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6

Somatosensitivity, viscerosensitivity, 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

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

✓ Parasympathetic nervous system (VII., IX., X., sacral PNS)
– „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 discussed in lecture about motor system

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

- Three systems
- (Archispinothalamic)
 - Interconnection of adjacent
- Paleospinothalamic
- Neospinothalamic
 -
- Dorsal column-medial lemniscus
 - tr.

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Evolutionary old structures have not been replaced by new ones during evolution, but the old has been kept and the new added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

Somatosensory pathways

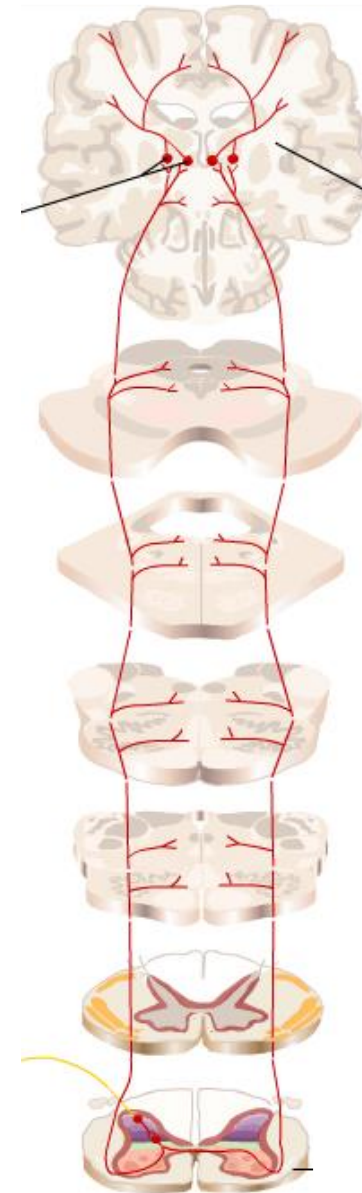
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Immediate survival

Long-term survival

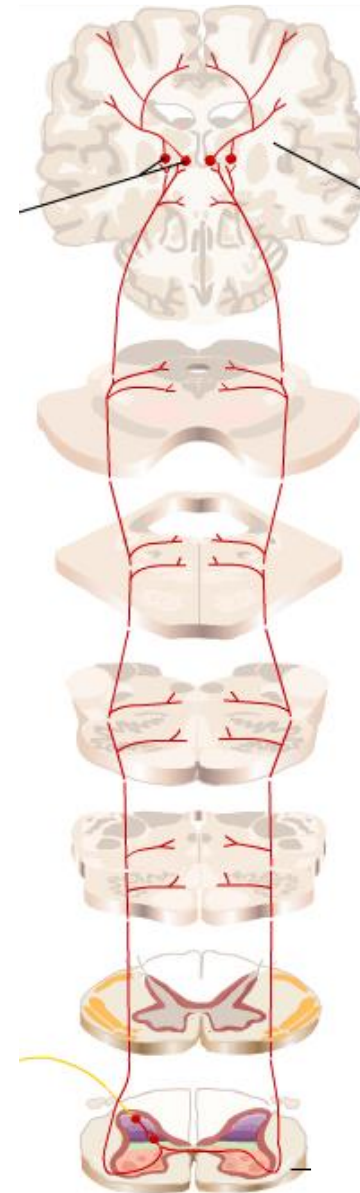
Paleospinothalamic system

- Tr. Spinoreticularis, spinotectalis...



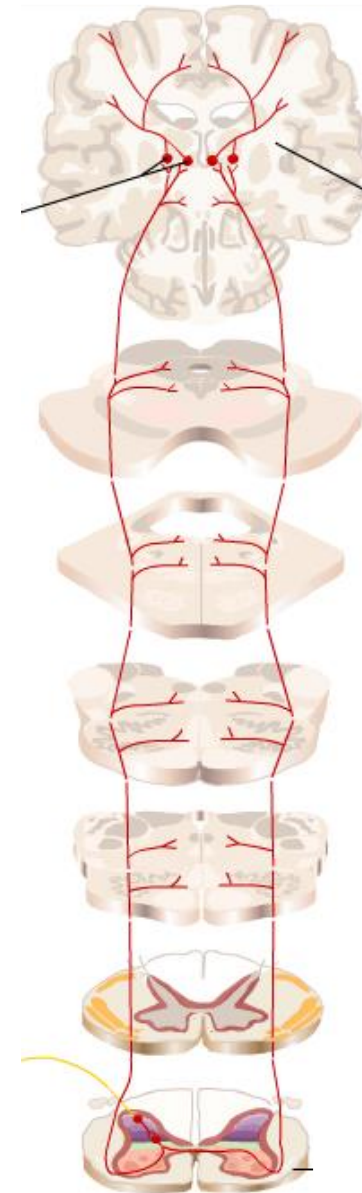
Paleospinothalamic system

- Tr. Spinoreticularis, spinotectalis...
- Evolved before neocortex
- The primary connection to the subcortical structures



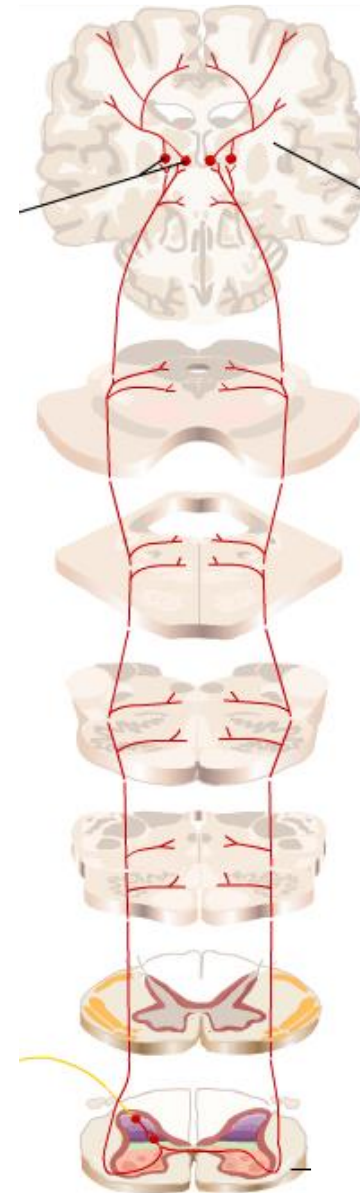
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- Basic defensive reactions and reflexes - vegetative response, reflex locomotion - opto-acoustic reflexes etc.



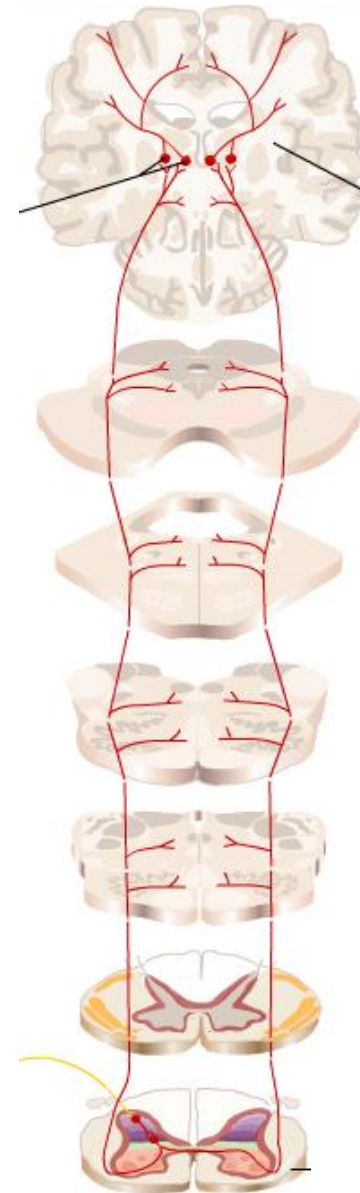
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- Secondarily connected to cortex (after its evolution; tr. Spino-reticulo-thalamicus), but this system has a small resolutions – dull diffuse pain



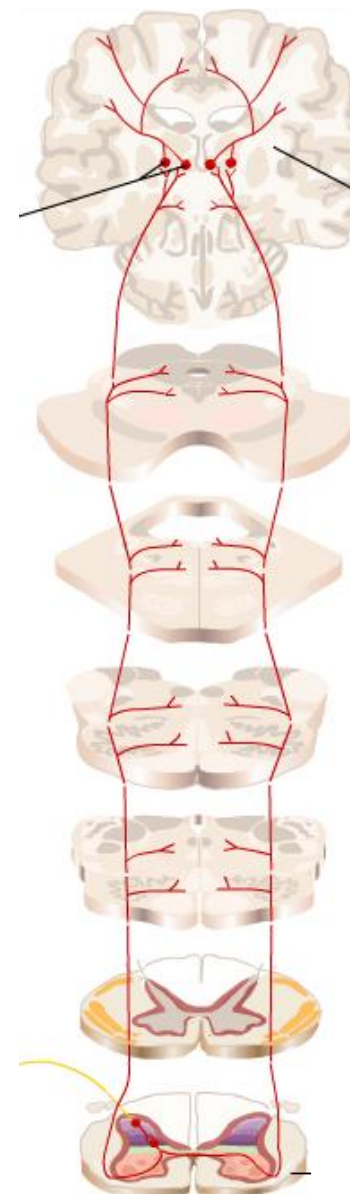
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- This tract is not designed for „such a powerful processor as neocortex“

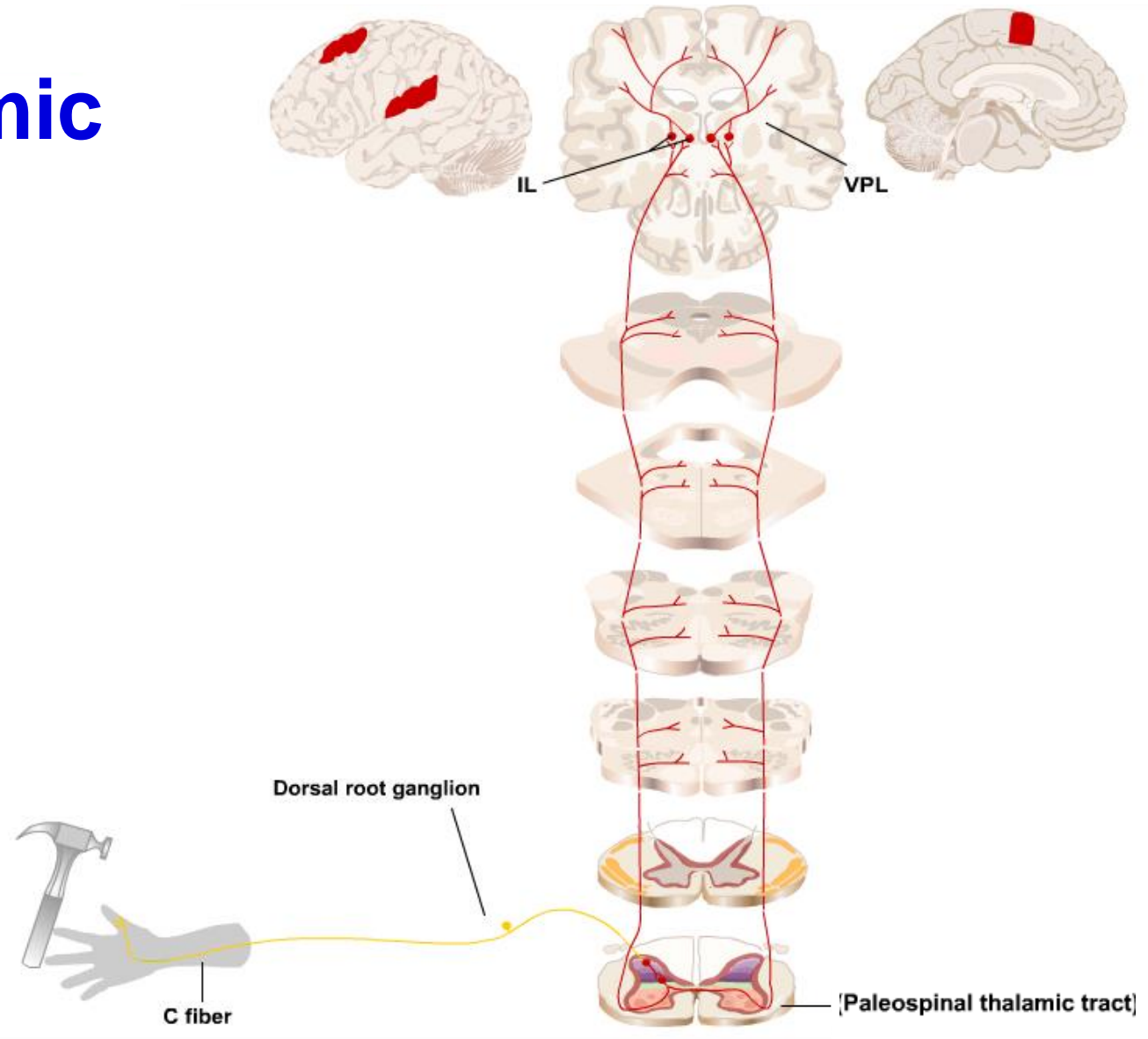


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- Secondarily connected to cortex (after its evolution; tr. Spino-reticulo-thalamicus), but this system has a small resolutions – dull diffuse pain
- This tract is not designed for „such a powerful processor as neocortex“
- Approximately half of the fibers cross the midline

