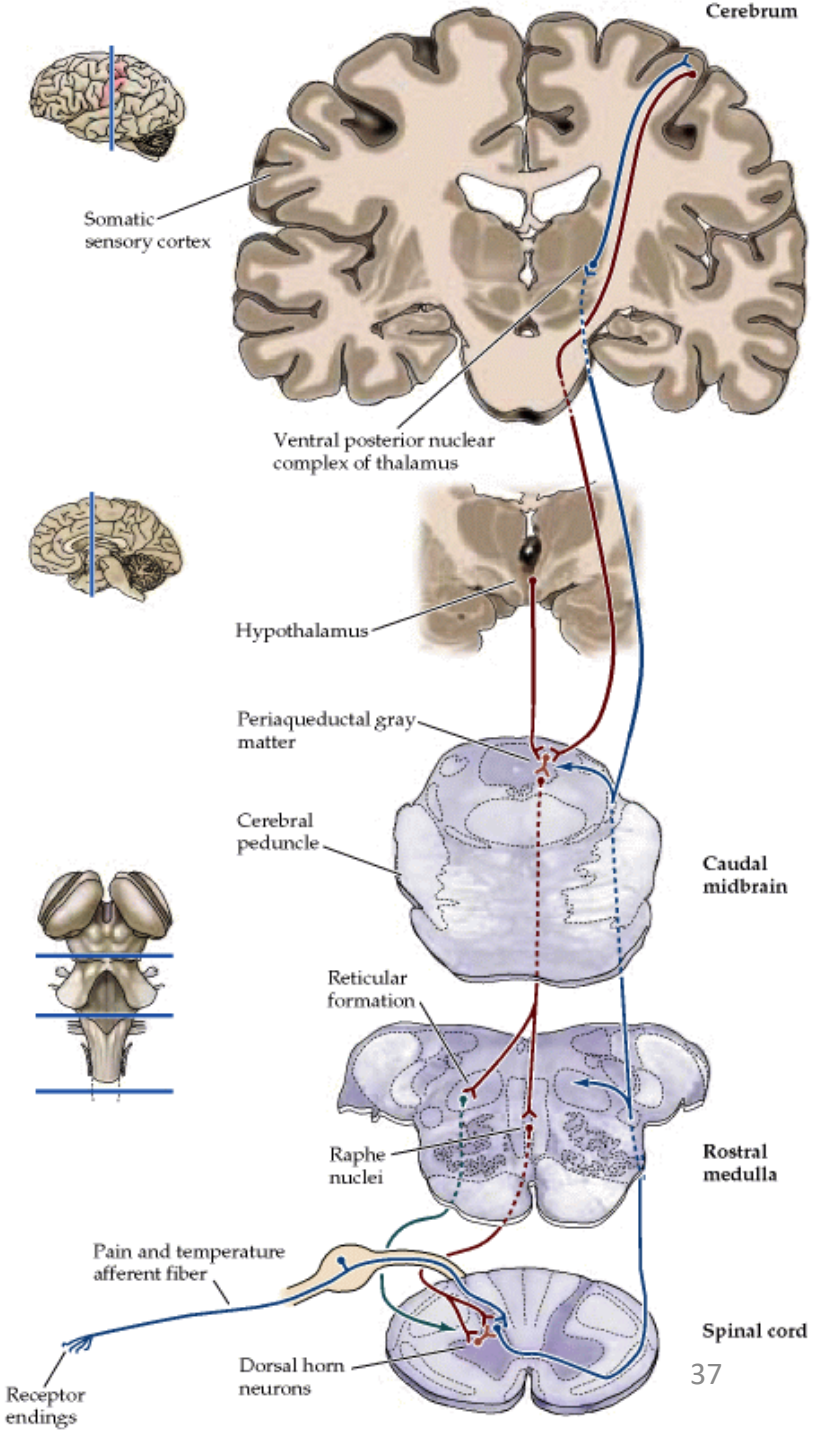


Figure 1 The corticolimbic circuit integrates motivationally salient information, including pain, and makes decisions about action selection. The NAc receives afferent nociceptive information through connections with the thalamus, parabrachial area (PB), amygdala (Amy) and ACC. Direct projections from the spinal cord to the NAc may be postulated on the basis of findings in rodents[47] (red lines). VTA dopaminergic inputs to the NAc signal saliency, as well as the value of pain or relief. Corticostriatal connections from prefrontal, orbitofrontal and anterior cingulate cortices contribute to affective, emotional and cognitive control of pain perception and are involved in motivational decision-making. In the NAc, glutamatergic outputs from the amygdala converge on dopaminergic terminals from the VTA and influence motivated behavior in response to stress and anxiety (black lines). A descending pathway from the NAc that can modulate spinal nociceptive signals, possibly via the RVM, has been suggested[109] (gold dotted line). Chronic pain states are characterized by anatomical and functional reorganization of the corticolimbic circuit, including changes in gray matter density in the PFC, ACC and NAc and increased functional connectivity between the PFC and NAc[108].

NAc – nucleus accumbens
ACC – ant. Cingulate cortex.
RVM – rostral ventromedial medulla

