

# **PSYCH 260**

## Sensation

Rick Gilmore

2021-11-04 08:56:27

# Prelude (4:56)



# Announcements

- Blog post 3 due today

# Today's Topics

- Sensory systems
- Somatosensation
- Pain

# Sensory systems

# My smartphone and me...



# Let's design the Galaxy 20/iPhone XX

- What information do your users need to acquire?
- Why do they need to know it? In what context, for what purpose?
- What types of information does your device need to gather, through which channels?

# Multisensory processing in a smartphone

- Accelerometer
- Gyroscope
- Magnetometer
- Proximity sensor
- Ambient light sensor
- Barometer

[http://www.phonearena.com/news/Did-you-know-how-many-different-kinds-of-sensors-go-inside-a-smartphone\\_id57885](http://www.phonearena.com/news/Did-you-know-how-many-different-kinds-of-sensors-go-inside-a-smartphone_id57885)

# Multisensory processing in a smartphone

- Thermometer
- Mic
- Camera
- Radios (Bluetooth, wifi, cellular, GPS)

[http://www.phonearena.com/news/Did-you-know-how-many-different-kinds-of-sensors-go-inside-a-smartphone\\_id57885](http://www.phonearena.com/news/Did-you-know-how-many-different-kinds-of-sensors-go-inside-a-smartphone_id57885)

# My turn...

- What information do I need to acquire?
- Why do I need to know it? In what context & for what purpose?
- What types of information do I need to gather, through which channels?

# Dimensions of sensory processing

- *Interoceptive*
  - How am I?
- *Exteroceptive*
  - What's in the world, where is it?

# Questions for interoception: How are you?

- Tired or rested?
- Well or ill?
- Hungry or thirsty or sated?
- Stressed vs. coping?
- Emotional state?
- Where are you?

# Questions for exteroception

- Who/What is out there?
- Where is it?

# Mrs. Potraz was wrong...there aren't 5 senses

**TABLE 8.1** Classification of Sensory Systems

Type of sensory system	Modality	Adequate stimuli
Mechanical	Touch	Contact with or deformation of body surface
	Hearing	Sound vibrations in air or water
	Vestibular	Head movement and orientation
	Joint	Position and movement
	Muscle	Tension
	Seeing	Visible radiant energy
Thermal	Cold	Decrement of skin temperature
	Warmth	Increment of skin temperature
Chemical	Smell	Odorous substances dissolved in air or water in the nasal cavity
	Taste	Substances in contact with the tongue or other taste receptor
	Common chemical	Changes in CO <sub>2</sub> , pH, osmotic pressure
	Vomeronasal	Pheromones in air or water
Electrical	Electroreception	Differences in density of electrical currents

BIOLOGICAL PSYCHOLOGY, Fourth Edition, Table 8.1 © Sinauer Associates, Inc.

# How sensory channels differ

- What is the energy/chemical source?
- How does the channel inform...
  - What is out there?
  - Where it's located?

# Somatosensation

# What is somatosensation

- Sensations about the body

# Types of somatosensation

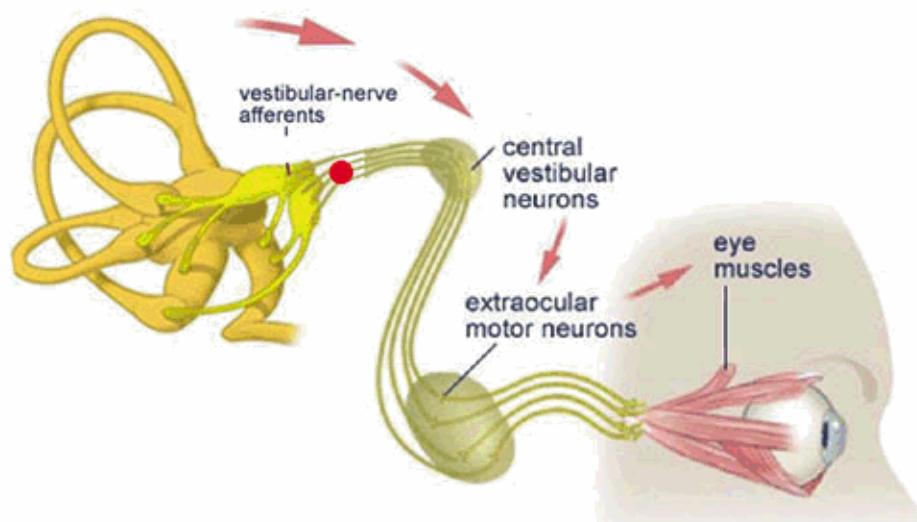
- Internal (interoceptive)
  - Where am I? How do I feel?
  - Proprioception
- External (exteroceptive)
  - What's in the world?
  - Where is it?

# Internal senses

- Vestibular sense
  - Head position (relative to gravity)
  - Head movement (rotation, translation)

Vestibulo-ocular reflex 13/25





# Vesibulo-ocular response (VOR)

- Keeps eyes steady when head moves
- Can't walk & text without it

Texting While Walking Fails | Peoples Walking Into Things Funny



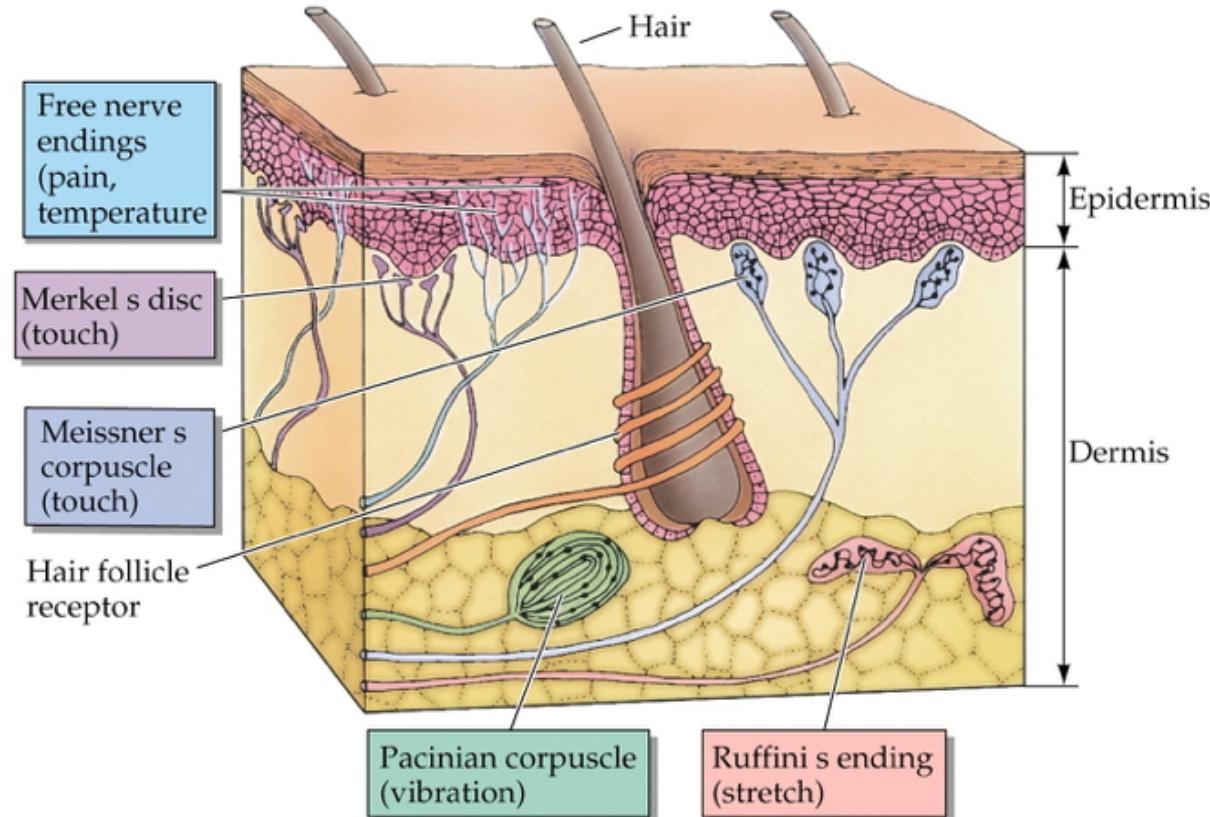
# Internal senses

- Kinesthesia
  - Body position
  - Movement
- Pain

# External senses

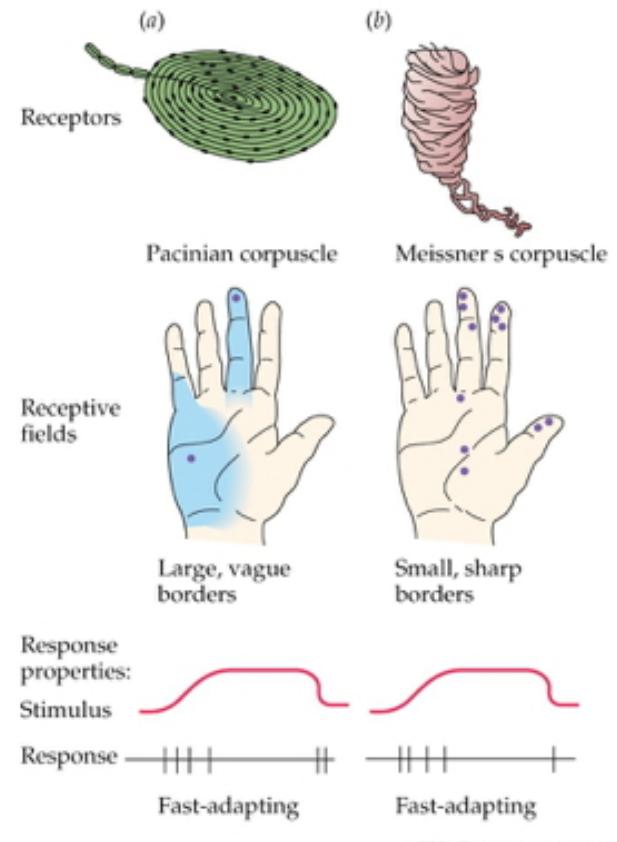
- Cutaneous senses (touch)
  - Hot, cold
  - Pressure
  - Vibration
  - Damage (pain)
- Plus kinesthesia (why?)