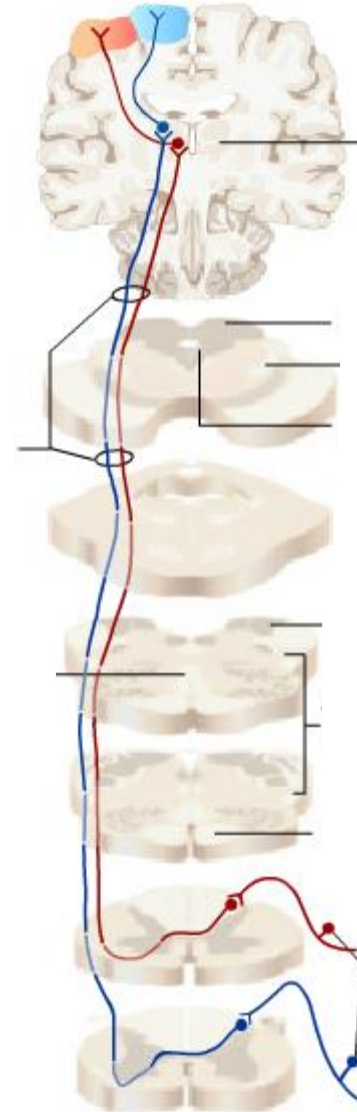


Paleospinothalamic system



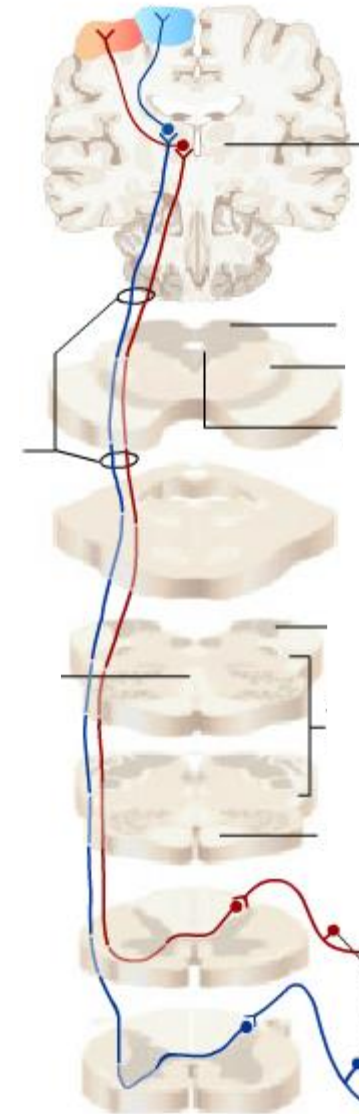
Neospinothalamic system

- Tr. Spinothalamicus



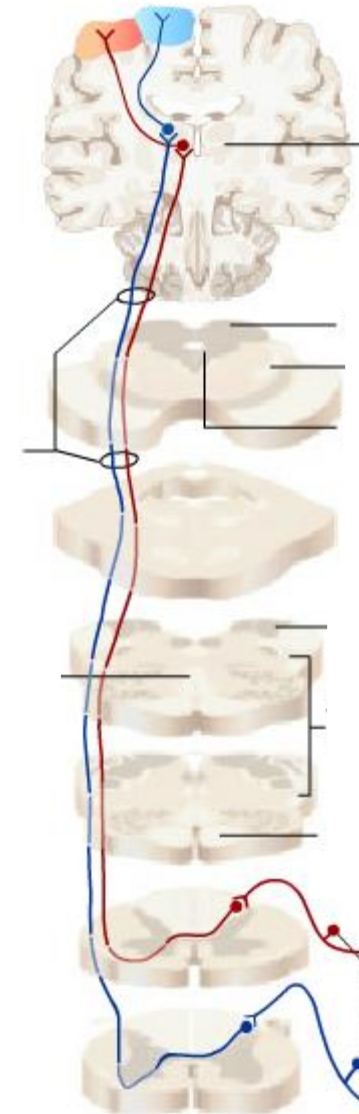
Neospinothalamic system

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



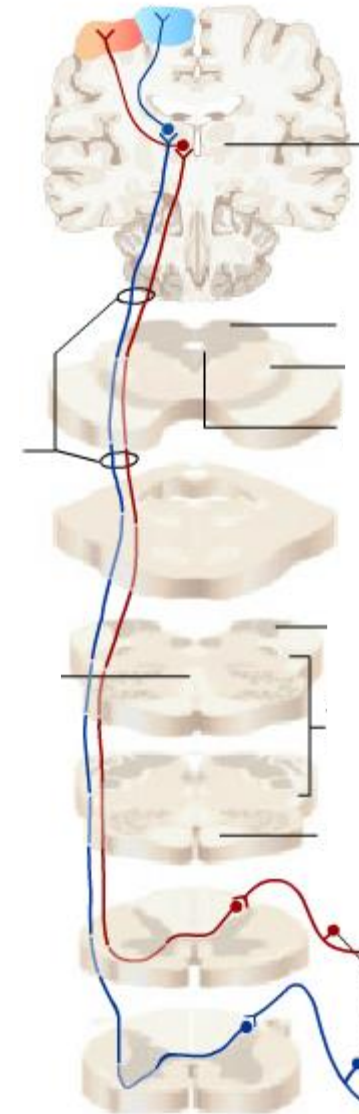
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- Detail information about pain stimuli (sharp, localized pain)
- Information about temperature



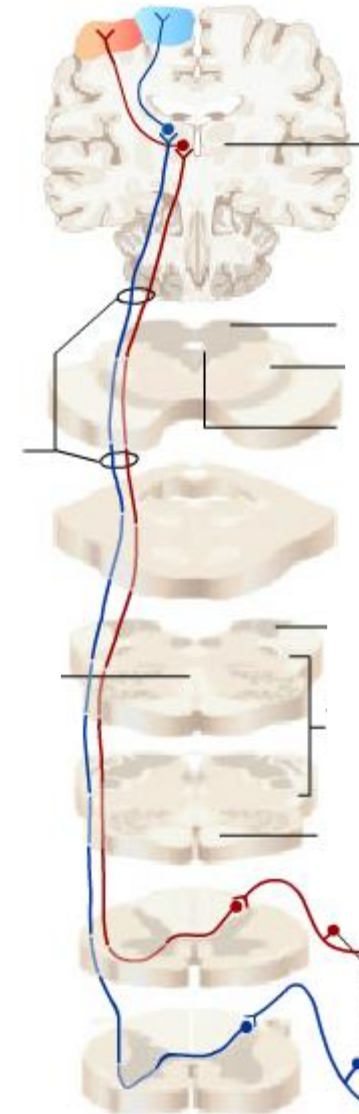
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- Crude touch sensation

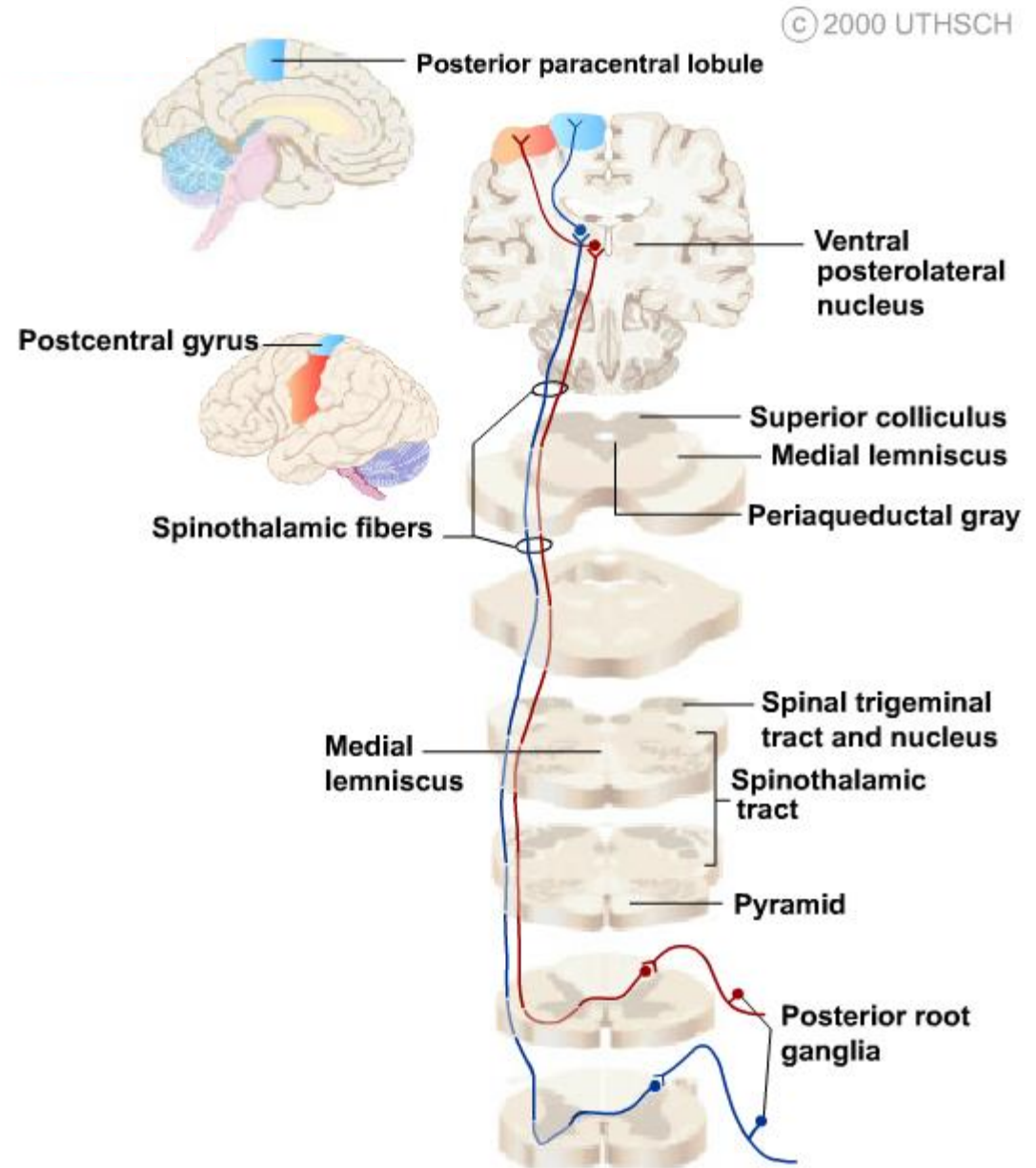


Neospinothalamic system

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- 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

