Biology 70, Lectures 5-6
Fall 2007

Biology 70
Part II
Sensory Systems
lectures 5-6

http://www.biology.ucsc.edu/classes/bio70/

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sound wave: variation in pressure (density)

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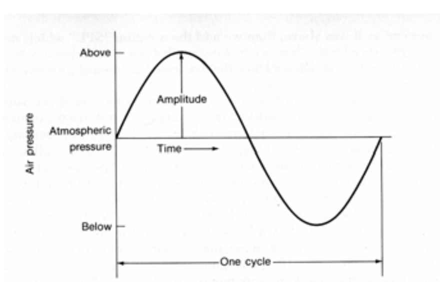
sound wave: amplitude, wavelength, frequency



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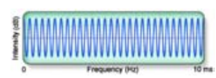
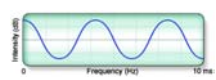
examples of sounds of various frequencies





http://www.neuroreille.com/promenade/english/sound/sound.htm

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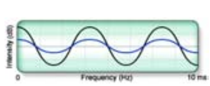
examples of variation of amplitude of sound wave



http://www.neuroreille.com/promenade/english/sound/sound.htm

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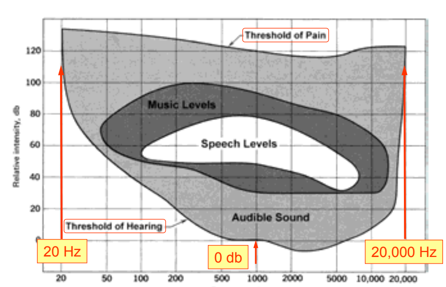
range of loudness and pitch perception



http://www.themusicpage.org/data/Sensitivity.html

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more loudness: decibels

Table 15.1
SOUND LEVELS IN DECIBELS FOR A NUMBER OF COMMON SOUNDS.

Sound	Intensity level (dB)
Rocket launch (from 150 ft)	180
Jet plane take-off (from 80 ft)	140
Pain threshold	130
Loud thunder	120
Inside subway train	100
Inside noisy car	80
Normal conversation	60
Normal office level	50
Quiet room	30
Soft whisper	20
Absolute hearing threshold (for 1000-Hz tone)	0

NOTE: Levels are only rough guesses and may vary tremendously.

loudness: decibels

Table 10.1 Some Common Sound Pressure Levels (in decibels)

Sound	Pressure (dynes/cm²)	SPL (dB)
Barely audible sound (threshold)	0.0002	0
Leaves rustling	0.002	20
Quiet residential community	0.02	40
Average speaking voice	0.2	60
Loud music from radio/Heavy traffic	2.0	80
Subway	20.0	100
The Rolling Stones	200.0	120
Jet engine at takeoff	2,000.0	140

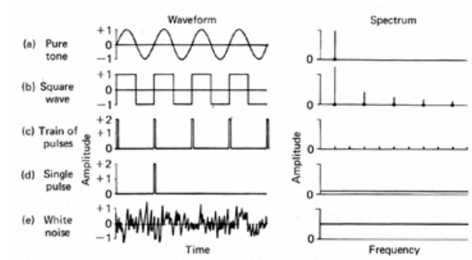
Pain threshold	**130**

from lecture outline:

1. To what properties of sound waves do each of the following refer:

- a. pitch
- b. loudness
- c. dB
- d. pure tone (sinusoid)
- e. overtone
- f. timbre
- g. echoes

sounds: waveform vs spectrum



flute 1568 Hz: a reasonably 'pure tone'

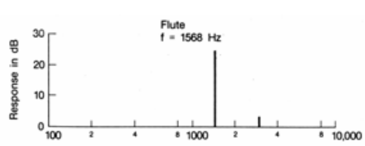
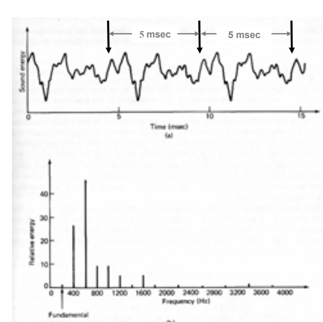


Figure 11.5 Frequency spectrum of a flute playing a tone with a fundamental frequency of 1,568 Hz. (Olson, 1967)