# Cutaneous receptors

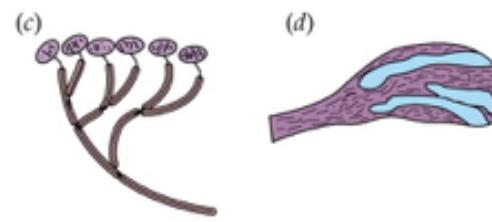


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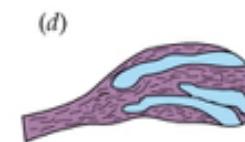
# Receptors specialize



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Merkel's discs



Ruffini's ending



Small, sharp borders



Large, vague borders



Slow-adapting

Slow-adapting

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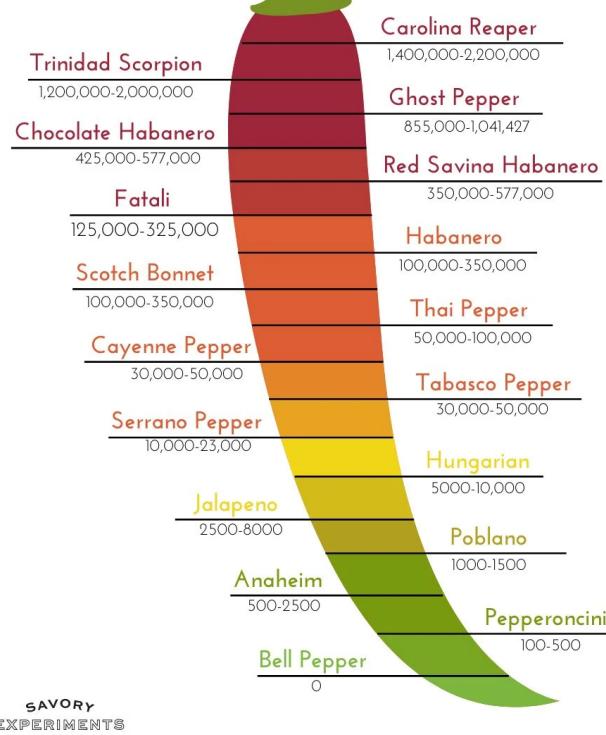
# Combined thermo and chemo receptors

- Why are spicy foods hot?
- Why are minty foods cool?

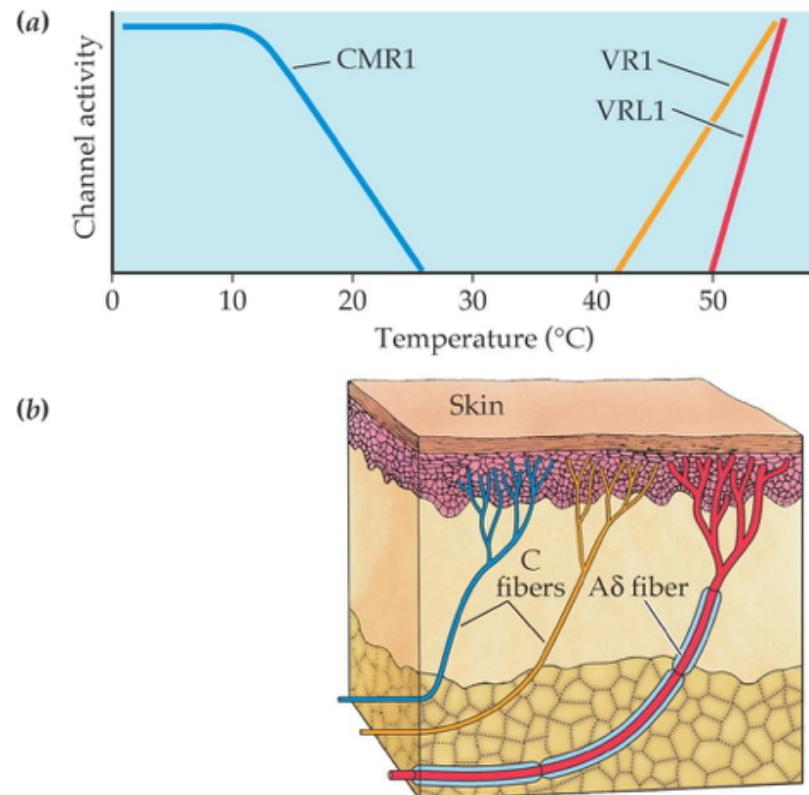
# Combined thermo (heat/cold) and chemo receptors

- Menthol/mint receptor (CMR1)
  - Also signals “cool” temperatures
- Vanilloid Receptors (TrpV1/VR1, VRL1)
  - Respond to capsaicin (in peppers), allyl isothiocyanate (in mustard, wasabi)
  - Also signal “hot” temperatures

# Scoville Heat Scale



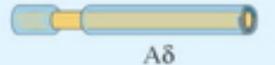
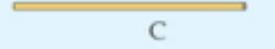
# Menthol & vanilloid receptors



*BIOLOGICAL PSYCHOLOGY*, Fourth Edition, Figure B.23 © 2004 Sinauer Associates, Inc.

# Size/speed trade-off

**TABLE 8.2** Fibers That Link Receptors to the CNS

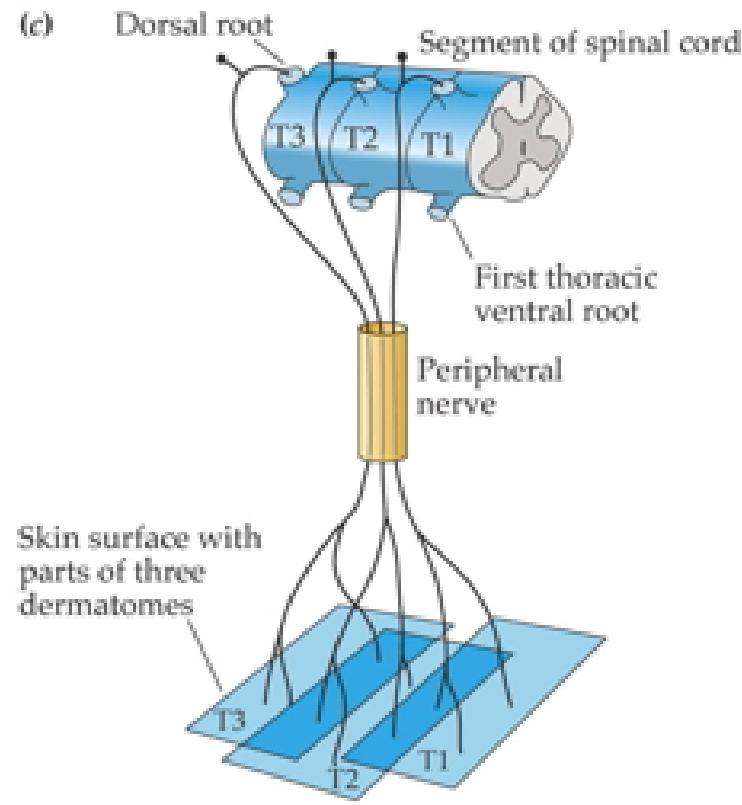
Sensory function(s)	Receptor type(s)	Axon type	Diameter (μm)	Conduction speed (m/s)
Proprioception (see Chapter 11)	Muscle spindle	 A $\alpha$	13–20	80–120
Touch (see Figures 8.12 and 8.13)	Pacinian corpuscle, Ruffini's ending, Merkel's disc, Meissner's corpuscle	 A $\beta$	6–12	35–75
Pain, temperature	Free nerve endings; VRL1	 A $\delta$	1–5	5–30
Temperature, pain, itch	Free nerve endings; VR1, CMR1	 C	0.02–1.5	0.5–2

BIOLOGICAL PSYCHOLOGY, Fourth Edition, Table 8.2 © Sinauer Associates, Inc.