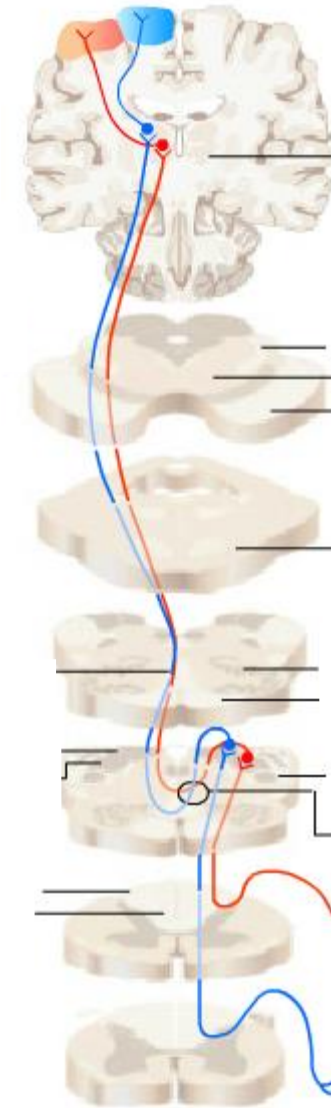


Neospinothalamic system



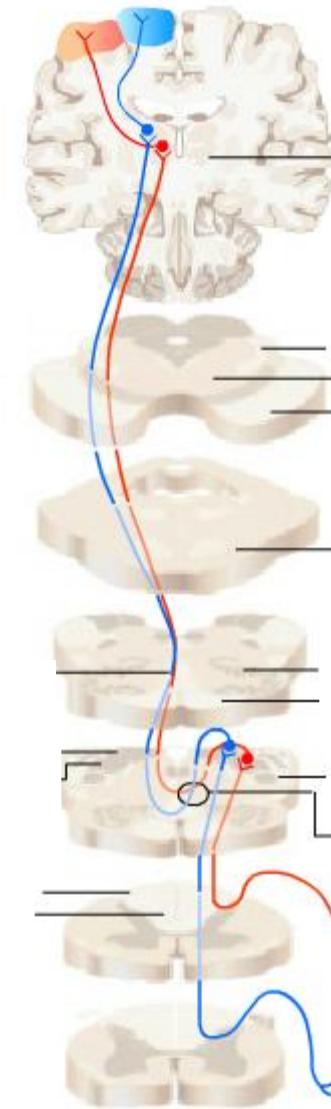
Dorsal column system

- Tr. Spinobulbaris



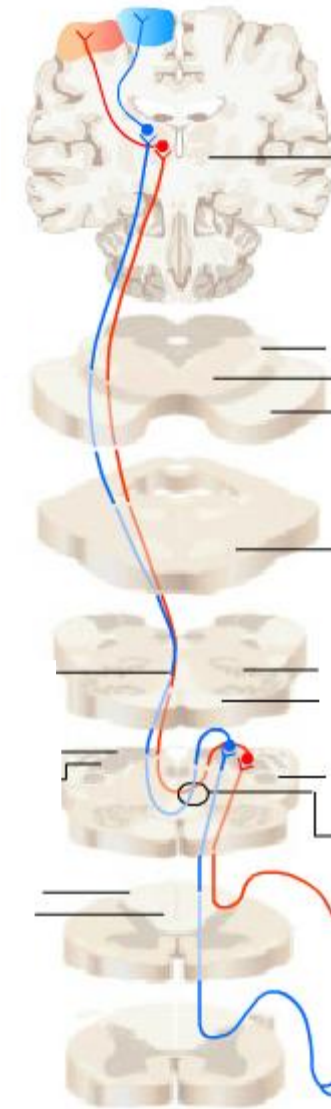
Dorsal column system

- Tr. Spinobulbaris
- The youngest system
- High capacity



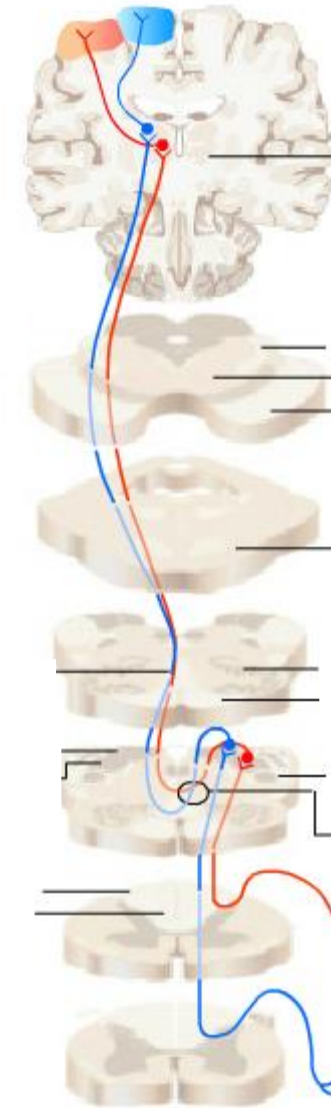
Dorsal column system

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



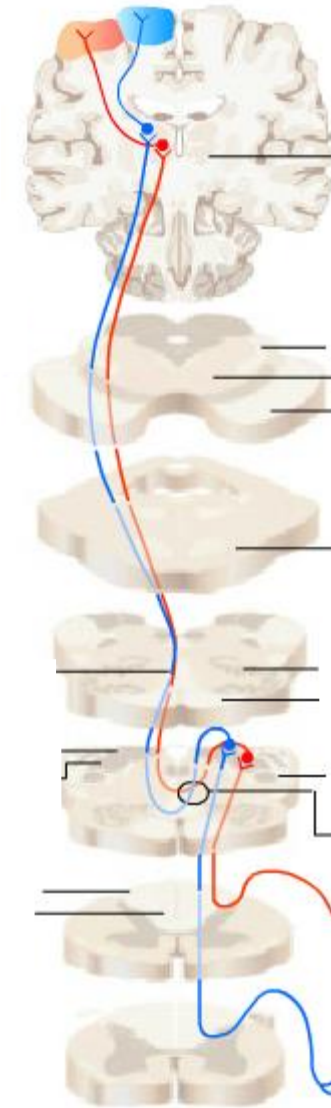
Dorsal column system

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

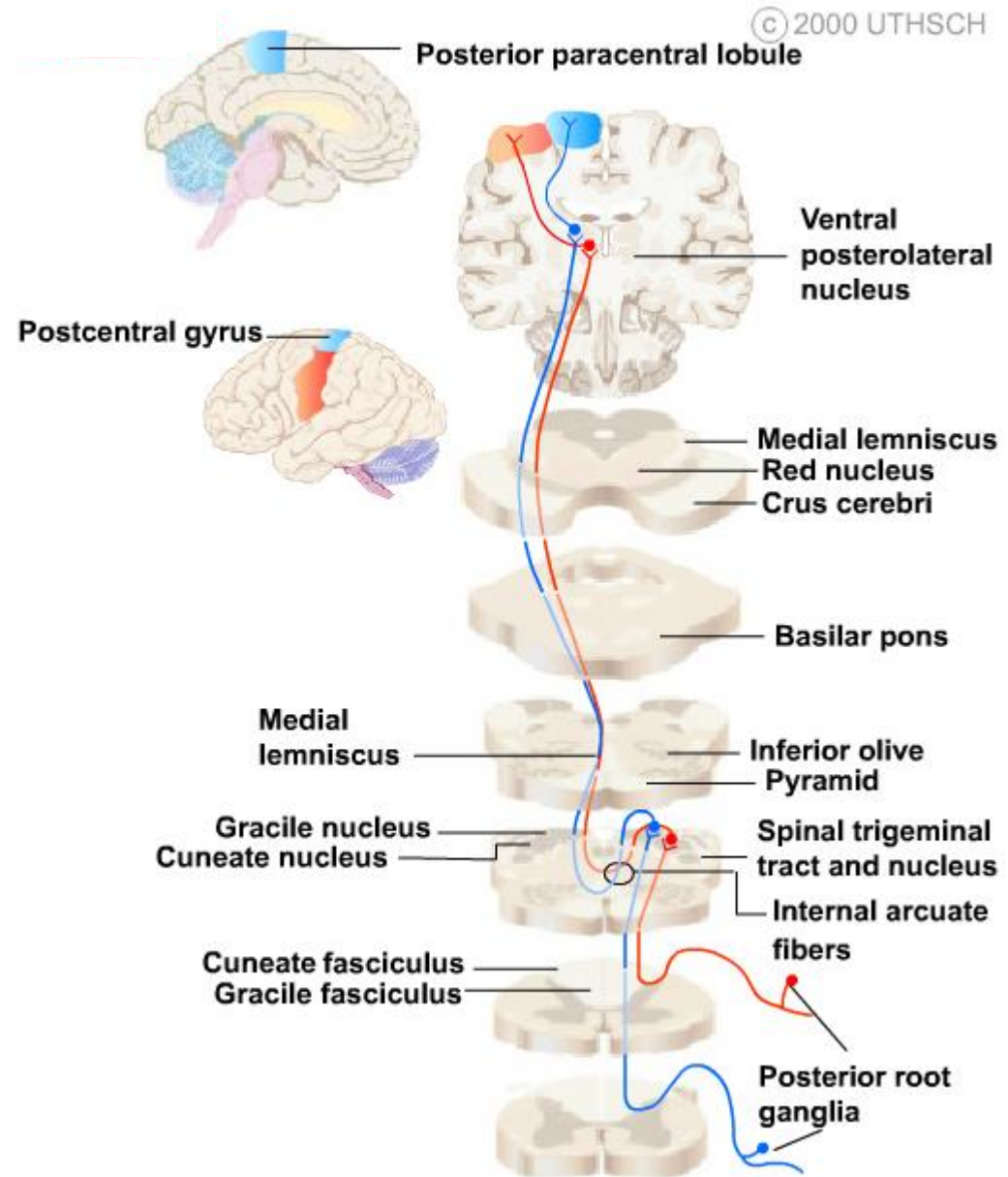


Dorsal column system

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

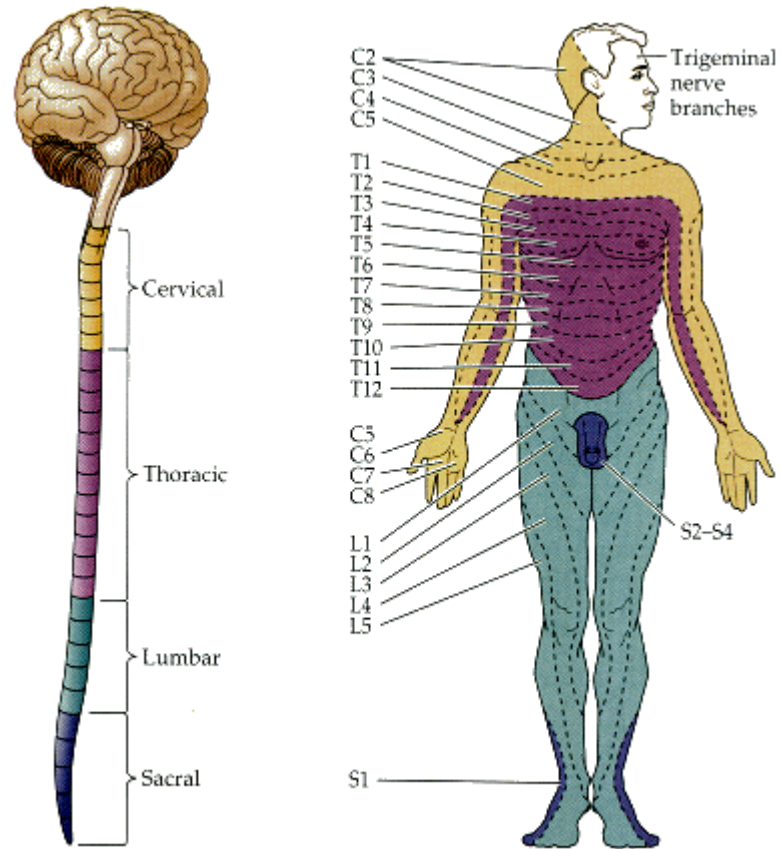


Dorsal column system



Dermatoms

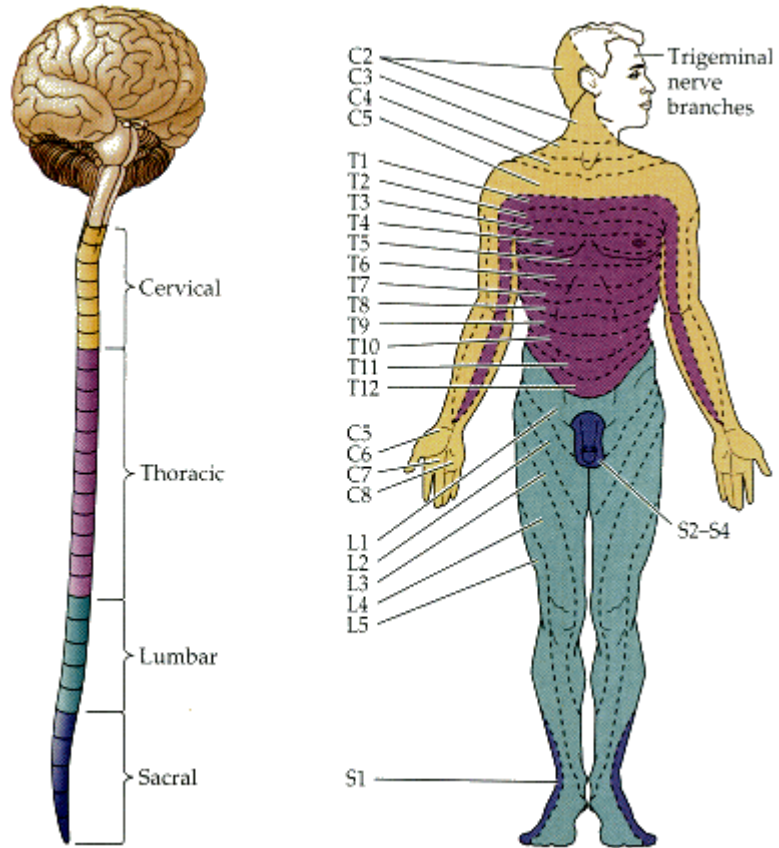
- Somatotopic organization somatosensitive nerves



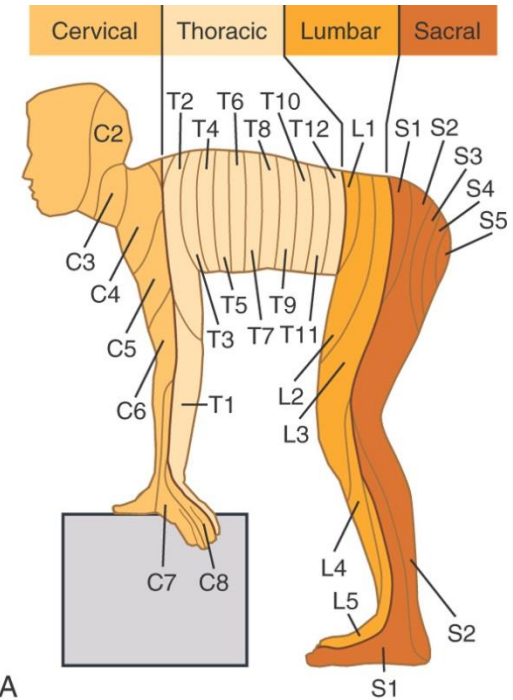
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Dermatomes

