SOMATIC SENSORY PATHWAYS

Different sensory modalities

- **Discriminative touch** — Two-point discrimination, recognition of textures, lateral movement of stimuli on skin
- **Conscious proprioception** — This is awareness of position and movement of joints.
- **Simple or "crude" touch** — Even light stimuli can be accurately localized, but without detailed recognition of the object that is in contact with the skin.
- **Thermal sensation** — The skin recognizes differences in temperature, but absolute values cannot be accurately judged.
- **Pain** — The conscious feeling of injurious stimuli.

Somatic sensory pathways.

**General principles**

1. There are two pathways, which carry different types of sensation from skin, muscles etc (not internal organs) to the first somatic sensory area of the cerebral cortex.

2. Each pathway consists of three populations of neurons:
   - **First-order neuron**
   - **Second-order neuron**
   - **Third-order neuron**

   - **Unipolar, with its cell body in a sensory ganglion**
   - **Its axon** — decussates.
   - **ends in the thalamus.**

   - **Cell body in thalamus. Axon ends in cortex.**

   (Decussation = a place where axons from L & R sides cross the midline)

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**The spinothalamic system.**

- First somatic sensory area (post-central gyrus)
- Axons of thalamocortical neurons pass through the internal capsule
- Spinothalamic fibres are located laterally at all levels of the brain stem
- Spinothalamic fibres end in the ventral posterior lateral nucleus of the thalamus.
- Some fibres end in the intralaminar thalamic nuclei, which project to many cortical areas.
- Second order neuron has cell body in dorsal horn of spinal grey matter (Most are in the nucleus proprius)
- First order neuron has its unipolar cell body in a spinal ganglion
- Axons of 2nd-order neurons then ascend in the spinothalamic tract
- Axons of 2nd-order neurons cross midline ventral to the central canal
- Third-order neuron has its cell body in the VP nucleus (VPL for parts of the body below the head; VPM for head)
- Spinothalamic fibres end in the lateral posterior nuclear group of the thalamus
- Some fibres end in the intralaminar thalamic nuclei, which project to many cortical areas
- Receptors for pain, temperature, light touch etc.
**Medial lemniscus system**

Axons of 1st order neurons ascend ipsilaterally in the dorsal funiculus, and end in the gracile and cuneate nuclei in the medulla.

- First order neurons (Upper limb) are in spinal ganglia.
- Lower limb: Receptors for discriminative sensations—fine touch, proprioception.

Gracile nucleus

Cuneate nucleus

Third-order neurons in VPL nucleus of thalamus project to primary somatosensory area.

(The medial lemniscus is close to the midline in the medulla. It moves laterally as it ascends through the pons and midbrain.)

Axons of 2nd-order neurons (internal arcuate fibres) cross in caudal medulla and then ascend as the medial lemniscus.

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**Comparison of the anterolateral with the dorsomedial system**

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<thead>
<tr>
<th>First order neurons</th>
<th>Spinothalamic system</th>
<th>Medial lemniscus system</th>
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</thead>
<tbody>
<tr>
<td>Detect pain, temperature and non-discriminative touch.</td>
<td>Detect discriminative tactile features and position and movement of joints.</td>
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<tr>
<td>Project to dorsal horn of spinal grey matter.</td>
<td>Long axons ascend in dorsal column, to end in the gracile and cuneate nuclei in medulla.</td>
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<table>
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<tr>
<th>Second order neurons</th>
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<tr>
<td>Axons decussate in spinal cord, ascend as contralateral spinothalamic tract.</td>
<td>Axons decussate in caudal medulla, ascend as the medial lemniscus.</td>
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<tr>
<td>Project to VPL thalamic nucleus (also to IL nucleus).</td>
<td>Axons do not have collateral branches in brain stem.</td>
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<tr>
<td>Spinothalamic fibres have branches to reticular formation and periaqueductal grey matter.</td>
<td>In dorsal column nuclei, feed-forward and feedback inhibition sharpen localization of most strongly stimulated part of the receptive field.</td>
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<td>In ventral posterior nucleus of thalamus (lateral division).</td>
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<tr>
<td>Project to primary somatosensory area (postcentral gyrus).</td>
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<td>Intralaminar nuclei → whole cortex.</td>
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**There is an additional pathway for conscious proprioception from the lower limb.**

Nucleus Z (of Brodal and Papez): (To cerebellum, by way of inferior cerebellar peduncle).

Dorsal spinocerebellar tract

Nucleus thoracicus (Clarke's column) in segments T1 - L3

Gracile fasciculus

Ganglia L2 - S3

Proprioceptive endings in muscles and joints of lower limb

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(A chain of **four** neurons)
Synapses do not simply relay signals. The signals are modified by other inputs to the postsynaptic neurons. The gate control theory is a postulated mechanism for determining whether a stimulus will be felt as being painful.

Inhibition is also used to sharpen the localization of the most strongly stimulated site, by suppressing the transmission of weaker signals from adjacent areas. This happens in the gracile and cuneate nuclei and in many other places.

Descending tracts can modify the upward transmission of sensory data.
Consider also:

Pressure on nerve root S1 by a disk protrusion.

Damage to the larger myelinated axons in the radial nerve (e.g. diabetic mononeuropathy).

Destruction of a small part of the postcentral gyrus (e.g. small tumour or stroke).

A longitudinal surgical incision that bisects the spinal cord (separating its left & right halves) in the range S1-S5. (Why might this be done?)

Position of a surgical incision for the relief of severe pain (not relieved by drugs) in the right leg.