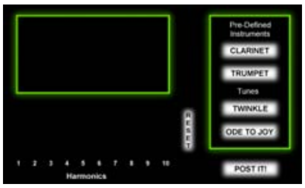
violin: G note (200 Hz)



harmonics or overtones

f is fundamental frequency

2f, 3f, 4f, … are the harmonics or overtones of *f*



http://library.thinkquest.org/19537/cgi-bin/showharm.cgi

timbre: combination of overtones giving 'quality' of note

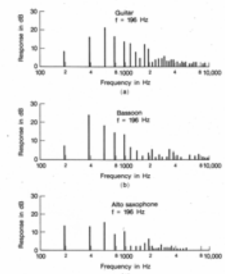


Figure 11.4 Frequency spectra for a guitar, a bassoon, and an alto saxophone playing a tone with a fundamental frequency of 196 Hz. (Olson, 1967)

from lecture #5-6 outline:

1. To what properties of sound waves do each of the following refer:

- a. pitch
- b. loudness
- c. dB
- d. pure tone (sinusoid)
- e. overtone
- f. timbre
- g. echoes

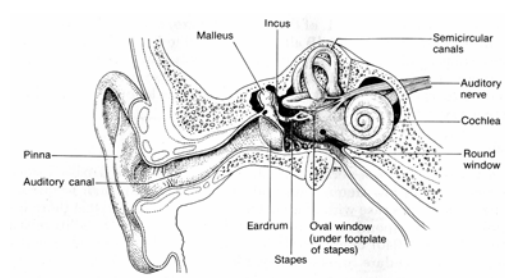
MOVIE

from lecture outline

2. Be able to identify the following parts of the ear and brain and know the functions which they perform. For the items marked with an *, be able to name a part of the eye which has an analogous function.

- a. pinna
- b. ear canal or external auditory meatus
- c. ear drum or tympanic membrane
- d. *ossicular chain (malleus, incus, stapes)
- e. *cochlea
- f. oval window
- h. tectorial membrane
- i. *hair cells
- j. *auditory nerve
- k. *muscles of the middle ear (tensor tympani, stapedius)
- l. *auditory cortex
- m. *tonotopic map

parts of the ear



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cross section of cochlea

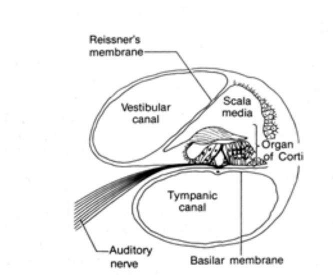
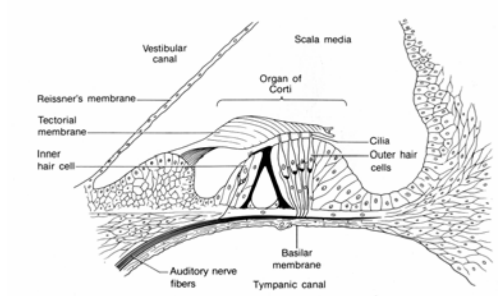
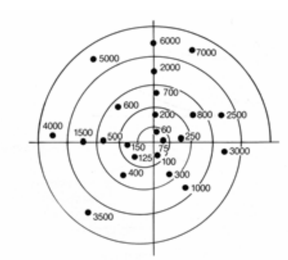


Figure 10.6

cochlea: organ of corti



pitch: activation along cochlea



auditory cortex: tonotopic mapping

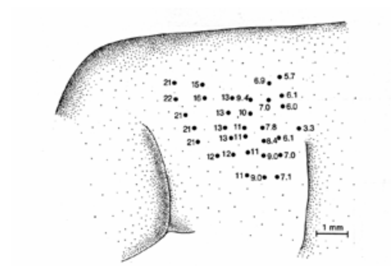


Figure 10.17 Tonotopic map on the surface of the auditory cortex of the cat. Each large dot represents a single neuron, and the number beside each dot represents the characteristic frequency of that neuron in thousands of Hz.

auditory cortex: more tonotopic mapping

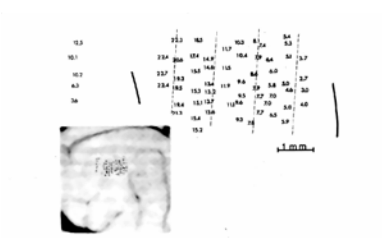
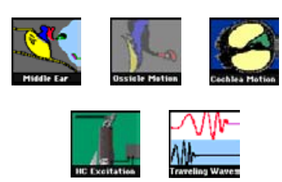


