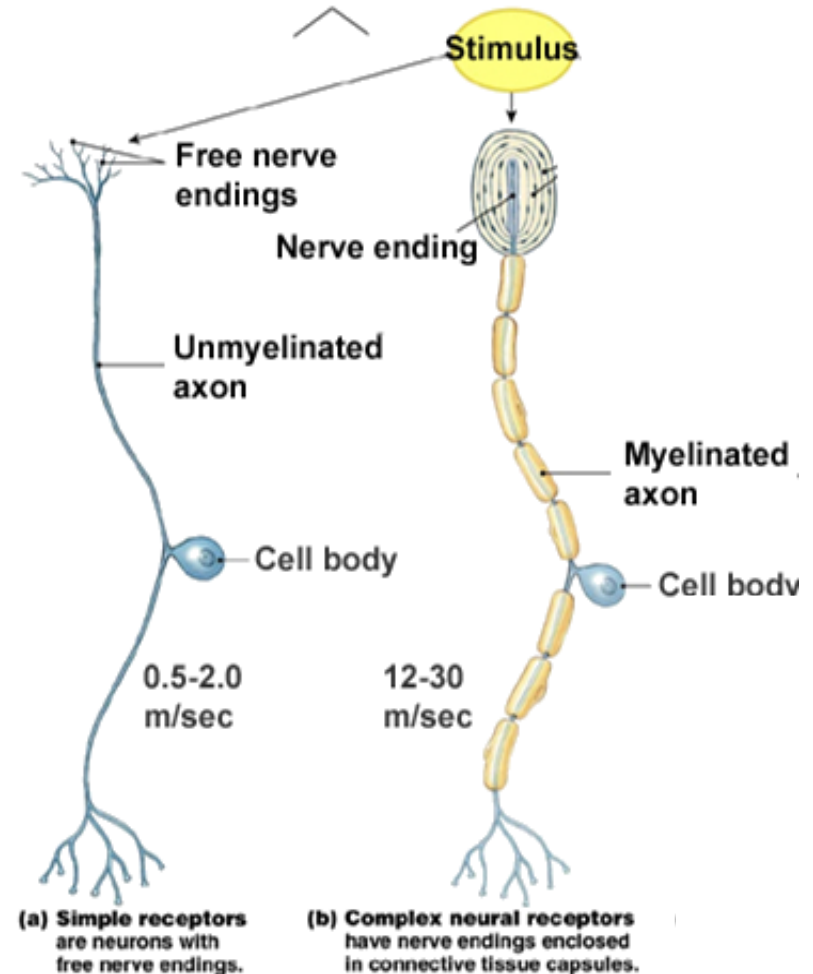


6 - 7

**Somatosensitivity,
viscerosensitivity, proprioception
and pain II**

Evolutionary point of view

- The signals indicating potential damage are the most important and the corresponding systems evolved early
 - Pain
 - Temperature
- The touch signals have adaptive value and evolved later



Evolutionary point of view

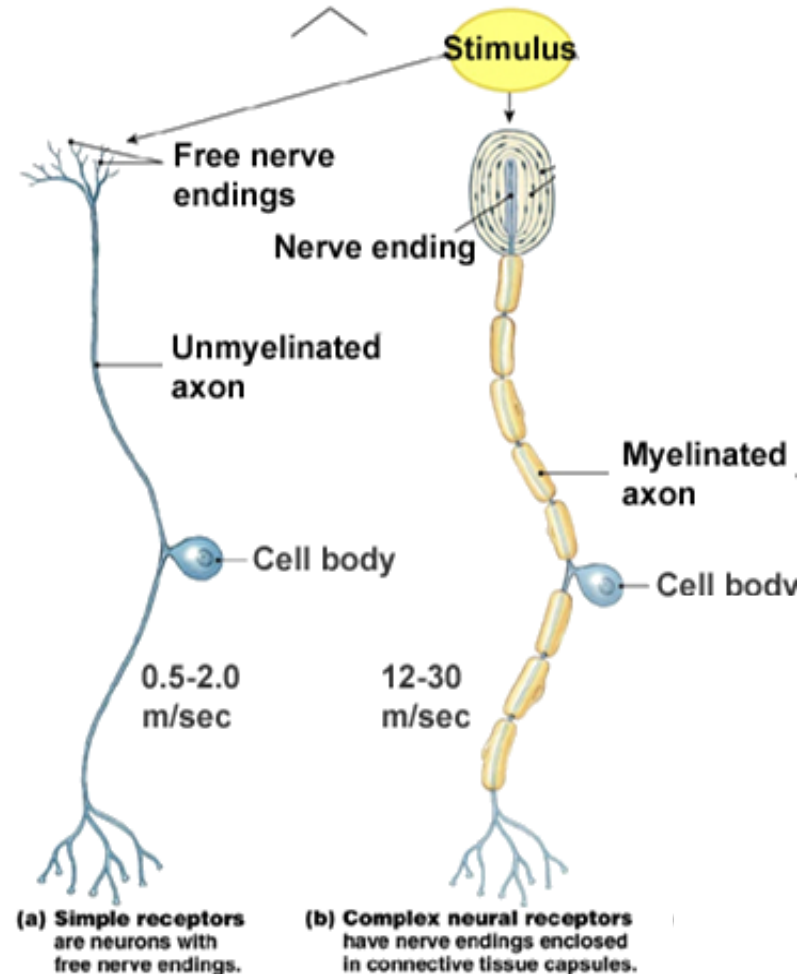
- The signals indicating potential damage are the most important and the correct ones evolved

