

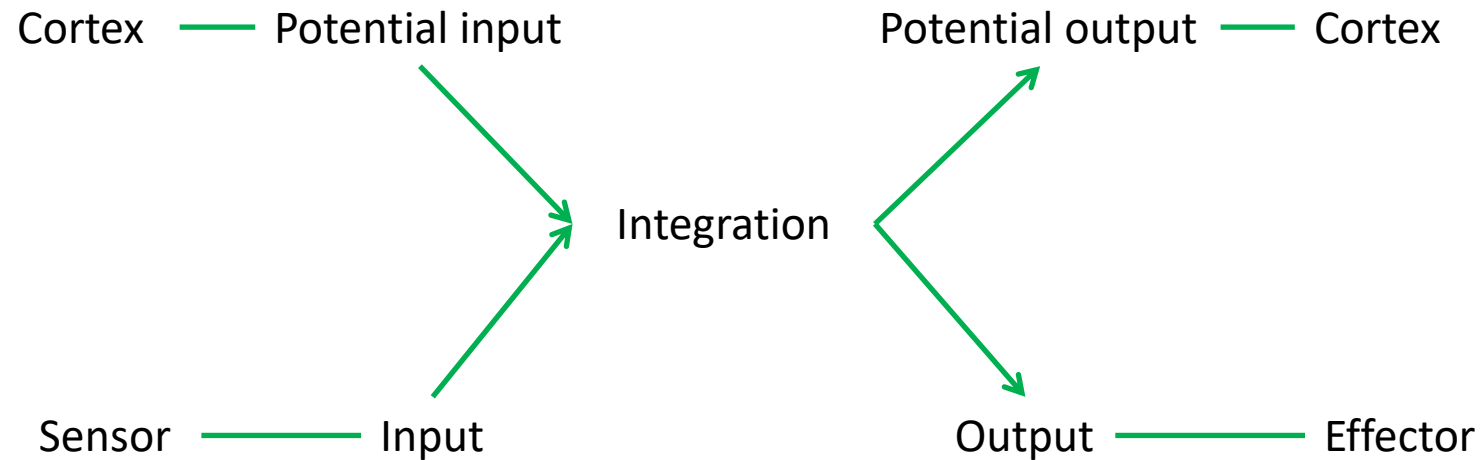
M U N I

M E D

Somatosensitivity, pain

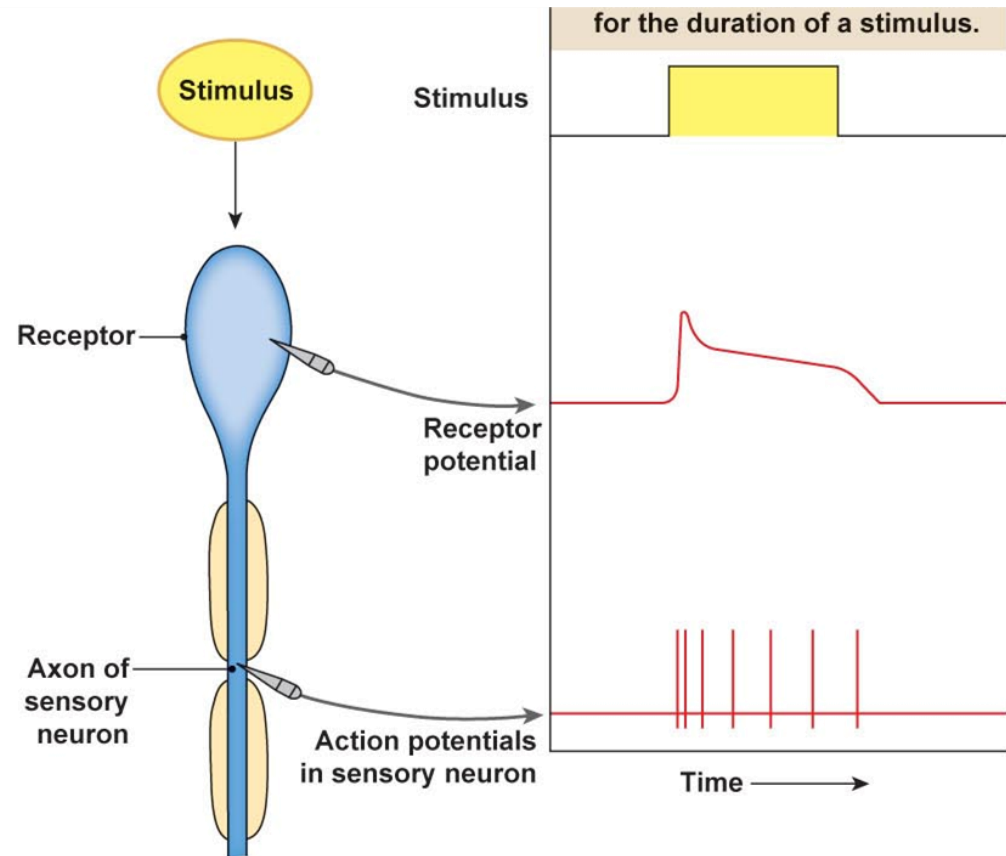
The role of nervous system

ANTICIPATION



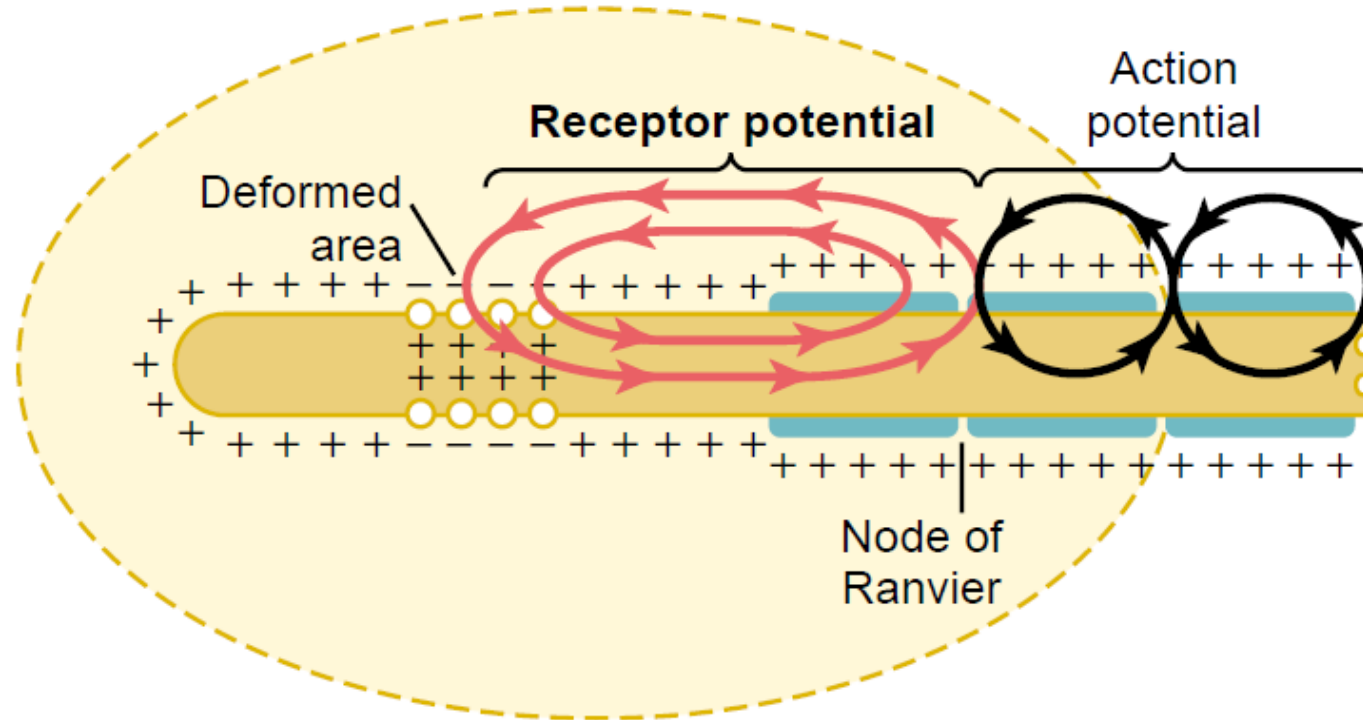
Receptors/sensors

- Energy convertor
 - Signal reception
 - Signal transformation
- Receptor potential
 - Generator potential
- Action potential



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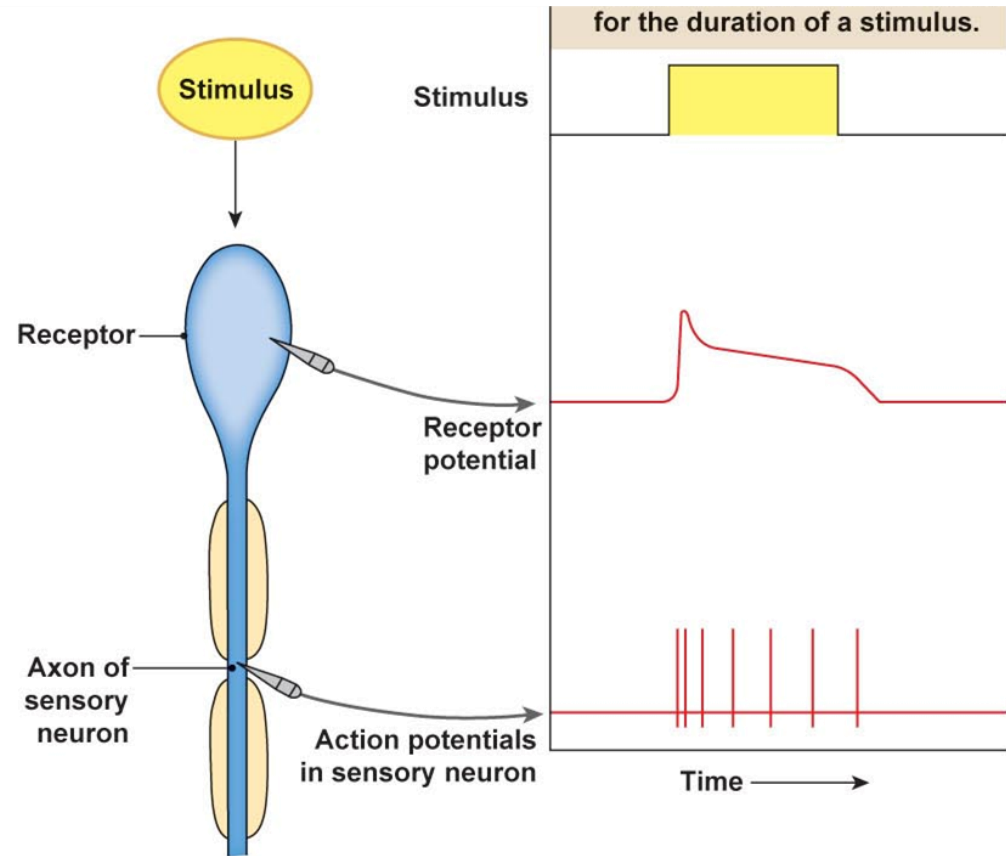
Receptor/generator and action potential