# From skin to brain

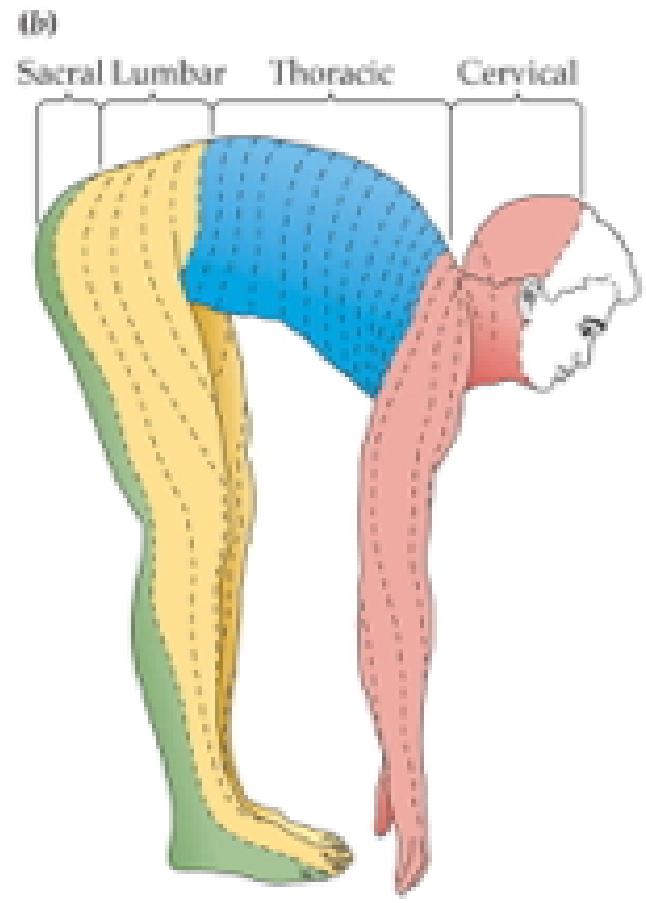
- Cutaneous receptors
- Dorsal root ganglion
- Ventral posterior lateral thalamus
- Primary somatosensory cortex (S-I)
  - Post-central gyrus of parietal lobe

# Dermatomes



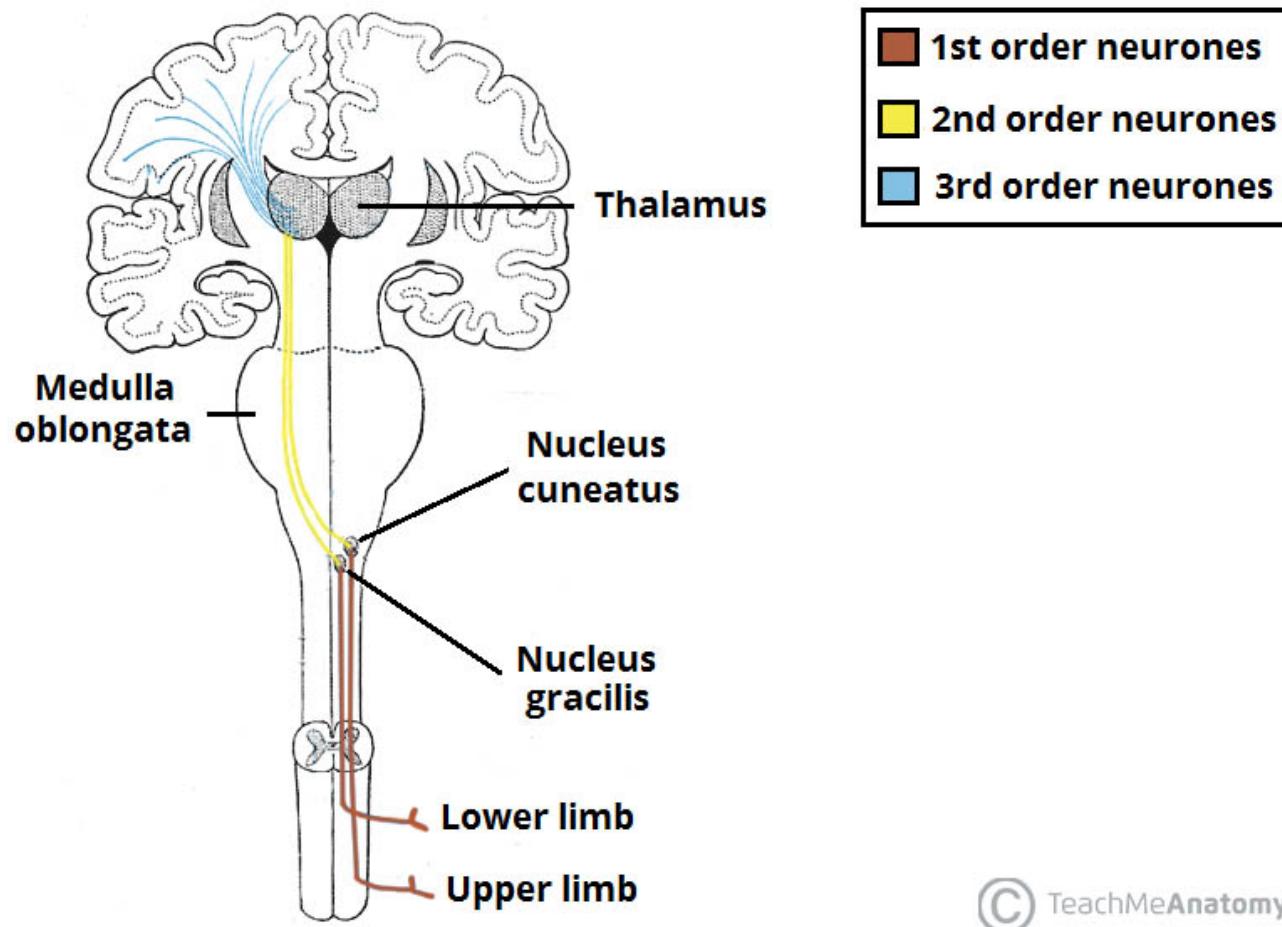
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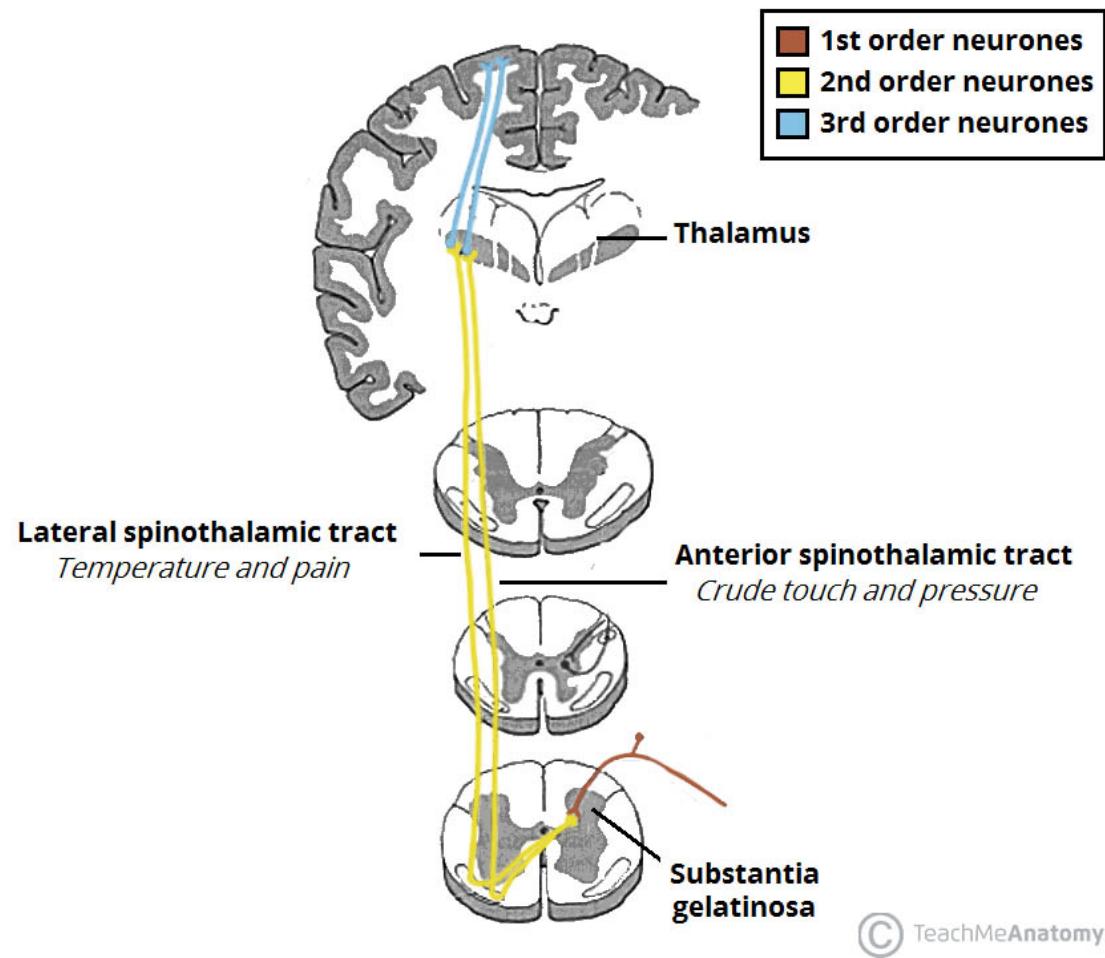
# Dermatomes



