9.04
Audition Lectures

- Second half of course
- Given by Chris Brown

Introductory Reading (see course website):

Brown, M. C. and J. Santos-Sacchi (2008). Audition. Fundamental Neuroscience. 3rd ed. Edited by L. R. Squire et al. New York, Elsevier

Textbook:

Auditory Neuroscience: Making Sense of Sound (2011) by J. Schnupp, I. Nelken, A. King. Cambridge, MA: MIT Press.

9.04: List of Lectures for Audition (see course website)

- **Oct. 28. Sound; External, middle, and inner ears**

  Research Report: Hofman, P. M., J. G. A. Van Riswick and J. Van Opstal (1998). Relearning sound localization with new ears. Nature Neurosci. *1:* 417-421.

- **Oct. 30. Hair Cells: Transduction, Electrophysiology and "Cochlear Amplifier"**

  Research Report: Liberman MC, Gao J, He DZZ, Wu X, Jia S and Zuo J (2002) Prestin is required for electromotility of the outer hair cell and for the cochlear amplifier. Nature 419: 300-304.

- Etc, etc, etc,

- **Written Assignment for Audition**

- Final Exam

The Auditory Periphery: External, Middle and Inner Ears

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- The inner ear structure involved in hearing is the cochlea. Its name comes from the Greek word, kokhlias, which means "snail". Like a snail shell, the cochlea is a long, coiled tube. Along this tube, sound vibrations are separated according to frequency (see next page of the handout).

- Within the cochlea are receptor cells (hair cells) that transduce the mechanical energy of sound into electrical signals, which are used in the nervous system. The auditory nerve fibers transmit these signals to the brain.

Frequency Coding in the Auditory System: Place vs. Time coding

Place Coding: Auditory Nerve Fibers are Tuned to Sound Frequency

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Response of a fiber to obtained by sweeping sound frequency at a number of different sound levels. Each vertical blip (response or action potential) occurs in a limited region whose outline is called the tuning curve.   At low levels, responses are narrowly tuned to frequency.

7LPH&RGLQJ $XGLWRU 1HUYH)LEHUV3KDVH/RFNWRWKH6RXQG:DYHIRUP

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Synchronization of spikes for a low-frequency stimulus. Shown are several superimposed traces. The spikes cluster at one particular phase of the sound waveform, even though the waveforms are less than 1 millisecond apart. This ability to phase lock to high-frequency stimuli is unique to the auditory system.

Cochlear Implant: Electrical Stimulation of Nerve Fibers in Deaf Patients

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- Diseases and other processes can cause hearing loss. For instance, most of us lose hearing as we grow older, a process known as presbycusis. Also, loud sounds and certain drugs can damage the sensory cells – if these cells are destroyed, deafness results.

- A cochlear implant can restore hearing in deaf individuals. The cochlear implant is the most successful neural prosthesis. Although many cochlear implant users can understand speech, there are limitations and there is variability in implant success between individuals.

- Some deaf individuals who lack an auditory nerve cannot benefit from a cochlear implant. In these individuals, an auditory brainstem implant can be placed directly onto the brainstem. This device does not restore speech comprehension as well as a cochlear implant.

Binauaral Cues for Sound Localization

Interaural time differences

Interaural level differences

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The Auditory Central Nervous system: Many Brainstem Nucleii

Ascending Auditory System

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Compared to the visual and other sensory systems, the auditory central nervous system contains more nuclei in the brainstem. The primary functions of these nuclei are probably to process information concerning the location of a sound source (interaural time and interaural level differences).

Auditory Cortex

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The auditory cortex is the highest level of the auditory pathway.
Electrophysiological studies in animals have revealed the presence of at least 7 different cortical areas in animals like the cat. Area AI is likely to be involved in sound localization behavior, since after it is lesioned, cats have trouble localizing sounds. The functional importance of the other cortical areas is not well known.

Human Cortex

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- In humans, the auditory cortical areas are located on the superior surface of the superior temporal gyrus. Nearby fields include those devoted to processing language (Wernicke's and Broca's areas). Lesions in these areas (as sometimes occurs after interruption of the blood supply by a stroke) interrupt the processing of language or speech. These areas are unique in the nervous system in that they are lateralized to the dominant hemisphere of the cortex.

Tour, of Eaton-Peabody Laboratory:
at Massachusetts Eye and Ear Infirmary
Teaching hospital of Harvard Medical School

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