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Receptors/sensors

- Energy convertor
 - Signal reception
 - Signal transformation
- Receptor potential
 - Generator potential
- Action potential
- Adequate stimulus
- Non adequate stimulus

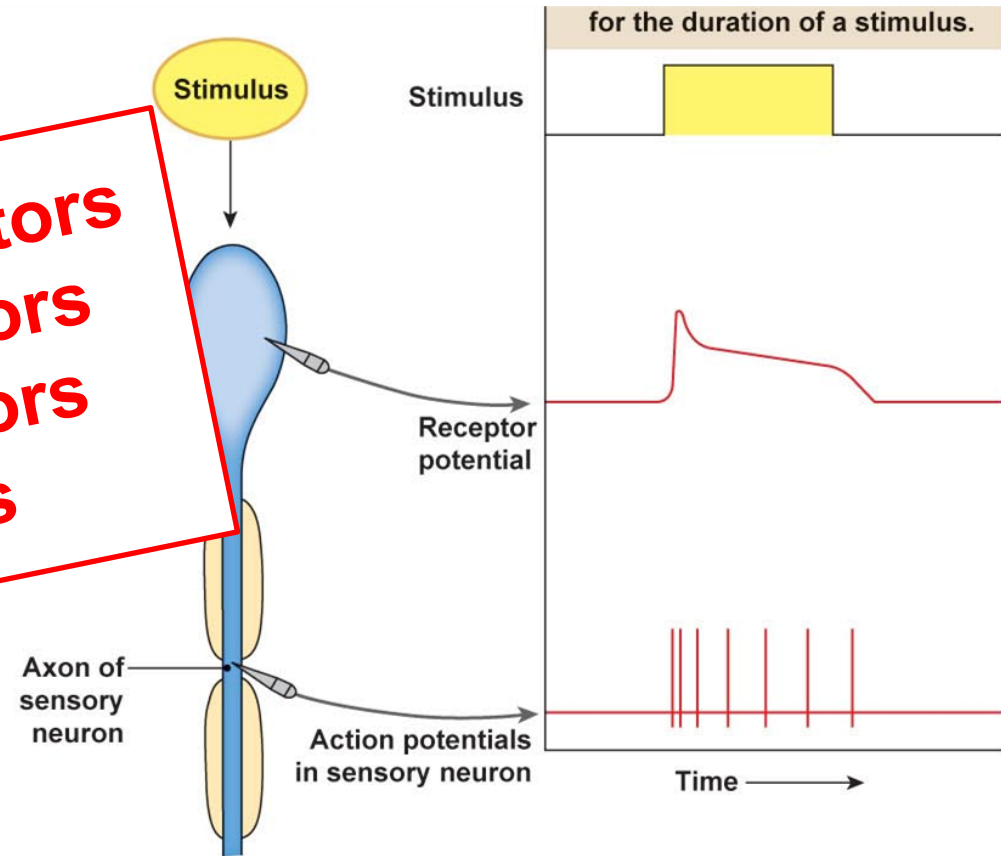


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Receptors/sensors

- Energy convertor
 - Signal reception
 - Signal transformation
- Receptor potential
 - Generator potential
- Action potential
- Adequate stimulus
- Non adequate stimulus

✓ **Mechanoreceptors**
✓ **Thermoreceptors**
✓ **Chemoreceptors**
✓ **Fotoreceptors**



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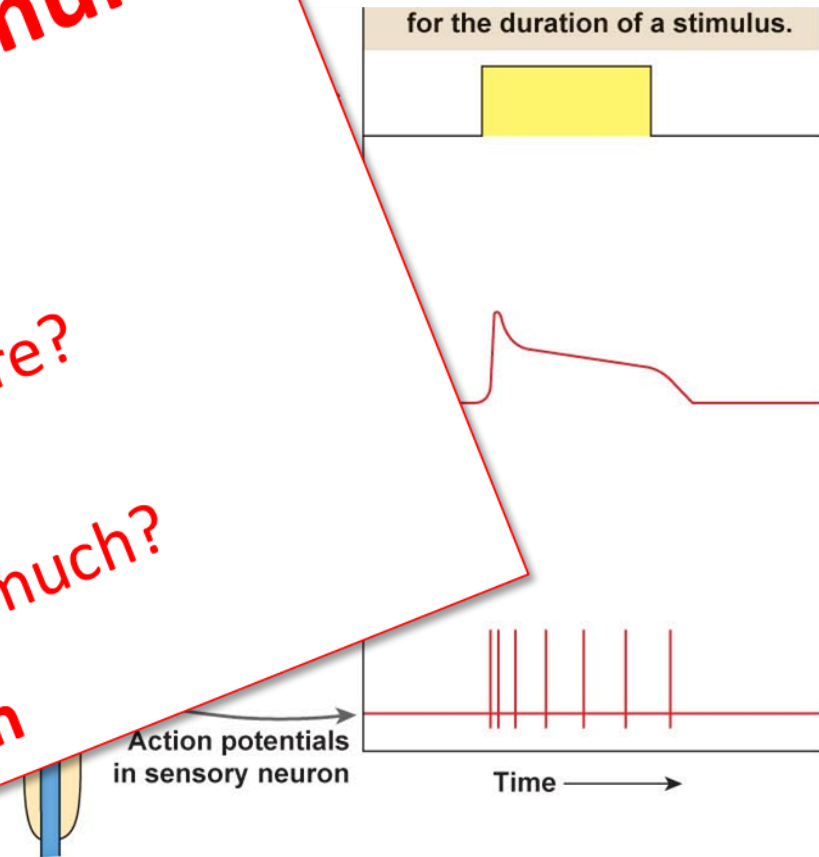
Receptors/sensors

- Energy convertor
 - Signal reception
 - Signal transformation
- Receptor potential
 - Generator potential
- Action potentials
- Adequate stimulus
- Non adequate stimulus

Basic attributes of stimulus

Qualitative
Modality - What?
Localization - Where?

Quantitative
Intensity - How much?
Duration

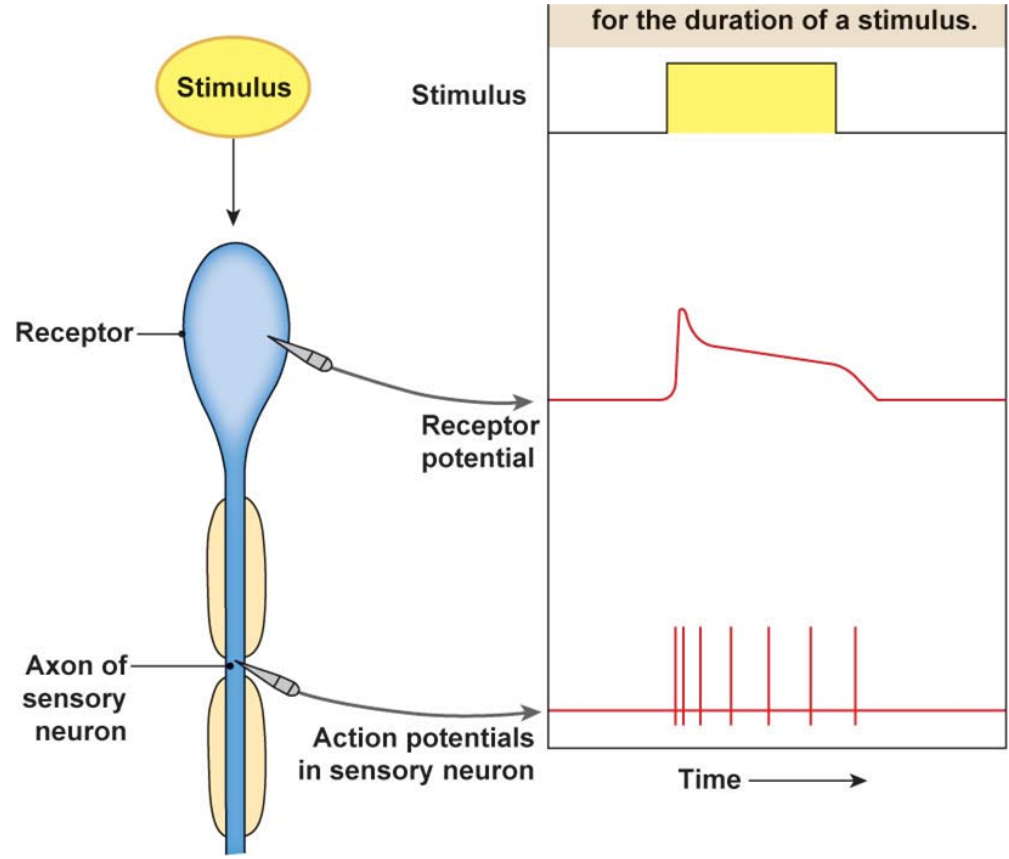


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Intensity coding

How much?