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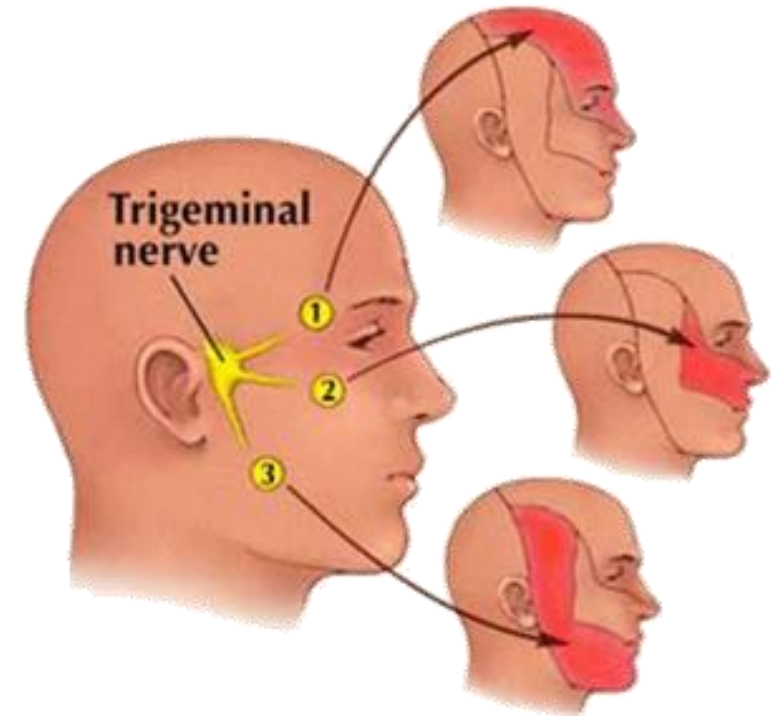
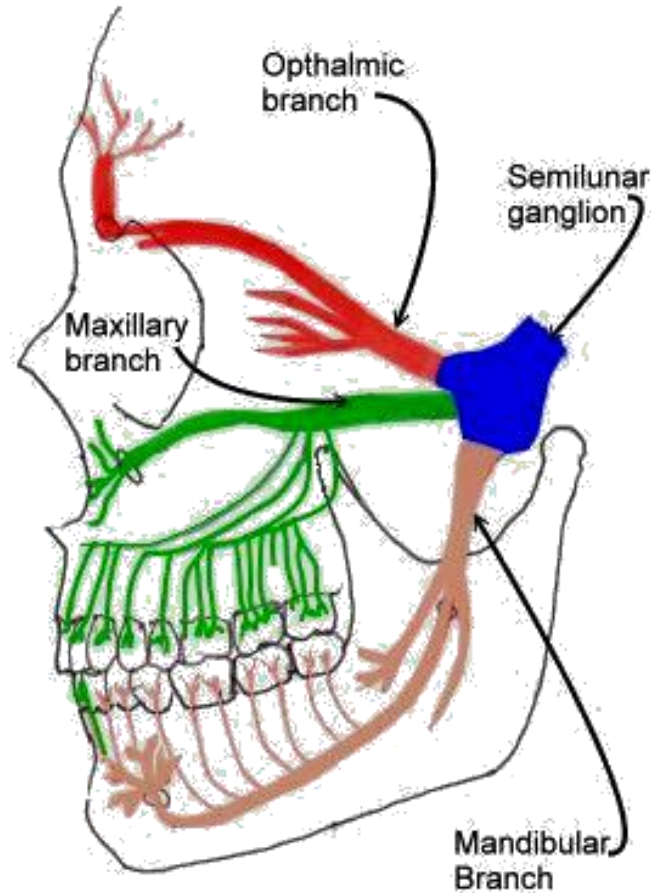
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Trigeminal system

- Spinal TS
 - Pain, temperature
- Main sensory TS
 - Touch, proprioception



Somatosensory pathways

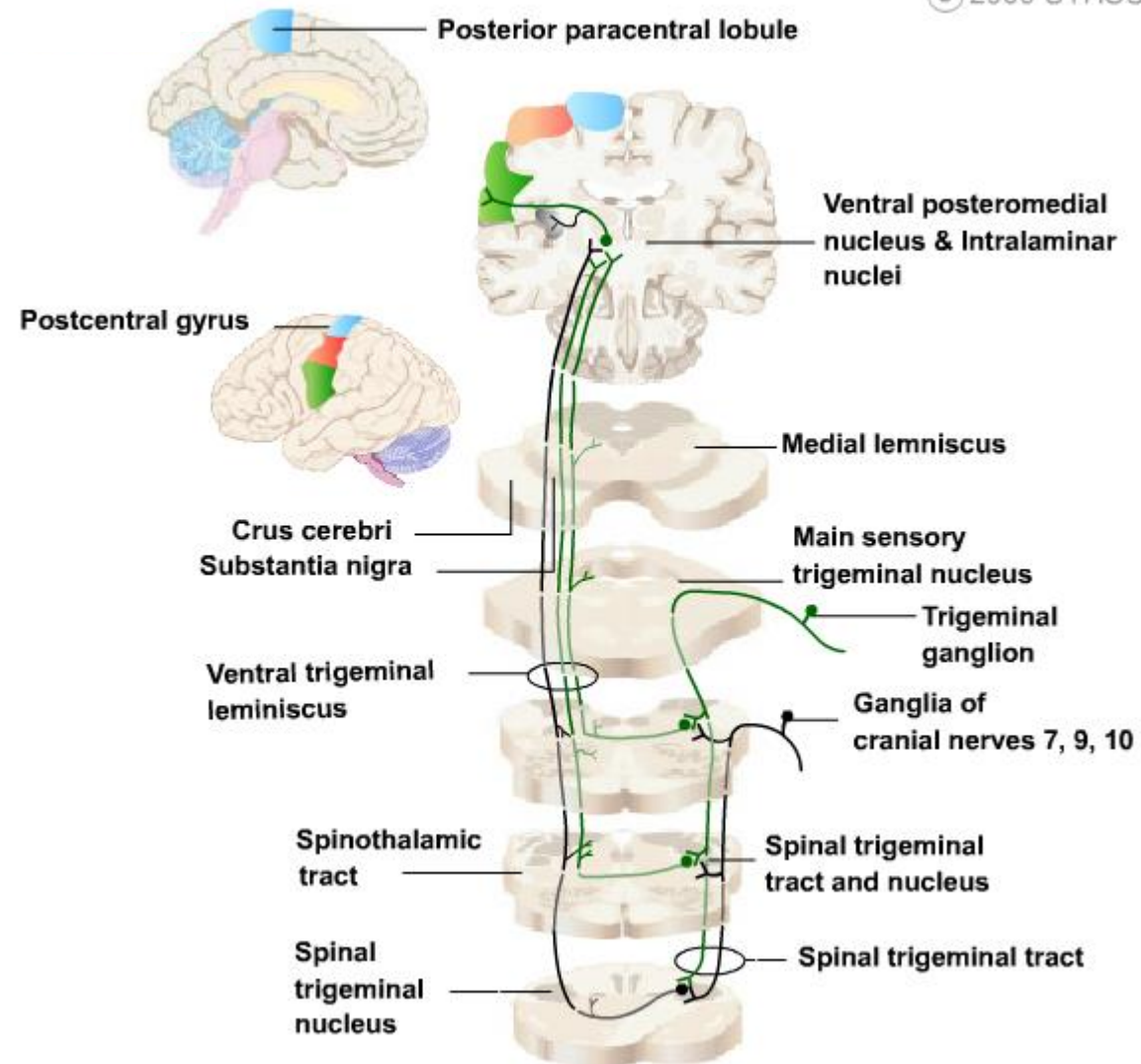
<p style="text-align: center;"><i>Table I</i> <i>The Sensory Modalities Represented by the Somatosensory Systems</i></p>				
Modality	Sub Modality	Sub-Sub Modality	Somatosensory Pathway (Body)	Somatosensory Pathway (Face)
Pain	sharp cutting pain		Neospinothalamic	Spinal Trigeminal
	dull burning pain		Paleospinothalamic	
	deep aching pain		Archispinothalamic	
Temperature	warm/hot		Paleospinothalamic	
	cool/cold		Neospinothalamic	
Touch	itch/tickle & crude touch		Paleospinothalamic	
	discriminative touch	touch	Tr. spinobulbaris	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		

<http://neuroscience.uth.tmc.edu/s2/chapter02.html>

Trigeminal system

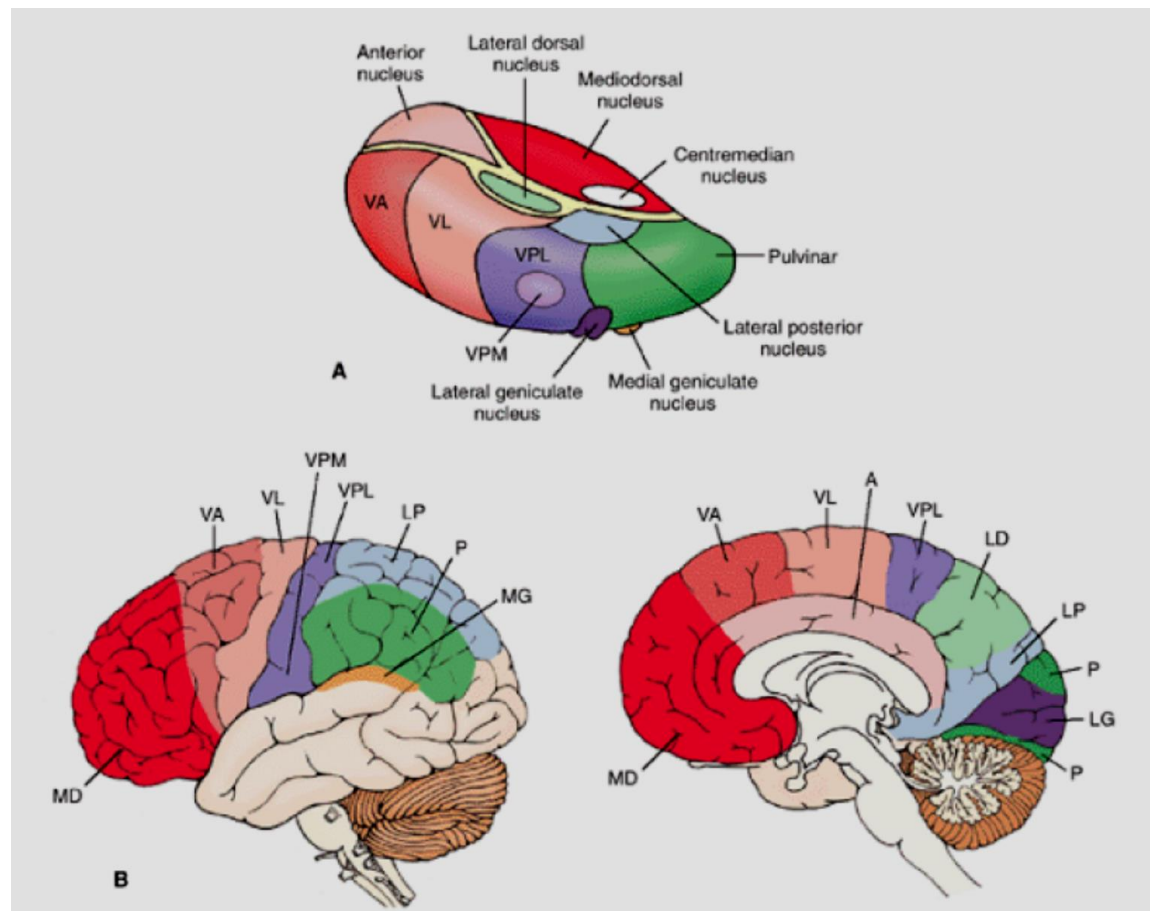
© 2000 UTHSCH

- Spinal TS
 - Pain, temperature
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Thalamus and neocortex

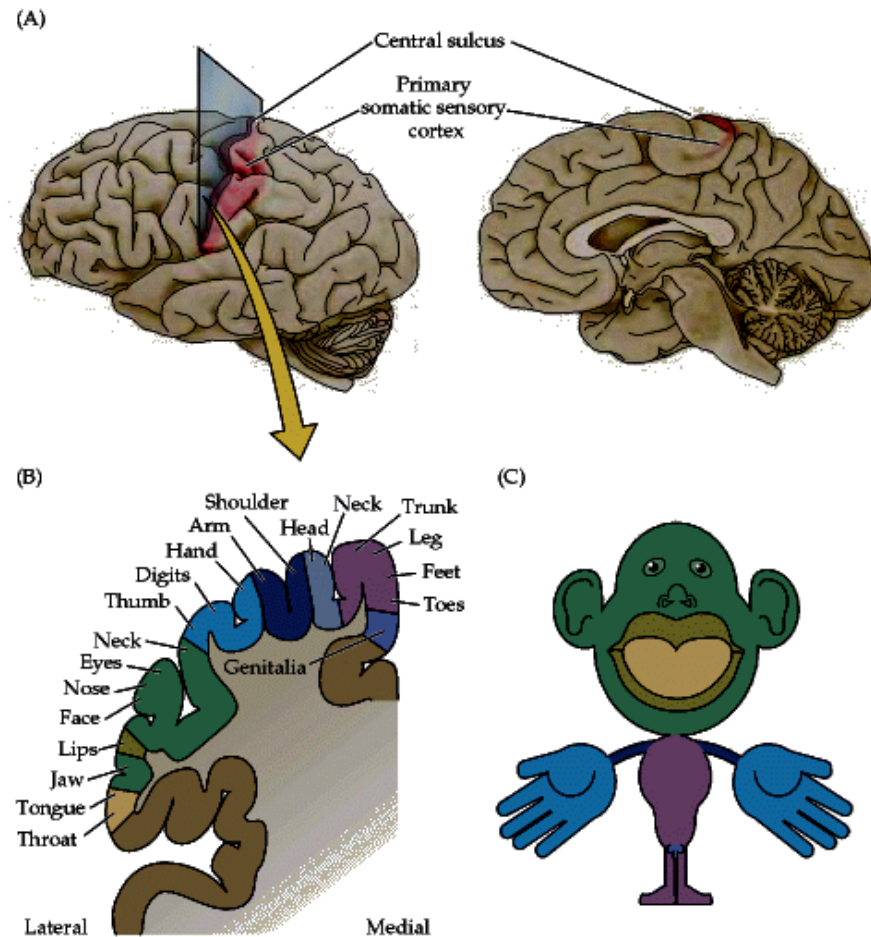
- Almost all the afferent information gated in the thalamus
- Olfaction is an exception
- Bilateral connections between neocortex and thalamus