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# Functional segregation





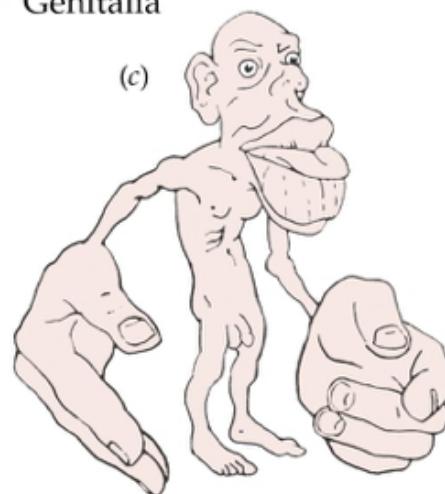
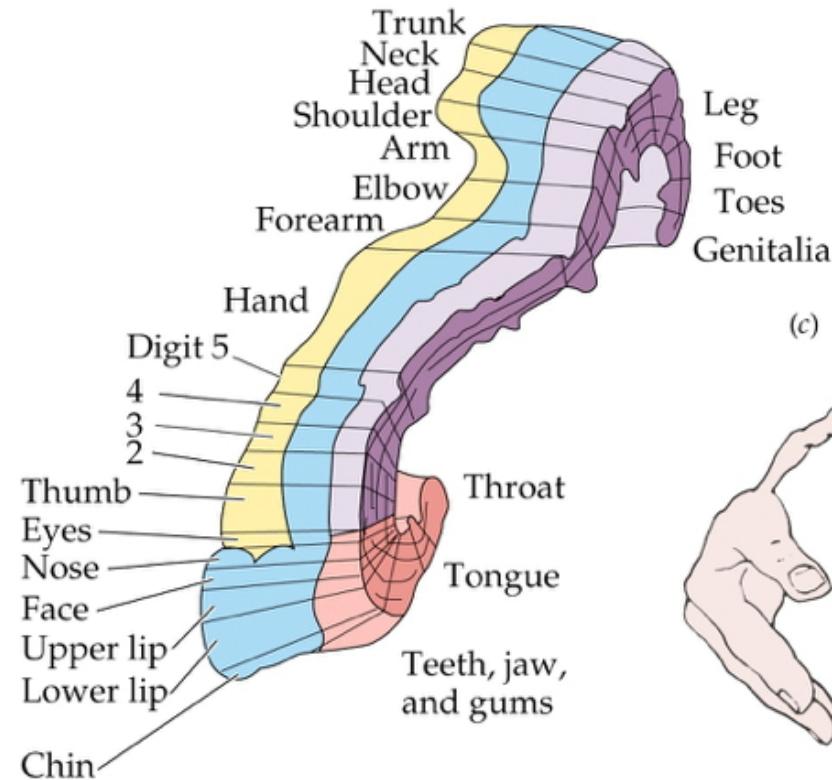
TeachMeAnatomy

# Functional segregation

- Separate pathways for different information types
- Dorsal column/medial leminiscal pathway
  - Touch, proprioception
- Spinothalamic tract
  - Pain, temperature

# Somatotopic maps

(b)

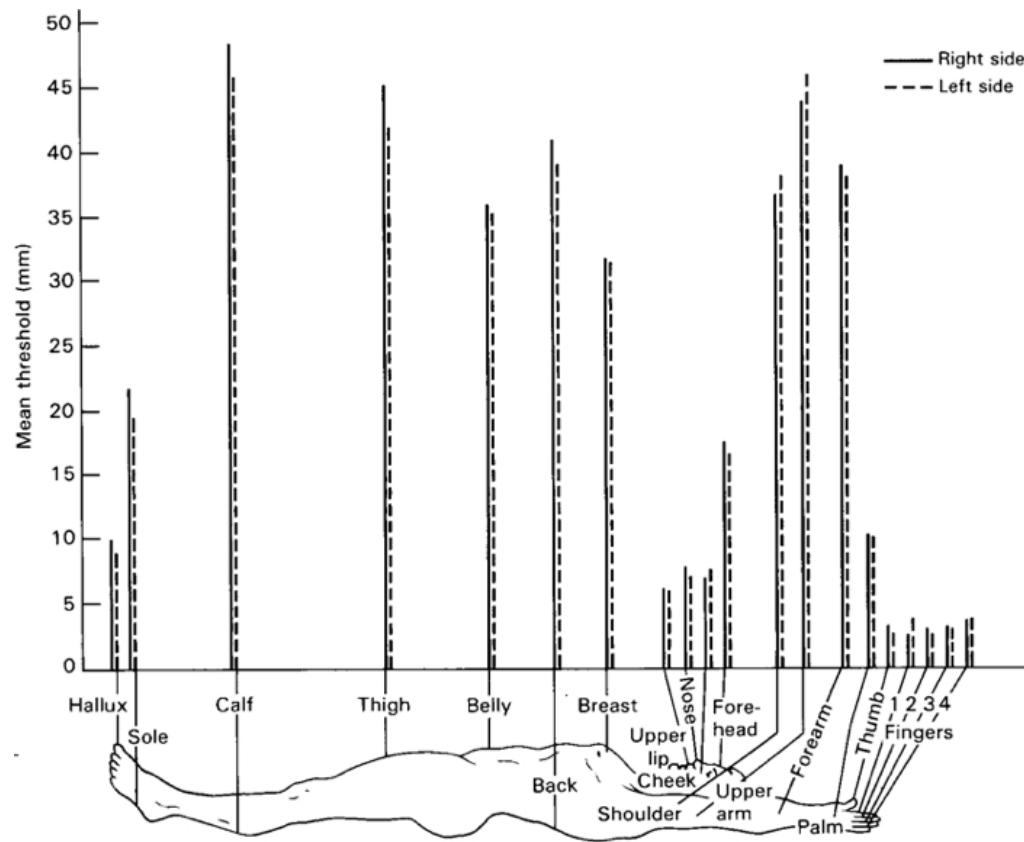


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# Non-uniform mapping of skin surface



# Non-uniform mapping of skin surface

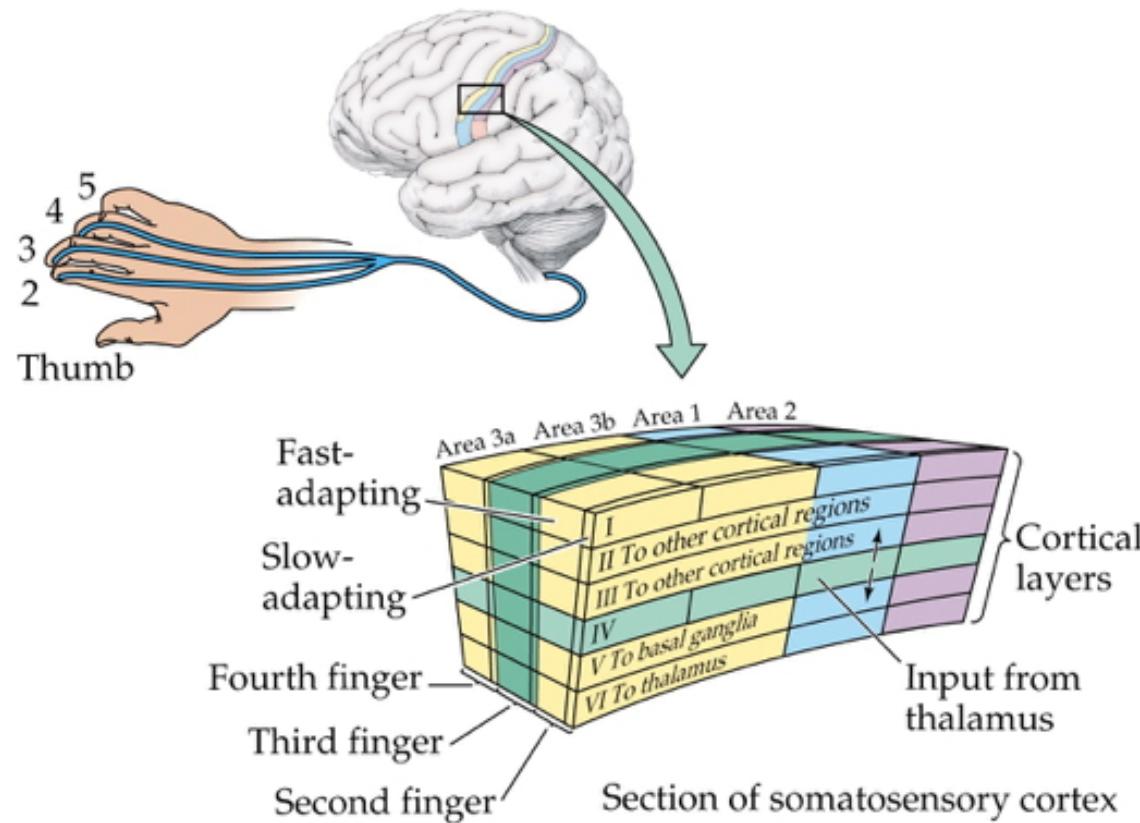


<http://jov.arvojournals.org/data/Journals/JOV/933499/jov-3-10-1-fig001.jpeg>

2 point discrimination (moving)



