Receptor Types

• Several Classification Systems

• Location of stimulus:
  • Interoceptors (monitor events within the body)
  • Exteroceptors (monitor events outside the body)
  • Proprioceptors (monitor changes in position of body or its parts).

• Type of stimulus:
  • Chemoreceptors (chemical senses)
  • Photoreceptors (visual)
  • Thermoreceptors (hot, cold)
  • Mechanoreceptors (mechanical deformation)
  • Nociceptors (pain).
Receptor Types (cont.)

- **Long or short receptors:**
  - **Short receptors** are usually receptors that contact the next cell in its neural pathway close to the site of transduction (e.g., photoreceptors and bipolar cells).
  - **Long receptors** are usually unipolar cells that have a specialized ending to an axon-like structure. The neuron has a long distance to conduct information to CNS (e.g., touch, temperature).
  - **Receptor potential** is often called a *generator potential*.

- **Differential rate of adaptation**
  - **Fast adapting**: transient response to stimulus onset and/or offset. With sustained stimulation, receptor stops responding (“on-off”).
  - **Slow adapting**: continued responding with sustained stimulation (“on” sustained).
Receptive fields and adaptation

- 2-point threshold – minimum distance needed to perceive two points
- Point localization

12.2

12.3

<table>
<thead>
<tr>
<th>Adaptation</th>
<th>Receptive field size</th>
<th>Small</th>
<th>Large</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapid</td>
<td>Meissner’s corpuscle</td>
<td></td>
<td>Pacinian corpuscle</td>
</tr>
<tr>
<td>Slow</td>
<td>Merkel’s disk</td>
<td></td>
<td>Ruffini’s ending</td>
</tr>
</tbody>
</table>

Stimulus probe movement
Axon firing
Unipolar (DRG) cell: Axonal Fibers

Fiber Classifications

GENERAL Classification system

<table>
<thead>
<tr>
<th>Fiber Type</th>
<th>Diameter (μm)</th>
<th>Speed (m/s)</th>
<th>Spike Duration (ms)</th>
<th>Abs. Ref. Per. (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aα</td>
<td>3-20</td>
<td>75-120</td>
<td>0.4-0.5</td>
<td>0.4-1</td>
</tr>
<tr>
<td>Aβ</td>
<td>6-12</td>
<td>30-75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aγ</td>
<td>3-6</td>
<td>15-30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aδ</td>
<td>2-5</td>
<td>12-30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>&lt;3</td>
<td>3-15</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>C (nonmyelinated)</td>
<td>0.1-1.5</td>
<td>0.5-2.3</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Sometimes used for SENSORY neurons.

<table>
<thead>
<tr>
<th>Number</th>
<th>Fiber Type</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ia</td>
<td>Aα</td>
<td>Muscle spindle, annulospiral ending</td>
</tr>
<tr>
<td>Ib</td>
<td>“</td>
<td>Golgi Tendon Organ</td>
</tr>
<tr>
<td>II</td>
<td>Aβ</td>
<td>Muscle spindle, flowerspray ending, touch, pressure</td>
</tr>
<tr>
<td>III</td>
<td>Aδ</td>
<td>Pain and cold receptors; some touch receptors</td>
</tr>
<tr>
<td>IV</td>
<td>C (dorsal root)</td>
<td>Pain, temperature, and other receptors</td>
</tr>
</tbody>
</table>
Figure 12.8 The structure of a segment of the spinal cord and its roots.

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Uncrossed Spinothalamic/Dorsal Column-medial lemniscus

1. Nucleus cuneatus (arms)
2. Nucleus gracilis (legs)
3. Dorsal columns

Ventral Posterior Lateral
Medial Lemniscus

Stimulus probe
Receptive field
Median nerve
Lateral Spinothalamic: Temperature and Pain Pathways

12.26

Receptor

1°
Unipolar or DRG cells

12.29

2°
Lateral spinothalamic or Transmission cells

3°
Primary somatosensory cortex (SI)

VPL

Substantia gelatinosa
Dorsal root
C fiber
Ventral root
Zone of Lissauer

to brain

Figure 12.26 Spinal connections of nociceptive afferent axons.
Face and brain stem

12.15

Figure 12.15 The trigeminal nerve pathway. This is the route by which somatosensory information from the face reaches the cerebral cortex.

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Trigeminal (CN 5): Medial lemniscus – touch, pressure
Trigeminal Spinothalamic – temperature, pain**
Figure 12.16 Somatic sensory areas of the cortex. All of the illustrated areas lie in the parietal lobe. The lower drawing shows that the postcentral gyrus contains S1, area 3b.

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Homunculus at Cortex

Which side of the body?
Cortical cells within the homunculus

(12.21) Owl money cortex
Cortical columnar organization and receptive fields

Each area (Brodmann’s) receives input from one type of receptor from a specific body part.

RA = Rapid adaptation
SA = Slow adaptation

Note overlapping receptive fields of receptors.

Cells in column share same central location on the skin.

Size of 2-point threshold depends upon lateral inhibition.
Clinical symptoms

Consider the following:
1. What symptoms would occur at each site of injury?
2. Conversely, if you were given a set of symptoms, could you deduce the injury site, which side, etc?

Sites of injury:
1. Lumbar (L5)
2. Cervical (C2-C3)
3. Brainstem at tectum
4. Cortical injury
Pressure Sensitivity

- Receptor density
- Size of receptive fields
- Dermatomes
- Somatosensory topography
- Cortical area

Figure 5.7. Regional variations in the tactile sensitivity of males. Females show a similar distribution of tactile sensitivity but were slightly more sensitive than the males. The measurements were made with a set of modified von Frey-type nylon filaments calibrated on a chemical balance for the force exerted. (Figure 10-2 from Weinstein, 1968.)
Point Localization

Same factors:
Point Localization
2-point threshold

Slight gender differences
Side differences
Pressure Receptor

- **Pacinian corpuscle**
  - Wrapped in a lamellated capsule, appears like an onion in cross section. Layers (20-70) of thin epithelial cells, with fluid spaces between adjacent layers.
  - **Rapid adapting; large receptive field**

- **Stimulus**
  - Rapid indentation of skin surface.
  - It can respond to indentations as small as 1 micrometer.
Touch Receptors

- **Hair follicles**
  - Endings vary. Usually short receptor.
  - Bending hair deforms receptor and leads to short burst of action potentials in neuron.
  - Rapid adapting (“bending hair follicle”).

- **Meissner’s corpuscle**
  - Oriented with long axis perpendicular to skin surface.
  - Elongated, encapsulated endings in hairless skin (glabrous; e.g., finger tips) just below the epidermis.
  - Detection of textured objects
  - Rapid adapting (“indentation”); small receptive field.
Touch Receptors (Cont.)

- **Ruffini Cylinder**
  - Encapsulated ending of collagenous strands with processes intertwined.
  - Parallel orientation to surface: Detects skin stretching?
  - Slow adapting (“steady indentation”).
  - Large receptive field.

- **Merkel Ending**
  - Receptor (?): Disc-shaped expansion of the terminal ending of a neuron is inserted into a specialized cell called a Merkel cell.
  - Synapse with nerve ending (receptor?).
  - Thought to be involved in “haptic” discrimination – edges, shapes, textures.
  - Slow adapting (“steady indentation”).
  - Small receptive field.