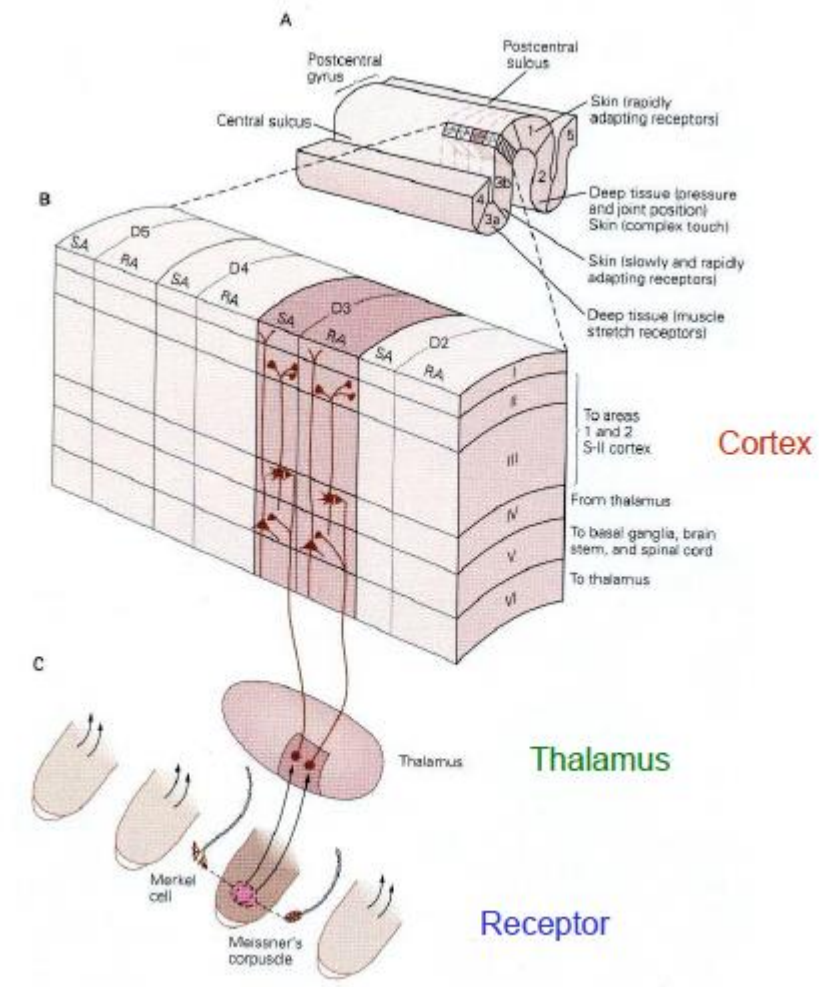
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Neocortex

- Somatotopic organization
- Cortical magnification



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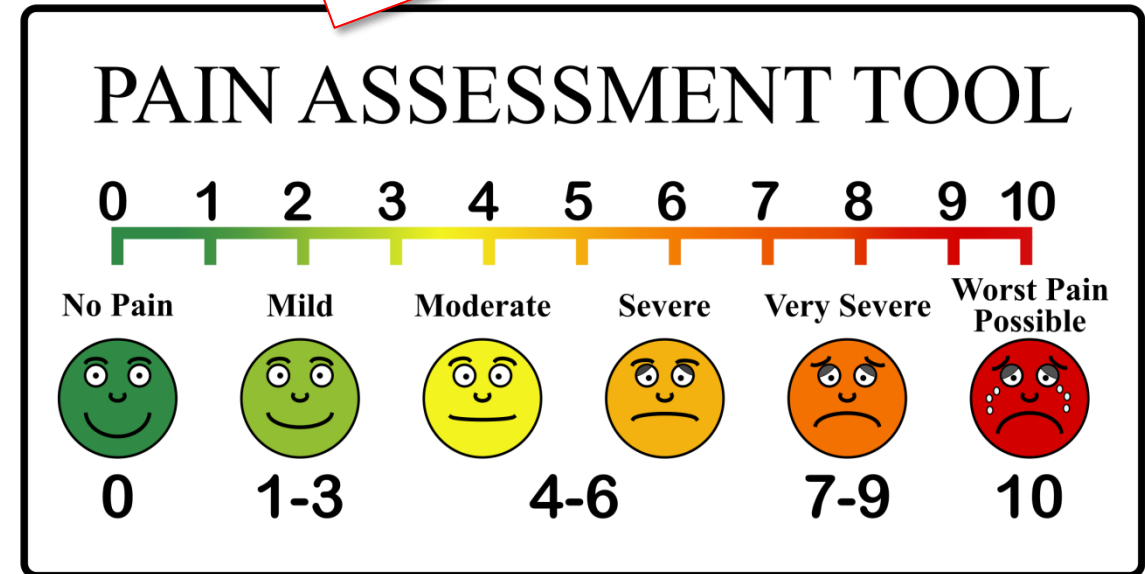


http://www.shadmehrlab.org/Courses/physfound_files/wang_5.pdf

Pain

- Distressing feeling associated with real or potential tissue damage
- Sensor x psychological component

Subjective character

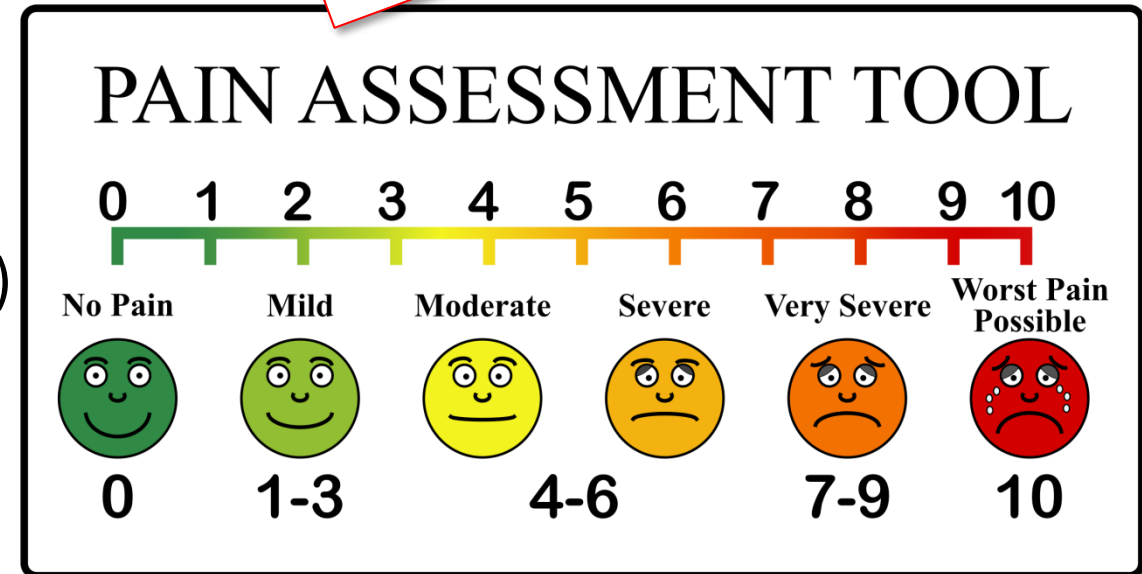


https://www.cheatography.com/uploads/davidpol_1460561912_Pain_Scale__Arvin61r58.png

Pain

- Distressing feeling associated with real or potential tissue damage
- Sensor x psychological component
- ✓ Physiological pain (nociceptor activation)
- ✓ Pathological pain (not mediated by nociceptors)

Subjective character

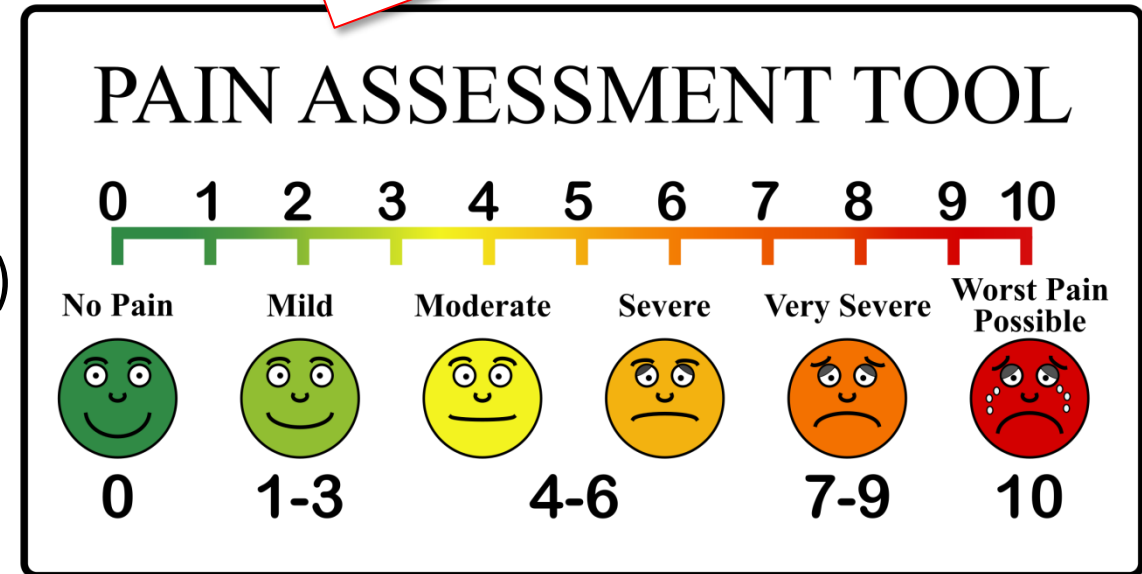


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Pain

- Distressing feeling associated with real or potential tissue damage
- Sensor x psychological component
- ✓ Physiological pain (nociceptor activation)
- ✓ Pathological pain (not mediated by nociceptors)
- Acute (up to 6months) – „activating“
- Chronic (more than 6 months) – „devastating“

Subjective
character

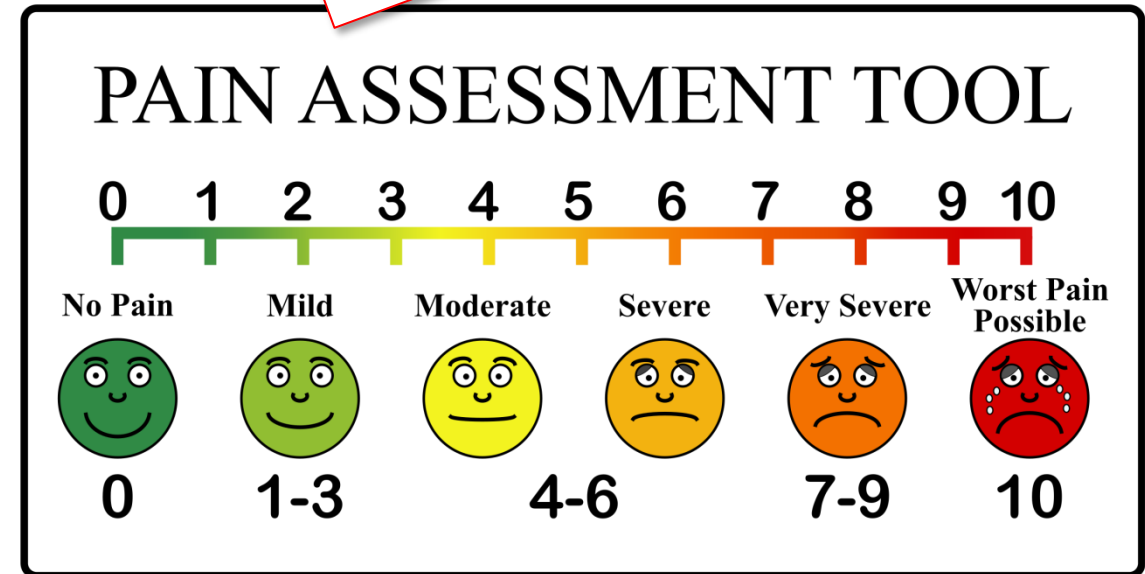


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Nociceptors

1. Polymodal (free nerve endings)
2. Thermal
3. Mechanosensitive (pressure)

Subjective
character

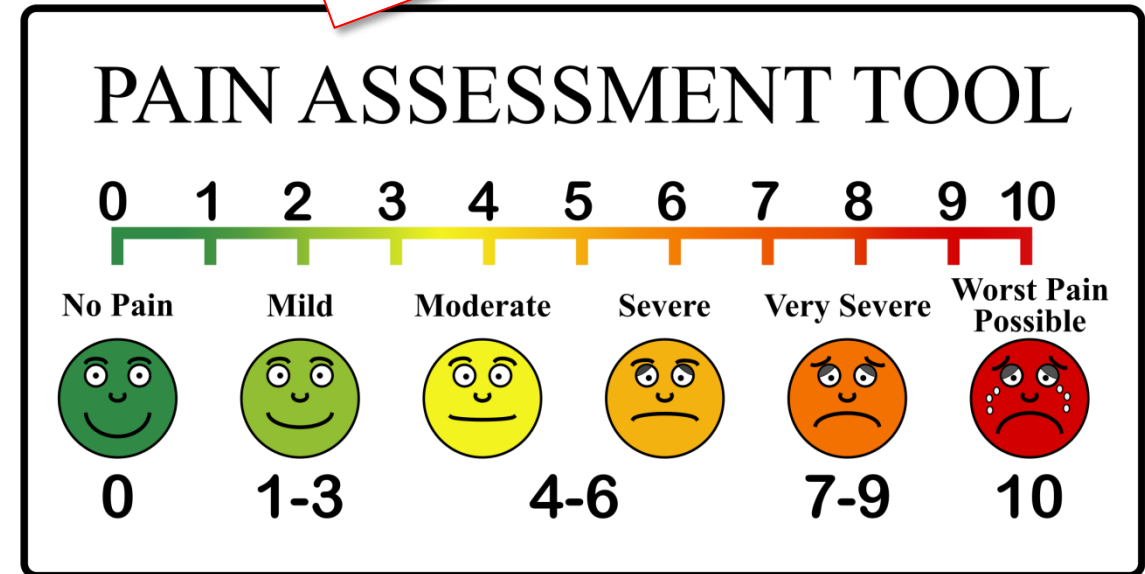


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Nociceptors

1. Polymodal (free nerve endings)
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 3. Mechanosensitive (pressure)
- Skin
 - Viscera
 - Free nerve endings
 - In all connective tissues except of brain