# Columnar organization/functional segregation



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# Phantom Limbs

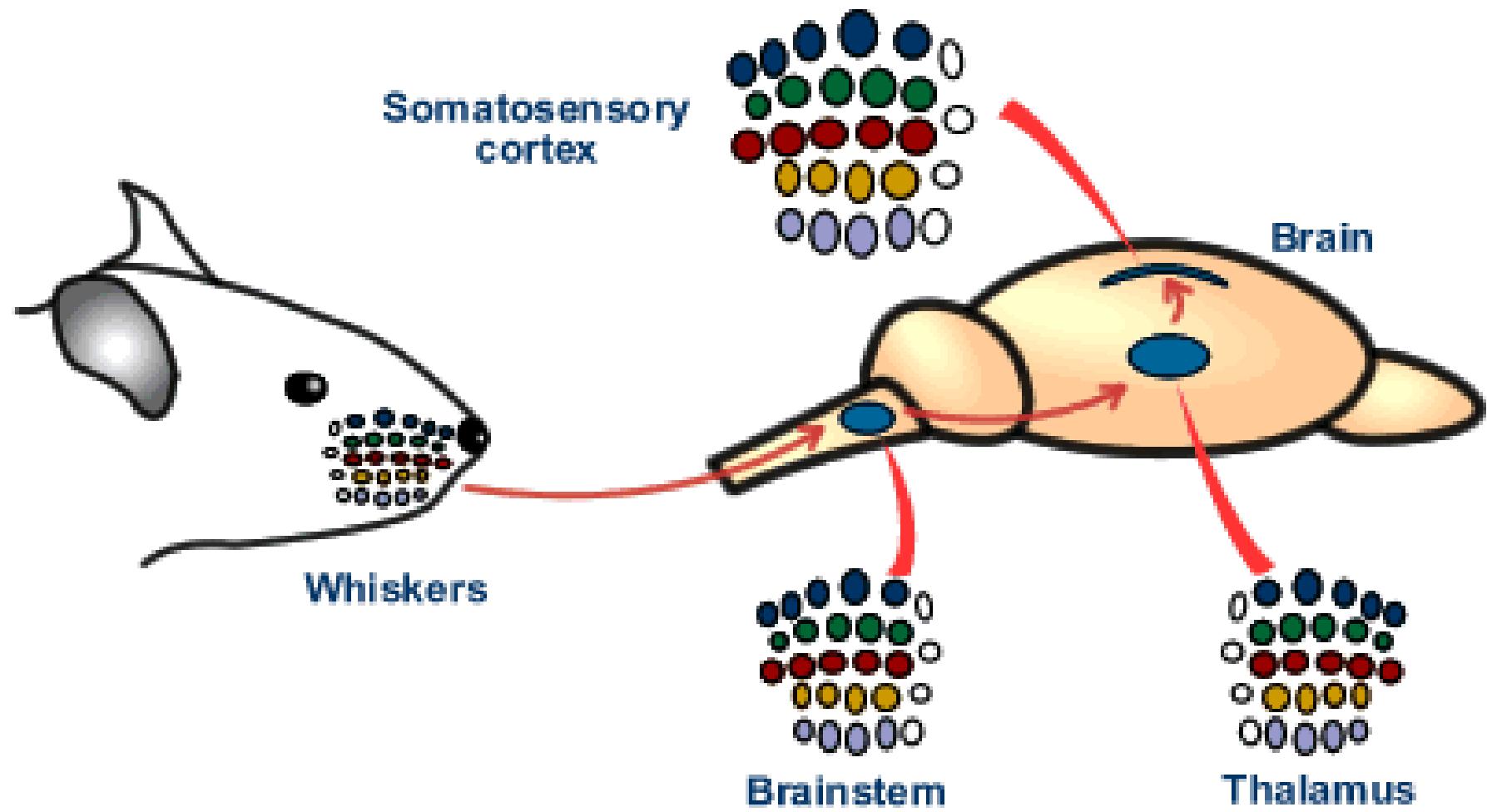
Phantom Limb Video



# What/where

- Perceiving Where
  - Somatotopic maps – where on skin
  - Kinesthesia – configuration of limbs
- Perceiving What
  - Patterns of smoothness, roughness, shape, temperature

# Somatosensation in other animals



Pain

# The neuroscience of pain

- *Nociceptors* (Latin *nocere* to harm or hurt) detect harmful or potentially harmful stimuli of varied types:
  - chemical
  - mechanical
  - thermal

# Nociception

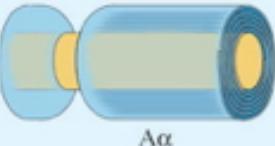
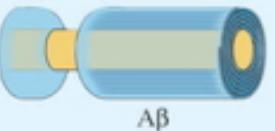
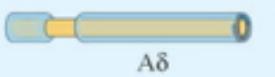
- External
  - Skin, cornea (eye), mucosa
- Internal
  - Muscles, joints, bladder, gut

# Different types of nociceptors...

- metabolism (acidic pH, hypoxia, ...)
- cell rupture (ATP and glutamate)
- cutaneous parasite penetration (histamine)
- mast cell (white blood cell) activation (serotonin, bradykinin, ...)
- immune and hormonal activity (cytokines and somatostatin)

# Fast ( $A\delta$ ) and slow ( $C$ ) transmission to CNS

**TABLE 8.2** Fibers That Link Receptors to the CNS

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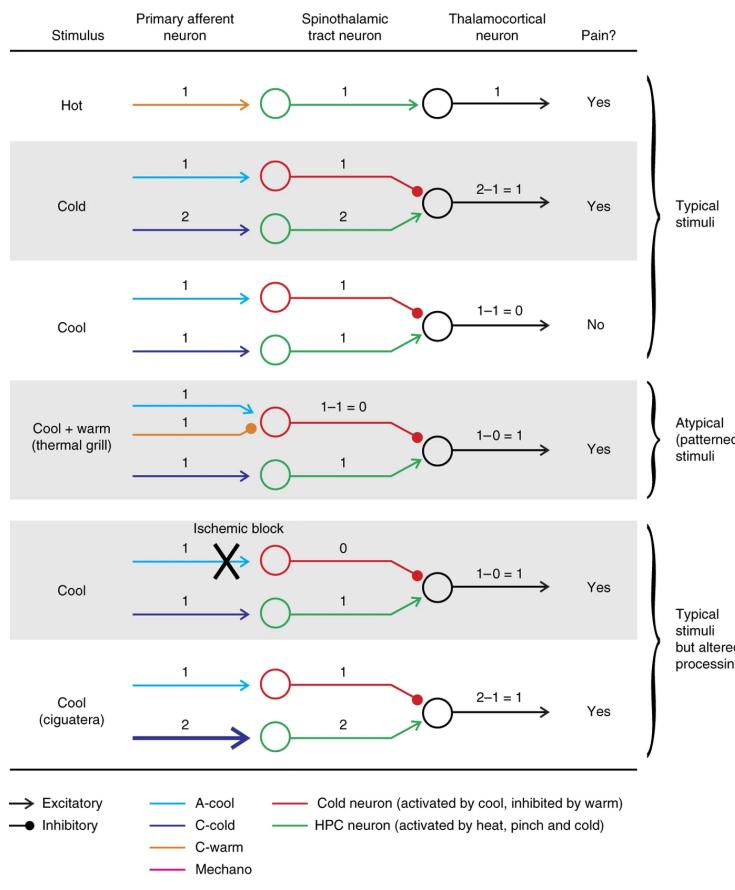
# Thermal grill illusion

