The different sensory modalities register different kinds of energy from the environment.

The sense of touch registers mechanical energy.

Basic idea: we bump into things, our skin gets depressed, and receptors in the skin transduce this mechanical deformation into a voltage.

We can also sense temperature, with receptors that detect heat gradients.

The skin is thus the receptor organ for touch.

Like the retina in vision, the receptors in our skin are laid out such that they provide a spatial map of stimulation over the body.

Unlike vision, though, usually only part of the skin is stimulated at any one time.

And despite this spatial map provided by the receptors, people are not very good at localizing stimulation on the skin.

Our sense of touch is usually best when we move our skin over whatever it is that we want to feel.

Sensitivity to touch is measured via the minimum pressure needed to detect a sensation.

Touch sensitivity varies drastically over the skin. The lips are the most sensitive. Maybe this is why we kiss with our lips?

Females are more sensitive than males.

Touch & the somatic senses

Imagine not having it. What would you lose?

Provides information that allows you to:

Identify objects
Sense texture
Detect mechanical properties -rough, smooth, hard, fuzzy, sharp…
Feel pleasure and pain

Also:
Touch needed for normal development (growth hormone)
Social communication
Acuity of touch

Acuity is measured with 2 point thresholds. Note that this is not the same as sensitivity, although they are correlated.

Why might acuity vary over different parts of the body?

Somatosensory receptors fall into four functional classes:
- Mechanoreceptors - signal mechanical stimulation
- Proprioceptors - signal muscle tension and joint position
- Nociceptors - signal pain
- Thermoreceptors - signal temperature

Schematic of skin
There are four kinds of mechanoreceptors.
Each has unique properties.

Mechanoreceptors are differentiated in two ways:
They can be rapidly adapting or slowly adapting.
And their receptive fields can be punctate or diffuse.

Rapidly adapting (info about change or dynamic quality of stimuli)
- Found just beneath the epidermis of fingers, palms, and soles.
- Receptive fields are punctate.
- Most common receptors of glabrous skin (smooth and hairless).
- Account for ~40% innervation of the human hand.
- Responds best to low frequency vibration (30-50 Hz).

Images removed due to copyright considerations.

Figure 11.1, p. 382.

Acuity is measured with 2 point thresholds.
Note that this is not the same as sensitivity, although they are correlated.
Located in the epidermis, precisely aligned with dermal ridges.

Punctate receptive fields.

~25% of the receptors in hand, and are particularly dense in the fingertips, lips, and external genitalia. Stimulation introduces a sense of light pressure.

Located deep in the skin, as well as in the ligaments and tendons.

Diffuse receptive fields.

Particularly responsive to stretching. They account for ~20% of the receptors in the hand.

To summarize the mechanoreceptors:

<table>
<thead>
<tr>
<th></th>
<th>Rapidly Adapting</th>
<th>Slowly Adapting</th>
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</thead>
<tbody>
<tr>
<td>Punctate</td>
<td>Meissner Corpuscle</td>
<td>Merkel Disk</td>
</tr>
<tr>
<td>Diffuse</td>
<td>Pacinian Corpuscle</td>
<td>Ruffini Ending</td>
</tr>
</tbody>
</table>

Proprioceptors: “receptors for self.” Primary purpose is to give info about position of limbs and body parts

Include (low-threshold): muscle spindles, golgi tendon organs, and joint receptors

Muscle spindles: Provide info about muscle length

Muscle Spindles & Golgi Tendon Organs

- Muscle spindles: tightly wound coils around a muscle fiber. Sensitive to muscle stretch/elongation

Muscle spindles: located in tendons, axons in collagen fibers, so that if tendon is stretched, they are compressed and fire

* Golgi-tendon organs: located in tendons, axons in collagen fibers, so that if tendon is stretched, they are compressed and fire
Nociceptors: from the Latin nocis, “hurt”

Nociceptors are just nerve fibers of various sorts.
Only lightly myelinated, or unmyelinated.
Conduct slowly compared to mechanoreceptors.

Aβ family (myelinated) and C fibers (unmyelinated)
Both typically have large receptive fields
Aβ mechanosensitive nociceptors
Aβ mechanothermal nociceptors

First and second pain:
Myelinated and unmyelinated pain fibers convey signals at different speeds.

On to the Cortex…

Two main systems:
1) subsystem for detecting mechanical stimuli (touch, vibration, pressure)
2) subsystem for detecting painful stimuli and temperature

Why do some objects feel cold (steel), whereas others feel warm (plastic)?
Why do cold objects feel heavier than warm objects (coin experiment)?

Two paths to cortex:
Dorsal column-medial lemniscus pathway:
info from mechanoreceptors that mediate tactile discrimination and proprioception

Spinothalamic (anterolateral pathway):
pain and temperature sensation
Both pathways project to the ventral posterior nucleus of the thalamus.
Note that motor cortex and somatosensory cortex are right next to each other in the brain. This is probably because much of touch involves bodily motion, and motor and somatosensory info need to be integrated.

There is a map of the body laid out in somatosensory cortex. Some body parts get more area than others. The area devoted to a particular body part is determined by the receptor density there.

This map is often known as the homunculus.

Somatosensory Cortex: 6 Principles of Sensory Cortical Organization/Function

1. Cortical Maps
2. Multiple Cortical Areas
3. Cortical Columns
4. Cortical Magnification
5. Mirror Maps between Cortical Areas
6. Adult Cortical Plasticity

Somatosensory Cortex: 2. Multiple Cortical Areas

* Penfield in humans and Woolsey and colleagues using recordings in animals defined area SII
* Large, sometimes bilateral receptive fields
* Robust attentional modulation of activity level & firing synchrony across neurons

Figure 11.9, p. 398.


(Image removed due to copyright considerations.)
<table>
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<tr>
<th>Somatosensory Cortex: 3. Cortical Magnification</th>
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<tbody>
<tr>
<td>* Cortical Magnification Rule: Space devoted to a skin surface is inversely proportional to the size of the receptive field in that area (<a href="#">Sur et al., 1980</a>).</td>
</tr>
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<thead>
<tr>
<th>Somatosensory Cortex: 4. Cortical Columns</th>
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<tbody>
<tr>
<td>* Also discovered &amp; explicated by Mountcastle, cells in a vertical dimension across the layers of the neocortex tend to have the same rf</td>
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<tr>
<th>Somatosensory Cortex: 5. Mirror Maps</th>
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<tr>
<th>Somatosensory Cortex: 6. Adult Cortical Plasticity</th>
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<tr>
<th>Somatosensory Cortex: 6. Adult Cortical Plasticity</th>
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<tr>
<td>* Phantom Limbs, reference zones</td>
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<th>Perceptual Consequences</th>
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Perceptual Consequences Beyond Phantom Limb?

* Increased spatial tactile resolution in 'reference' zones.
First discovered by Teuber (founder of the Department)
* Possible cause?

Cortical Plasticity: Adaptive Effects

Trained skin regions develop expanded cortical representations
String instrument players have expanded representations of the 'picking' hand

Cortical Plasticity: Adaptive Effects

Blind individuals activate visual cortex when they read braille.
Zapping occipital cortex in the blind impairs tactile discriminations.
Normal people can get tactile-induced occipital activation if they walk around with a blindfold for a week.

Haptics - interaction between touch and movement/proprioception.

Spatial frequency & amplitude of textures
Why doesn’t the texture change as you change the rate that you move your finger?
Remember efference copies?

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Figure 11.3, p. 384.