Immediate survival

- Temperature

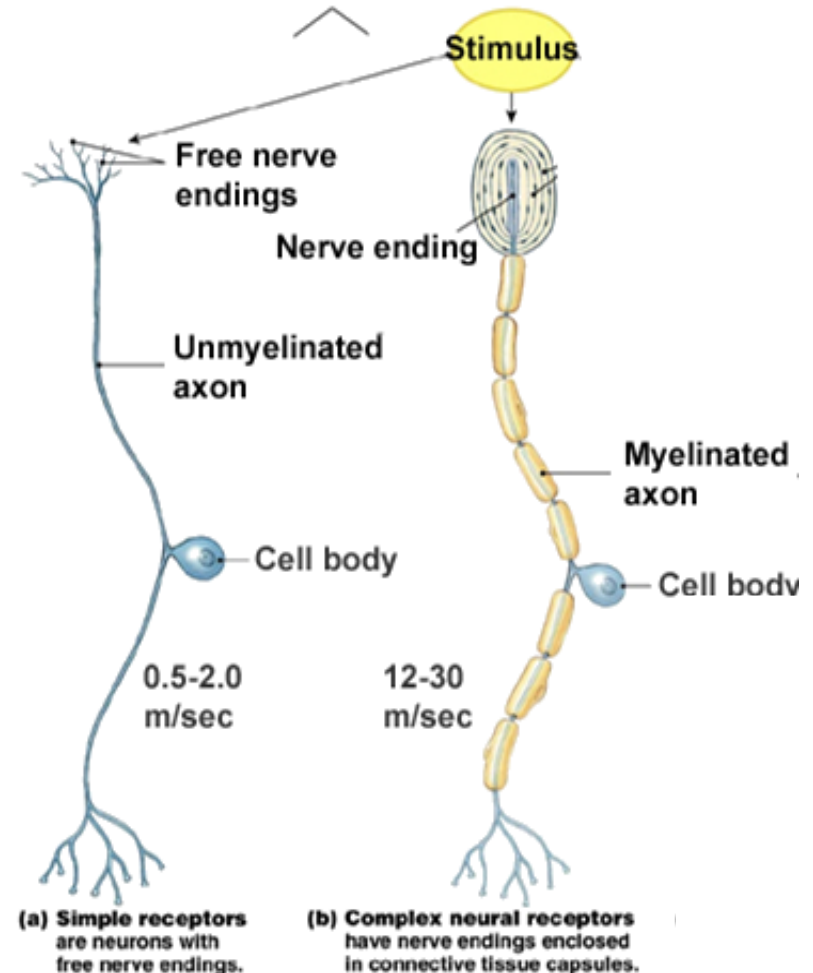
- The signals have adaptive value

Long-term survival



Evolutionary point of view

- The signals indicating potential damage are the most important and the corresponding systems evolved early
 - Pain
 - Temperature
- The touch signals have adaptive value and evolved later
- The structure of the receptor, nerve fibers and pathways reflects the evolution



Somatosensory pathways

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

Somatosensory pathways

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 - Interconnection of
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 - tr. Spinoreticular
- Neospinothalamic
 - tr. Spinothalamic
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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Evolutionary old structures have not been replaced by new ones during evolution, but the old has been kept and the new added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

Somatosensory pathways

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Immediate survival

Long-term survival

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	
		pressure		
		flutter		
		vibration		
Proprioception	Position: Static Forces	muscle length		
		muscle tension		
		joint pressure		
	Movement: Dynamic Forces	muscle length		
		muscle tension		
		joint pressure		
	joint angle		Main Sensory Trigeminal	

Paleospinothalamic system

- Tr. Spinoreticularis, spinotectalis...

Paleospinothalamic system

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- Evolved before neocortex

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- Basic defensive reactions and reflexes - vegetative response, reflex locomotion - opto-acoustic reflexes etc.

Paleospinothalamic system

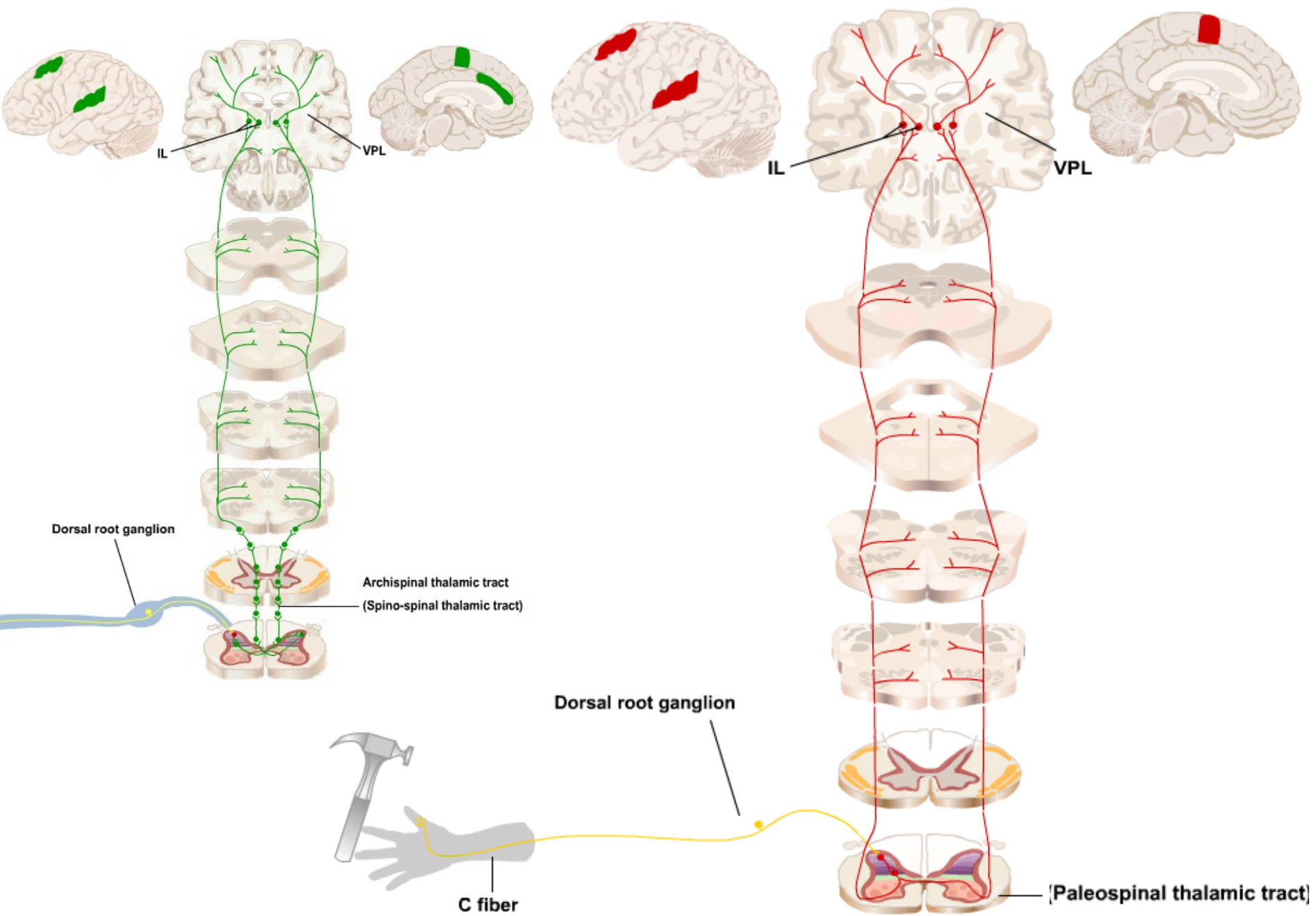
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- This tract is not designed for „such a powerful processor as neocortex“
- Approximately half of the fibers cross the midline



Neospinothalamic system

- Tr. Spinothalamicus

Neospinothalamic system

- Tr. Spinothalamicus
- Younger structure primarily connected to neocortex
- „High capacity/resolution“