Dune pain box - thermal grill illusion

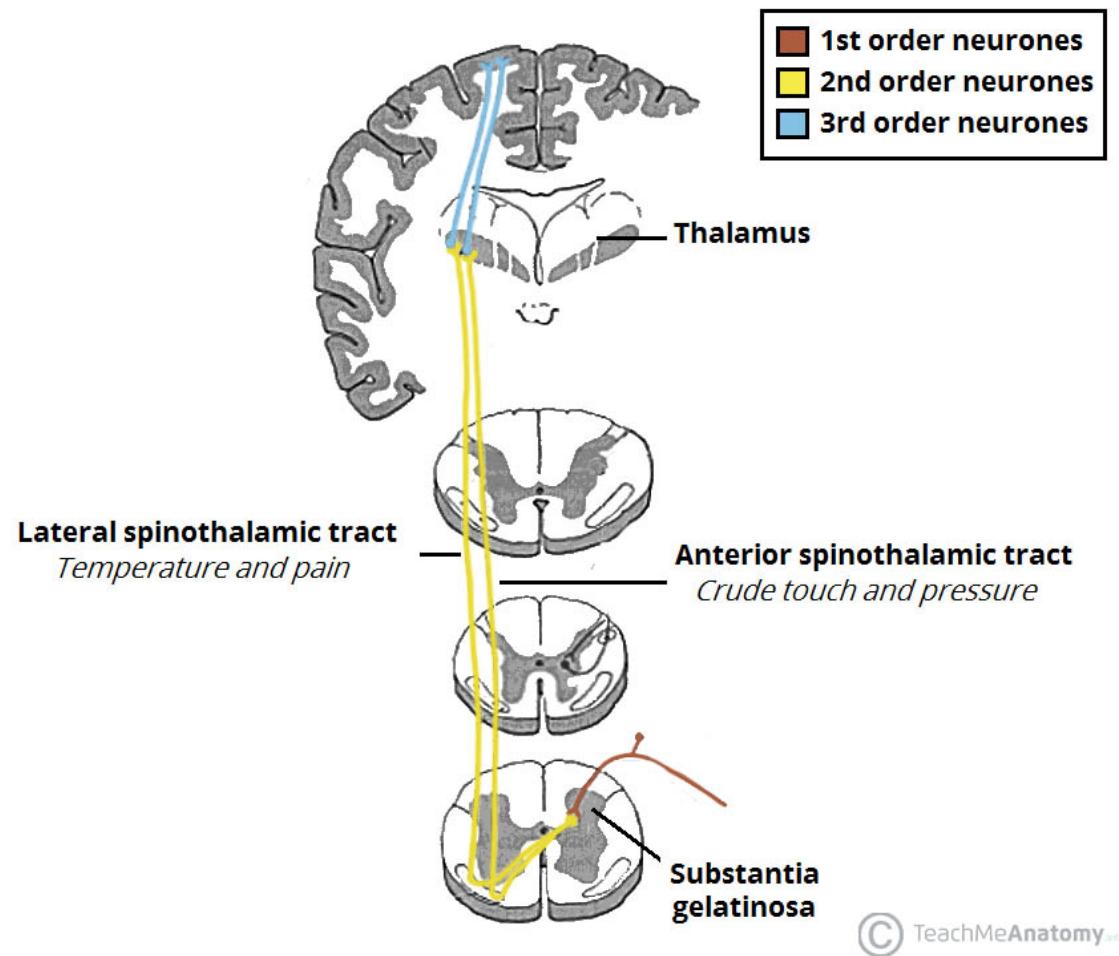


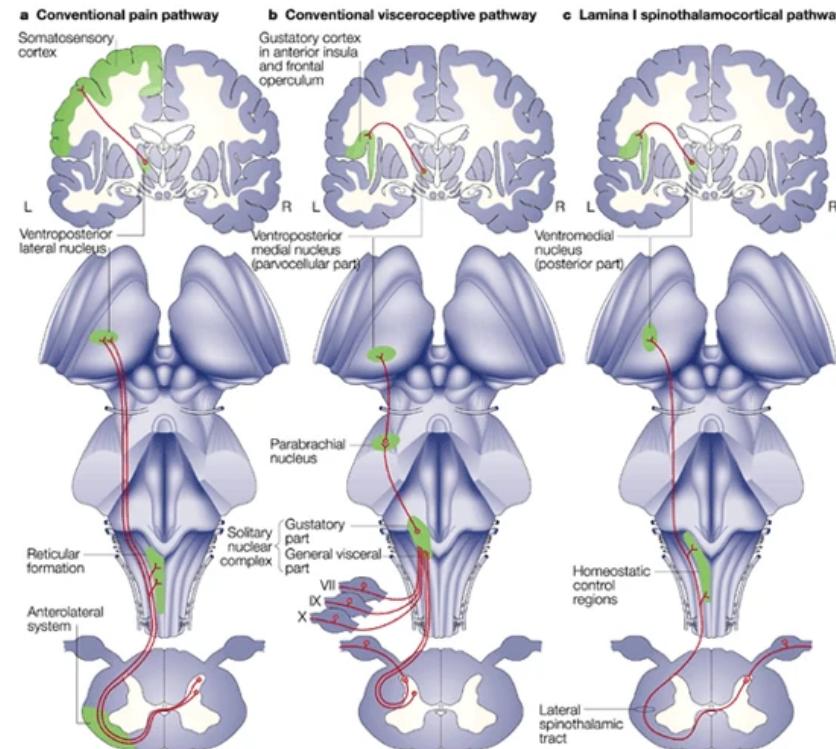


# 'Cross-talk' between nociceptor channels



# Projection to brain via anterolateral system





Nature Reviews | Neuroscience

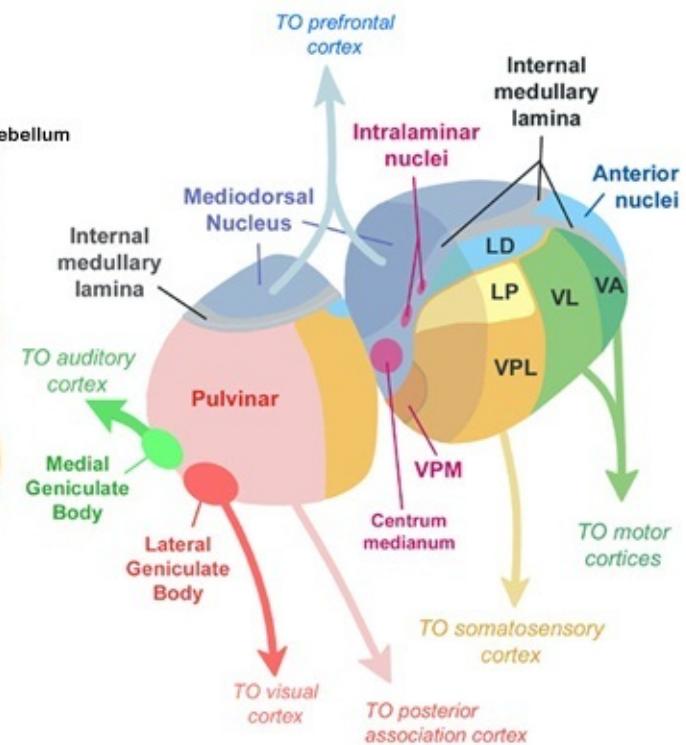
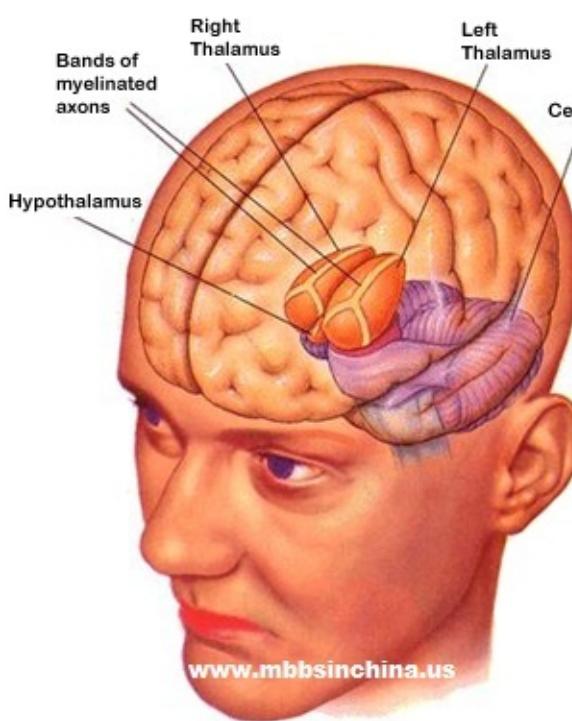
(Craig, 2002)

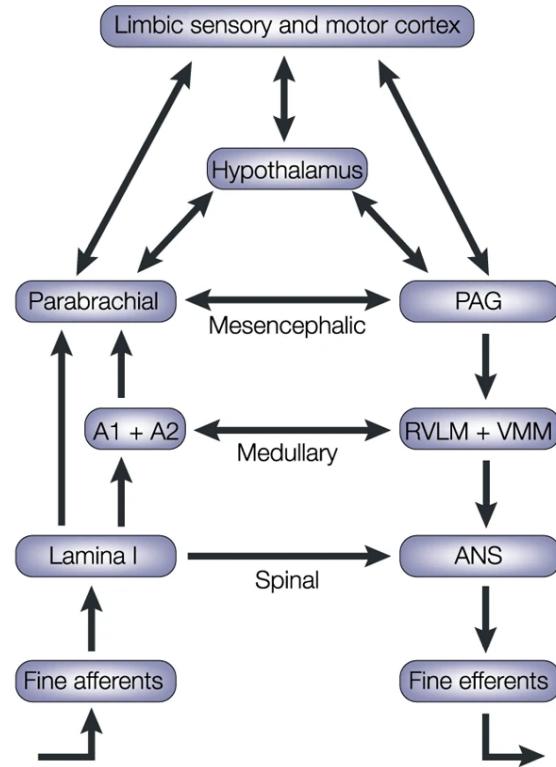
# Key CNS nodes in network

- Periaqueductal grey (PAG) in midbrain
- Insular cortex (insula)
- Hypothalamus
- Amygdala

# Key CNS nodes in network

- Thalamus
  - Ventroposterior lateral nucleus
  - Ventroposterior medial nucleus
  - Ventromedial nucleus