Subjective character

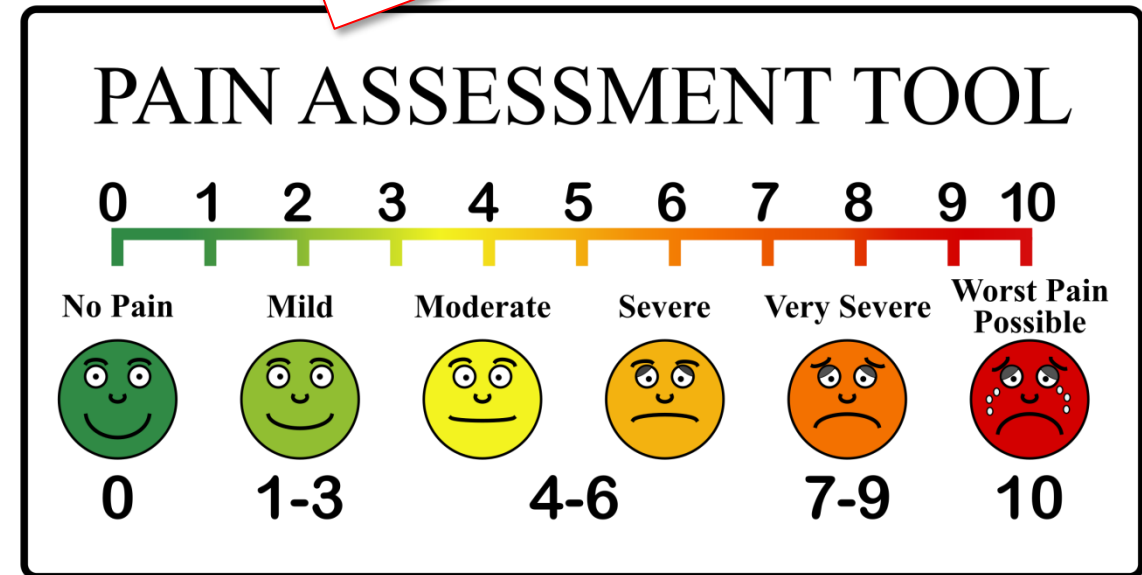


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Nociceptors

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- Skin
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 - C fibers – paleospinothalamic system
 - ✓ 1., 2.
 - A δ fibers – neospinothalamic tract
 - ✓ 1., 2., 3.

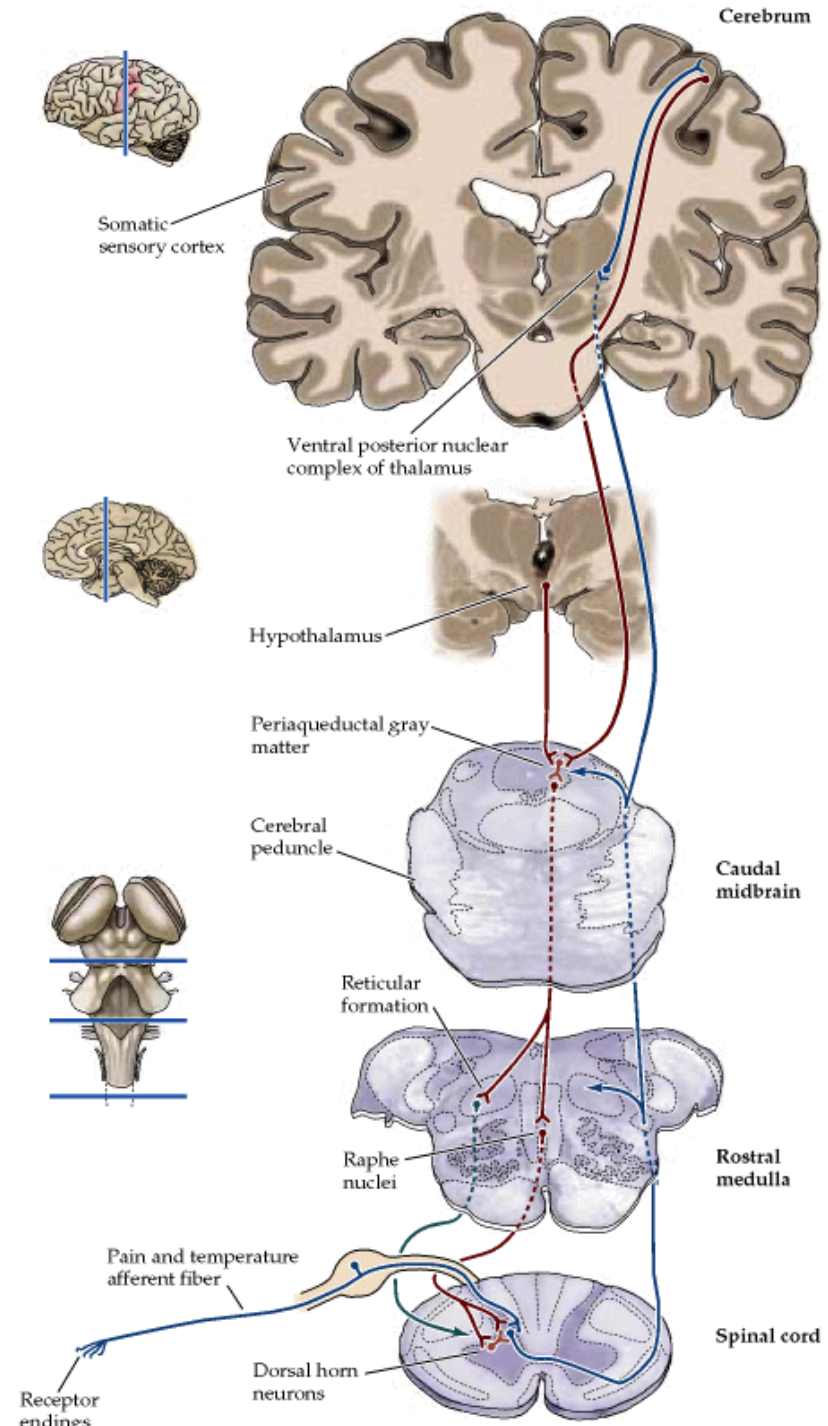
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Pain modulations

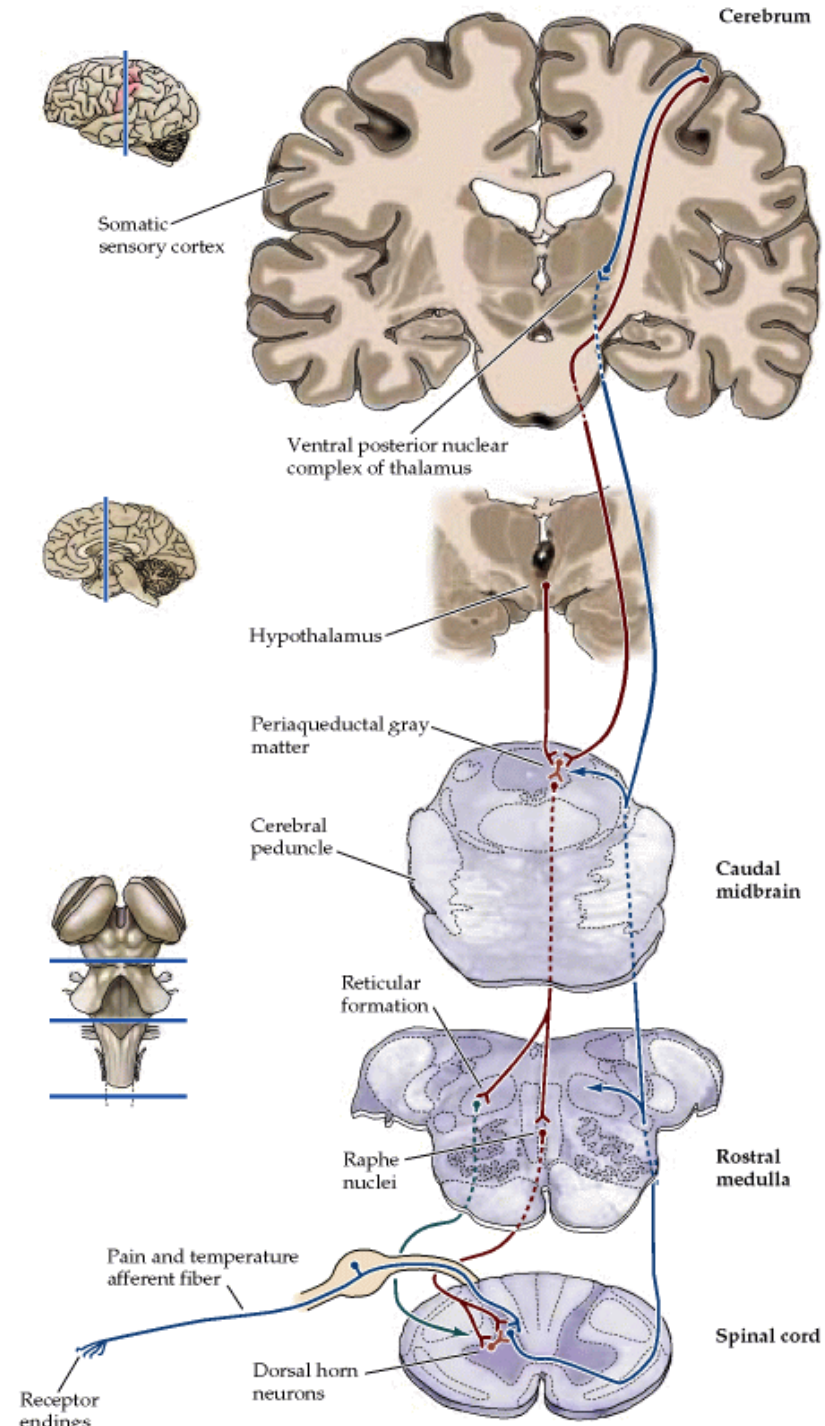
- Modulation of receptor sensitivity
 - Increased sensitivity
 - Local compounds (H⁺, bradykinin, histamine)
 - Retrograde compounds (substance P)



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Pain modulations

- Modulation of receptor sensitivity
 - Increased sensitivity
 - Local compounds (H⁺, bradykinin, histamine)
 - Retrograde compounds (substance P)
- Modulation at the segmental level
 - Sensitization of the posterior spinal horn
 - By the activity of interneurons, the afferentation is also interconnected contralaterally
 - Gate control theory
 - The main mechanism of modulation at the segmental level



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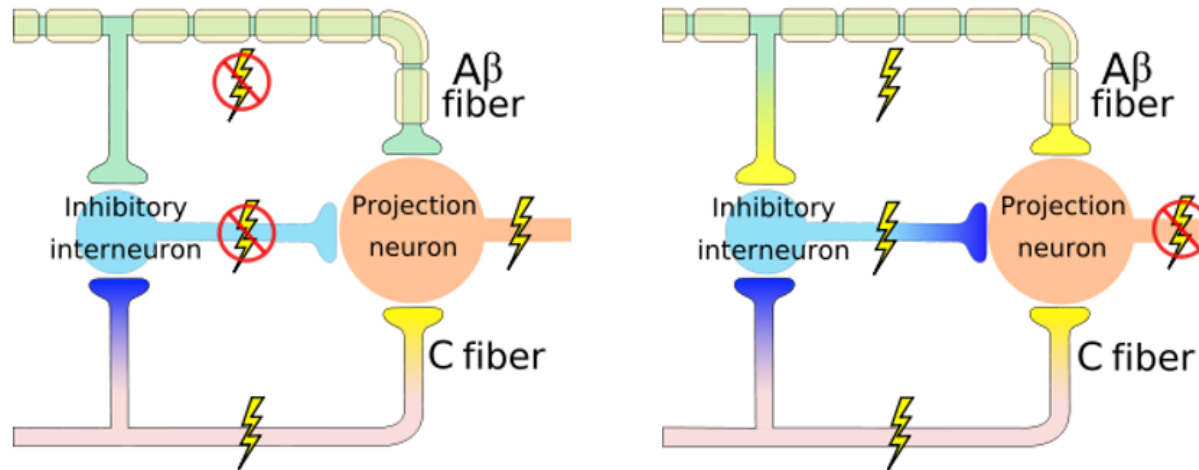
Pain modulations

- Modulation of receptor sensitivity
 - Increased sensitivity
 - Local compounds
 - Retrograde conduction
- Modulation at the spinal level
 - Sensitization of the nociceptors
 - By the activity of the descending pathways
 - Gate control theory
 - The main mechanism