Neospinothalamic system

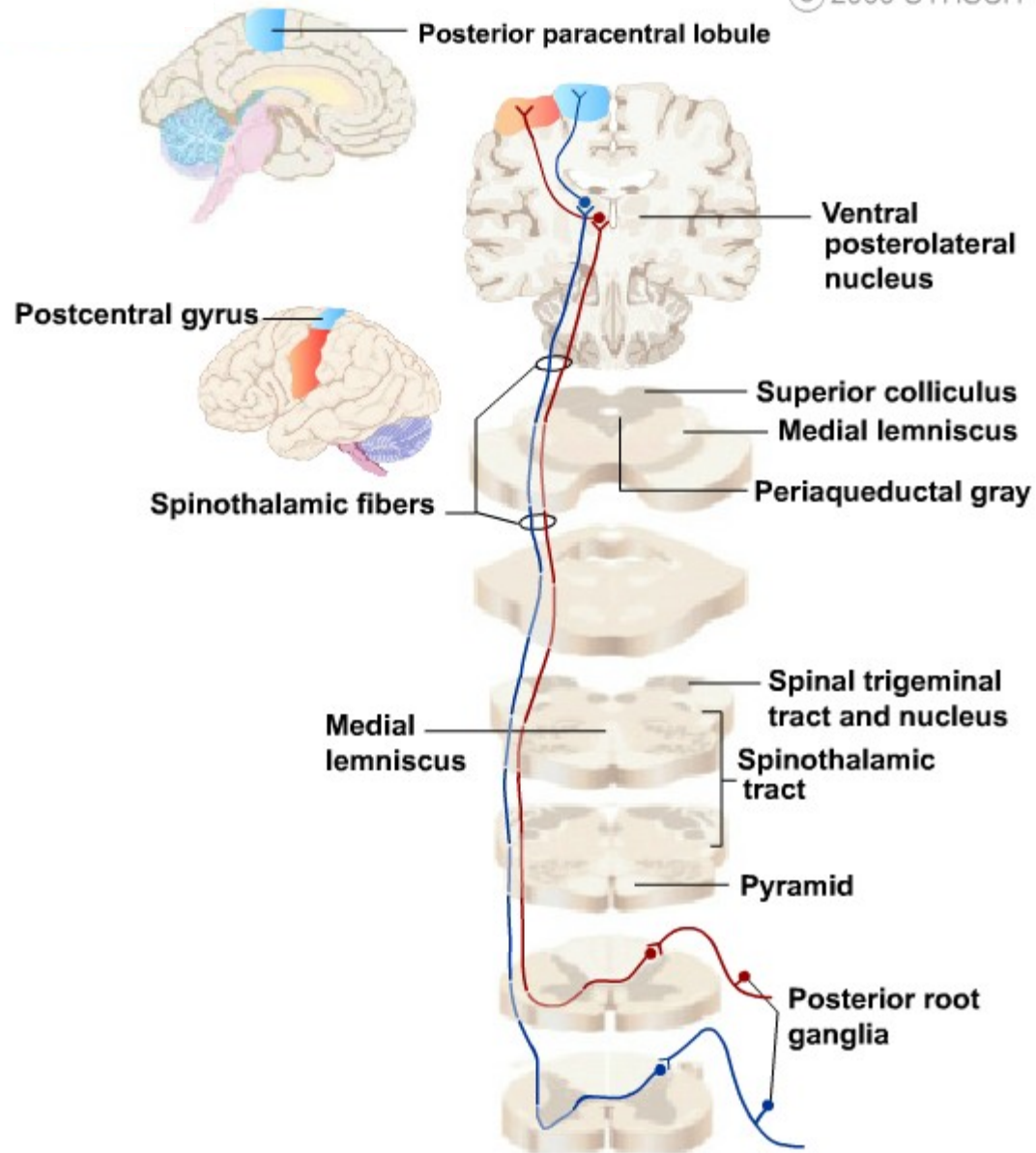
- Tr. Spinothalamicus
- Younger structure primarily connected to neocortex
- „High capacity/resolution“
- Detail information about pain stimuli (sharp, localized pain)
- Information about temperature

Neospinothalamic system

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Neospinothalamic system

- Tr. Spinothalamicus
- Younger structure primarily connected to neocortex
- „High capacity/resolution“
- Detail information about pain stimuli (sharp, localized pain)
- Information about temperature
- Crude touch sensation
- The fibers cross midline at the level of entry segment



Dorsal column system

- Tr. Spinobulbaris

Dorsal column system

- Tr. Spinobulbaris
- The youngest system
- High capacity

Dorsal column system

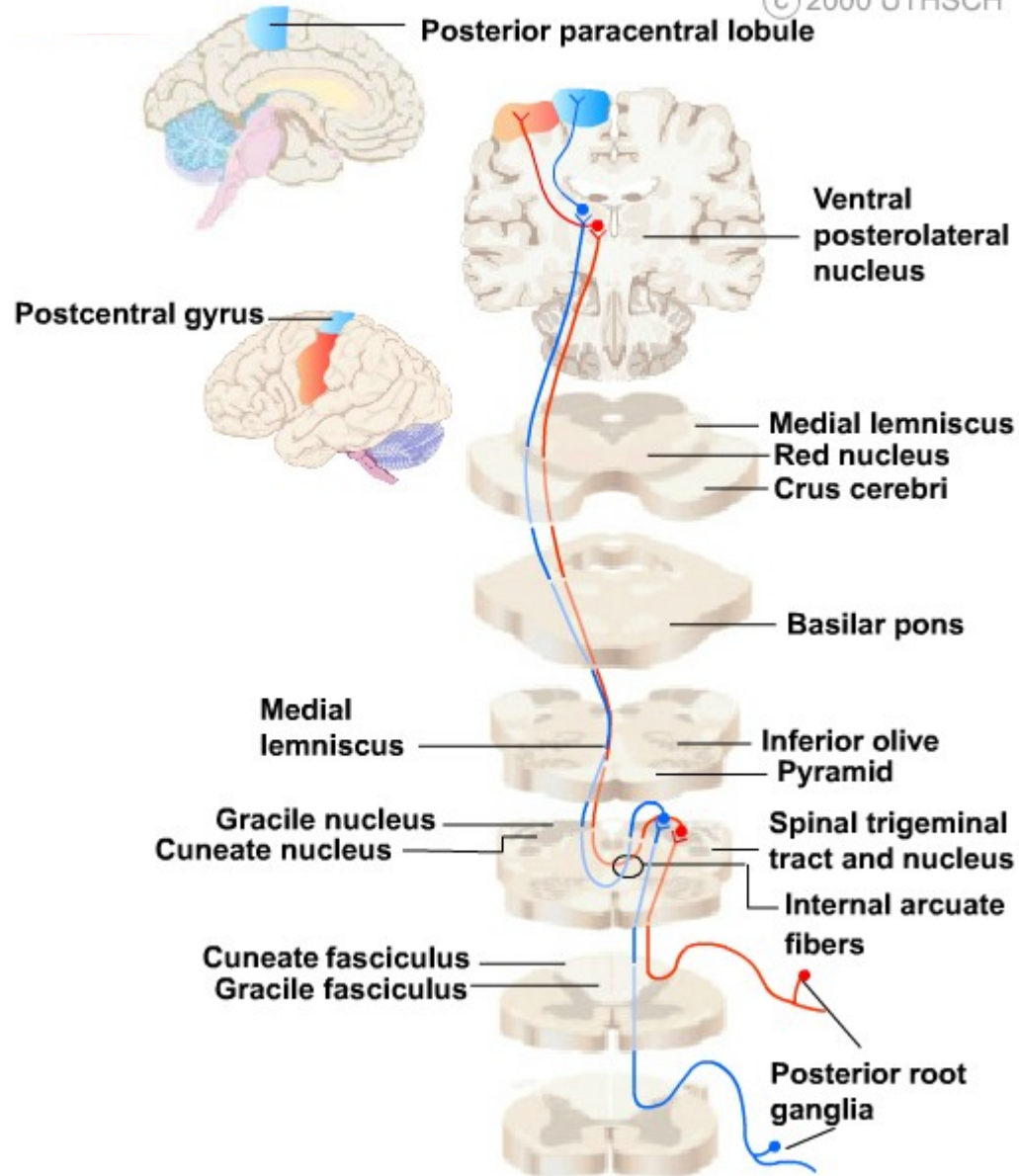
- Tr. Spinobulbaris
- The youngest system
- High capacity
- Tactile sensation
- Vibration
- Proprioception