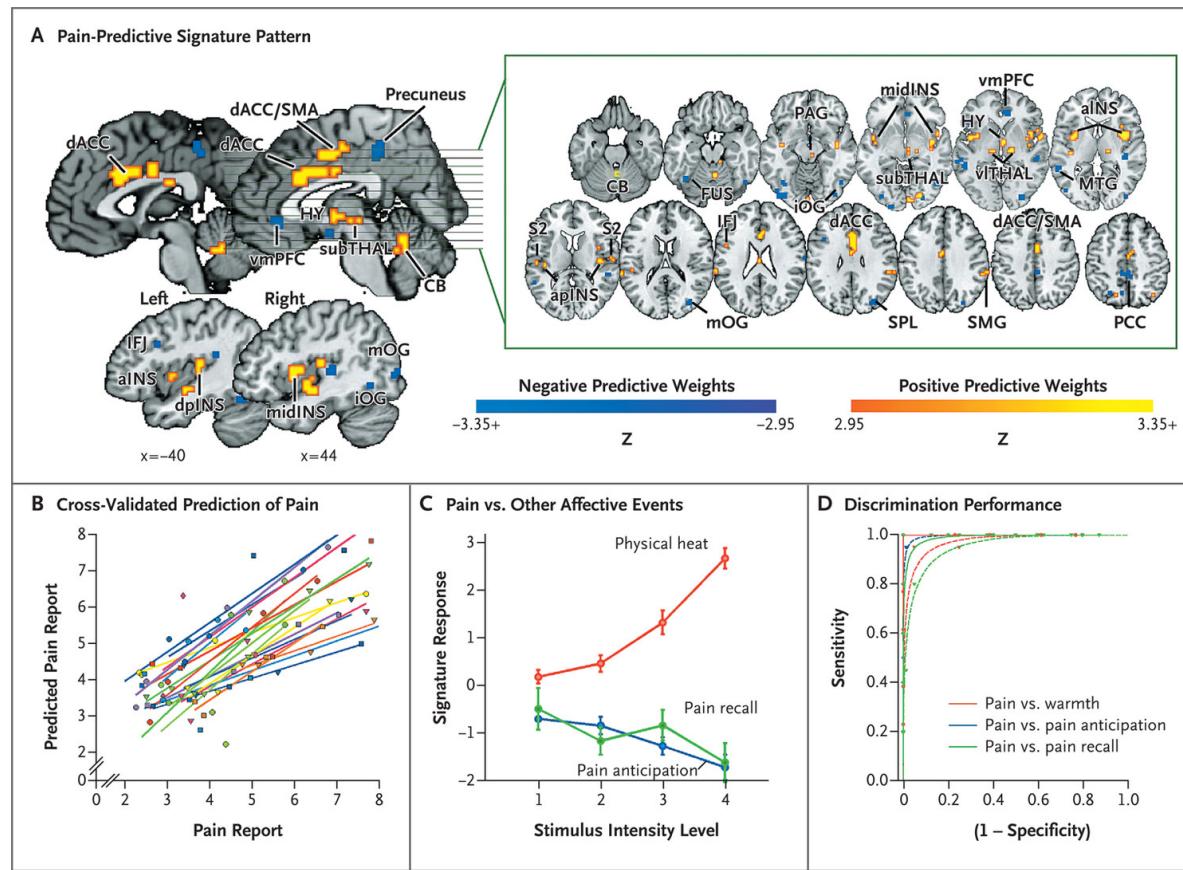




Nature Reviews | Neuroscience

(Craig, 2002)

# Pain in the brain



(Wager et al., 2013)

# Pain in the brain

*"...we used machine-learning analyses to identify a pattern of fMRI activity across brain regions — a neurologic signature — that was associated with heat-induced pain. The pattern included the thalamus, the posterior and anterior insulae, the secondary somatosensory cortex, the anterior cingulate cortex, the periaqueductal gray matter, and other areas..."*

(Wager et al., 2013)

# Pain relief

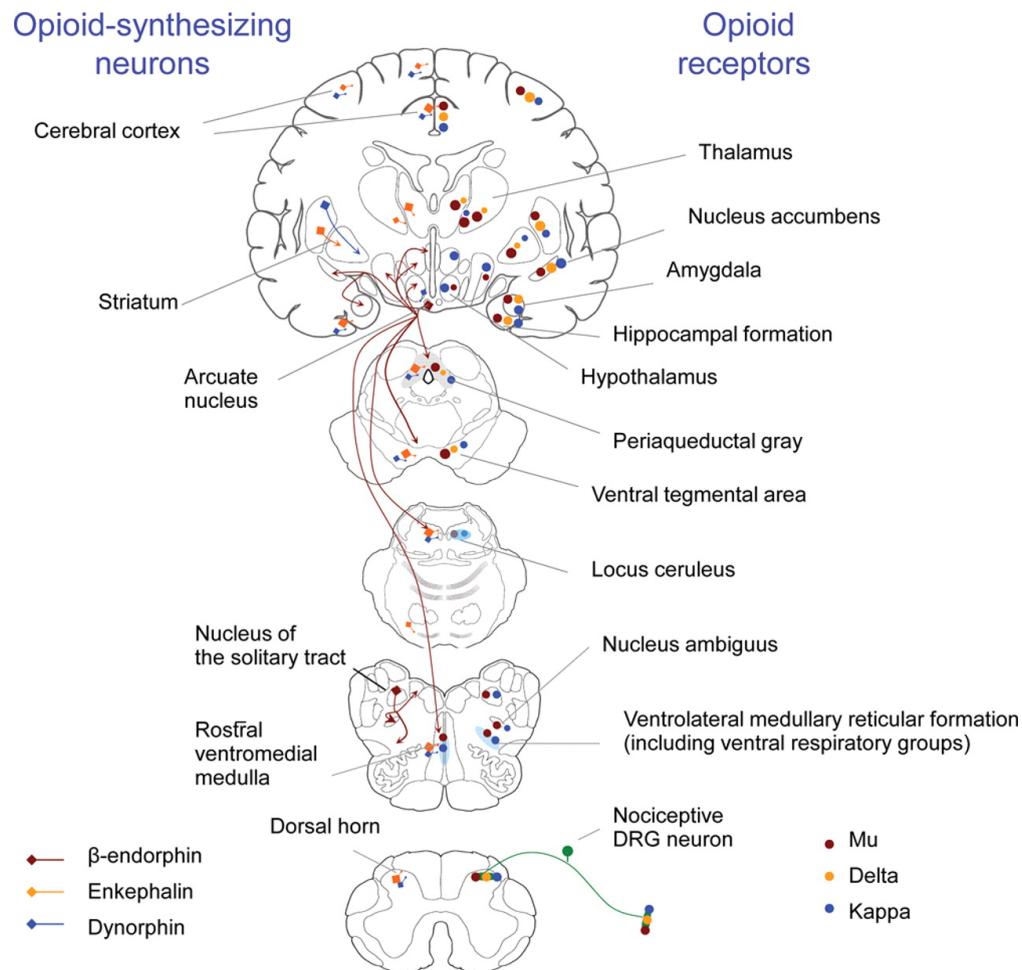
- *Prostaglandins*
  - hormone-like effects, but released in many places
  - trigger vasodilation and inflammation

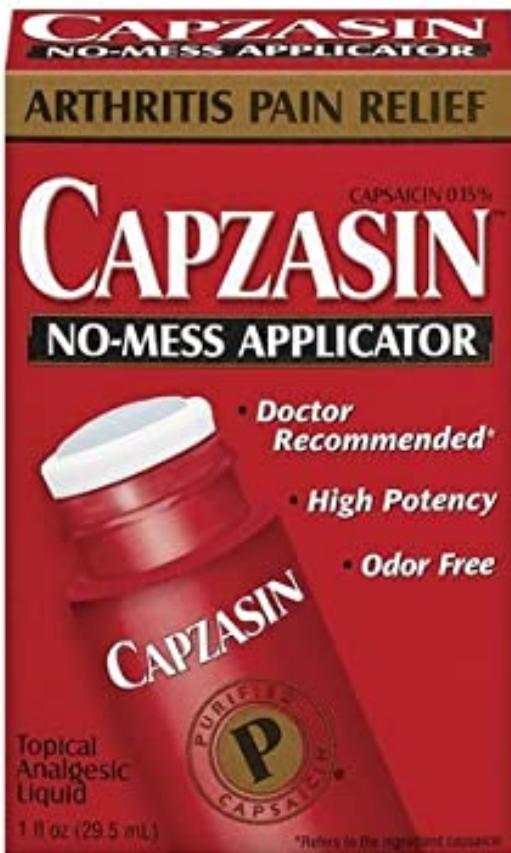
# Pain relief

- *Paracetymol (acetaminophen)*
  - Mechanism not fully understood
  - inhibits synthesis of prostaglandins via cyclooxygenase (COX) enzyme
  - may modulate endocannabinoid system
- *Nonsteroidal anti-inflammatory drugs (NSAIDs): aspirin, ibuprofen*
  - Also inhibit prostaglandins via COX

# Pain relief

- *Opioids*
  - Activate endogenous opioid systems
  - multiple receptor types ( $\delta$ ,  $\kappa$ ,  $\mu$ ,...)
  - peripheral sensory neurons, amygdala, hypothalamus, PAG, spinal cord, cortex, medulla, pons,...
  - brainstem opioid neurons provide *descending* inhibition of nociceptors





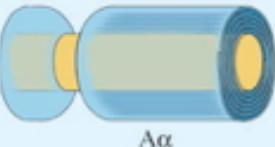
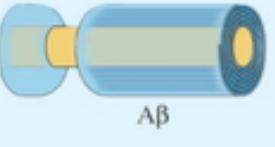
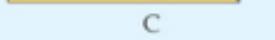
# Pain relief

- *Capsaicin*
  - Binds to TrpV1/VR1 thermo/nociceptors
  - Eventually causes decrease in TrpV1 response
  - Alters how peripheral neuron responds to mechanical stimulation
  - (Borbiro, Badheka, & Rohacs, 2015)

