SOMATIC SENSATION PART I: ALS
ANTEROLATERAL SYSTEM  (or SPINOThALAMIC SYSTEM)
FOR PAIN AND TEMPERATURE

Reading: Waxman 26th ed, :
Ch. 14 Somatosensory Systems
Ch. 12 Vascular Supply of the Brain  pp. 163-69. Much of this we have alluded to. You are responsible for this material. Note this was not on the original syllabus given day 1.
Sensory Pathways Homework document with instructions to color items is posted on the WebCT site and should be done after reviewing and reading the lecture material (like a self-test)

Waxman Cases involved with chapters 7, 8, 14

Use an Atlas to familiarize yourself with classic cross sections of cord, medulla, pons, midbrain and thalamus. Do not focus on structures that are not discussed in class.

Objectives: (Note: some of the objectives require information presented in the second part of the lecture on the dorsal column-medial lemniscus system for vibration, 2-point discrimination, and position sense.)

1. Describe the sensory modalities mediated by the ALS. Locate the first, second, third order neurons, and know where the crossing occurs for the anterolateral system.
2. Trace the ALS pathway from the periphery to the cortex.
3. Identify cranial nerve motor nuclei that are near the ALS pathway and that might be supplied by the same artery.
4. Define a dermatome and explain why they are useful.
5. Explain the sensory loss with a pathological enlargement of the central canal at the level of C 5,6,7. Why might there be atrophy of the hand muscles?
6. Explain why an extradural tumor pressing on the left side of the spinal cord at spinal level T8 only produces loss of pain and temperature and not other sensations from the leg. Which leg?
7. Define the term somatotopic and explain how this applies to the cerebral cortex.
8. Explain why there is a larger area of the postcentral gyrus responding to information from the hand than from the foot.
9. A vascular lesion of which cerebral vessel would result in loss of somatic sensation from the hand? From the foot?

I. GENERALITIES ABOUT SENSORY SYSTEMS:

A. Sensory information underlies motor control and arousal as well as perception of the sensation

B. All sensory systems extract the same basic information
   1. Modality or Specific quality
   2. Specific intensity
   3. Duration
4. Localization

C. Labeled Lines
1. Receptors are most sensitive to one particular stimulus
2. The stimulus must reach a sufficient threshold
3. Receptor central connections are segregated according to stimulus

D. Central Projections of sensory information to three general regions. See diagram next page.
1. Axon collaterals are important in reflex activity in spinal cord and 
   brainstem: Make automatic adjustments to the stimuli. Example A
2. Tracts that project to the cerebral cortex for perception and relay in 
   the thalamus. Example B
3. Axons that end in the Brain Stem Reticular Formation for arousal 
   and modulation. Example C

Young and Young: Clinical Neuroanatomy p. 2

![Diagram of sensory pathways](image)

A. THREE NEURON REFLEX CIRCUIT

B. THREE NEURON SENSORY RELAY CIRCUIT

C. REFLEX AND RELAY WITH RETIC. FORM. ACTIVIATION
II. THE ANTEROLATERAL SYSTEM = ALS (Spinothalamic, other name)
By system we mean a group of functionally related pathways or tracts. The first pathway we are going to study does not end in just one place. It includes the spinothalamic fibers and the spinoreticular fibers. We will focus on the former.

A. Functional Significance
   For light touch (cotton swab), temperature, itch, tickle as well as fast (A-delta) and slow (C-fiber) pain. The fast pain pathway permits localization of sharp pain. This pathway goes to the thalamus and then cortex. The slow pain wanders through the reticular formation and involves other thalamic and cortical areas that are ill defined and which you will not be required to identify.

   ALS takes its name from the Anterior Lateral Quadrant of spinal cord where the tract travels). Older books or older anatomists call these the ventral and lateral spinothalamic tracts. We group the tracts and use the term ALS and spinothalamic interchangeably.

   Clinical-pathological correlation: When the anterolateral quadrants of the cord are bilaterally disrupted (anterior lateral cordotomy), there is loss of pain and temperature sensation, but discrete tactile sensation and proprioception is preserved. When done therapeutically, the pain messages often find a way around the lesion after a few months. Therefore, usually done only on near terminal patients.