Dorsal column system

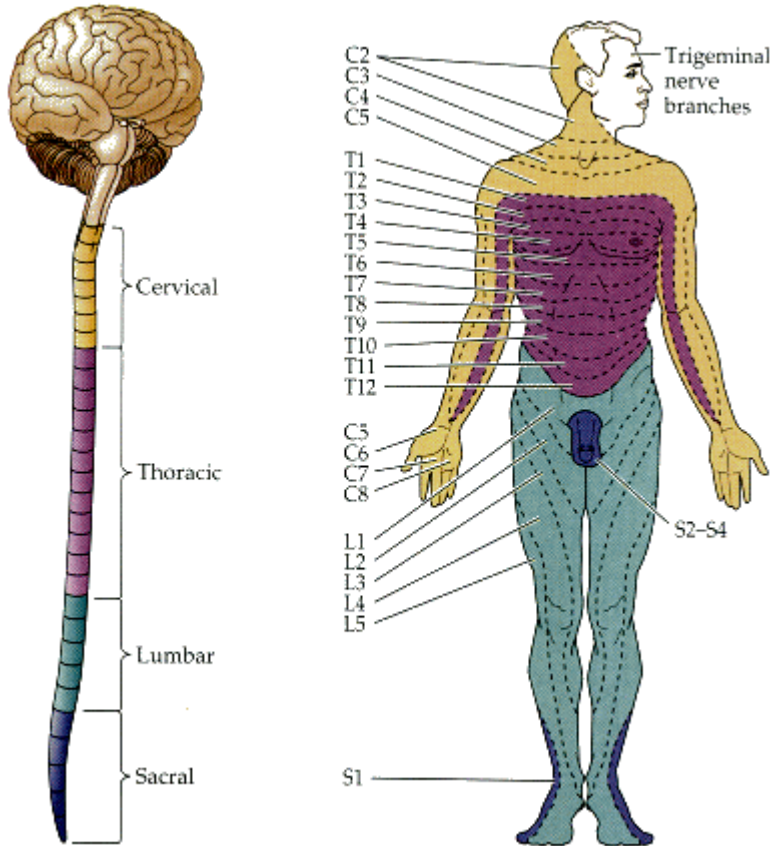
- Tr. Spinobulbaris
- The youngest system
- High capacity
- Tactile sensation
- Vibration
- Proprioception
- Fine motor control
- Better object recognition
- Adaptive value

Dorsal column system

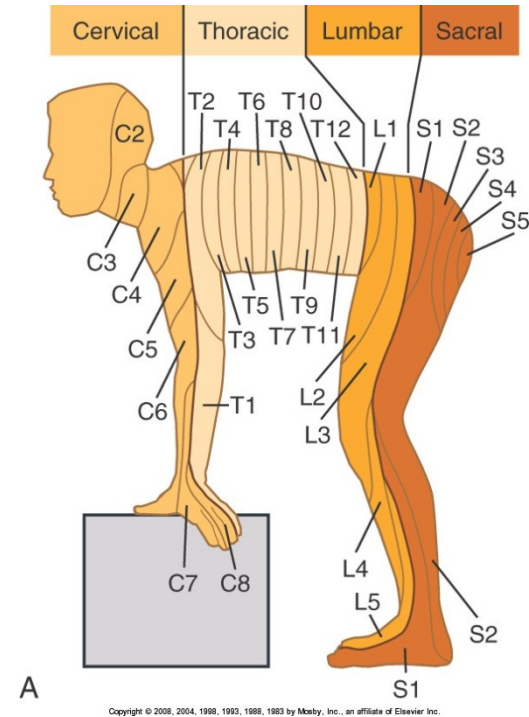
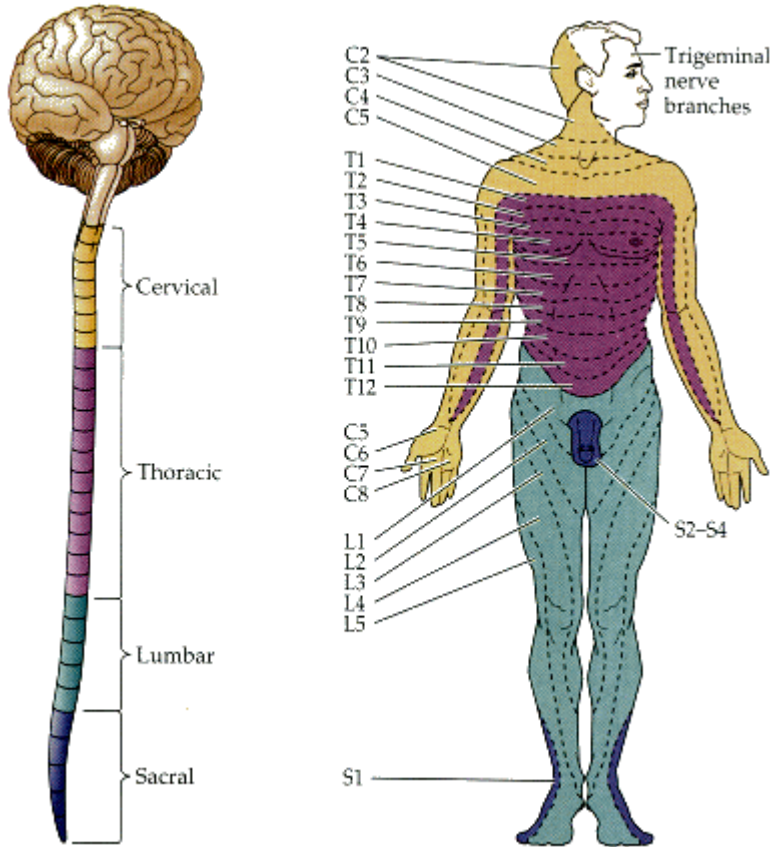
- Tr. Spinobulbaris
- The youngest system
- High capacity
- Tactile sensation
- Vibration
- Proprioception
- Fine motor control
- Better object recognition
- Adaptive value
- The fibers cross midline at the level of medulla oblongata