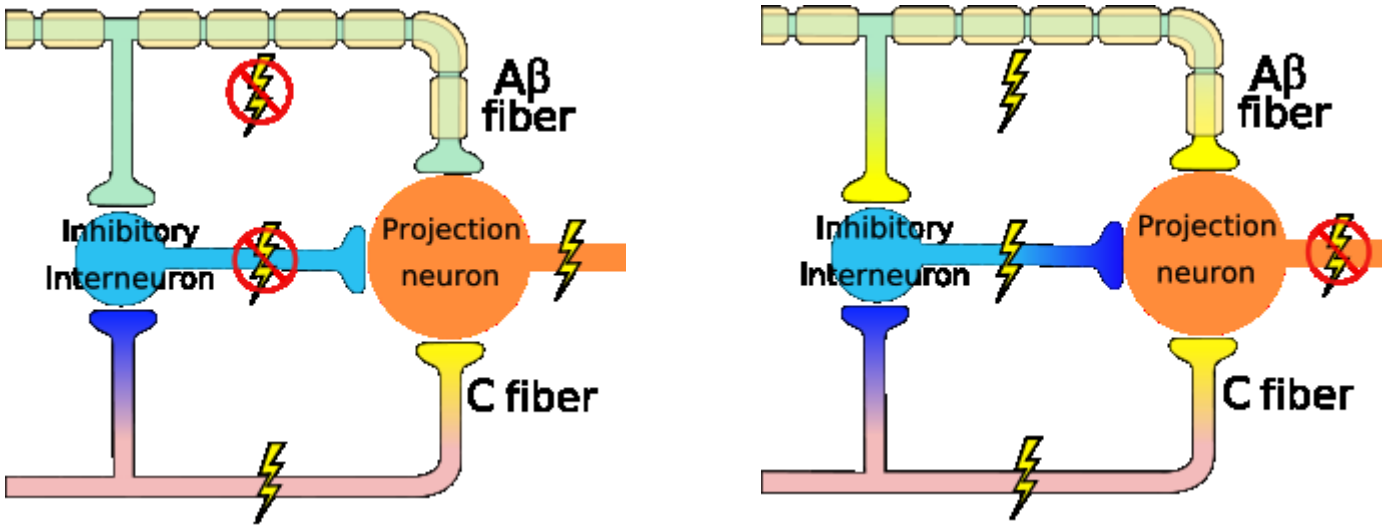
Descendent pathways modulating pain

- Somatosemcoric cortex
- Hypotalamus
- Periaquaeductal gray
- Nuclei raphe



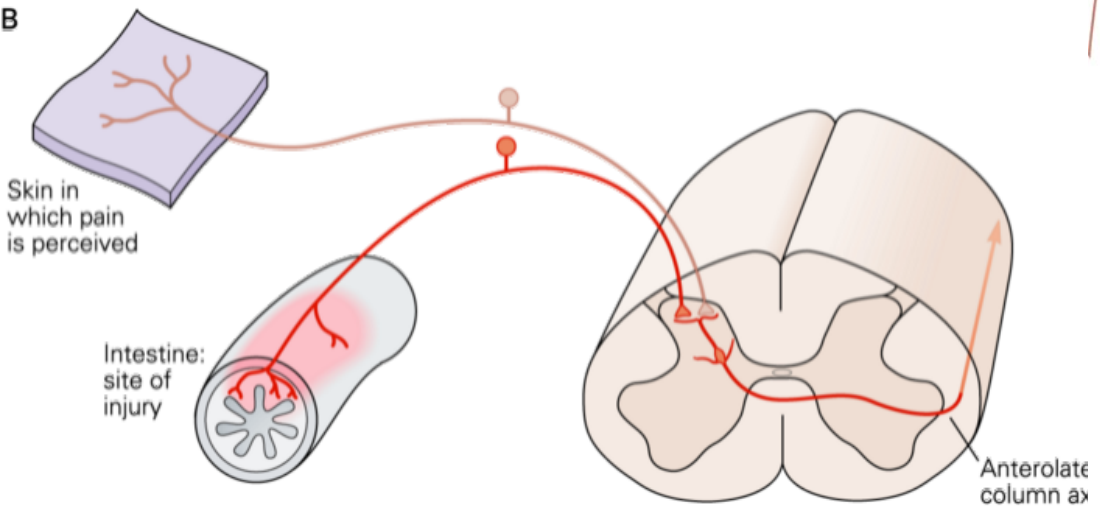
