Sound Waves

Compressed

Rarefied (negative pressure)

Sound waves

Eardrum
The Physical and Perceptual Dimensions of Sound Waves

<table>
<thead>
<tr>
<th>Physical Dimension</th>
<th>Perceptual Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amplitude (intensity)</td>
<td>Loudness</td>
</tr>
<tr>
<td>Frequency</td>
<td>Pitch</td>
</tr>
<tr>
<td>Complexity</td>
<td>Timbre</td>
</tr>
</tbody>
</table>

- loud vs. soft
- low vs. high
- simple vs. complex
Cross section through the Cochlea

- Tectorial membrane (vibrations exert stretch on cilia of hair cells)
- Outer hair cells
- Inner hair cell
- Axons of auditory nerve
- Basilar membrane
- Organ of Corti
- Auditory nerve
- Spiral ganglion
- Bone
- Membrane surrounding cochlea

Slice Through Cochlea

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Responses to Sound Waves

- Sound waves enter the ear and cause the eardrum to vibrate.
- The vibration is transmitted through the ossicles (malleus, incus, and stapes).
- The stapes moves against the oval window, causing the basilar membrane to vibrate.
- Different frequencies of sound cause vibrations at specific regions of the basilar membrane.
- This stimulation of the basilar membrane is detected by the inner ear and transmitted to the brain.

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The Experimental Setup used by Denk et al. (1995) to Detect the Influx of Calcium into the Cilia of Hair Cells of the Inner Ear

The Pathway of the Auditory System
Receptive Organ of the Semicircular Canals

- Semicircular canals
- Vestibular sacs (utricle and saccule)
- Vestibular nerve
- Cochlea
- Section of ampulla
- Filled with endolymph
- Cupula
- Hair cells
- Axons of ampullary nerve

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Cutaneous Receptors

- Hairy Skin
- Glabrous Skin
- Hair
- Sweat gland
- Merkel's disks
- Free nerve endings
- Meissner's corpuscle
- Ruffini corpuscles
- Pacinian corpuscle
- Artery
- Vein
- Subcutaneous fat
Hypothetical Explanation of Transduction of Somatosensory Information

- Mechanical force opens ion channel
- Carbohydrate chains linked to ion channel
- Cations enter, membrane depolarizes
- Ion channel

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Somatosensory Pathways from the Spinal Cord to the Somatosensory Cortex

- Primary somatosensory cortex
- Ventral posterior nucleus of thalamus
- Midbrain
- Nuclei of the dorsal columns
- Medulla
- Dorsal columns (precise touch, kinesthesia)
- Spinothalamic tract (pain, temperature)
- Dorsal root ganglion

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Neural Circuit That Mediates Opiate-Induced Analgesia

- Opiates inhibit activity of inhibitory neuron, thus removing inhibition on neuron that communicates with nucleus raphe magnus.
- To brain: Axon contains opiate receptors.
- Pain pathway: Interneurons inhibit neurons that transmit pain messages to brain.
- Cell body in dorsal root ganglion: Pain receptor.

Locations:
- Periaqueductal gray matter in midbrain
- Nucleus raphe magnus in medulla
- Dorsal horn of spinal cord gray matter
The Tongue

(a) Papilla
   Surface of tongue

(b) Taste buds
    Taste receptors
    Afferent axons
Transduction of Taste Information

1. Sodium ions enter ion channel, depolarize membrane.
2. Hydrogen ion binds with receptor, closes potassium channel. Potassium ions cannot leave cell, membrane depolarizes.
3. Bitter substance binds with receptor, activates gustducin, which activates phosphodiesterase, destroying cyclic AMP.
4. Sweet substance binds with receptor, activates gustducin, which activates an enzyme, producing cyclic AMP.

- Receptor
- Gustducin
- Phosphodiesterase
- Enzyme
- Cyclic AMP

(a) Salty
(b) Sour
(c) Bitter
(d) Sweet

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Neural Pathways of the Gustatory System

Ventral posteromedial nucleus of thalamus
Primary gustatory cortex
Lateral hypothalamus
Amygdala
Chorda tympani (branch of Vllth nerve)
Nucleus of the solitary tract
IXth nerve
Caudal medulla
Xth nerve
The Olfactory System

- To thalamus, orbitofrontal cortex
- To hypothalamus
- To amygdala
- Piriform and entorhinal cortex (Primary olfactory cortex)
- Olfactory bulb
- Olfactory mucosa
- Turbinate bones
- Tongue
- Myelin sheath
- To olfactory bulb
- Axons
- Olfactory receptor cell
- Supporting cell
- Cilia of olfactory receptor cells

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