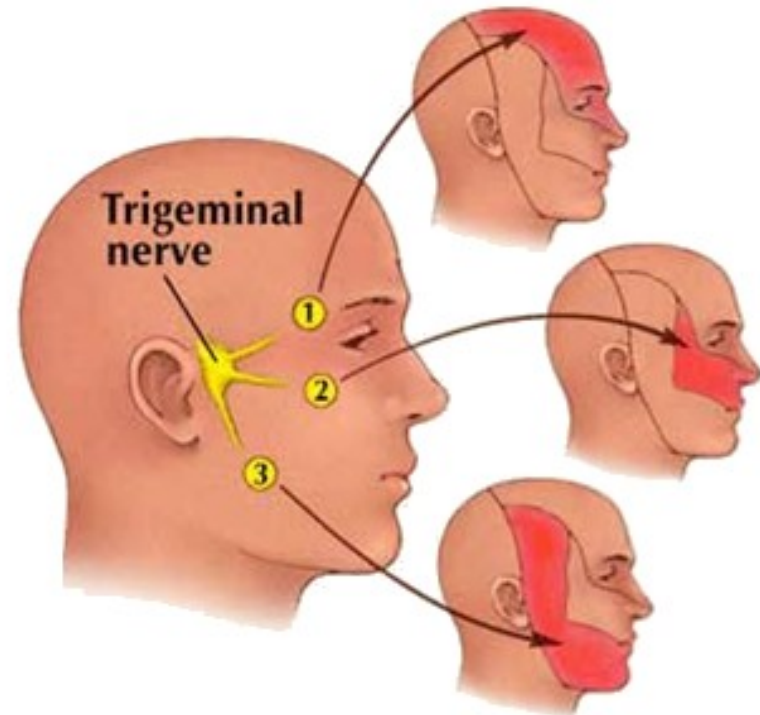
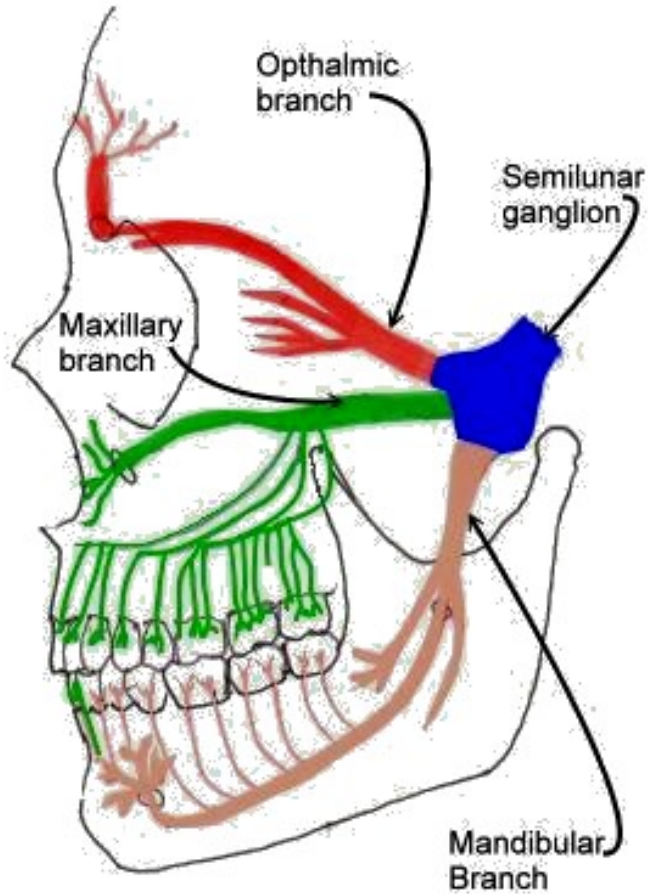
Dermatomes