# Pain relief

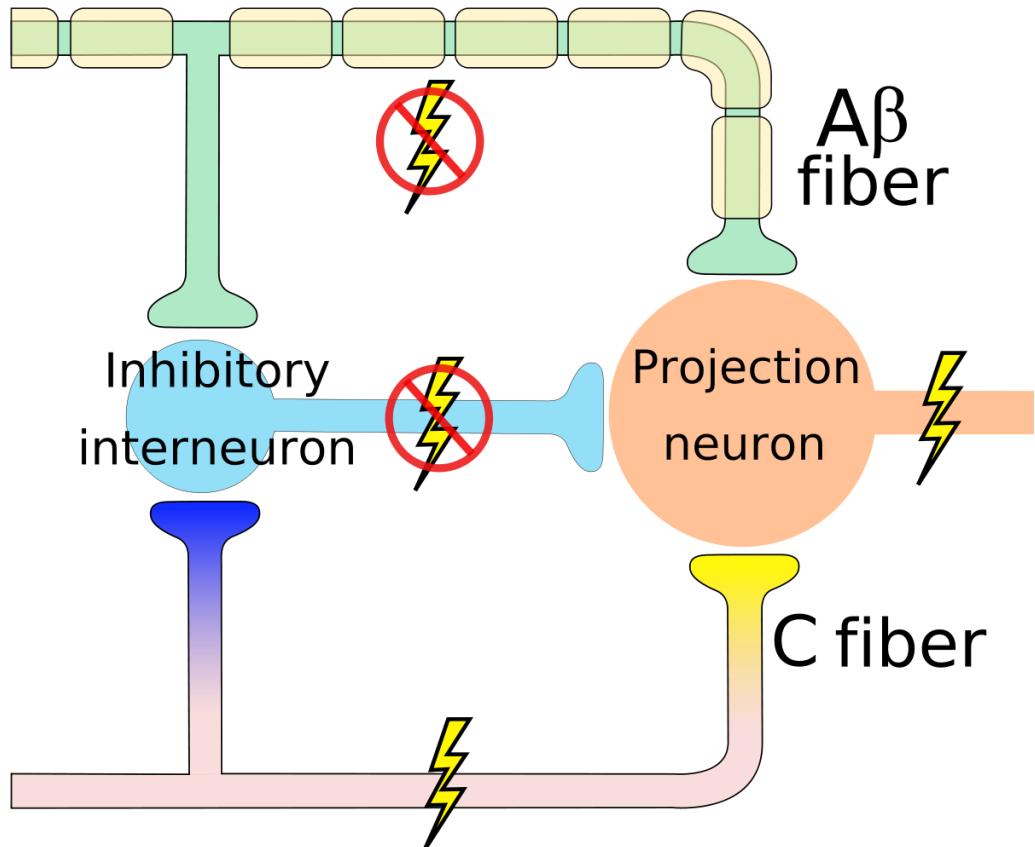
- Why rubbing can help

**TABLE 8.2 Fibers That Link Receptors to the CNS**

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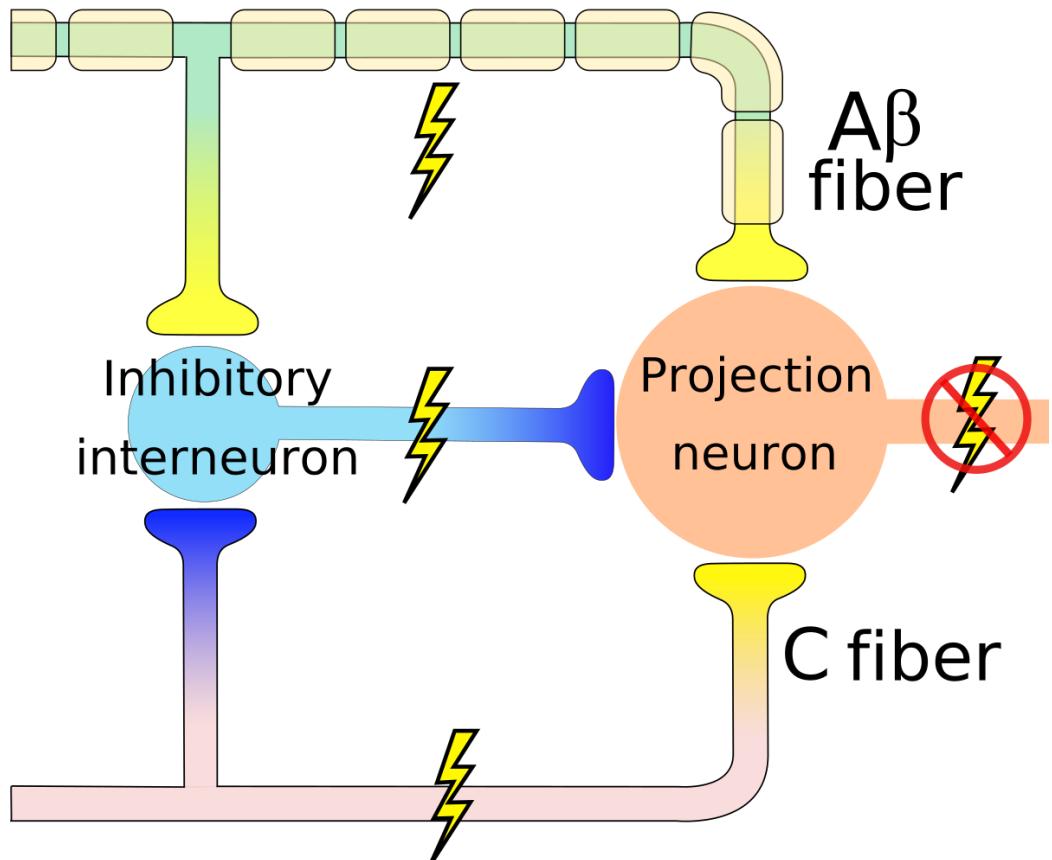
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# Gate control theory (Melzack & Wall, 1965)



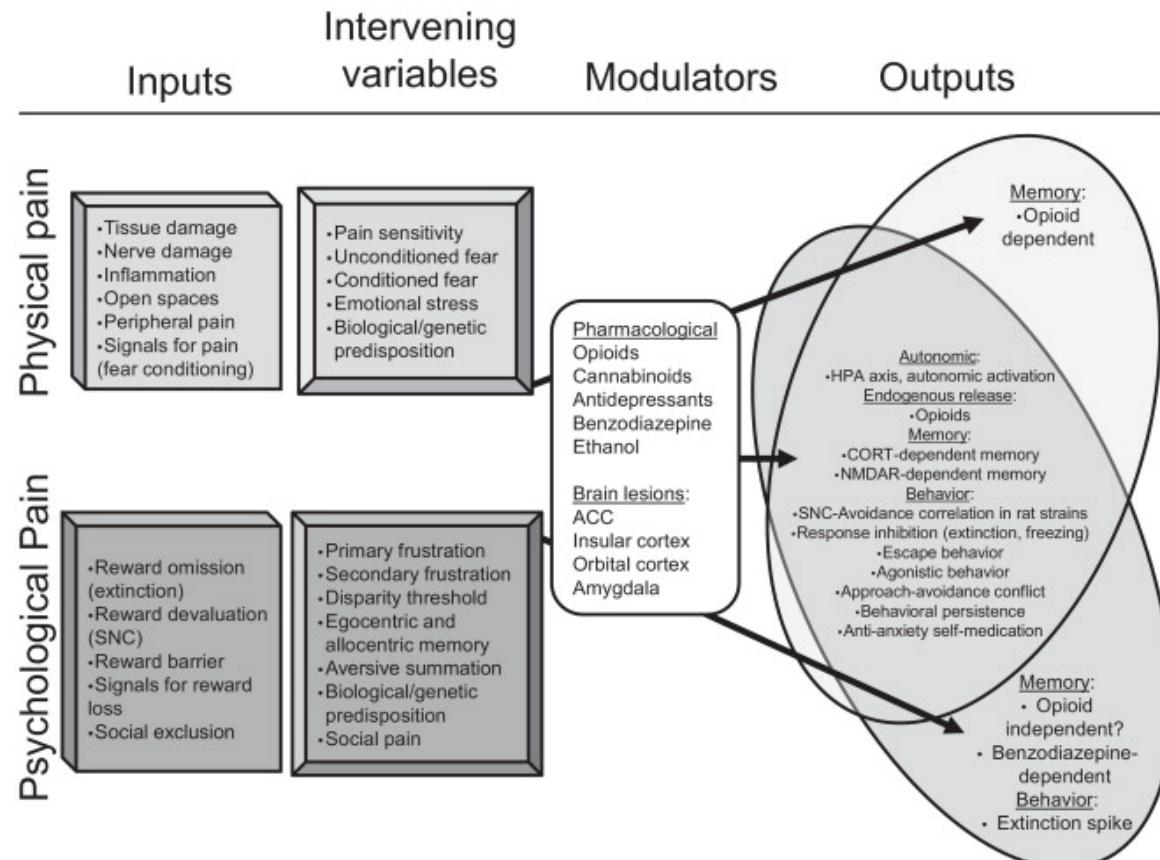
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# Gate control theory (Melzack & Wall, 1965)



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# Psychological and physical dimensions



(Papini, Fuchs, & Torres, 2015)

# Main points

- Somatosensation
  - Exteroception via
    - Cutaneous receptors + proprioception
  - Interoception via
    - Widely distributed receptors
    - Specific and non-specific

# Main points

- Pain
  - Multiple receptor channels
  - Highly interconnected CNS network
  - Multiple targets for modulation

# Next time...

- Action!

# References

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