- Amplitude of receptor potential is transduced into the frequency of AP



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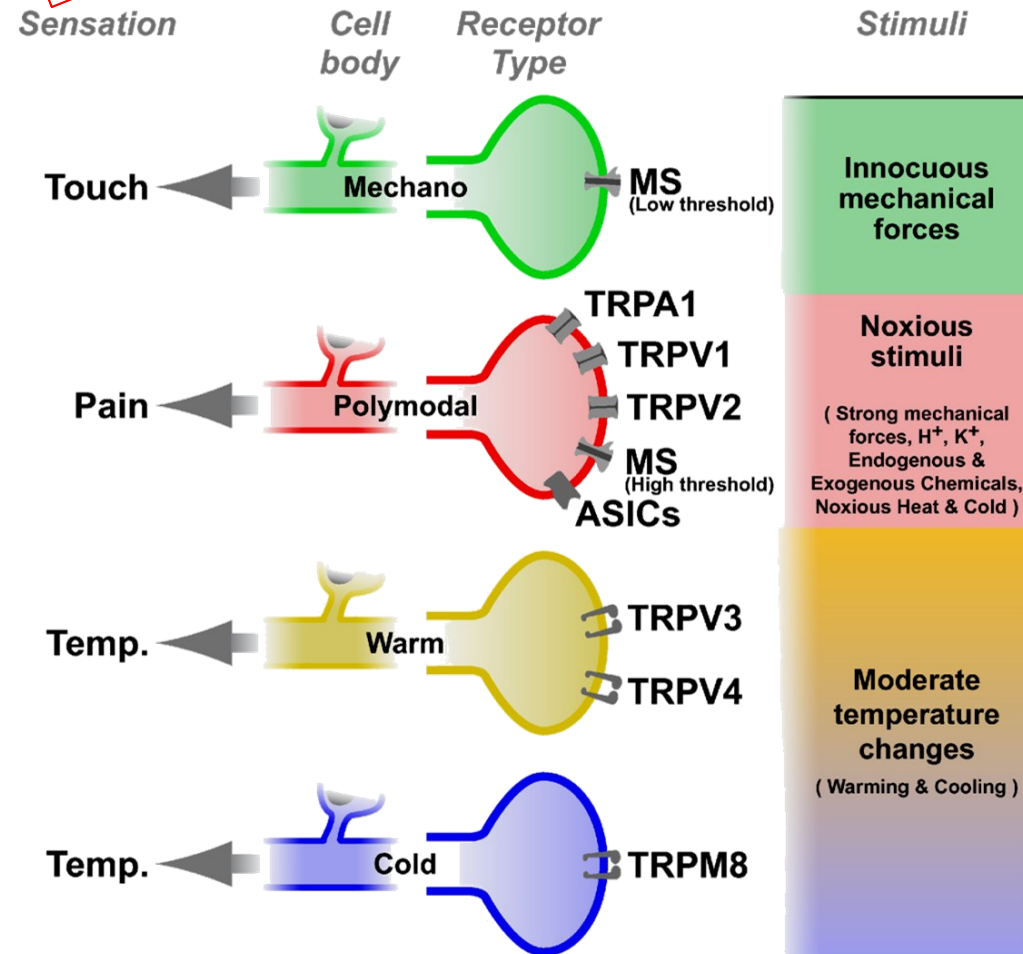
Qualitative information

What?
Where?

- The law of specific nerve energies:

The nature of perception is defined by the pathway over which the sensory information is carried

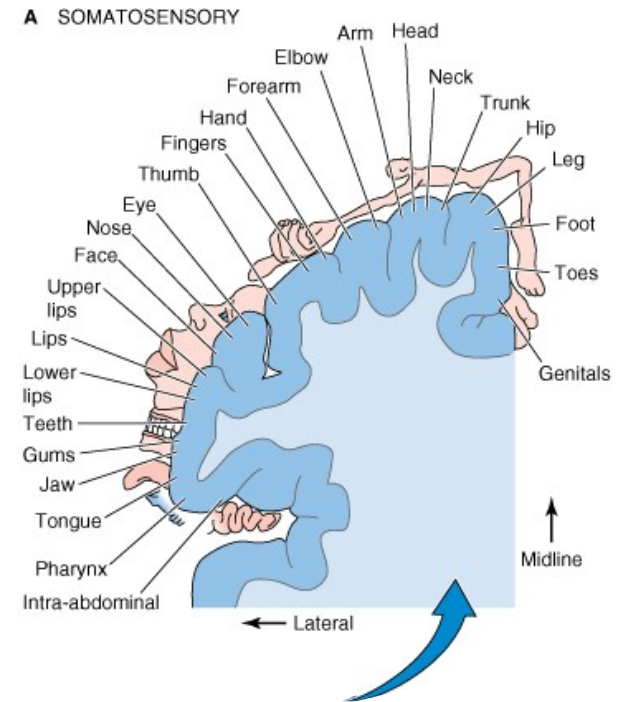
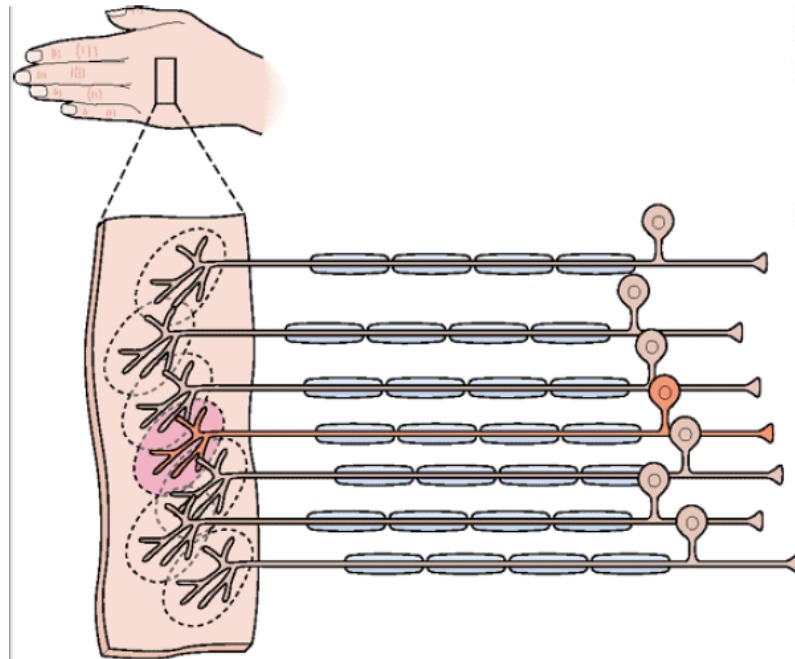
- Labeled line coding define the information about quality



Qualitative information

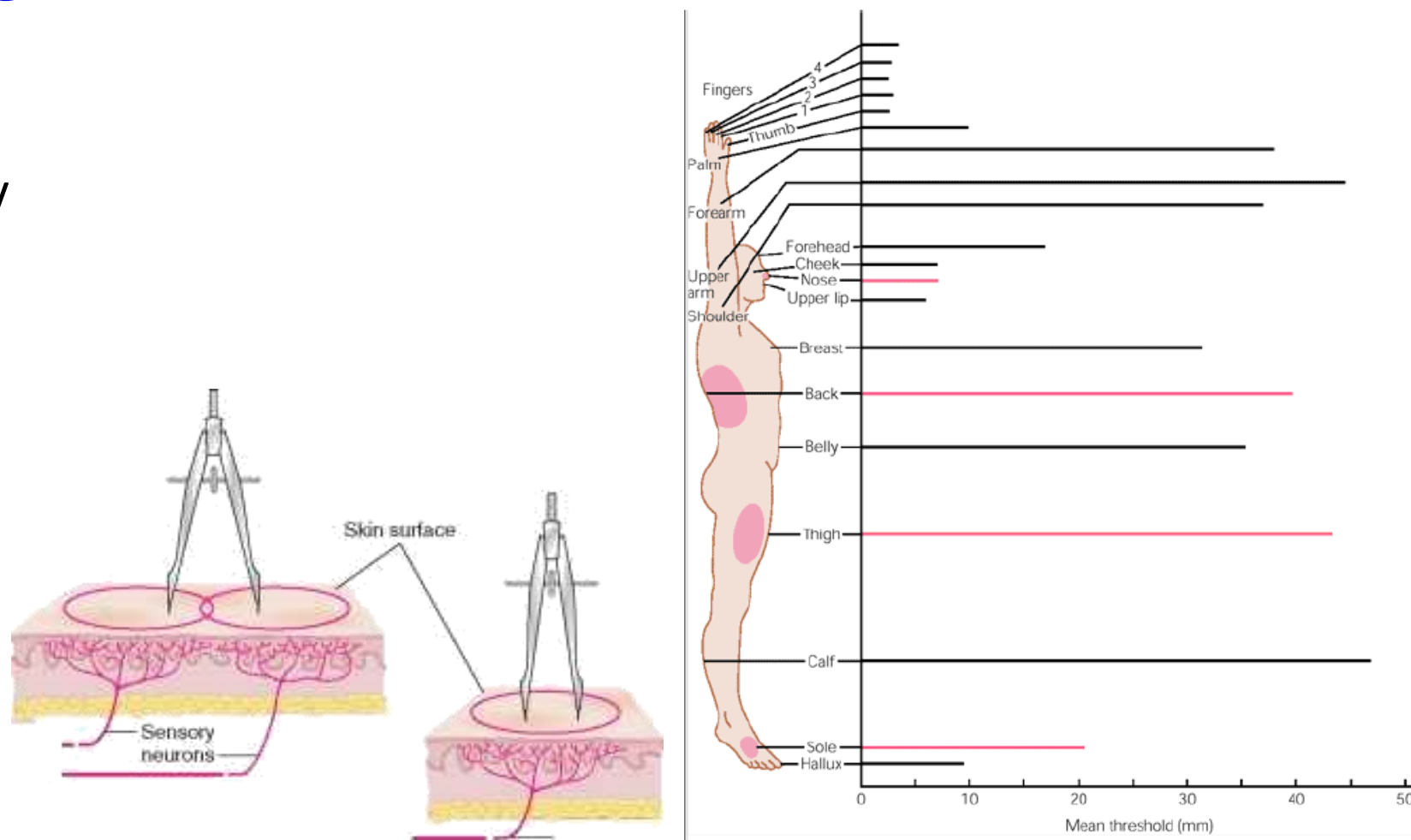
What?
Where?