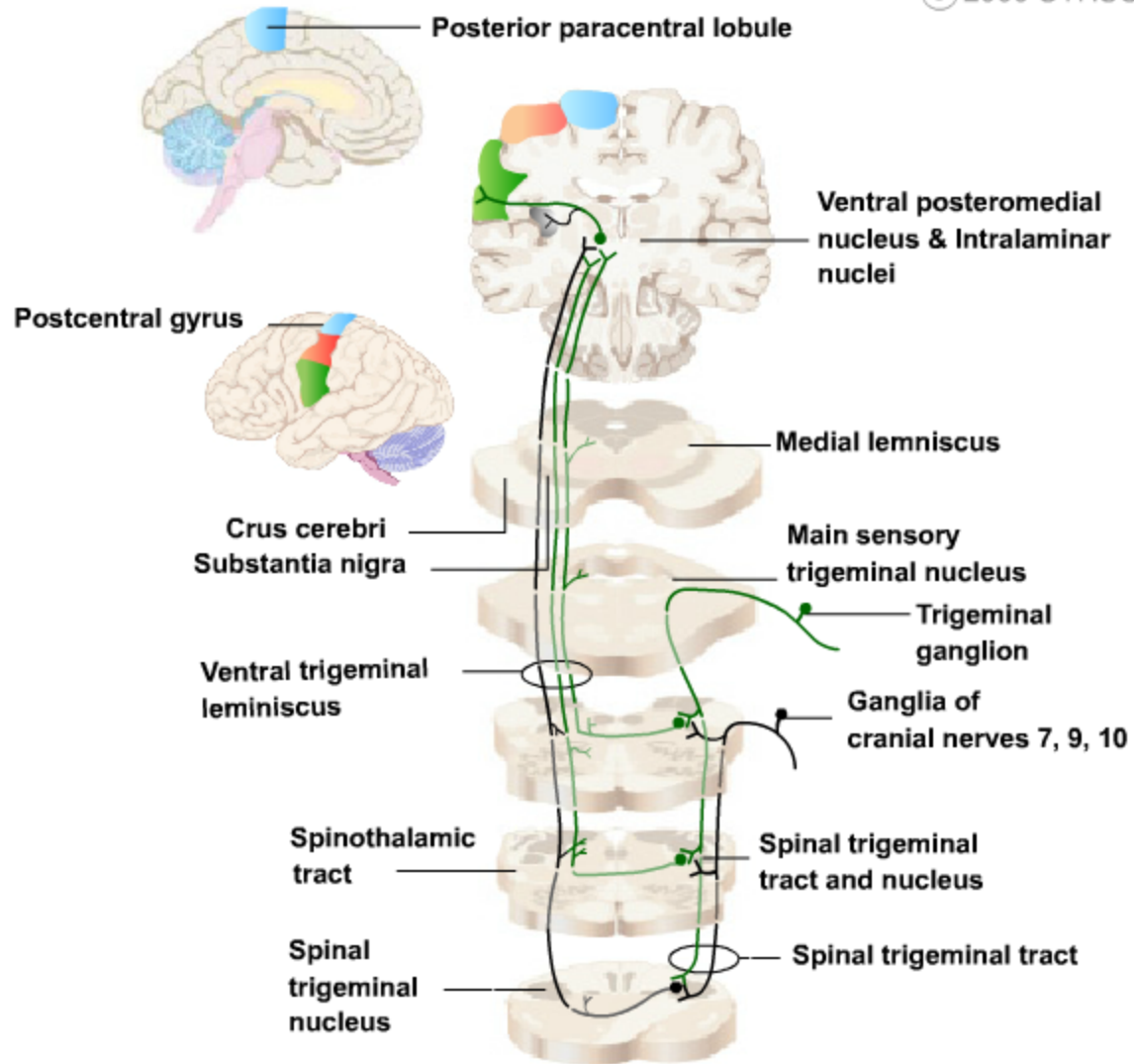


Dermatomes



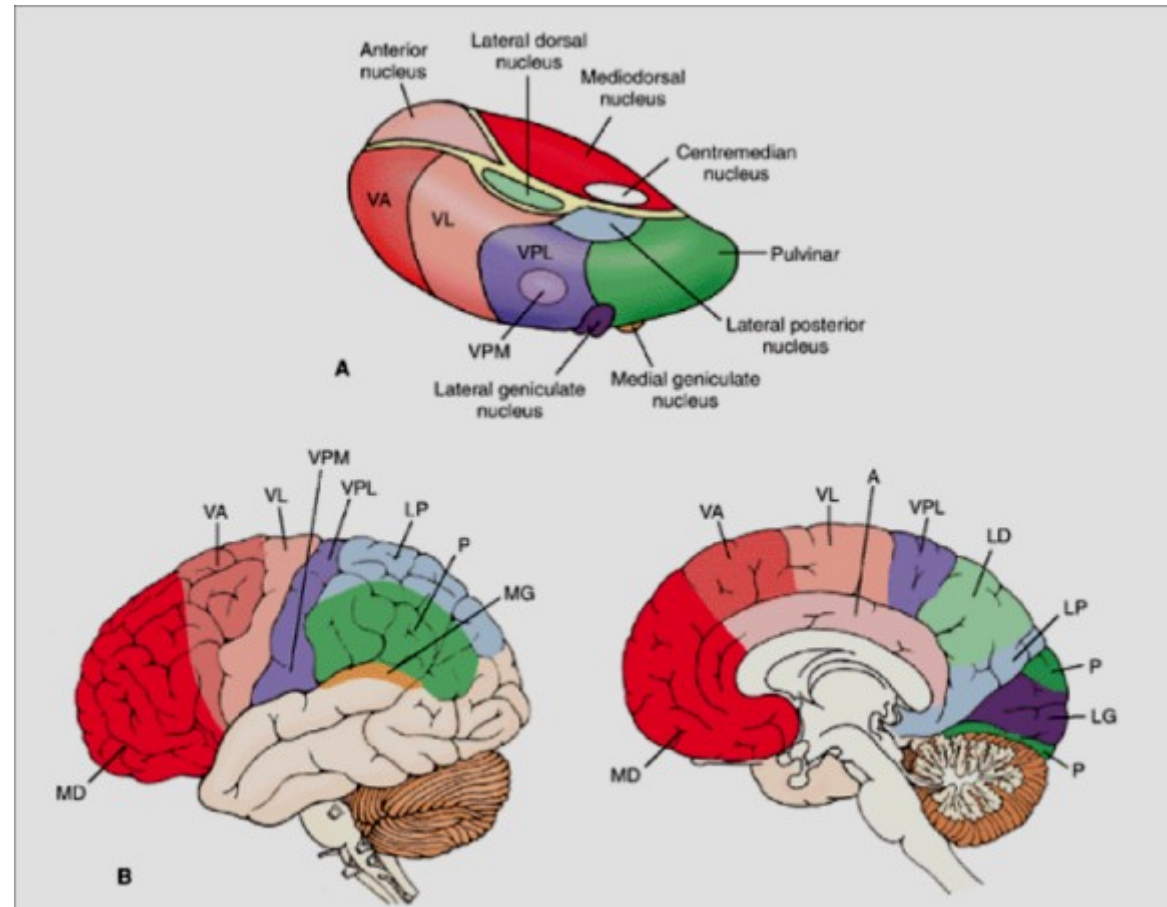
Trigeminal system



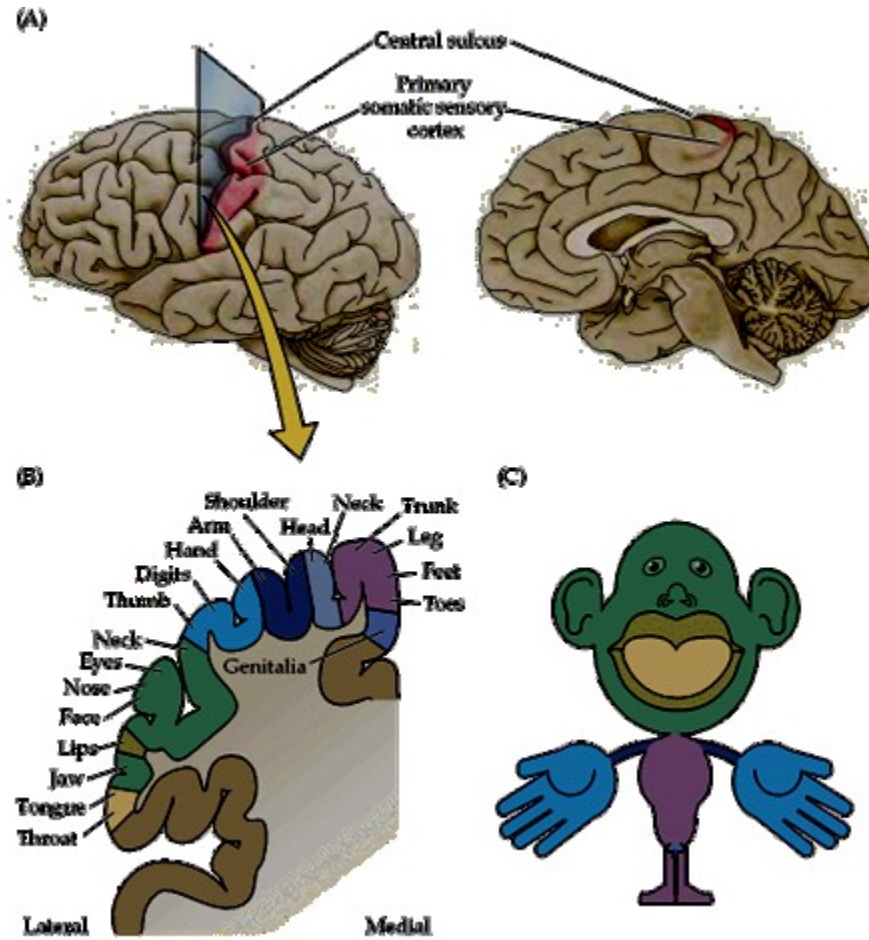


Thalamus a neocortex

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



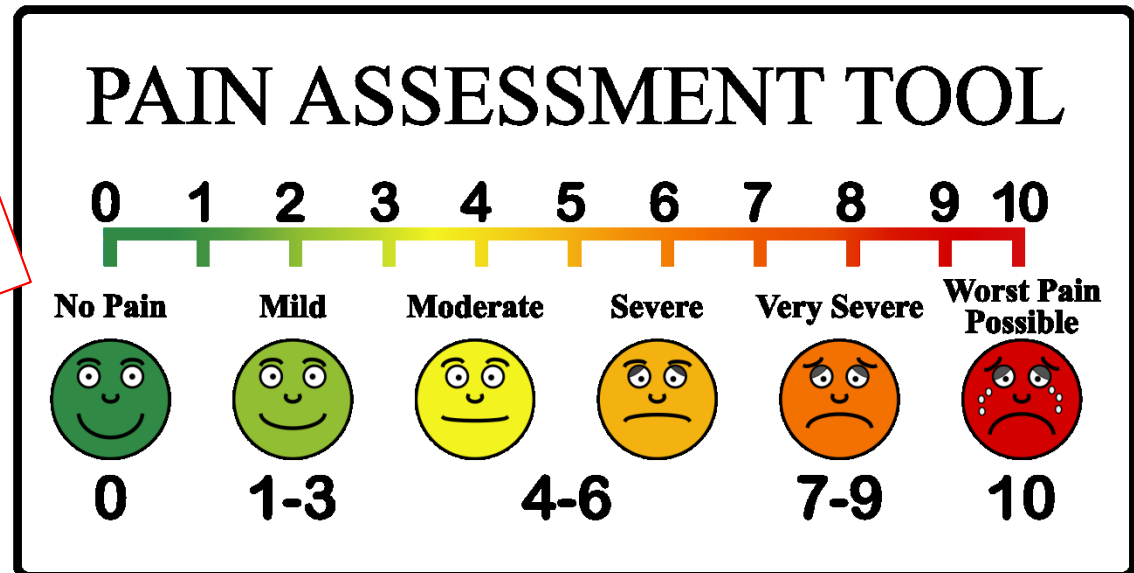
Neocortex



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)