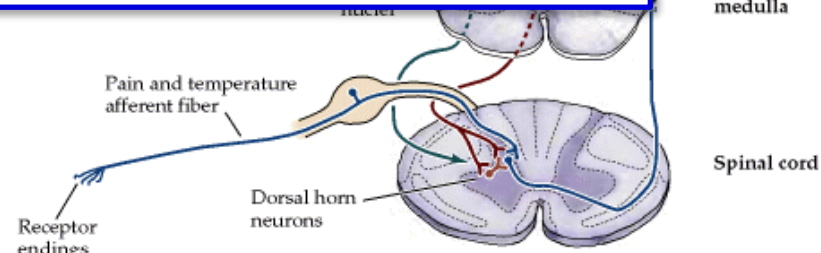


Pain modulation on the spinal level

Gate control theory of pain



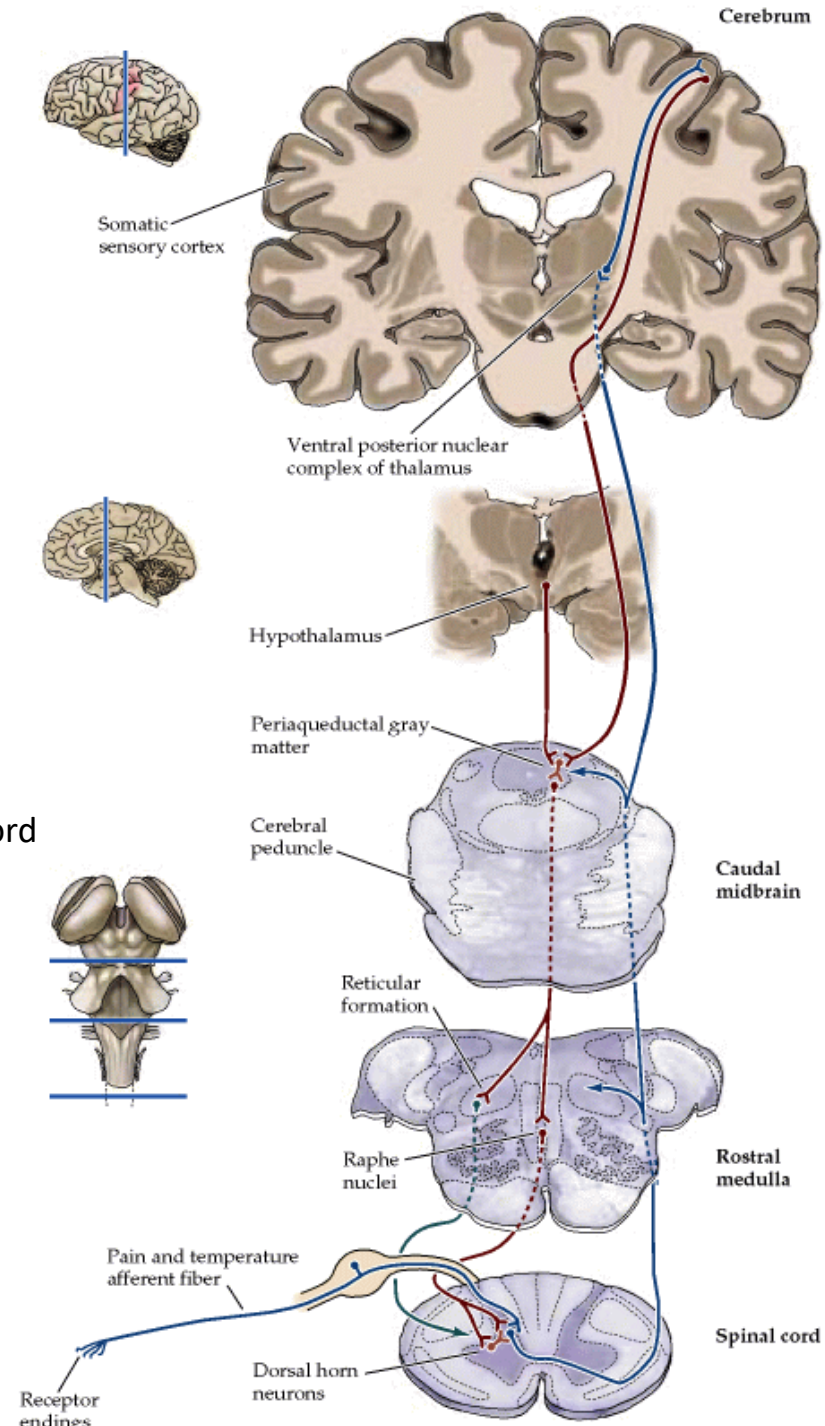
https://en.wikipedia.org/wiki/Gate_control_theory



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Pain modulations

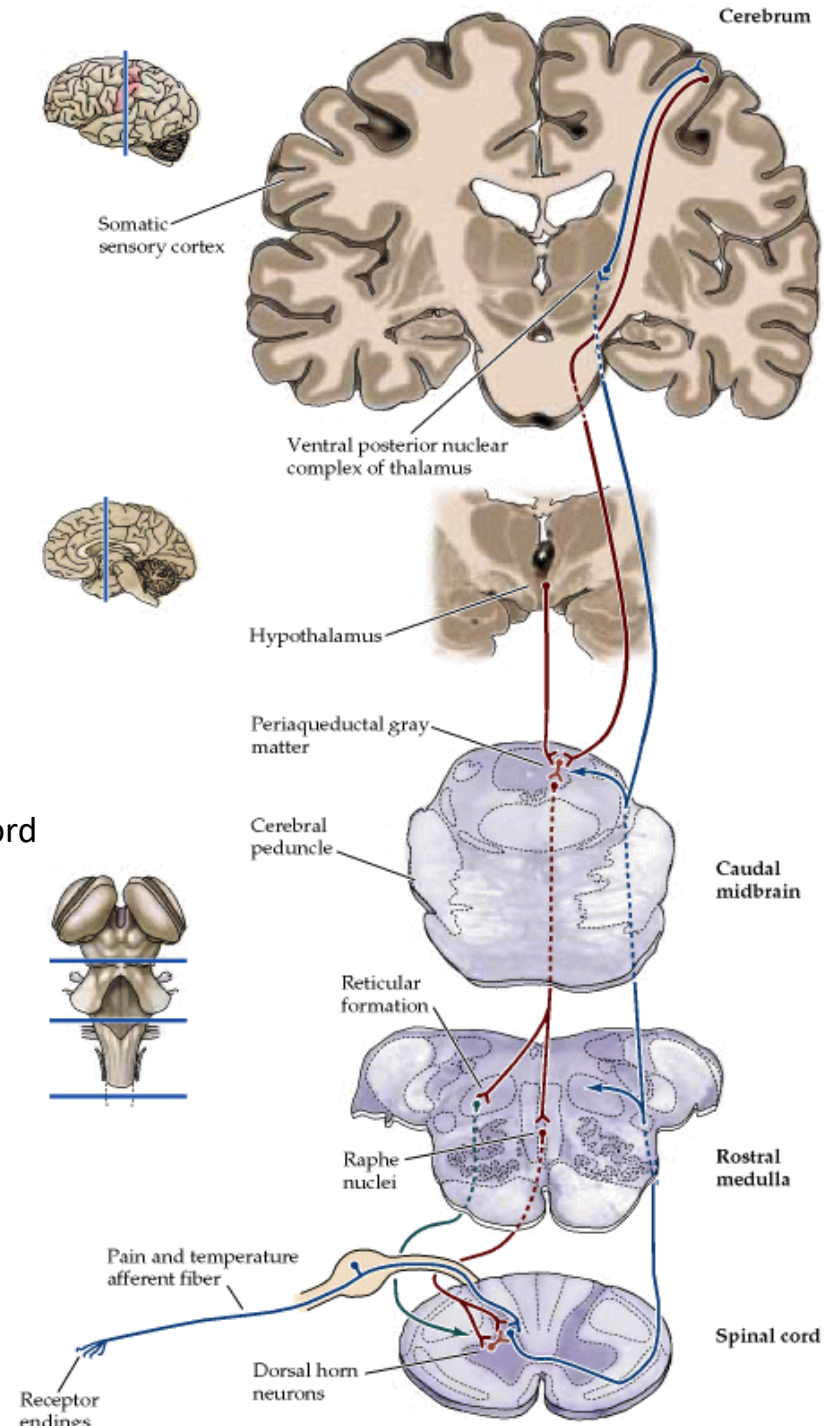
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- Modulation via the reticular formation
 - Nucleus raphe magnus
 - Periaqueductal gray
 - Descendent antinociceptive system
 - Tonic inhibition tr. Spinothalamicus
 - Descending facilitation of nociceptors of the posterior horn of the spinal cord
 - Both inhibitory and facilitating effect



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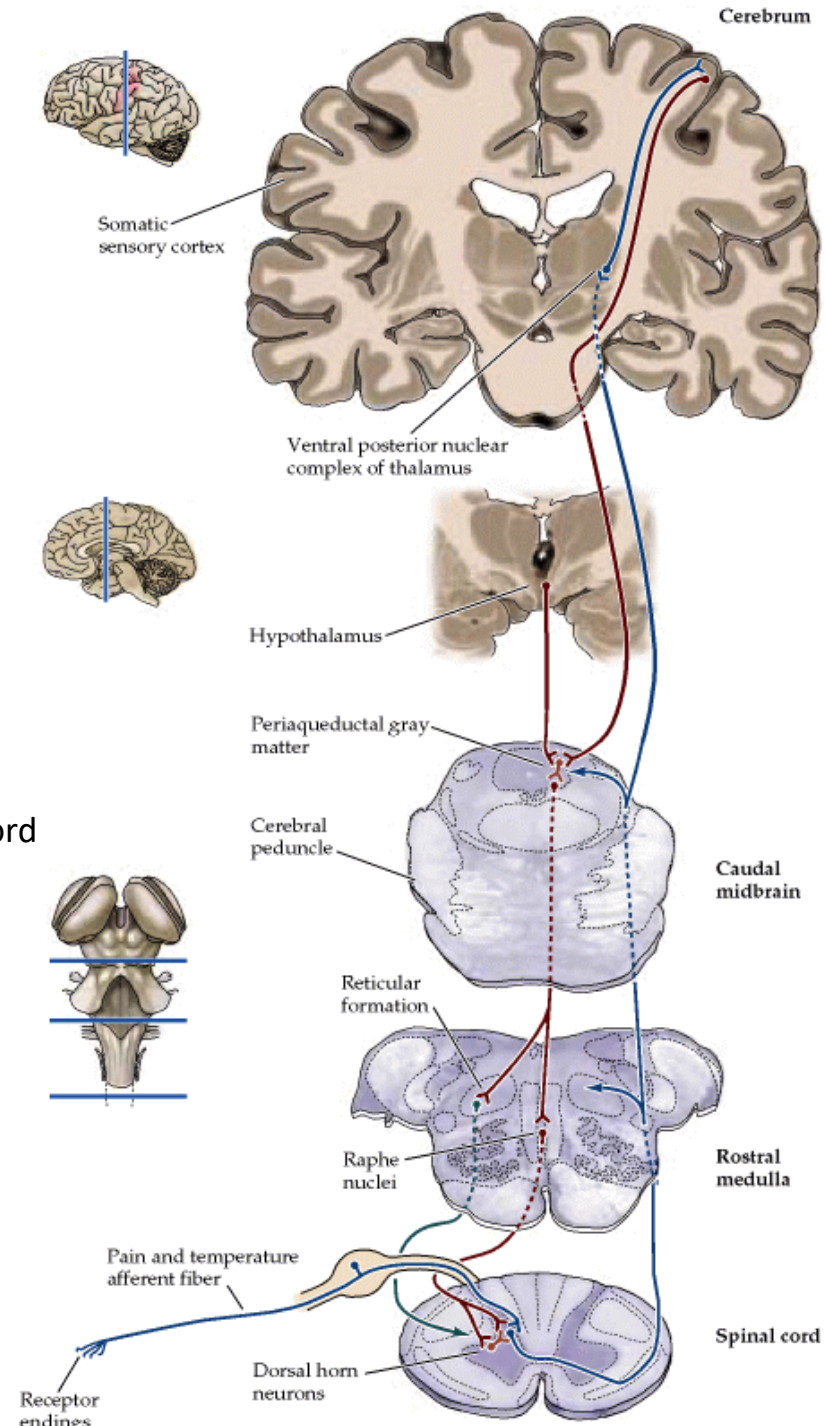
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 - Both inhibitory and facilitating effect
- Cortical modulation
 - Complex effect
 - anticipation, previous experience, etc.
 - Via reticular formation/reticulospinal tract
 - Via corticospinal tract
 - Modulation of thalamic and spinal activity