- Labeled line coding
- Receptive field
- Nerve stimulation mimics receptor stimulation



Receptive fields

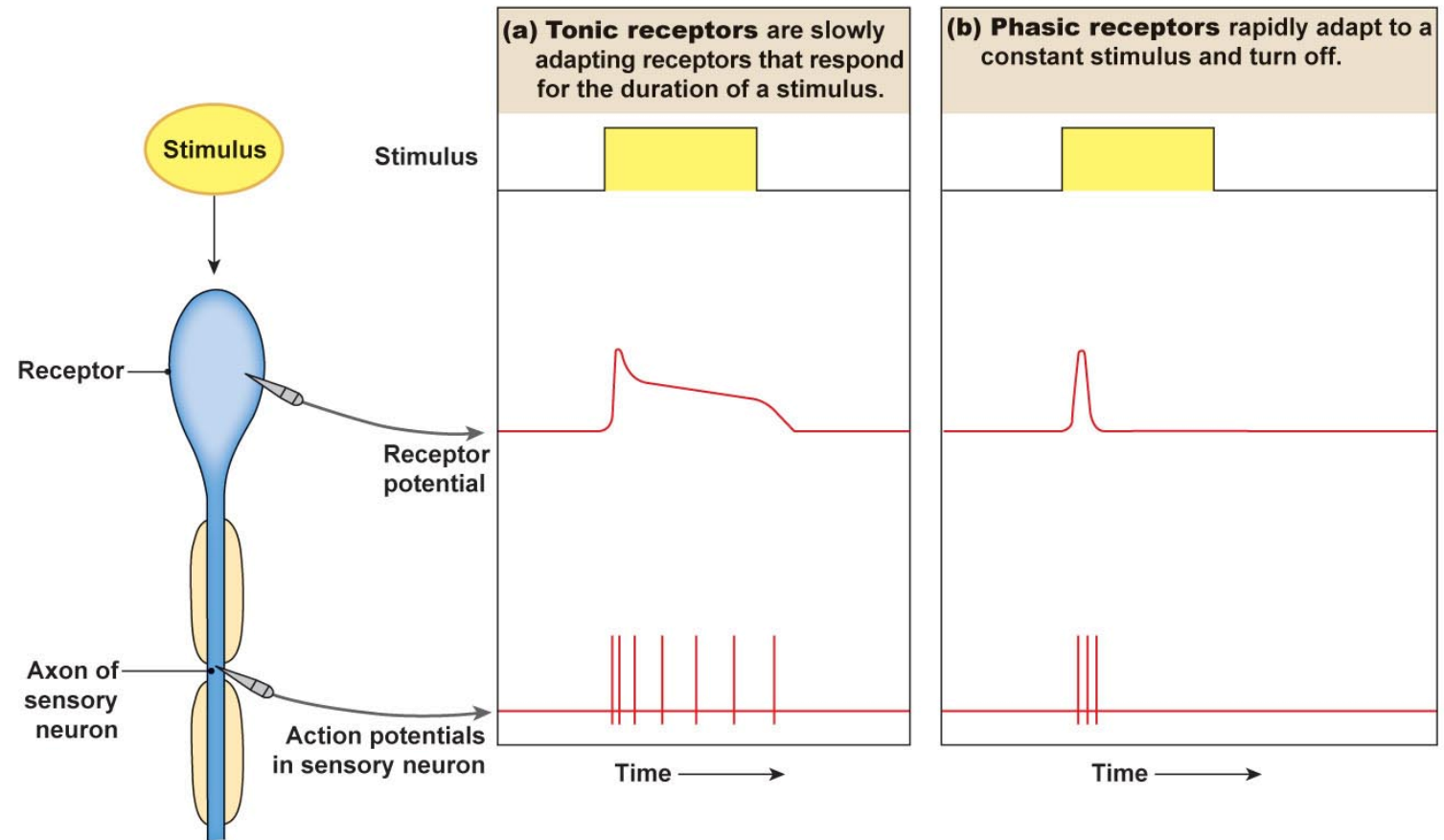
- Various size and overlap
- Small receptive field – high resolution
- Spatial resolving power increased by lateral inhibition



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Receptor adaptation

- The decline of receptor responses in spite of stimulus presence
- Tonic receptors – slow adaptation – presence of stimulus, position
- Phasic receptors – rapid adaptation – change of stimulus

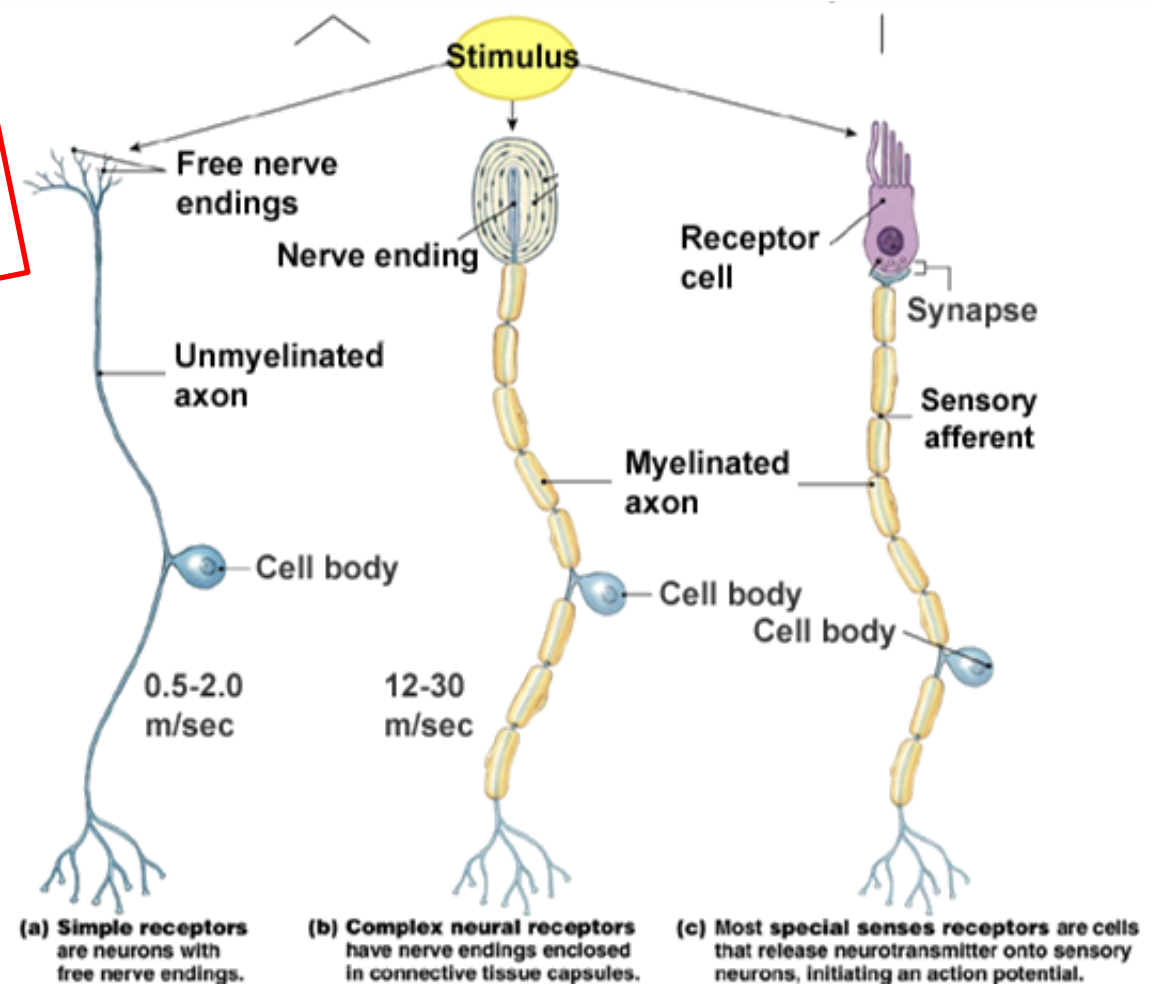


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Receptors

- ✓ Mechanoreceptors
- ✓ Thermoreceptors
- ✓ Chemoreceptors
- ✓ Fotoreceptors

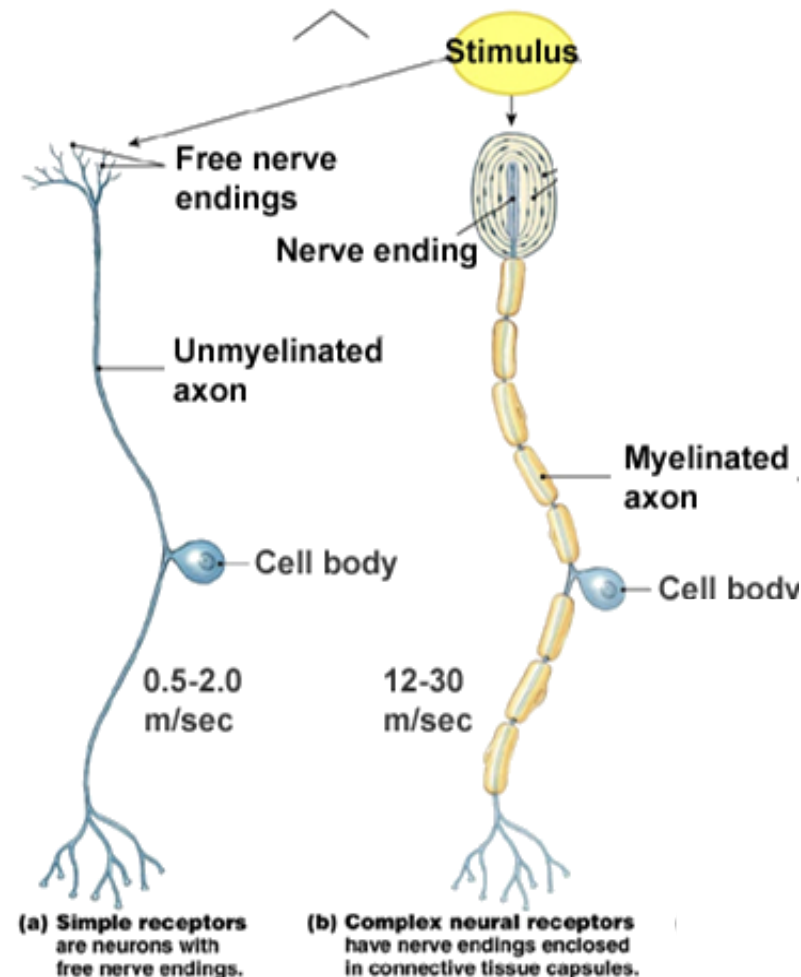
- Simple
 - Superficial – somatosensors
 - Deep – viscerosensors
 - Muscles, tendons, joints – proprioceptors
- General
 - Part of sensory organs
- Special
 - Part of sensory organs



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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