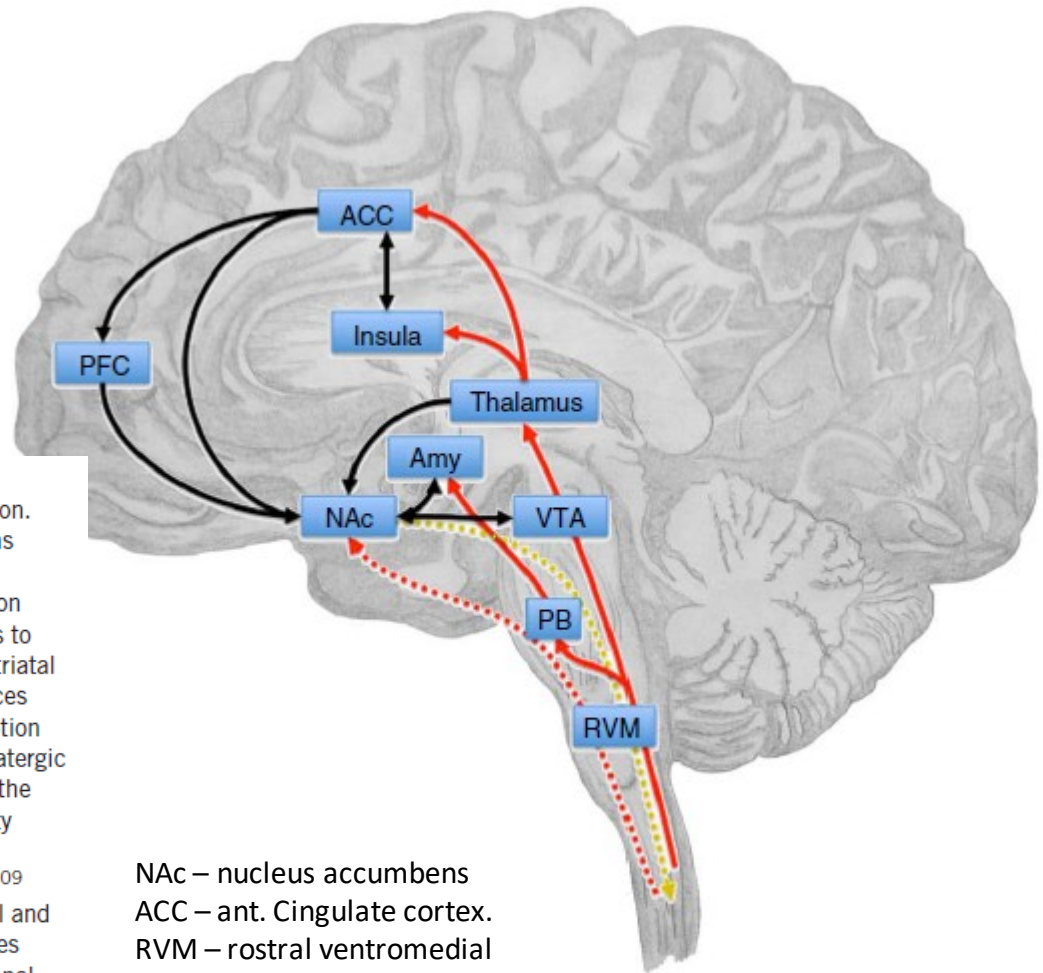
**Subjective
character**



Limbic system

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

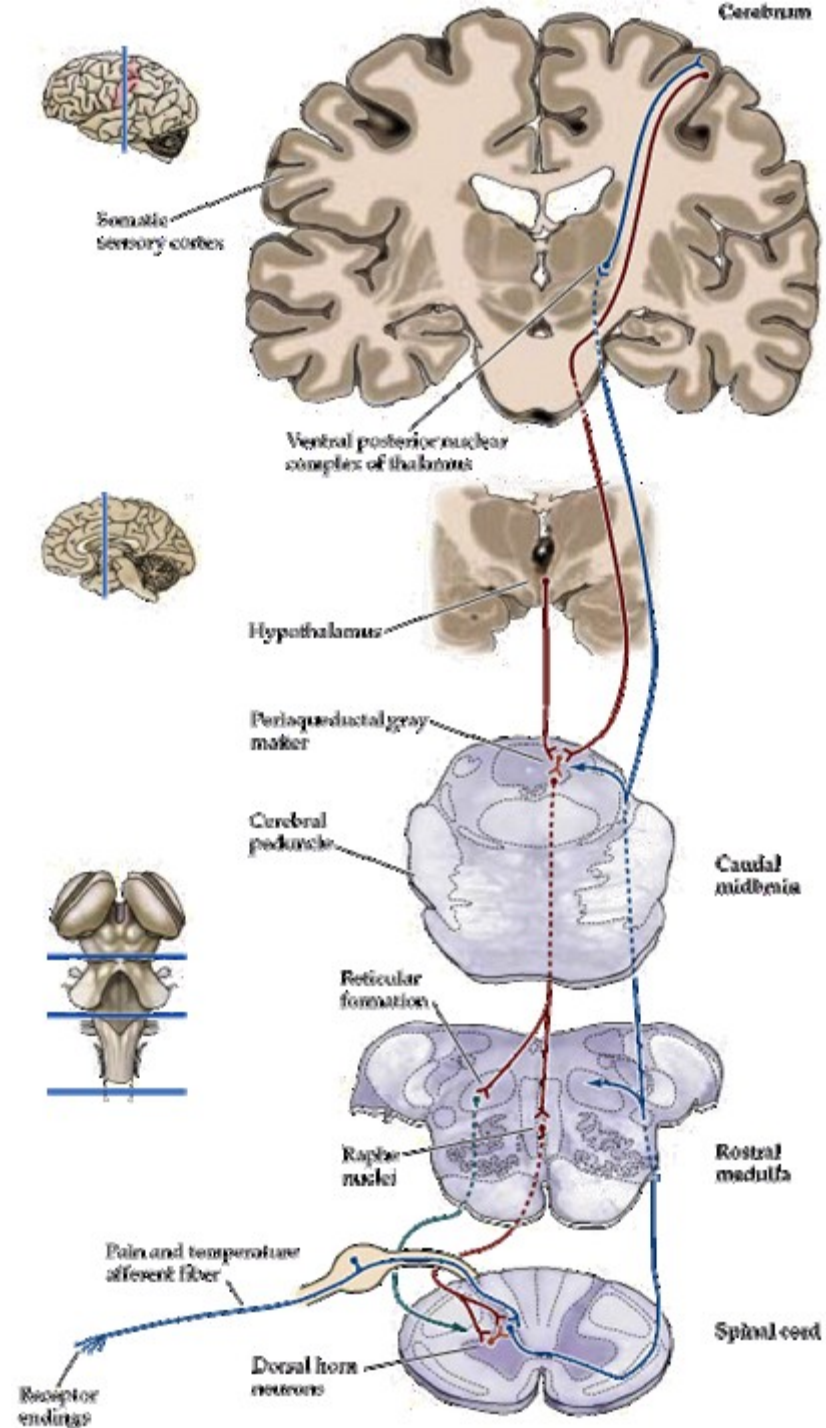
Figure 1 The corticolimbic circuit integrates motivationally salient information, including pain, and makes decisions about action selection. The NAc receives afferent nociceptive information through connections with the thalamus, parabrachial area (PB), amygdala (Amy) and ACC. Direct projections from the spinal cord to the NAc may be postulated on the basis of findings in rodents⁴⁷ (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 suggested¹⁰⁹ (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 NAc¹⁰⁸.