B. Receptor -- Transforms a particular stimulus into a coded electrical signal for a restricted region of the surface = receptive field. This is the basis for localization. Modalities include: Chemo-, Mechano-, Thermo-, Noci-, Photo- reception,

   1. Thermal receptors
      a. Cold receptors
      b. Warm receptors
   2. Encapsulated nerve endings for touch and pressure
   3. Pain: unmyelinated free nerve ending for nocicepton (c fibers) and myelinated (A-delta).
   4. Receptor distribution is NOT uniform over the body surface; receptor density varies, as does receptive field size. Results in distorted cortical maps representing different parts of the body.

C. 1° SENSORY NEURONS- the first neuron in the chain= first order
   1. Cell bodies are in dorsal root ganglia:
   2. Dermatome = the area of skin supplied by the somatosensory fibers from a single spinal nerve.
   3. Central processes terminate (=synapse on) specific areas of the dorsal horn of the spinal cord.
4. **Axon collaterals**

   a. The collaterals bifurcate and ascend or descend for 1-3 spinal cord segments before synapsing. They in turn connect with interneurons that can ascend or descend.

   b. The collaterals make reflex connections with 1-3 cord segments above and below the level of entry of the spinal nerve and are important in integrating activity in several segments to produce a reflex (e.g., the withdrawal reflex, a "multisegmental reflex").

From The Digital Anatomist Interactive Brain Syllabus. John Sundsten and Kate Mulligan, Univ.Washington School of Medicine. 1998 ©
The Anterolateral or Spinothalamic Pathway

The following sections are our classic brain stem levels. You should be able to locate the ALS tract on each of these diagrams if given to you unlabeled.
SPINAL CORD Suzanne S. Stensaas©

MEDULLA Suzanne S. Stensaas©
D. 2° SENSORY NEURONS – the second neuron in the chain=second order. The cell bodies are in the dorsal horn.

2. Their axons **CROSS the midline via the ventral or anterior white commissure** (Note: this is NOT the same structure as the anterior commissure in the forebrain that connects the two temporal lobes). Remember they **cross within 1-3 spinal cord segments**.

3. The axons form the **ALS or spinothalamic tract on the opposite side of the spinal cord**.

4. The anterolateral system or spinothalamic tract is made up of **second order neurons**
   a. **Somatotopic** organization
   b. Their **course** -- along the **lateral** aspect of the **brain stem** -- see diagram of medulla, pons, and thalamus.
   c. **Terminates in VPL, ventral posterior lateral nucleus, of thalamus.** This is what we call a specific relay (to cortex) nucleus.

From ? ©
E. 3’ SENSORY NEURONS – the third neuron in the chain is in the Thalamus

1. Their cell bodies reside in VPL (ventral posterior lateral thalamus)
2. Their axons project via the posterior limb of the internal capsule to the postcentral gyrus.
3. This is the end of the pathway.
F. PRIMARY, SOMATOSENSORY CORTEX, SI =Postcentral Gyrus and Posterior Paracentral Lobule

1. Brodmann's scheme of cortical numbers: Areas 1, 2, 3 see Y & Y pp.191-192
2. Somatotopically organized. and represented by homunculus
3. There are four different body maps in the postcentral gyrus to help extract texture, form, and motion. (After arriving to the cortex we stop using terms- first, second, third order sequencing.)
4. This is the end of the pathway. Other connections are to cortical association areas.

III. The role of the RETICULAR FORMATION: Painful stimuli also activate certain intralaminar thalamic nuclei, which project to diverse cortical areas to participate in arousal and attention.

Bottom line – there is the ALS path and there are others ways pain comes to consciousness! Pain comes to consciousness via the reticular formation. The following diagram might help you remember there is the ALS tract which we use all the time to localize pain and then there is the local, diffuse, circuitous route that is very flexible and manages to get those nasty, unrelenting signals through to consciousness.
Ascending visceral afferent input travels in the **anterolateral system** (dashed) and through multisynaptic circuits **via the reticular formation of the brain stem (spino-reticulo-thalamic pathway)** (solid). These fibers influence both specific and diverse areas of the cerebral cortex. Thalamic relays include intralaminar and midline nuclei and cortical areas include orbitofrontal cortex, insula and anterior cingulate gyrus. (Image Modified from Fundamental Neuroscience, Duane E. Haines, Churchill Livingston, 1997).