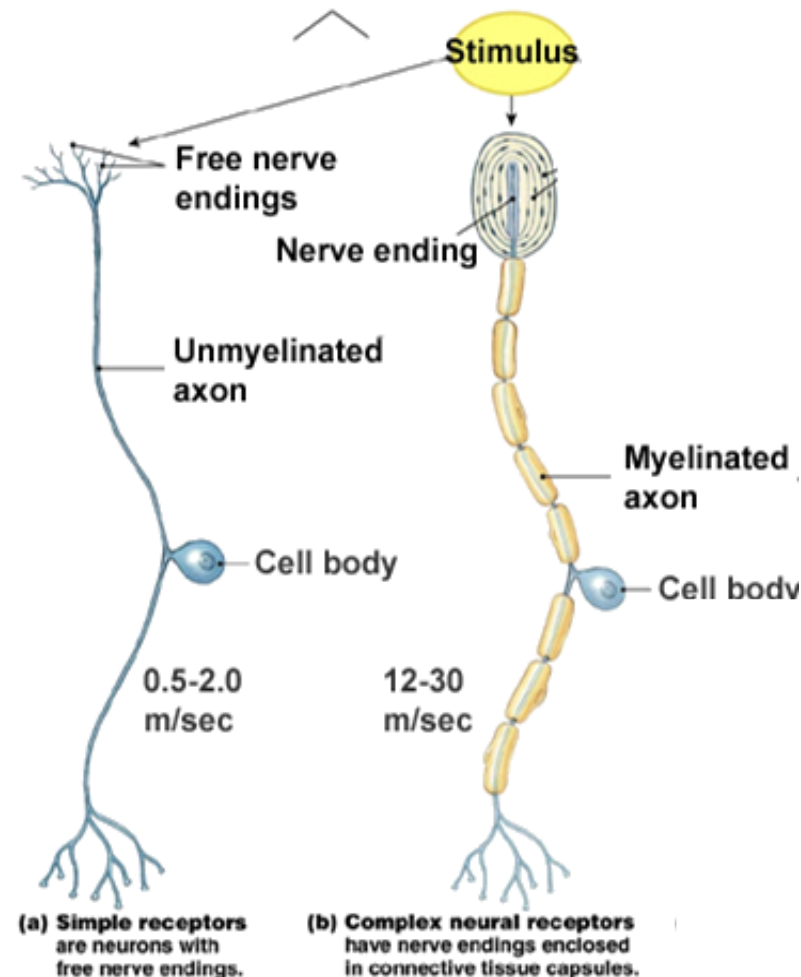


Evolutionary point of view

- The signals indicating potential damage are the most important for the corresponding early survival involved
 - temperature
- The touch receptor has an adaptive value and a higher conduction velocity

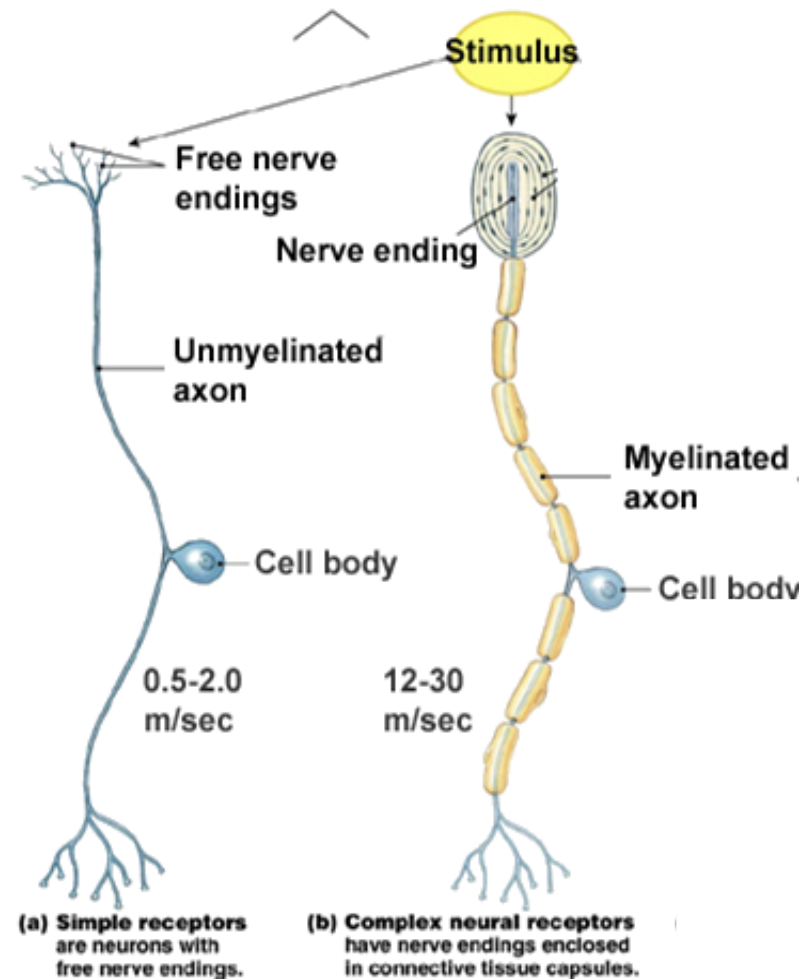
Immediate survival

Long-term survival

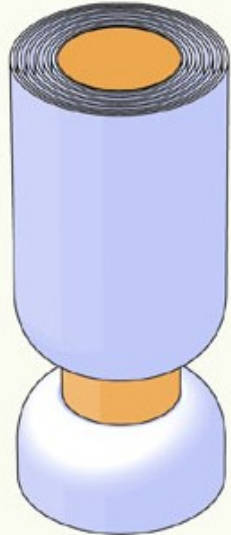

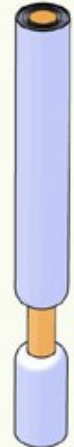



Evolutionary point of view

- The signals indicating potential damage are the most important for the corresponding early evolution involved
 - Temperature
- The touch receptors have adaptive value and are more complex
 - Immediate survival
 - Long-term survival
- The structure of the receptor, nerve fibers and pathways reflects the evolution



Nerve fibres

	A α	A β	A δ	C
Axons from skin				
Axons from muscles	Group I	II	III	IV
				
Diameter (μm)	13–20	6–12	1–5	0.2–1.5
Speed (m/sec)	80–120	35–75	5–30	0.5–2
Sensory receptors	Proprioceptors of skeletal muscle	Mechanoreceptors of skin	Pain, temperature	Temperature, pain, itch

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
 - Joints
- Important for
 - Precise coordination of movements
 - Overload protection

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

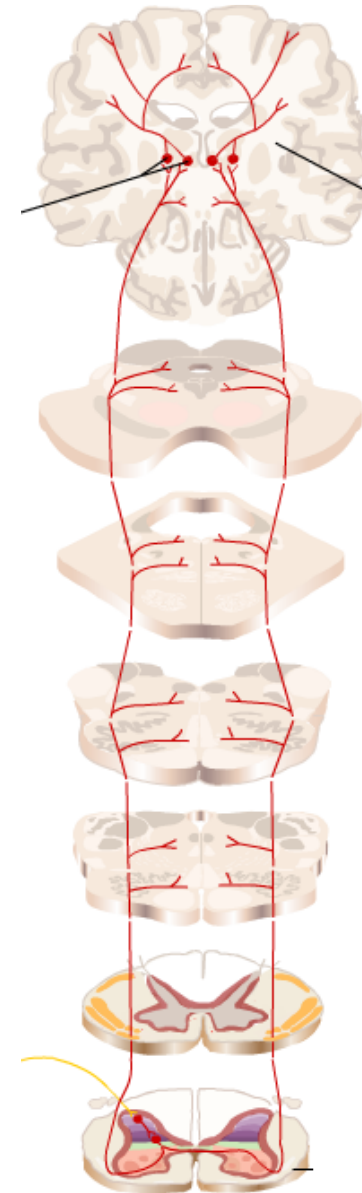
- Paleospinothalamic
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Immediate survival

Long-term survival

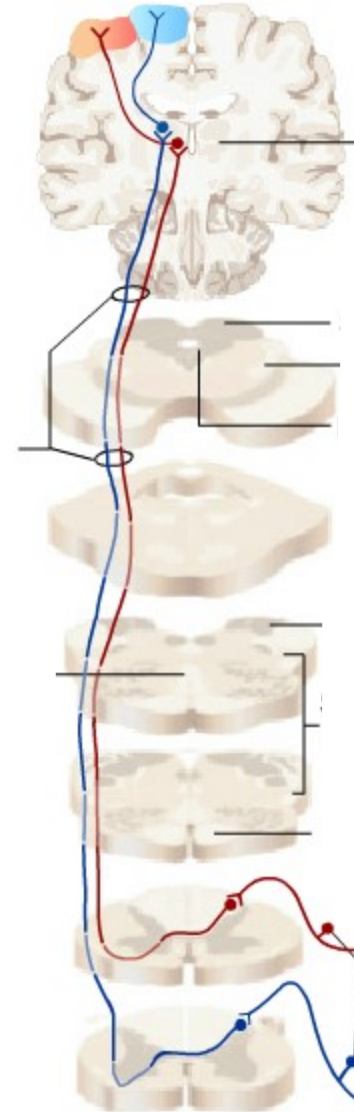
Paleospinothalamic system

- Tr. Spinoreticularis, spinotectalis...
- Evolved before neocortex
- The primary connection to the subcortical structures
- Basic defensive reactions and reflexes - vegetative response, reflex locomotion - opto-acoustic reflexes etc.
- 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