Pain modulations

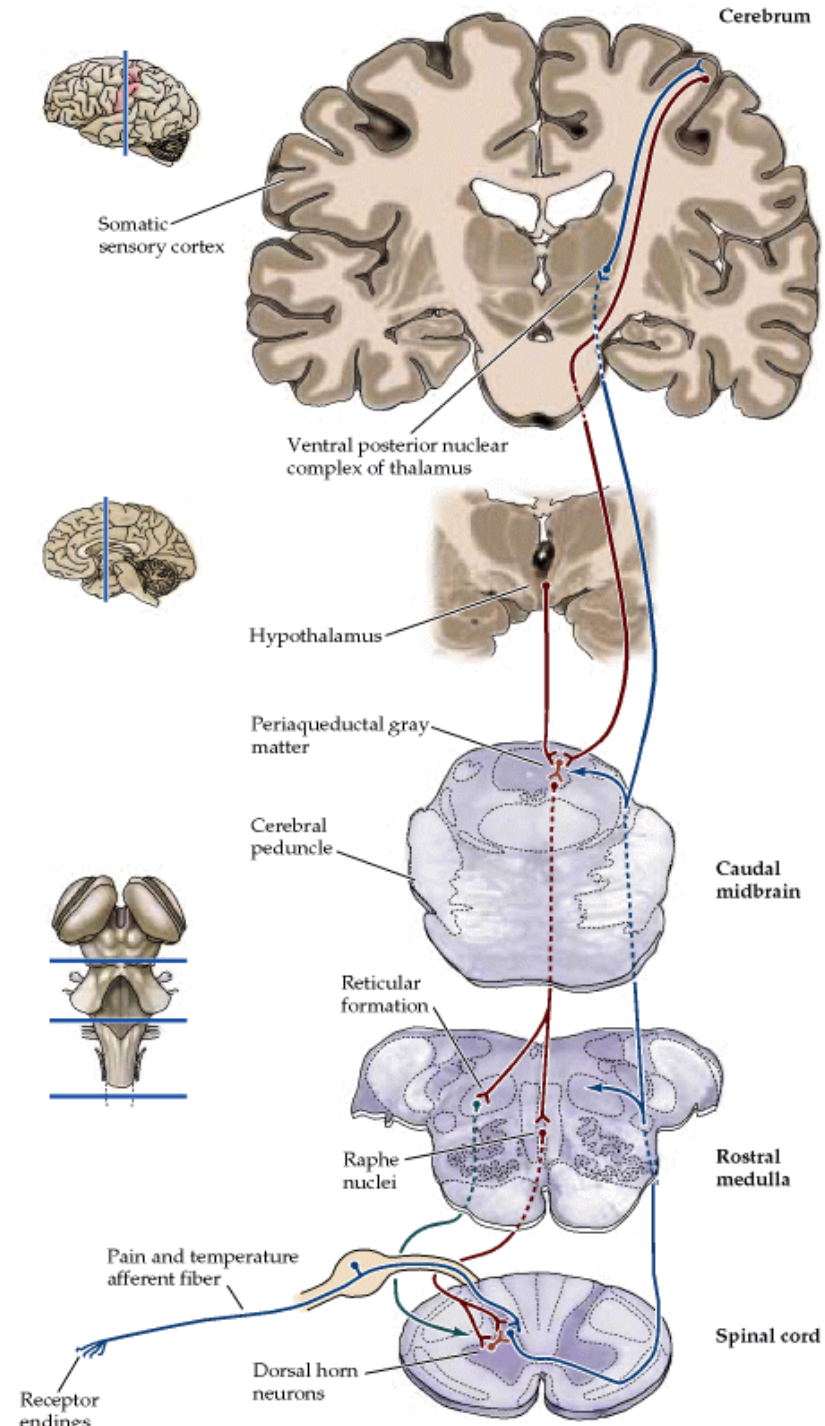
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 - Complex effect
 - anticipation, previous experience, etc.
 - Via reticular formation/reticulospinal tract
 - Via corticospinal tract
 - Modulation of thalamic and spinal activity
- Other structures involved in pain modulation
- Hypothalamus – limbic component vs. thalamus – somatic component



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Pain modulations

- Autonomic nervous system
 - Acute pain activates the SNS and the SNS facilitates nociception
 - The parasympathetic nervous system inhibits pain
- Endogenous opioids
 - Endorphins - dampening effect (β -endorphin)
 - Dynorphins – Both dampening and facilitating effect
 - Enkephalins - unresolved

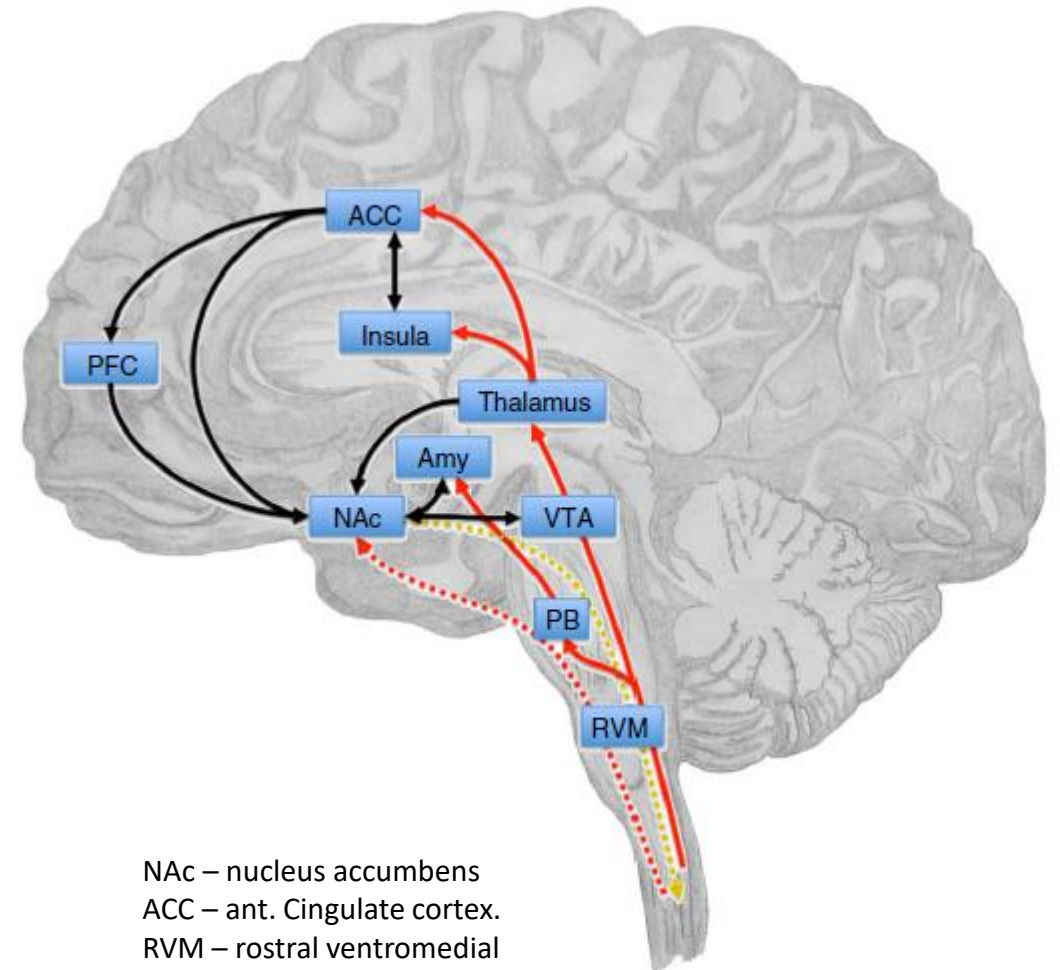


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Pain and limbic system

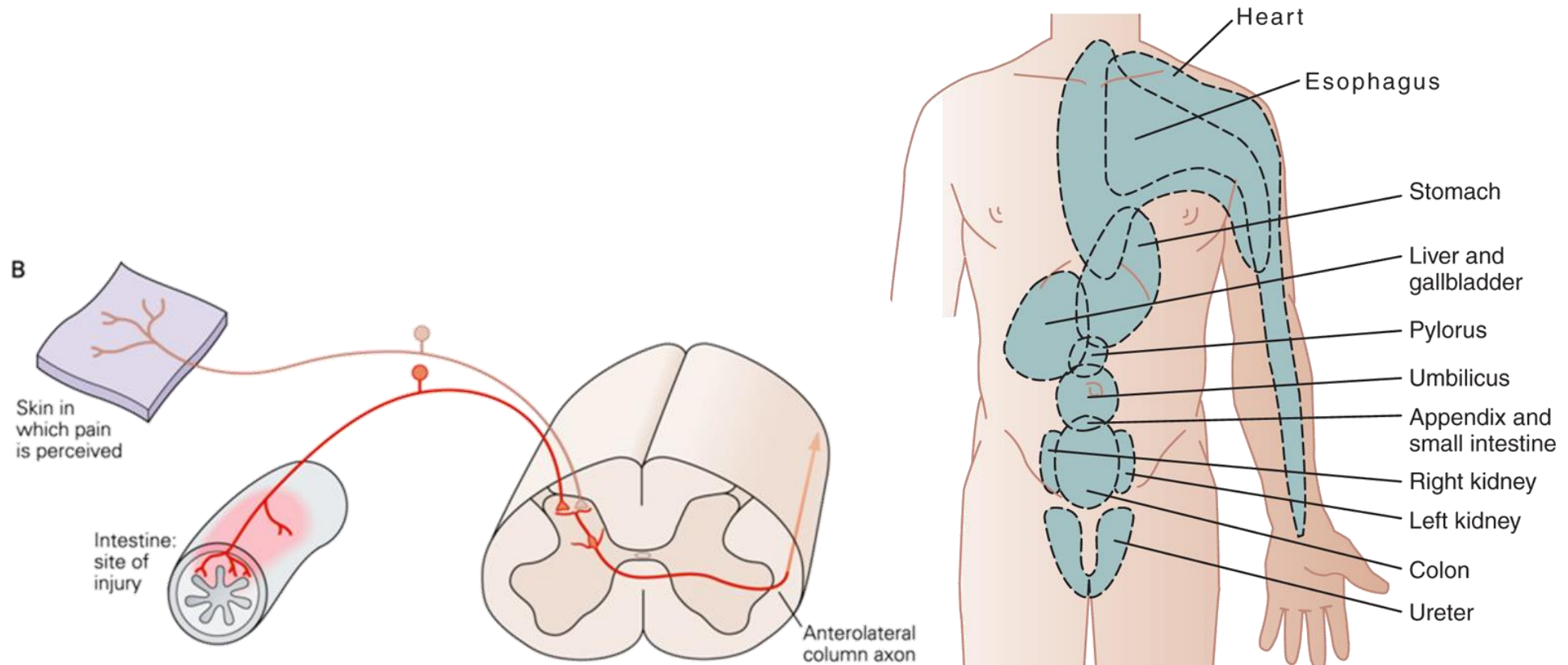
Navratilova E, Porreca F.
Reward and motivation
in pain and pain relief.
Nat Neurosci.
2014;17:1304–1312.

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.



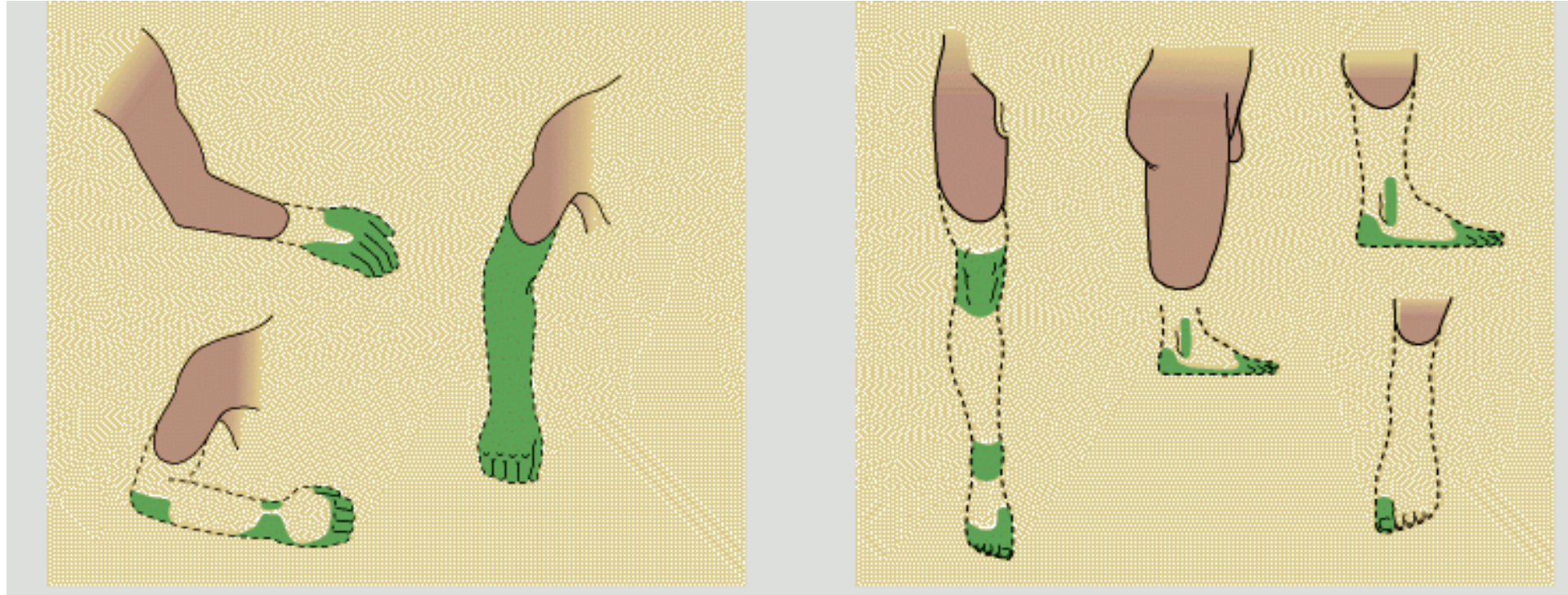
NAc – nucleus accumbens
ACC – ant. Cingulate cortex.
RVM – rostral ventromedial
medulla

Referred pain



<http://www.slideshare.net/drpsdeb/presentations>

Phantom limb pain



<http://www.slideshare.net/drpsdeb/presentations>

73. Basic functional comparison of somatosensitivity, viscerosensitivity and proprioception, the importance of sensitivity for immediate and long-term survival

- ✓ Somatosensitivity vs. viscerosensitivity vs. proprioception
 - Definition, functional comparison
- ✓ Somatosensory pathways (three systems)
 - Function/resolution
 - Importance for survival (i.e. pain for immediate, proprioception for better adaptation)
- ✓ Optionally brief overview of proprioception
 - Muscle spindles vs. Golgi tendon organs (Motor system I)

74. Pain

- ✓ Definition of pain
- ✓ Classification of pain (physiological, pathological, acute, chronic)
- ✓ Somatosensory pathways involved in pain perception
 - Fast vs. slow pain
- ✓ Pain modulation
 - Overview of structures involved in pain modulation
 - Gate control theory
- ✓ Referred pain vs. phantom limb pain

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