Thinking About Sound Waves

Waves vary in how many molecules are moved (amplitude) and how many waves per second (frequency).

Characteristics of Sound Waves

- https://www.youtube.com/watch?v=flIAxGsV1g0 A diagrammatic tour through the ear
- http://www.youtube.com/watch?v=U_HUgzhmq4U Real life views of the auditory structures

Fluid Motion in Cochlea
Cross section of Cochlea

Auditory Nerve fibers Basilar Membrane

http://www.youtube.com/watch?v=8wgfowbbTz0

Fluid Waves Traveling Thru Cochlea Cause Basilar Membrane Movement

- Where wave peaks varies with pitch & determines which hair cells will be most stimulated.

Georg von Bekesy – 1961 Nobel Prize for his research on the traveling waves in the cochlea.

http://www.youtube.com/watch?v=dyenMluFaUw&feature=related

http://www.youtube.com/watch?v=WO84KJyH5k8&feature=related

“Tonotopic” Relationship Between Place in Cochlea and Pitch

If our inner ear is working perfectly we can hear sound frequencies between 20-20,000 cps

Friction on tips of hair cells opens mechanically-gated K+ ion channels

K+ enters hair cells causing depolarization & transmitter release! (fluid in cochlea has a different ion balance – disruption of that balance can lead to hearing abnormal sounds (tinnitus))

Normal & “Trampled” Hair Cells Exposed to Loud Sounds

- http://www.youtube.com/watch?v=5095wqQySf0 (dancing hair cell)
- http://www.youtube.com/watch?v=Vvlk2ZulDoO (stereocilia)
Sound Localization

Brain processes time of arrival & intensity differences in what the right & left ears hear. Sound from right arrives sooner and louder in the right ear.

Note: Input from each ear goes to both sides of brain but more strongly to contralateral side. Brainstem areas involved in quick unconscious sound localization and auditory reflexes. Input passed on to cortex for our conscious awareness of sound. Notice that like the visual pathway the auditory pathway makes a processing stop in thalamus before going to cortex.

Types of Deafness

- ~250 million with hearing impairments; only a fraction are completely deaf
- Conductive or Middle Ear Deafness – auditory stimulus does not pass normally through middle ear to cochlea
- Nerve/Neural or Inner Ear Deafness – due to damage to inner ear hair cells or auditory nerve due to:
  - Genetics
  - Perinatal problems (illness during pregnancy, hypoxia during birth, fetal Alcohol Syndrome)
  - Illness (meningitis, MS, Merei's)
  - Ototoxic drugs (quinine, some antibiotics, high doses of NSAIDS, nicotine),
  - Loud sounds
- Test your hearing – have you lost your upper range already?
  - http://www.youtube.com/watch?v=9g0yThhJcxY
- Mosquito tones

Cochlear Implant can take the place of missing or damaged hair cells as long as auditory nerve fibers still run from cochlea to brain.
The Somatosensory System

Spinal Roots and Nerve
- 2 pathways carry sensations to brain:
  - Discriminative touch & Proprioception
  - Pain & Temperature

Somatosensory Cortex
- Pain also activates cingulate cortex to trigger emotional response
- Cortical map can change if you lose body part
Somatosensory Agnosias

- Astereognosia – can’t recognize objects by touch
- Asomatognosia – failure to recognize body parts as yours

The Experience of Pain

- Tissue injury leads to release of irritating chemicals (histamine, prostaglandins & others) which activate pain receptors & make receptors more sensitive
- Receptors release glutamate (when pain is mild) & also Substance P (when pain is more intense)

Cell Injury Causes Release of Compounds That Irritate Pain Receptor

Over the counter pain relievers work mostly by decreasing these irritating chemicals

The pain you experience does not just depend on the activation of pain receptors. It also depends on whether the pain “gate” is open or closed.
Several pain treatments probably activate sensory receptors which can close the gate:
- Acupuncture
- Linaments
- TENS
- Massage
- And even placebos

Gate can also be closed by descending pain control system.

Taste

Fungiform Papillae
(on the front of tongue)

Tastes Buds on Sides of Papillae

We only have taste receptors for these qualities: sweet, sour, salty, bitter, and “umami” (meaty flavor). Most of what we call “flavors” (orange, grape, bubble gum, etc) depend on smell more than taste.
Taste Bud

- Many receptors in a bud
- Specialized skin cells replaced every 10-14 days
- But have excitable membranes and release transmitter like neurons
- Receptors sensitive to salty, sour, sweet, bitter & "umami"
  - Salty opens Na+ channels,
  - Sour receptors also seem to be ionotropic.
- The others activate G proteins like metabotropic receptors.

Olfactory Nerves

- G-protein type receptors on cilia.
- In contrast to taste, hundreds of different types of olfactory receptors.
- In the rat, 1% of its genome is devoted to making these receptors. In humans at least 350 such genes.
- Cilia are dendrites dangling down from your nasal membranes

Olfactory Receptors

- Olfactory Bulbs connect to limbic system.
- Cells in olfactory bulb and olfactory cortex organized by type of odor

Olfactory Nerves in a precarious position in head injuries

- Head injuries can cause "anosmia" by shearing off these connections.
- People can also be born with specific anosmias (due to genetics)