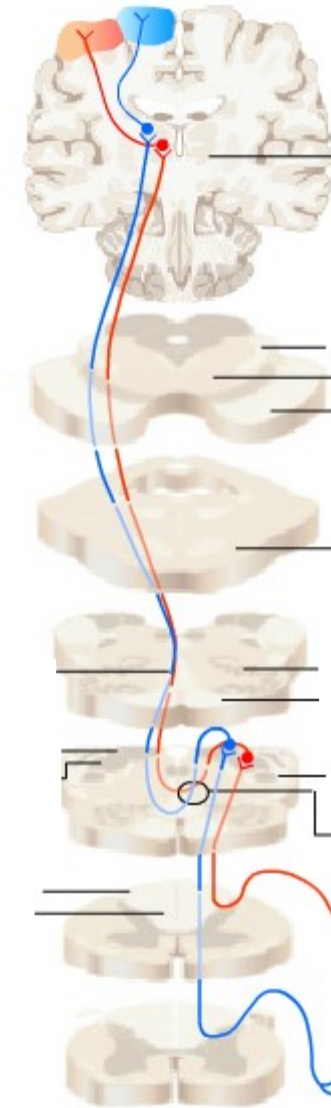
Neospinothalamic system

- 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



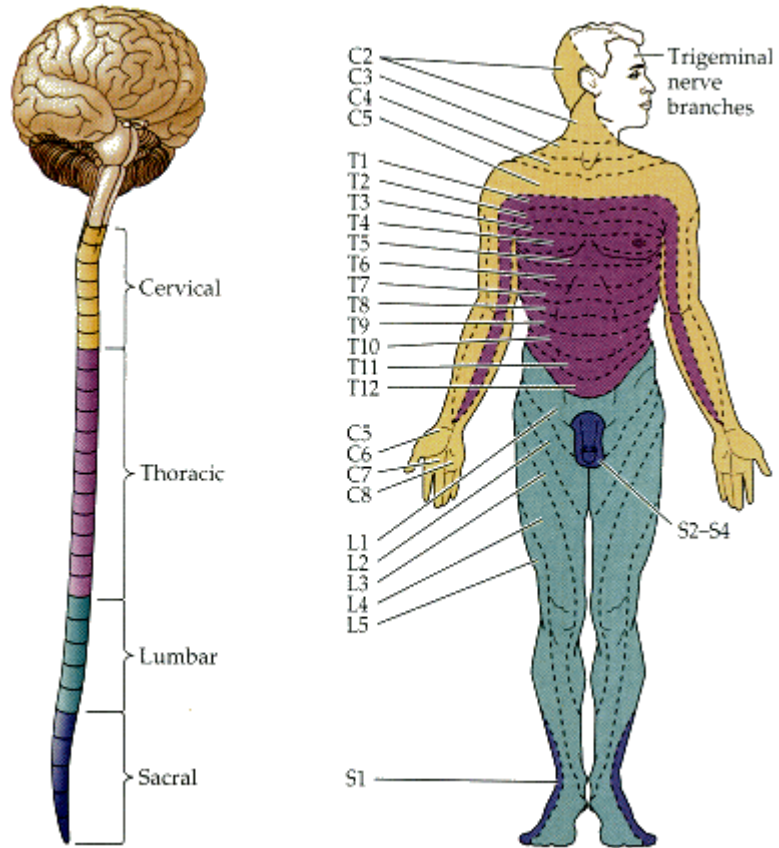
Dorsal column system

- Tr. Spinobulbaris
- 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

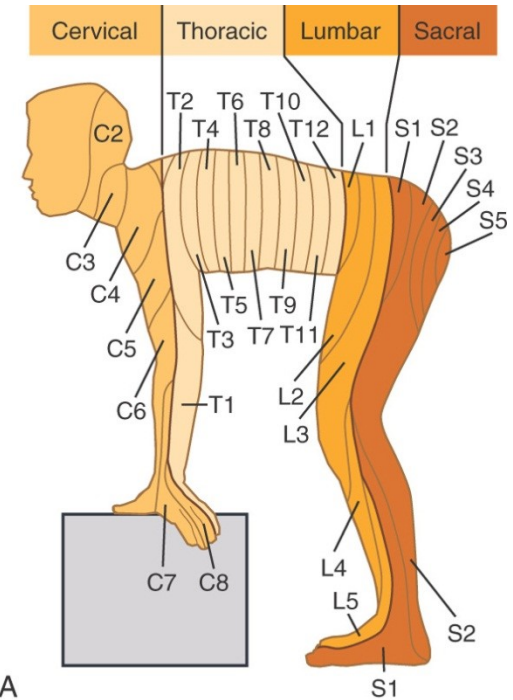


Dermatoms

- Somatotopic organization somatosensitive nerves



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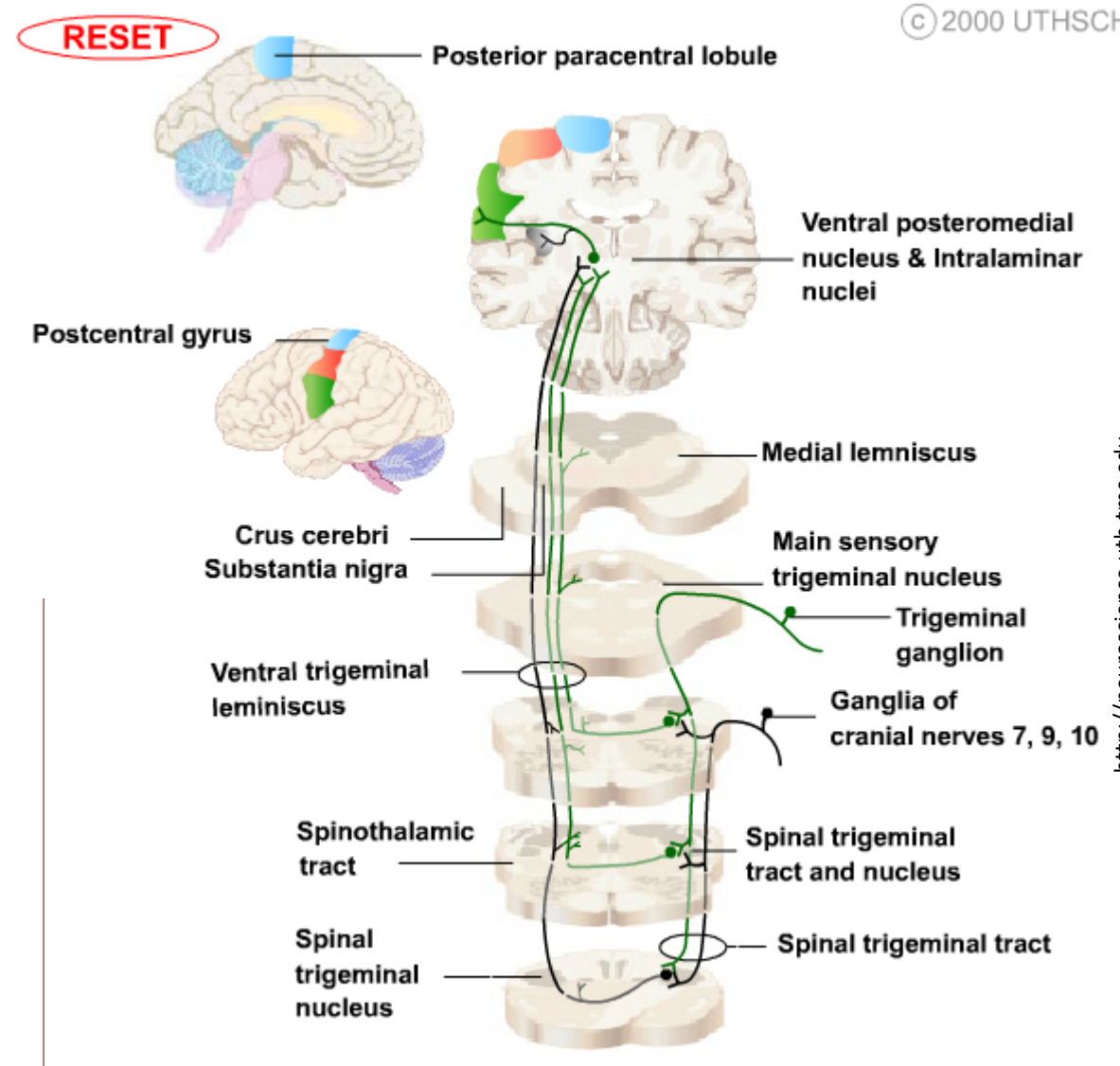
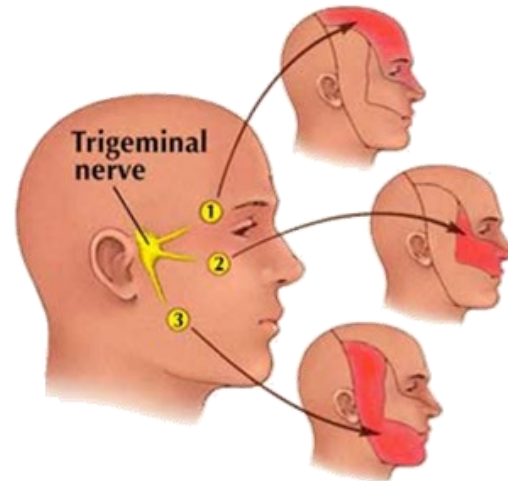
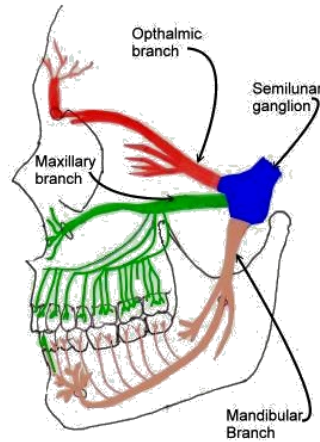
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Trigeminal system

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



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<http://neuroscience.uth.tmc.edu>

