

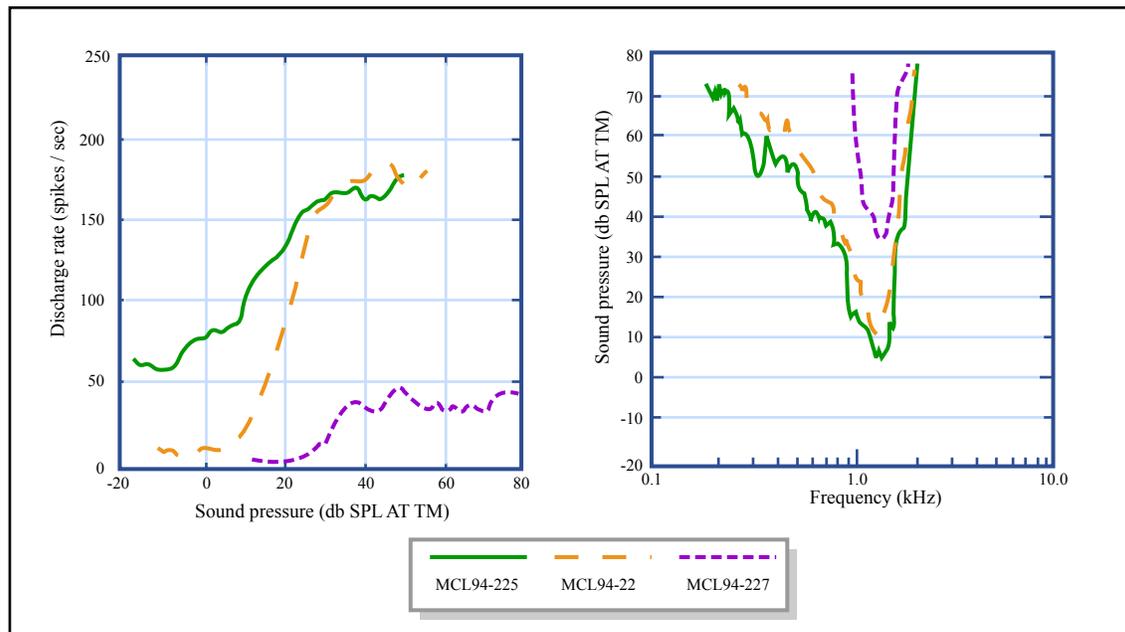
Problem Set 3: Afferent Transmission and Auditory Nerve Response

Due Date: 10-31-2005

These problems sets are intended to help you integrate the material learned in HST721. You are required to turn in individually written solutions sets. You are encouraged to work through the problems individually before discussing them in small groups. If you do work through the problems in small groups please include the names of your group members at the beginning of your write-up.

Problem 1:

The tuning curves (right) and rate-vs.-level functions (left) for tones at the characteristic frequency (CF) are shown for three auditory-nerve fibers with high, medium or low spontaneous rate (SR).



Images by MIT OCW.

- a) Identify which fiber belongs to which SR group and sketch graphically the relation between SR and threshold at the CF. Label all axes clearly.

Reconstruction of intracellularly labeled fibers such as these shows that each forms only a single afferent synapse and suggest that all three fiber types could contact the same inner hair cell.

- b) Outline the critical processes of afferent synaptic transmission both pre- and post-synaptically that theoretically should contribute to threshold sensitivity. Suggest differences in these processes that might produce the difference in sensitivity between high and low-SR fibers.

Intracellular labeling studies have also shown that low SR fibers have smaller diameters than those with high SR. The diameter difference is seen both for the unmyelinated portion within the organ of Corti and the myelinated portions outside the sensory epithelium. It has been suggested that the diameter differences per se cause the threshold differences between low- and high-SR fibers.

- c) Given what you have learned about the generation and transmission of electric potentials in nerve fibers, explain how this could come about. Assume: 1. EPSPs (excitatory post-synaptic potentials) are generated at the afferent synapse; 2. The

action potentials are generated at a point just outside the organ of Corti, at the onset point of myelination within the osseous spiral lamina.

Acoustic trauma can cause loss of stereocilia on inner hair cells: they break off at the apical surface of the cell, and the cell membrane reseals. Such stereocilia loss is correlated with an apparent decrease in SR of all auditory nerve fibers.

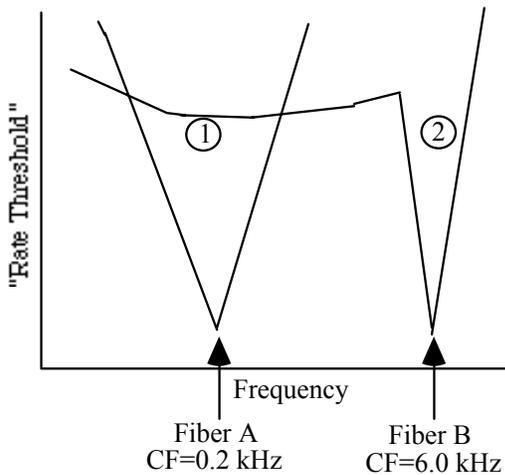
- d) Explain how loss of stereocilia might decrease spontaneous rate. Hint: 1) assume that the transduction channels are located in the tips of the stereocilia; 2) remember that the transduction channels are not always closed in the absence of acoustic stimulation

It seems possible that some (or all) of the "spontaneous" activity in the auditory nerve is actually a response to low-level noise in the environment or internal noise generated by the animal itself: i.e. that all fibers actually have low SR, and that the most sensitive fibers are always driven by background noise and thus appear to have higher SRs.

- e) How could you determine experimentally whether the rate measured in the absence of purposely applied sounds is truly "spontaneous" or actually sound-driven? Suggest a number of different experimental approaches. Hint: for one approach, think about the fine time-patterns of discharge you might expect in auditory nerve fibers if you purposely applied low-level broad-band noise (See Problem 2d).

Problem 2:

The graph to the left shows the rate-based tuning curves of two auditory nerve fibers (A and B). Assume that each of these fibers has a spontaneous rate of 50 sp/sec.



- a) Sketch the rate-vs-level functions expected for Fiber A and Fiber B for tone-burst stimulation at the CF. Supply numerical values for all axes.

- b) Sketch the **PST** histogram expected for a continuous tone presented at the frequency/level combination indicated by the numbers 1 and 2. Supply numerical values and units for all axes.

- b) Sketch the **interval** histograms expected for response to a continuous tone presented at the frequency-level combinations indicated by the numbers 1 and 2. Supply numerical values and units for all axes.

- c) Sketch the **period** histogram expected for a continuous tone presented at the frequency/level combination indicated by the numbers 1 and 2. Supply numerical values and units for all axes.

d) Sketch the **interval** histogram expected for the response to broadband noise presented at the level indicated by the numbers 1 and 2. Supply numerical values and units for all axis.