Pain modulation on the spinal level

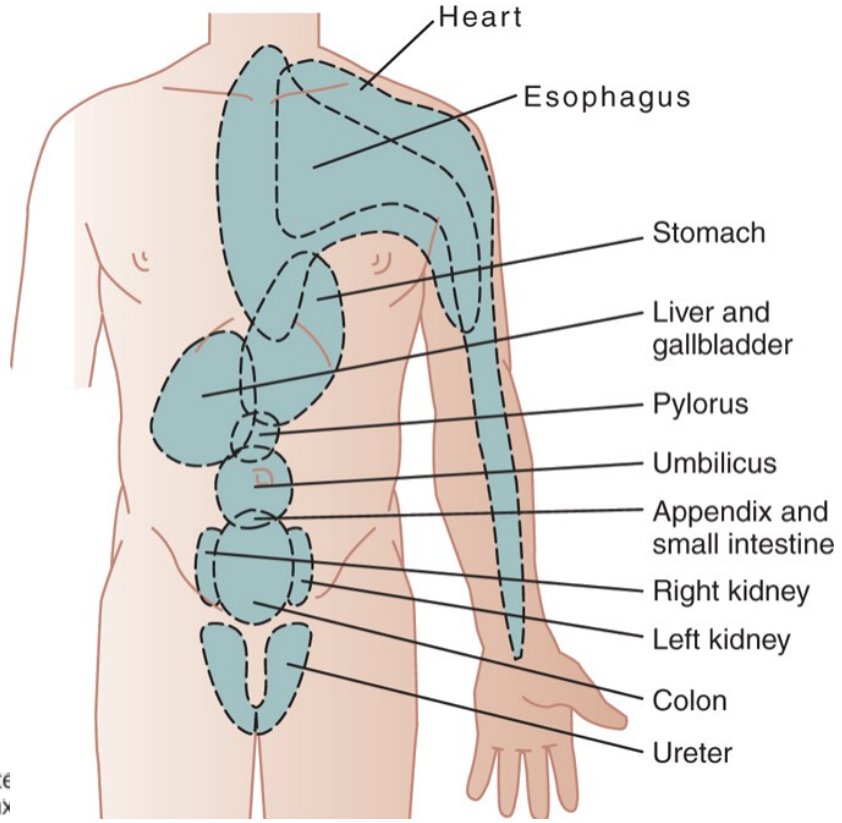
Gate control theory of pain



https://en.wikipedia.org/wiki/Gate_control_theory

Referred pain