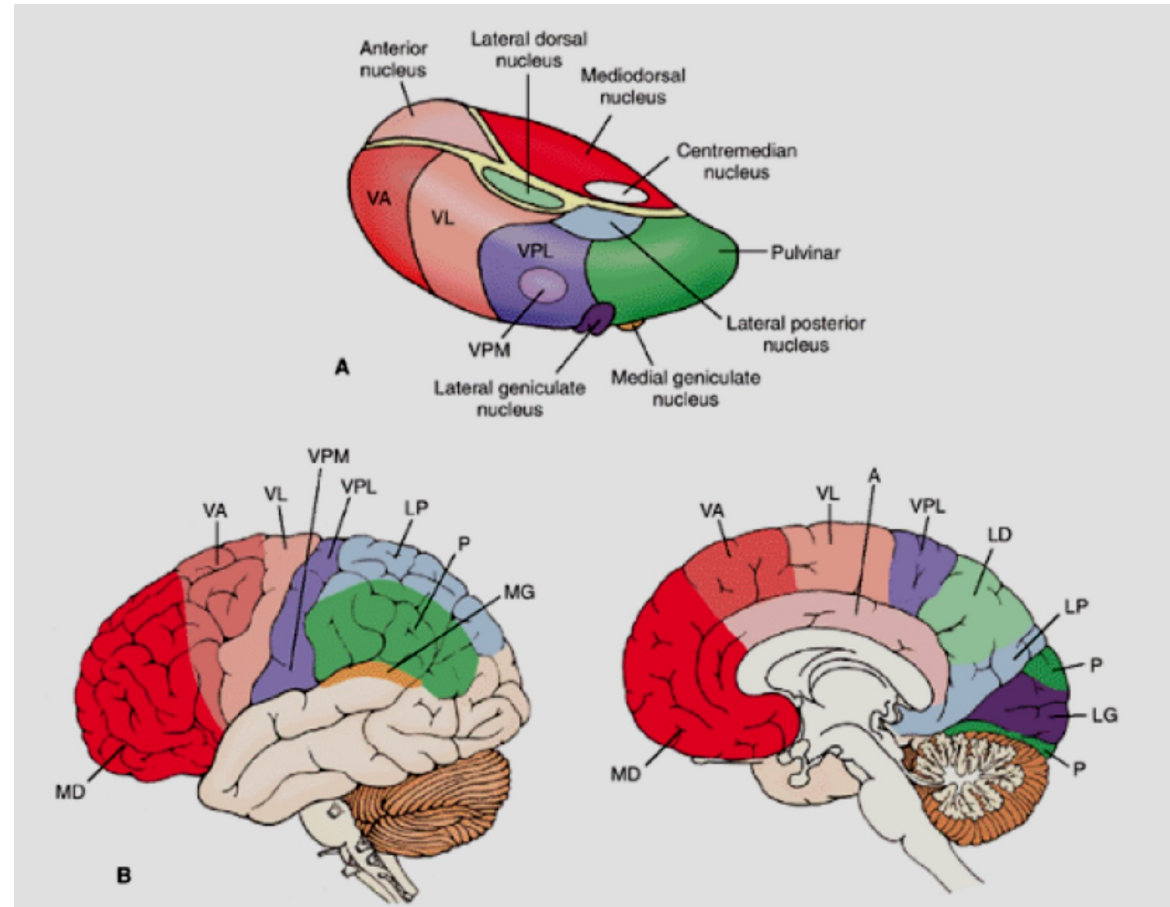
Somatosensory pathways

<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>

Thalamus and neocortex

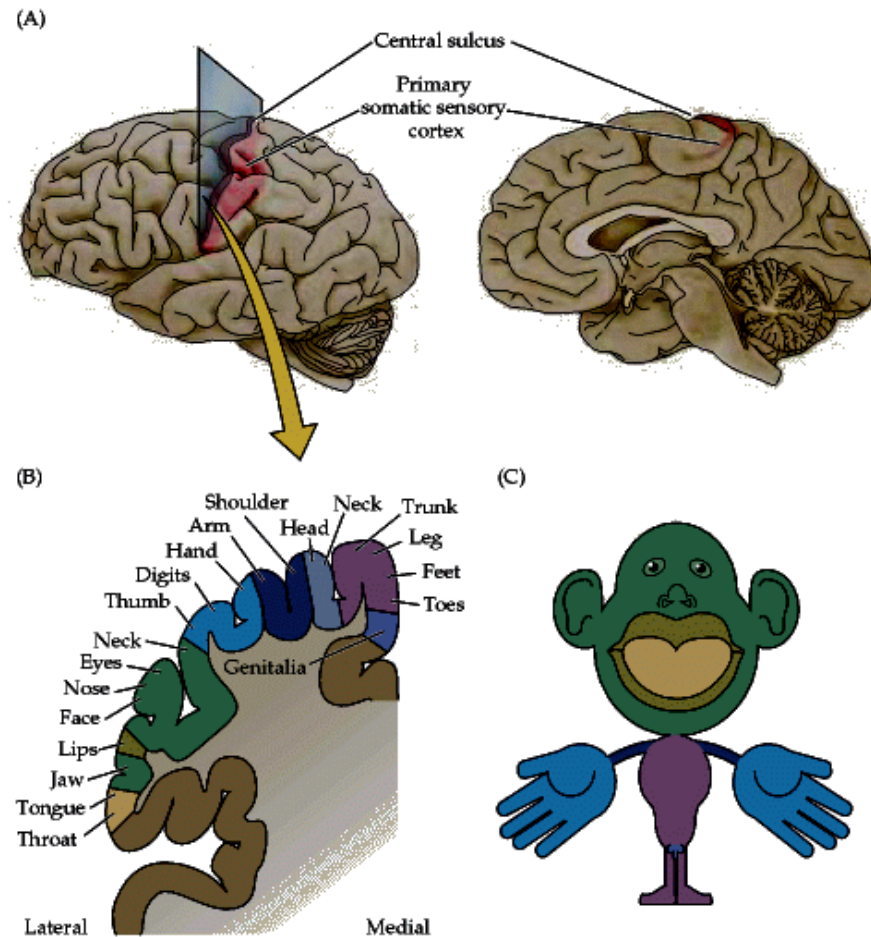
- Almost all the afferent information gated in the thalamus
- Olfaction is an exception
- Bilateral connections between neocortex and thalamus



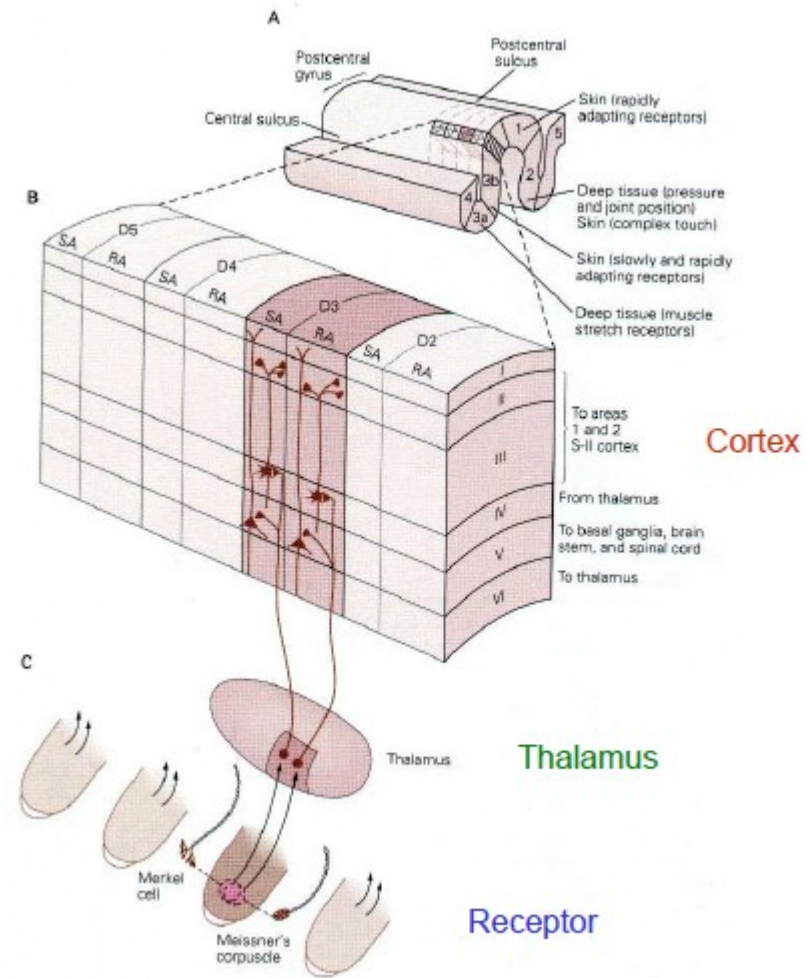
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Neocortex

- Somatotopic organization
- Cortical magnification



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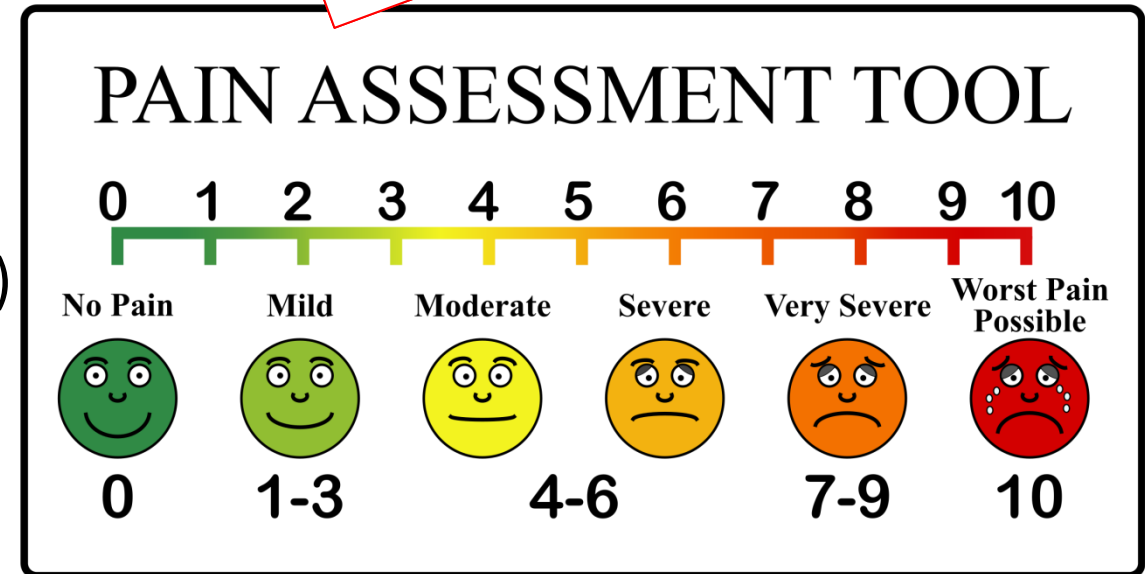


