The Special Senses

Auditory
The Nature of Sound

- All waves have basic characteristics:
  - Amplitude
  - Frequency
  - Wavelength

- These properties have particular names with reference to sound
  - Amplitude = loudness
  - Frequency = pitch
The Nature of Sound

- Sound
  - Range: 20 Hz to 20,000 Hz
  - Pitch: High pitch = high frequency; low frequency = low pitch
  - Intensity: High intensity louder than low intensity
Anatomy of the ear

Frontal section through the right side of the skull showing the three principal regions of the ear:

- Auricle
- Temporal bone
- Semicircular canal
  - Vestibulocochlear (VIII) nerve:
    - Vestibular branch
    - Cochlear branch
  - Internal auditory canal
- Cochlea
- To nasopharynx
- Elastic cartilage
- Cerumen
- Stapes in oval window
- Round window (covered by secondary tympanic membrane)
- External auditory canal
- Tympanic membrane
- Auditory tube
Anatomy of the ear
(a) Sections through the cochlea
(c) Section through one turn of the cochlea
(c) Section through one turn of the cochlea

- Tectorial membrane
- Hair bundle
- Outer hair cell
- Supporting cells
- Inner hair cell
- Basilar membrane
- Cells lining scala tympani
- Sensory and motor fibers in cochlear branch of vestibulocochlear (VIII) nerve

(d) Enlargement of spiral organ (organ of Corti)
Pivot points for tectorial and basilar membranes are offset.

- Inner hair cell
- Outer hair cells
- Basilar membrane
Receptor potential

Neural spike

Spontaneous activity
Increased impulse frequency
Depolarization

Excitation

Decreased impulse frequency
Hyperpolarization

Inhibition
Hyperpolarization

Depolarization

Nucleus

Ca²⁺ channel

Vesicles

Transmitter

Afferent nerve

To brain

Increased impulse frequency

Excitation

Decreased impulse frequency

Inhibition
Mechanically gated $K^+$ channels

(a) At rest (partially depolarized)
(b) Depolarized
Freqency of vibration at different regions of the basilar membrane:

- Near oval window, basilar membrane is narrow and stiff.
- Near helicotrema, basilar membrane is wide and flexible.

High-frequency sound:
- Oval window

Low-frequency sound:
- Oval window

Graph shows the width of the basilar membrane at different frequencies.

© 2011 Pearson Education, Inc.
transverse gyri of Heschl
Olivocochlear descending feedback loop
Middle ear reflex arc
Acoustic startle reflex
Types of Deafness

- **Conductive Deafness**
  - Due to impaired sound transmission in external and middle ear
  - Impacts all sound frequencies
  - Causes:
    - Plugging of the EAC with cerumen or foreign body
    - Otitis externa and otitis media
    - Perforation of eardrum
    - Osteosclerosis
Types of Deafness

- **Sensorineural Deafness**
  - Due to loss of cochlear hair cells
  - Problems with CN VIII
  - Lesions within the Central Auditory Pathway
  - Impairs the ability to hear certain pitches (permanent)
  - Causes:
    - Aminoglycosides
    - Prolonged exposure to noise
  - Tumors and vascular damage (presbyacusis)
Tinnitus

Some of these causes include high blood pressure, diabetes, listening to loud music, a tumor, thyroid conditions, and medications / antidepressants, sedatives, antibiotics, anti-inflammatory drugs, and aspirin.
Pontine auditory hallucinosis

- an orchestra out of tune, buzzing insects, or strands of music. These perceived auditory events are accompanied by more typical symptoms of pontine lesions of auditory, such as cranial nerve deficits and long tract signs. A perception of noise or sounds may also be experienced by patients with temporal lobe seizures or a temporal lobe lesion that damages auditory cortices.
Rinne and Weber Tests
Rinne’s test
Weber’s test
<table>
<thead>
<tr>
<th></th>
<th>Weber</th>
<th>Rinne</th>
<th>Schwabach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Method</strong></td>
<td>Base of vibrating tuning fork placed on vertex</td>
<td>Base of vibrating tuning fork placed on mastoid</td>
<td>Bone conduction of patient compared with that</td>
</tr>
<tr>
<td></td>
<td>of skull.</td>
<td>process until subject no longer hears it, then</td>
<td>of normal subject.</td>
</tr>
<tr>
<td><strong>Normal</strong></td>
<td>Hears equally on both sides.</td>
<td>held in air next to ear.</td>
<td></td>
</tr>
<tr>
<td><strong>Conduction deafness</strong></td>
<td>Sound louder in diseased ear because masking</td>
<td>Vibrations in air not heard after bone</td>
<td>Bone conduction better than normal (conduction</td>
</tr>
<tr>
<td>(one ear)</td>
<td>effect of environmental noise is absent on</td>
<td>conduction is over.</td>
<td>defect excludes masking noise).</td>
</tr>
<tr>
<td></td>
<td>diseased side.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sensorineural deafness</strong></td>
<td>Sound louder in normal ear.</td>
<td>Vibration heard in air after bone</td>
<td>Bone conduction worse than normal.</td>
</tr>
<tr>
<td>(one ear)</td>
<td></td>
<td>conduction is over, as long as nerve deafness</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>is partial.</td>
<td></td>
</tr>
</tbody>
</table>