The 2 principal somatic sensory systems:
1) Dorsal column-medial lemniscal system
2) Anterolateral system

Dorsal Column-Medial Lemniscal System
• Mediates mechanical sensations - touch, limb position sense, vibration sense
• Well established; clinical & experimental
Anterolateral System

- Mediates protective sensations
  - Pain
  - Temperature (cold & warmth)
  - Itch
- Not as definitively established as is the DC-ML system for touch

Why?
- Pain w/o tissue trauma
- Trauma w/o pain
- Cultural; pathological

Perspective:

- Peripheral somatic sensory receptors are sensitive to different stimulus qualities
  - Mechanical
  - Thermal (warm, cold)
  - Noxious (mechanical, thermal, polymodal)
- Different receptor classes provide input to different somatic sensory pathways
- Differential thalamic and cortical localization

Dorsal column-medial lemniscal system:

1. Somatic sensory cortex
2. Dorsal column nucleus
3. Thalamus: Ventral posterior nucleus

Peripheral nerve

1. Mechanoreceptor
2. Dorsal root ganglion
3. Medial lemniscus
4. Dorsal column
5. Thalamus: Ventral posterior nucleus
6. Somatic sensory cortex
Anterolateral system:
- Pain, Thermal, Itch

1. Nociceptor
- Thermoreceptor
- Itch/histamine

2. Anterolateral system:
- Spinothalamic tract
- Spinoreticular tract
- Spinomesencephalic tract

Dorsal horn

Peripheral axon

Dorsal root ganglion

1° somatic sensory cortex

Cingulate cortex

3. Thalamus:
- Ventral posterior...
- & Medial dorsal nuclei.

Insular cortex

& Medial dorsal nuclei.

Cingulate cortex

1° somatic sensory cortex

Mechanoreceptors are encapsulated

Merkel's receptor

Meissner's corpuscle

Pacinian corpuscle

Nociceptors, thermoreceptors, & itch receptors are bare nerve endings

Merkel's receptor

Meissner's corpuscle

Pacinian corpuscle

Bare nerve ending
Dorsal root ganglion neuron

Key Characteristics of DRG Neurons
- Peripheral receptive field
  - Spatial area within which stimulation activates the sensory neuron

Receptive field
CNS Neurons have Receptive Fields

Key Characteristics of DRG Neurons
- Peripheral receptive field
  - Spatial area within which stimulation activates the sensory neuron
- Response to constant stimulation
  - Slow adaptation
  - Rapid adaptation

Mechano-receptor receptive fields
- Rapidly adapting
- Slowly adapting
- Meissner's
- Merkel
- Pacinian
- Ruffini
Mechano-receptor receptive fields

- Rapidly adapting
- Slowly adapting

Meissner's corpuscle
Merkel's corpuscle
Pacinian corpuscle
Ruffini corpuscle

Nociceptors, thermoreceptors, & itch receptors are bare nerve endings

Nociceptors respond to noxious stimuli

- Blunt probe
  - High force; NOT NOXIOUS; NO RESPONSE

- Pin
  - Low force; NOXIOUS; RESPONSE

- Serrated forceps
  - Low force; VERY NOXIOUS; LARGE RESPONSE
Peripheral nerve cross section

Fiber Histogram: Sensory axon innervating the skin

Fiber Histogram: Sensory axon innervating a muscle

Mechanoreceptors
Dermatomes are the areas of skin innervated by all sensory fibers within a single dorsal root. Dermatomal boundaries vary. Dermatomes overlap, with pain dermatomes overlapping less than touch dermatomes. Dermatome facts include:

- Pain dermatomes overlap less than touch dermatomes.
- Dermatomal boundaries vary.
Dorsal column-medial lemniscal system

Meissner's corpuscle

Pacinian corpuscle

Anterolateral system

Bare nerve ending

Merkel's receptor

Reminder: Rexed's laminae

Somatotopic organization of the dorsal columns

Demyelination

Rostral

Caudal
**Spinal Hemisection**

- Ipsilateral loss of touch
- Contralateral loss of pain (2-3 segments caudal to injury)

**Syringomyelia**

- Bilateral loss of pain & thermal senses
- Preservation of mechanosensations

**Somatotopy of spinal paths**

- Medial septum
- gracile fascicle
- dorsal intermediate septum
- cuneate fascicle
Anterolateral system

Dorsal column-medial lemniscal system

Postcentral gyrus / Insular / Cingulate cortex

Also:
- Reticular formation
- Superior colliculus (mesencephalon)

Spinal commissure

Pain, thermal, itch

Dorsal horn

Dorsal column nuclei

Internal arcuate fibers

Mechano...

Somatic Sensory Thalamus

Medial dorsal

Ventral posterior medial-VPM (trigem)

Ventral posterior lateral-VPL (spinal)

Touch

Pain

Ventral posterior (VMpo)

Leg area

Arm area

Face area

Internal capsule

Ventral posterior nucleus
1° Visual Cortex

• Cell-stained section (Nissl)
• most 6 cell layers

Layer 1
Layers 2 & 3
Layer 4
Layer 5
Layer 6

• neuron density varies

Brodmann’s cytoarchitectonic areas

Over 50 areas
Defined on basis of histology

Somatic sensory areas:
1° somatic sen. cx = 1, 2, 3a, 3b
Somatic Sensory Cortical Areas for Mechanosensations

1° somatic sensory cortex
Area 5 (3° SScx)
Area 7 (Posterior Parietal cortex)

2° somatic sensory cortex
Skin receptors
Deep receptors

Stellate Neuron: interneuron
Pyramidal neuron: projection neuron

from Thalamus
back to Thalamus
to Other cortical areas

to Subcortical areas

1° Somatic Sensory Cortex Output Systems

VP lateral
VP medial
Ventral posterior

1° Somatic sensory cortex

Mechanosensation
### Summary

- Early morphological specialization of DRG neurons sets stage for separate mechanosensory and pain/temp/itch systems
- Different ascending pathways to distinct subcortical and cortical sites
- Single thalamic mechanosensory nucleus and 1° ctx
- Multiple thalamic pain nuclei and cortical areas
- Parietal lobe projections may play role in stimulus localization, esp. for touch
- Cortical pain representations closely tied to emotions

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<th>Thalamus</th>
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<th>Behavior</th>
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<td>Anterior cingulate</td>
<td>Emotional/salience/valence</td>
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<td>Ventral med. Post. (VM po)</td>
<td>Mid-insular cortex</td>
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<td>Ventral posterior (VPL/VPM)</td>
<td>1° SS Cortex</td>
<td>??/Localization/Discrimination</td>
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Cingulate gyrus: emotional/valence

Postcentral gyrus: localization

Insular pain representation: behavioral (autonomic; react)