Lecture 13 - 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

Relevant reading: chapter 22 in “Principles” and chapter 5 in “Neuroanatomy”
### 6. Overview of ascending systems:

<table>
<thead>
<tr>
<th>System</th>
<th>Modality</th>
<th>Submodal</th>
<th>Receptor</th>
<th>Myelin</th>
<th>Diameter</th>
<th>AP cond</th>
<th>Fiber type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DC-ML</strong></td>
<td></td>
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<td></td>
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<tr>
<td>Touch</td>
<td>superficial</td>
<td>Merkel, Meissner</td>
<td>++</td>
<td>Large</td>
<td>Fast</td>
<td>II $\alpha$</td>
<td></td>
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<tr>
<td></td>
<td>deep pres.</td>
<td>Ruffini</td>
<td>++</td>
<td>Large</td>
<td>Fast</td>
<td>II $\beta$</td>
<td></td>
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<tr>
<td></td>
<td>vibration</td>
<td>Pacinian</td>
<td>++</td>
<td>Large</td>
<td>Fast</td>
<td>II $\beta$</td>
<td></td>
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<tr>
<td>Position sense</td>
<td>static &amp; dynamic</td>
<td>Spindle</td>
<td>+++</td>
<td>Very large</td>
<td>Very fast</td>
<td>II $\alpha$, $\beta$</td>
<td></td>
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<tr>
<td><strong>Anterolat. system</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pain</td>
<td>sharp, pricking</td>
<td>Bare</td>
<td>+/0</td>
<td>Med, small</td>
<td>slow, very slow</td>
<td>III, IV A $\delta$, C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>dull, burning</td>
<td>Bare</td>
<td>+/0</td>
<td>Med, small</td>
<td>slow, very slow</td>
<td>III, IV A $\delta$, C</td>
<td></td>
</tr>
<tr>
<td>Thermal</td>
<td>cold</td>
<td>Bare</td>
<td>+/0</td>
<td>Med, small</td>
<td>slow, very slow</td>
<td>III, IV A $\delta$, C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>warmth</td>
<td>Bare</td>
<td>+/0</td>
<td>Med, small</td>
<td>slow, very slow</td>
<td>III, IV A $\delta$, C</td>
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</tr>
</tbody>
</table>

(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