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

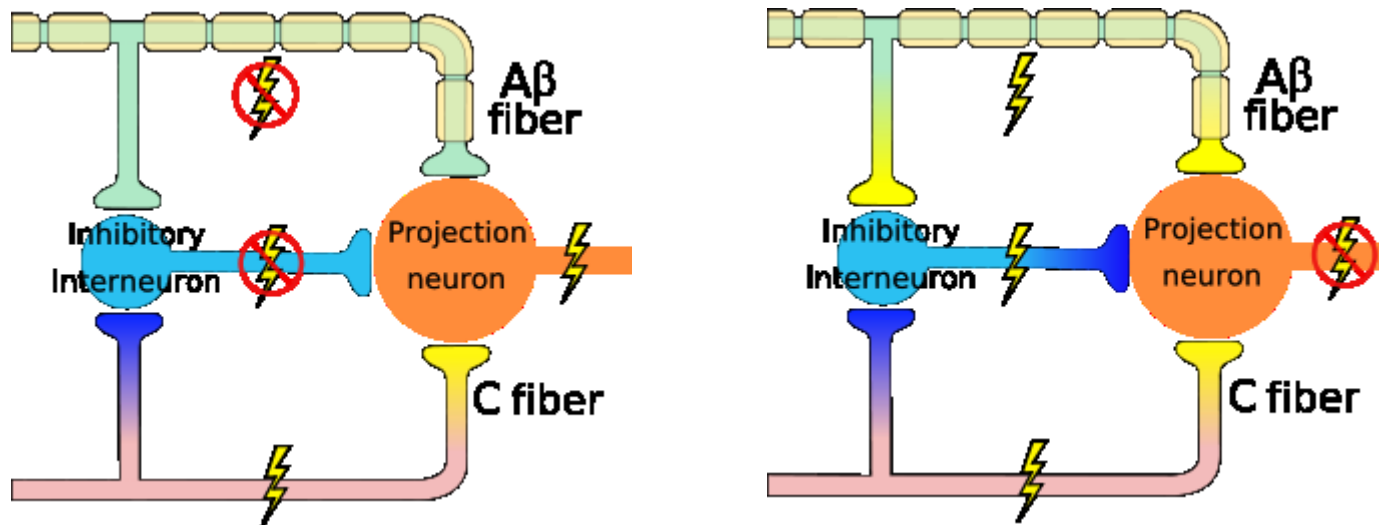
Descendent pathways modulating pain

- Somatosensory cortex
- Hypothalamus
- Periaqueductal gray
- Nuclei raphe

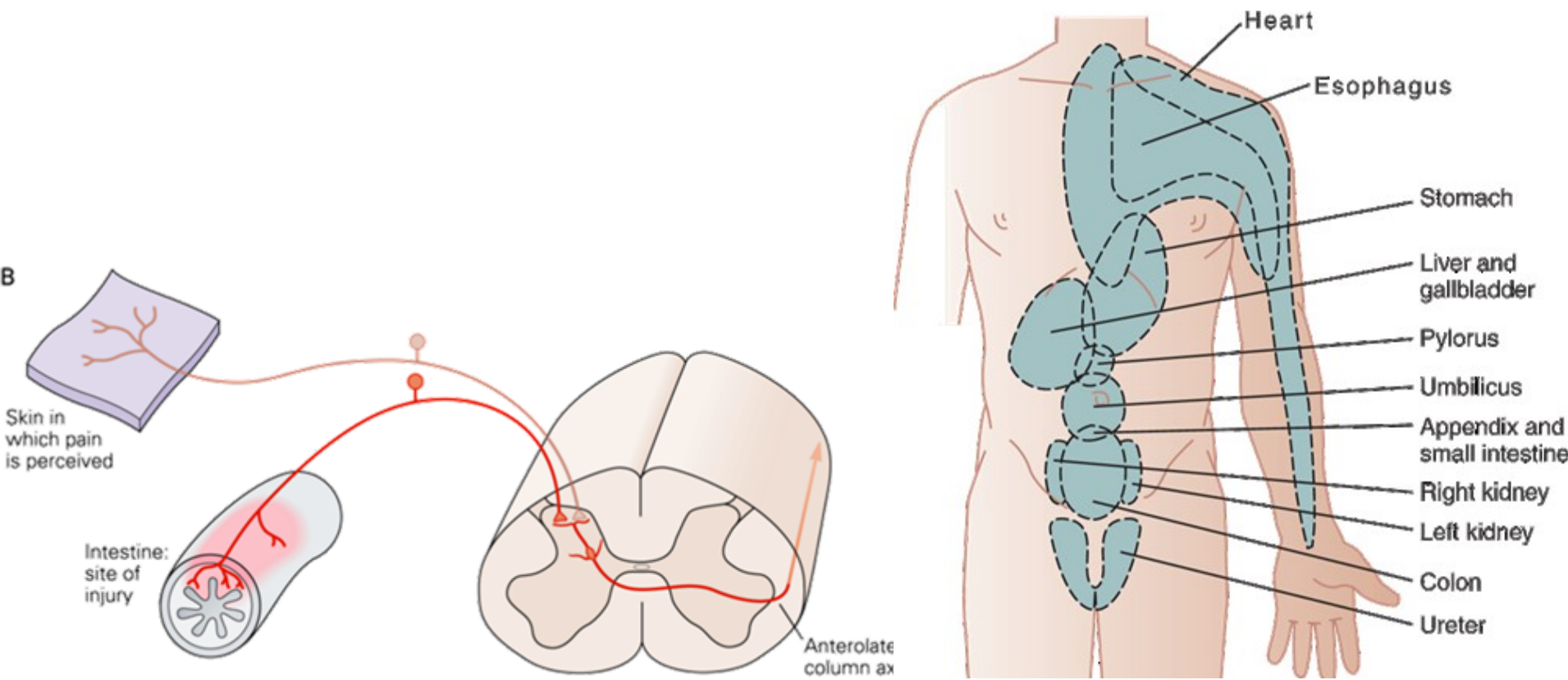


Pain modulation on the spinal level

Gate control theory of pain



Referred pain



Phantom limb pain