Fig. 16.9. Tonotopic map on the surface of the auditory cortex. Inset on the lower left shows exactly where this region of the brain is located. Numbers reflect the best frequencies of cells encountered at that location. From Merzenich, M. M., P. L. Knight, and G. L. Roth (1975) Representation of cochlea within primary auditory cortex in the cat. *J. Neurophysiol.* 38:231–249. Reprinted by permission.

great animations



http://www.neurophys.wisc.edu/h&b/auditory/animation/animationmain.html

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from lecture #5-6 outline

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   - l. *auditory cortex
   - m. *tonotopic map

from lecture #5-6 outline

hearing deficiencies

•conductive loss

• neural loss

from lecture #5-6 outline

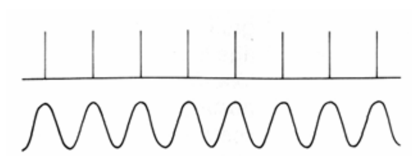
5. What are the differences between the place and frequency theories? Which is correct?

6. What is the volley principle and why is it important to the frequency theory?

7. What is binaural localization? How do phase (timing) and loudness cues contribute to our ability to localize sound?

How is pitch perceived?

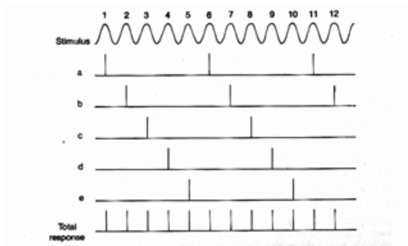
pitch perception: frequency theory



frequency theory of pitch perception

[15 Hz to 100Hz. 100Hz is 10 msec intervals]

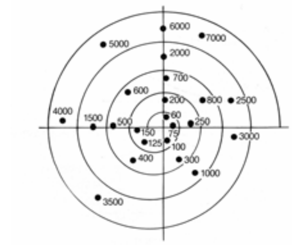
pitch perception: volley principle



Volley Principle

[100 Hz < f < 5000 Hz]

pitch detection: place theory



Place Theory

[100 Hz < f < 20000 Hz]

pitch perception: frequency vs place theories

15 Hz < f <	100 Hz	frequency theory
100 Hz < f <	5000 Hz	both (volley prin)
5000 Hz < f <	20,000 Hz	place theory

great animations

http://www.neurophys.wisc.edu/h&b/auditory/animation/animationmain.html

binaural localization

Perception of the direction of origin of a sound (localization in space)

localization of sound source: timing or phase clues

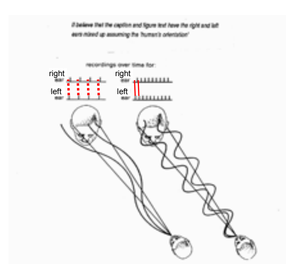


Figure 7-6. Phase differences between the ears as a cue for sound localization. Note that low pitches arrive at the ears only slightly out of phase. The ear for which the receptors fire first (here, the right one) is interpreted as being closer to the sound. The greater the difference between the ears, the farther the sound must be to the side. However, with higher-pitched sounds, as in the right part of the figure, the phase differences become too large to be useful, as it is ambiguous whether the sound wave in one ear is half a cycle ahead of the other ear or half a cycle behind.

Timing Clues

[f < 1500 Hz]

localization of sound source: loudness clues

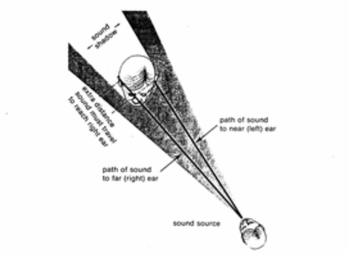


Figure 7-5. Differential loudness as a cue for sound localization. The sound shadow shown does not include the effects of diffraction or "bending" of sound waves around the head. (After Lindsay & Norman, 1972).

Loudness clues

[$f > 3000$ Hz]

from lecture outline

5. What are the differences between the place and frequency theories? Which is correct?

6. What is the volley principle and why is it important to the frequency theory?

7. What is binaural localization? How do phase (timing) and loudness cues contribute to our ability to localize sound?

FINIS !!!

please fill out class evals