

Problem Set 4: Efferent Control

Due: 11-21-2005

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:

Explain how electrical activation of the olivocochlear bundle (OCB) leads to its peripheral effects. Discuss the molecular mechanisms underlying this effect. Include a discussion of all relevant ion channels in the OHC and of how these channels are coupled to changes in cochlear threshold sensitivity.

Problem 2:

One hypothesized functional role of the middle-ear muscle (MEM) reflex and the medial olivocochlear (MOC) efferent reflex is anti-masking, i.e. the improvement of hearing in noisy environments.

a) The MEM reflex is thought to reduce the upward spread of masking, i.e. the phenomenon whereby a low-frequency noise or tonal "masker" can raise thresholds for the percept of a high-frequency "signal" tone. The upward spread of masking arises largely from suppressive masking related to the phenomenon of "two-tone suppression".

- Describe the phenomenon of two-tone suppression, and the mechanism by which this non-linearity arises.
- Describe how sound-evoked middle-ear muscle contraction can minimize the upwards spread of masking.

b) The MOC reflex is thought to improve discrimination of high-frequency transient signals against a background of continuous high-frequency noise. This type of masking arises largely from excitatory masking which is related to the phenomenon of adaptation.

- Describe the phenomenon of adaptation in the auditory nerve and the mechanisms by which this non-linearity arises.
- Describe how the MOC reflex could minimize adaptation and thereby increase the response to a transient signal tone.
- Explain why might the impact of MOC feedback is maximal for high-frequency stimuli.

Problem 3:

Use a simplified circuit diagram of current flow through the cochlear duct to explain why activation of olivocochlear efferents to the OHCs a) increases the magnitude of the cochlear microphonic (CM) while it b) decreases the compound action potential (CAP) to a moderate-level click or tone burst and c) decreases the Endolymphatic Potential (EP).

You need to consider only 4 lumped resistances in your diagram: 1) the transduction channels, 2) the channels activated at the efferent synapses (which are found exclusively at the bases of OHCs), 3) all other channels through the basolateral OHCs, and 4) the lumped extracellular resistance. Assume: 1. CM and CAP are recorded from a wire on the RW membrane referred to the tongue; 2. CM is generated by transduction current flowing through the OHCs; 3. CAP is the summed activity of auditory-nerve fibers discharging synchronously.