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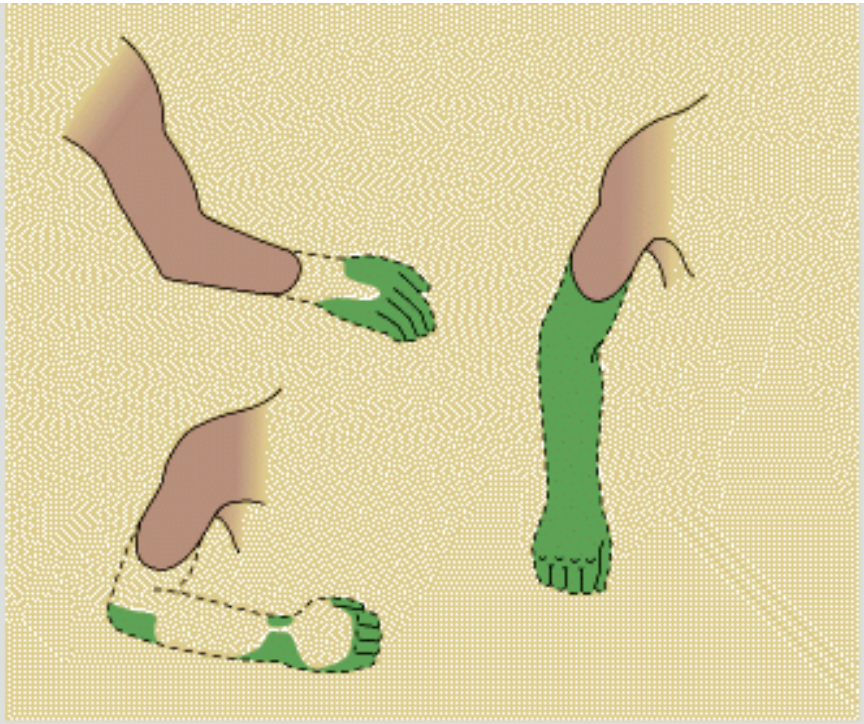
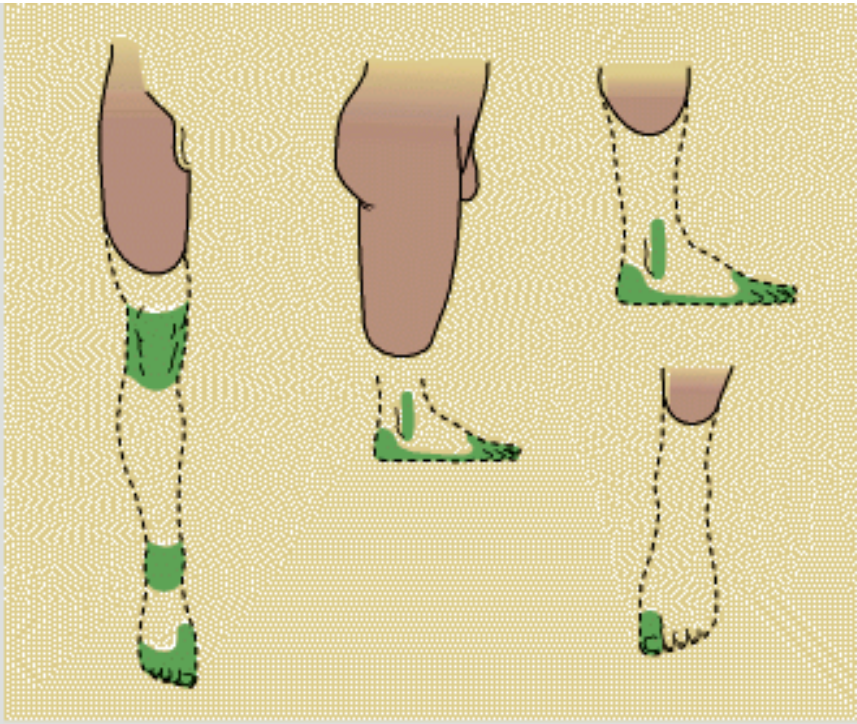
Phantom limb pain





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