

Lecture 14 - Anatomical Substrates for Somatic Sensation -- Martin

Objective

Learn organization of spinal systems for discriminative mechanosensations (touch, limb position sense), pain, and thermal sensations

1. General organization of dorsal column-medial lemniscal (DCML) and anterolateral systems (ALS)

DCML-single anatomical path

Components of anterolateral system:

Spinothalamic tract

Spinoreticular tract

Spinomesencephalic (or tectal) tract

2. Peripheral somatic sensory receptors

Dorsal root ganglion neuron

Receptive field organization

Mechanoreceptors

Nociceptors

3. Peripheral nerves: axonal diameters and action potential conduction velocities

Fiber density spectrum

A- α , A- β , A- δ , C

4. Dermatomes and dermatomal overlap

5. Central projections of primary afferent fibers

- Large diameter fibers—deep dorsal horn, intermediate zone, ventral horn; ascending projection to medulla
- Small diameter fibers—predominantly superficial dorsal horn

6. Overview of ascending systems:

System	Modality	Submodal	Receptor	Myelin	Diameter	AP cond	Fiber type
DC-ML	Touch	superficial	Merkel, Meissner	++	Large	Fast	II A β
		deep pres.	Ruffini	++	Large	Fast	II A β
		vibration	Pacinian	++	Large	Fast	II A β
	Position sense	static & dynamic	Spindle	+++	Very large	Very fast	II A α , β
Anterolat. system	Pain	sharp, pricking	Bare	+/0	Med, small	slow, very slow	III, IV A δ , C
		dull, burning	Bare	+/0	Med, small	slow, very slow	III, IV A δ δ , C
	Thermal	cold	Bare	+/0	Med, small	slow, very slow	III, IV A δ , C
		warmth	Bare	+/0	Med, small	slow, very slow	III, IV A δ , C

(Crude touch: not a modality; clinically tested residual form of touch after DC-ML damage)

7. Somatotopic organization of ascending pathways in the spinal cord white matter

8. Dorsal column-medial lemniscal system

Organization of dorsal column-medial lemniscal pathway

Locations of pathway neurons

Level of decussation

- Ascending branch of dorsal root ganglion neuron
- Cuneate and gracile tracts & nuclei
- Ventral posterior nucleus
 - VPL—back of head, limbs and trunk
 - VPM—face, oral cavity

9. Primary somatic sensory cortex

- Cytoarchitectonic areas 1, 2, 3a, and 3b
- Intracortical projections: 3a/b → 1 → 2 → posterior parietal lobe; motor cortex
- Input layer: 4
- Efferent projections of cortical layers:
 - layers 2,3 → ipsilateral and contralateral cortex
 - layer 4 → layers above and below 4
 - layer 5 → brain stem, spinal cord, striatum
 - layer 6 → ventral posterior nucleus

10. Anterolateral system—Pain, temperature, itch

- spinothalamic and spinomesencephalic: laminae 1, 5
- spinoreticular: more diffuse
- Diverse thalamo-cortical targets for different functions:
 - **Ventral posterior nucleus** (lateral and medial divisions; VPL, VPM). Projects to **postcentral gyrus**; may be more important in crude touch than pain
 - **Ventral medial posterior nucleus (VMPo)**. Projects to the **insular cortex**; may be the key relay for pain in humans; insular pain representation is more consistently activated in brain imaging studies when subjects receive painful stimuli
 - **Medial dorsal nucleus**. Projects to the **cingulate gyrus**; involved in the emotional aspects of pain
 - **Intralaminar nuclei**. Projects broadly to parietal and frontal lobes; involved in arousal

Relevant readings: chapters 22-24 in “Principles”; chapter 5 in Neuroanatomy, by Martin, 2nd ed