http://www.shadmehrlab.org/Courses/physfound_files/wang_5.pdf

Pain

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

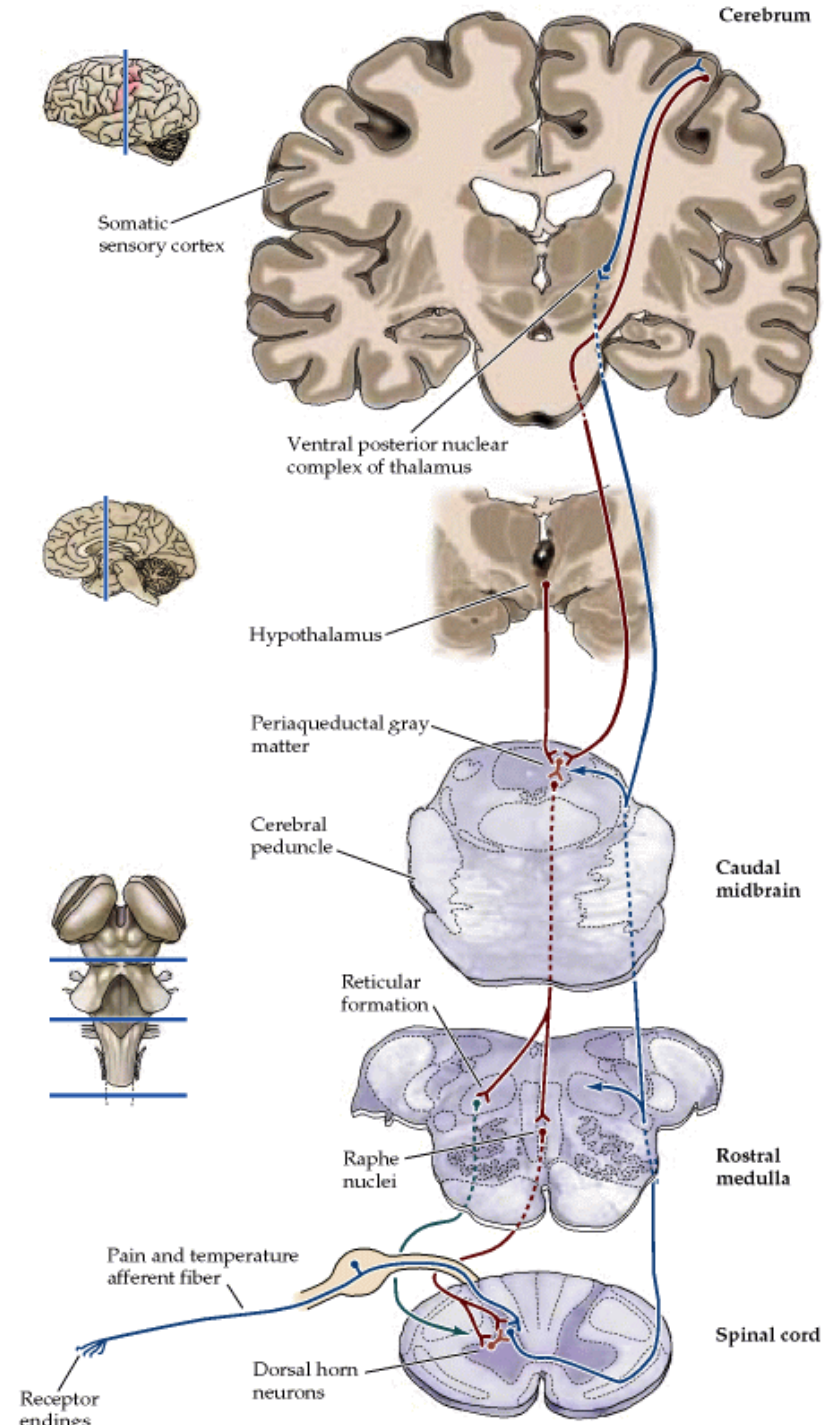
Subjective character



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

Descendent pathways modulating pain

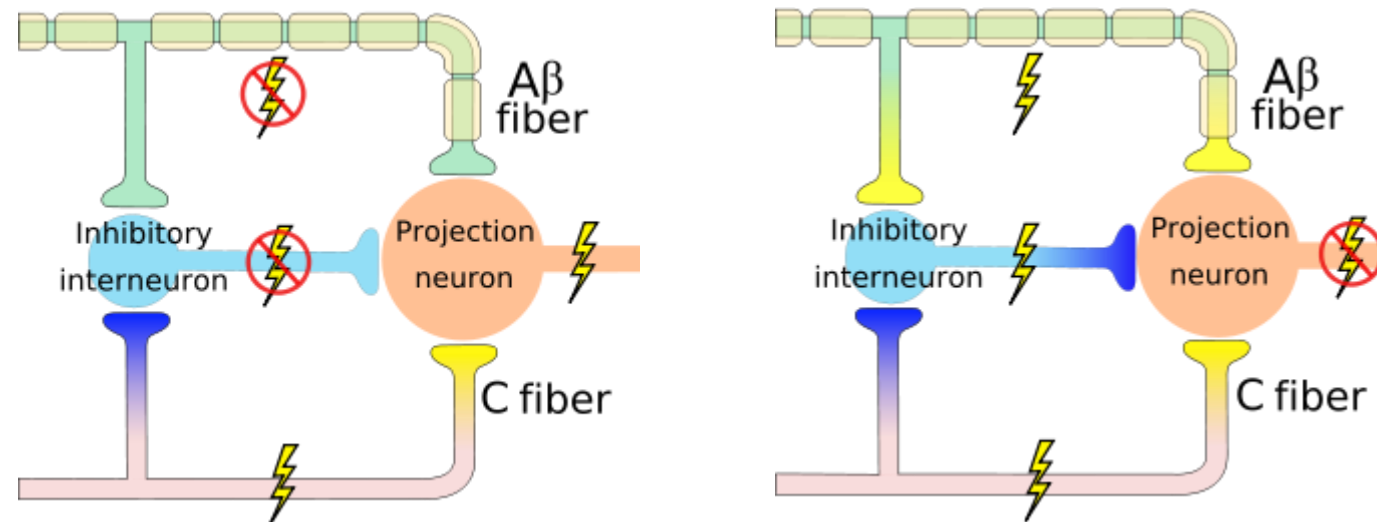
- Somatosensory cortex
- Hypothalamus
- Periaqueductal gray
- Nuclei raphe



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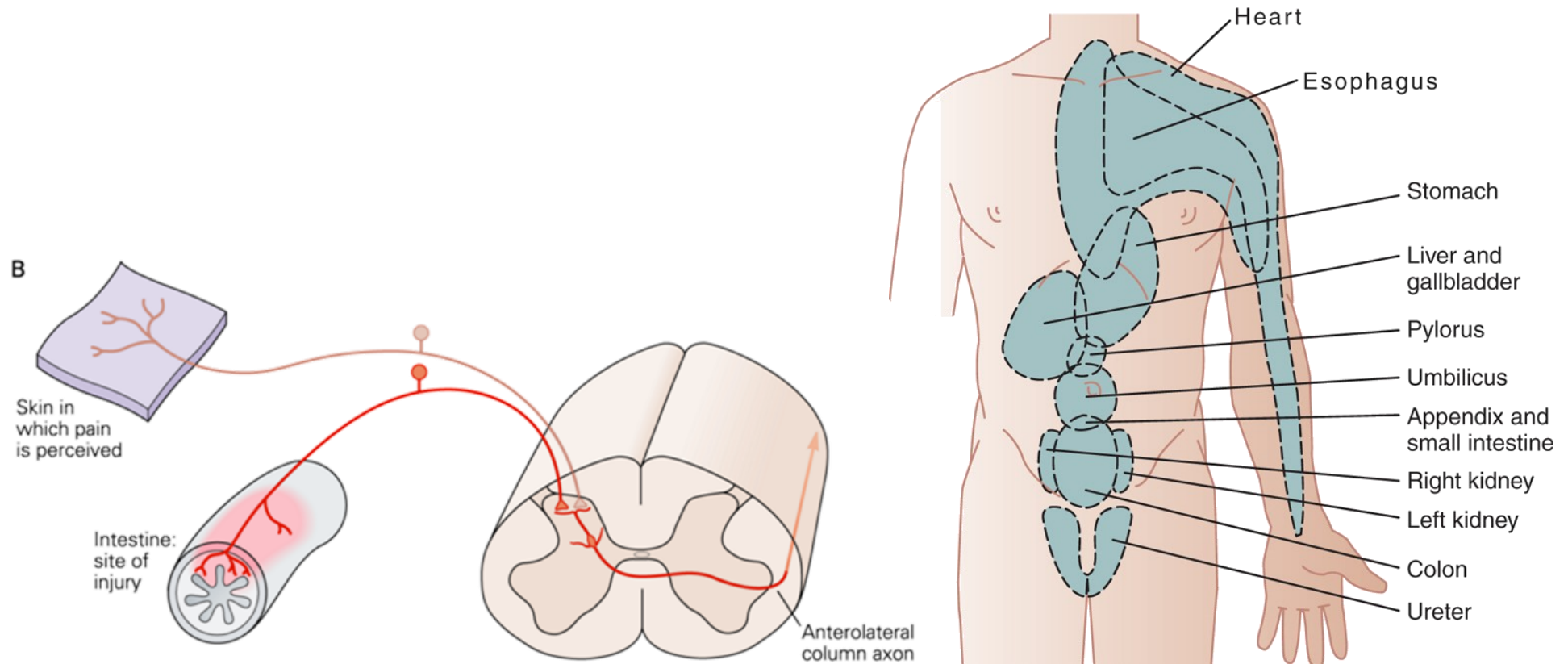
Pain modulation on the spinal level

Gate control theory of pain



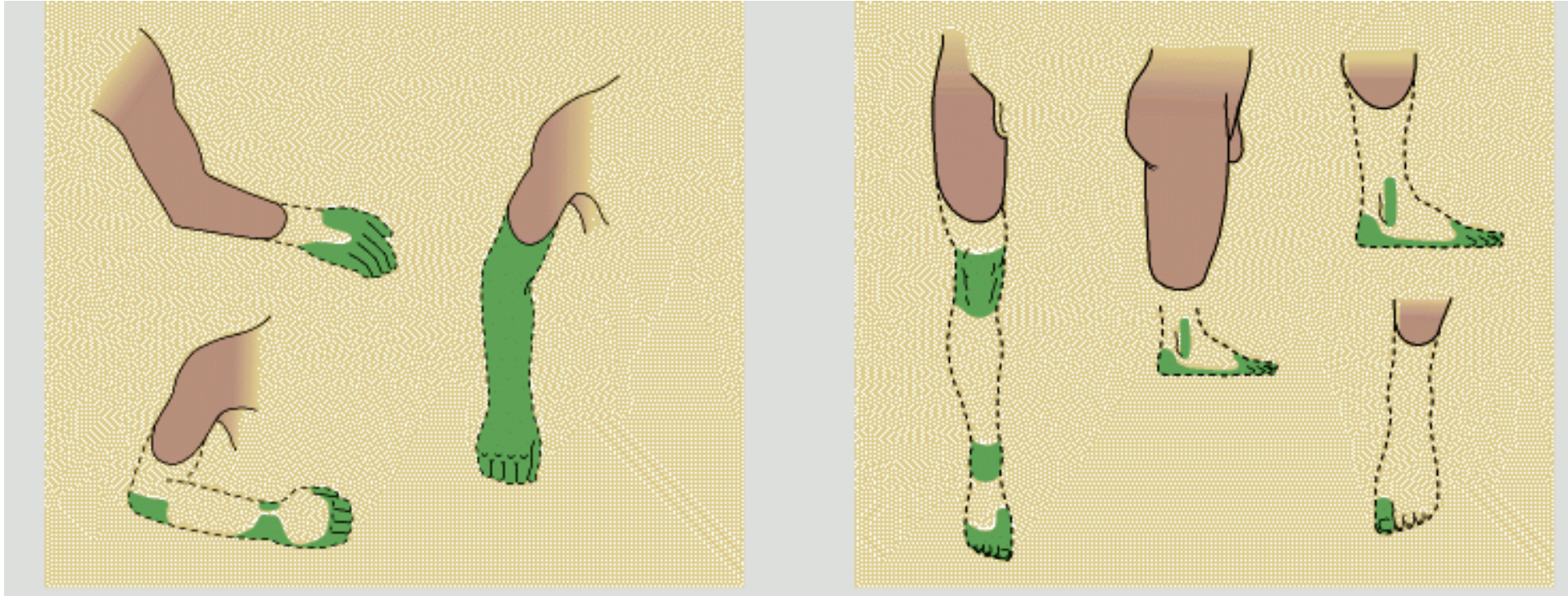
https://en.wikipedia.org/wiki/Gate_control_theory

Referred pain



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Phantom limb pain



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