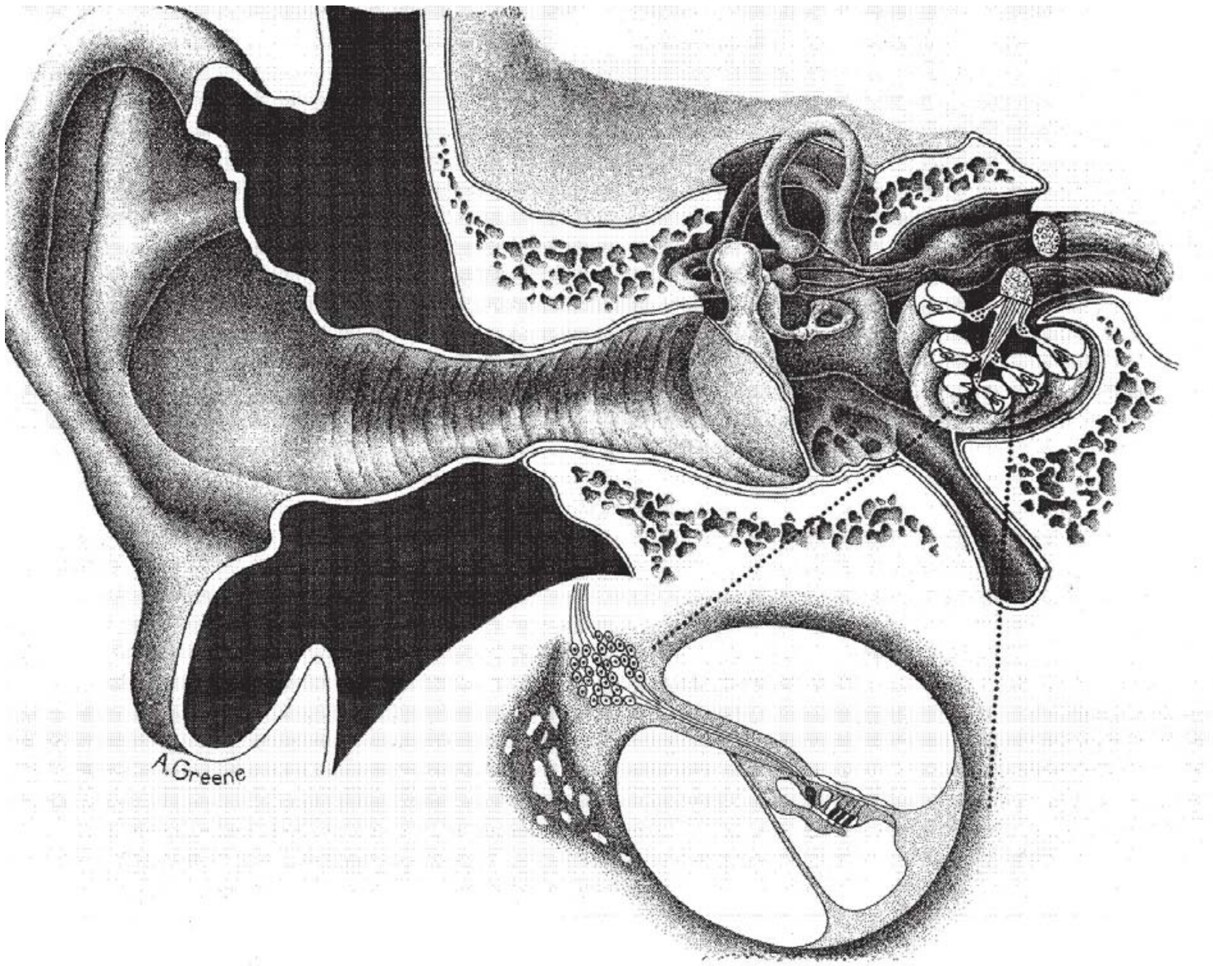
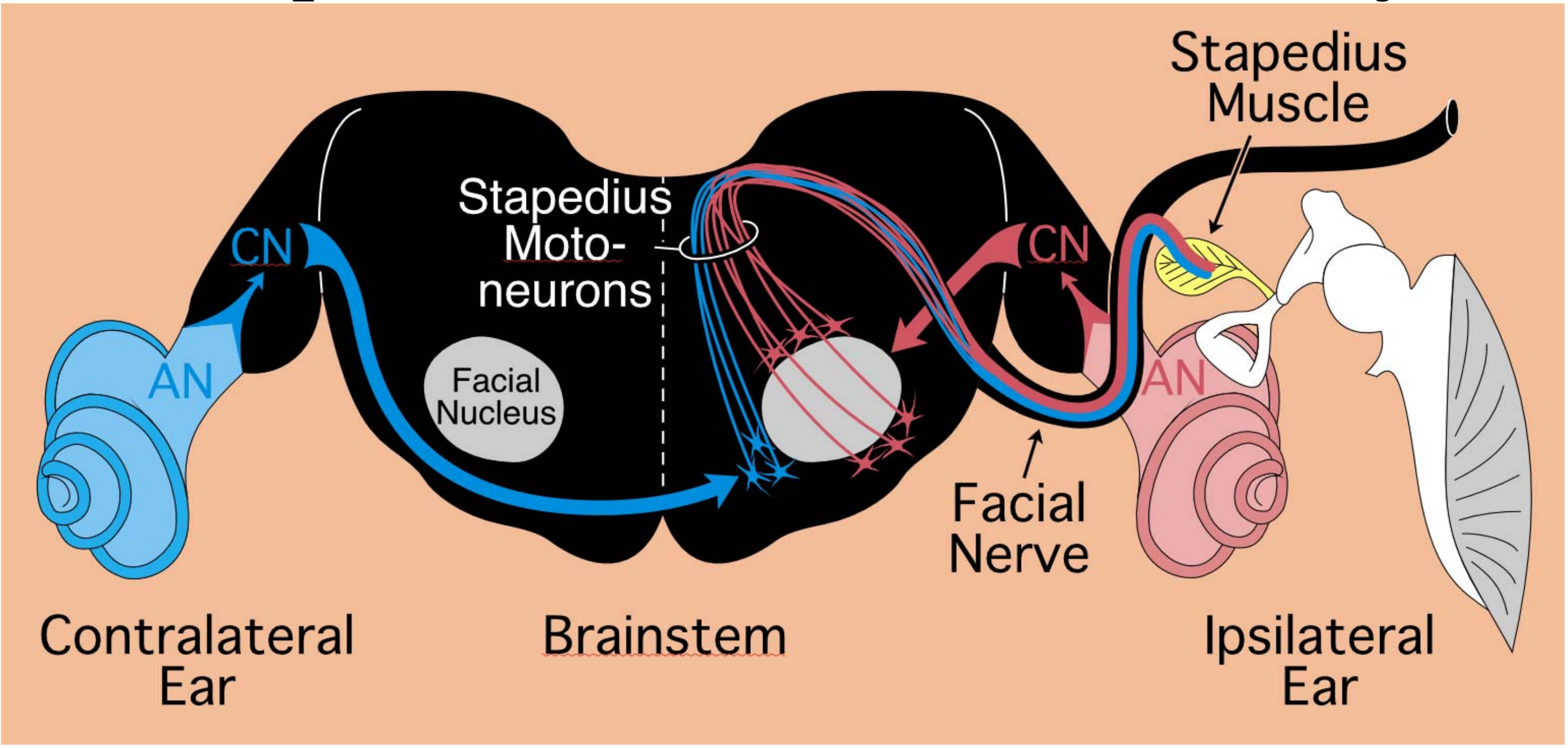
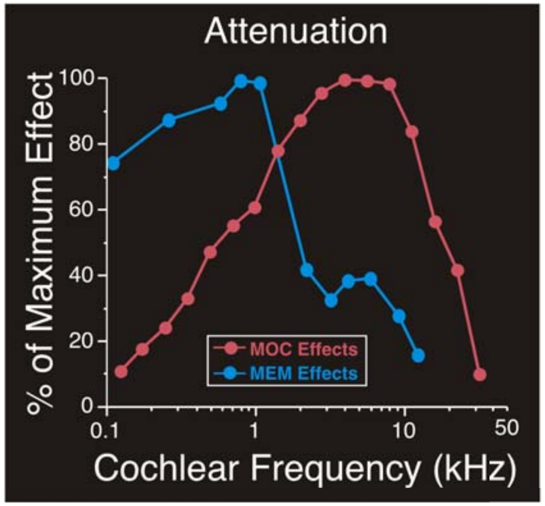
HST 721 Efferent Control Lecture

October 2004



Stapedius Muscle Central Circuitry





Hypotheses for MEM Function

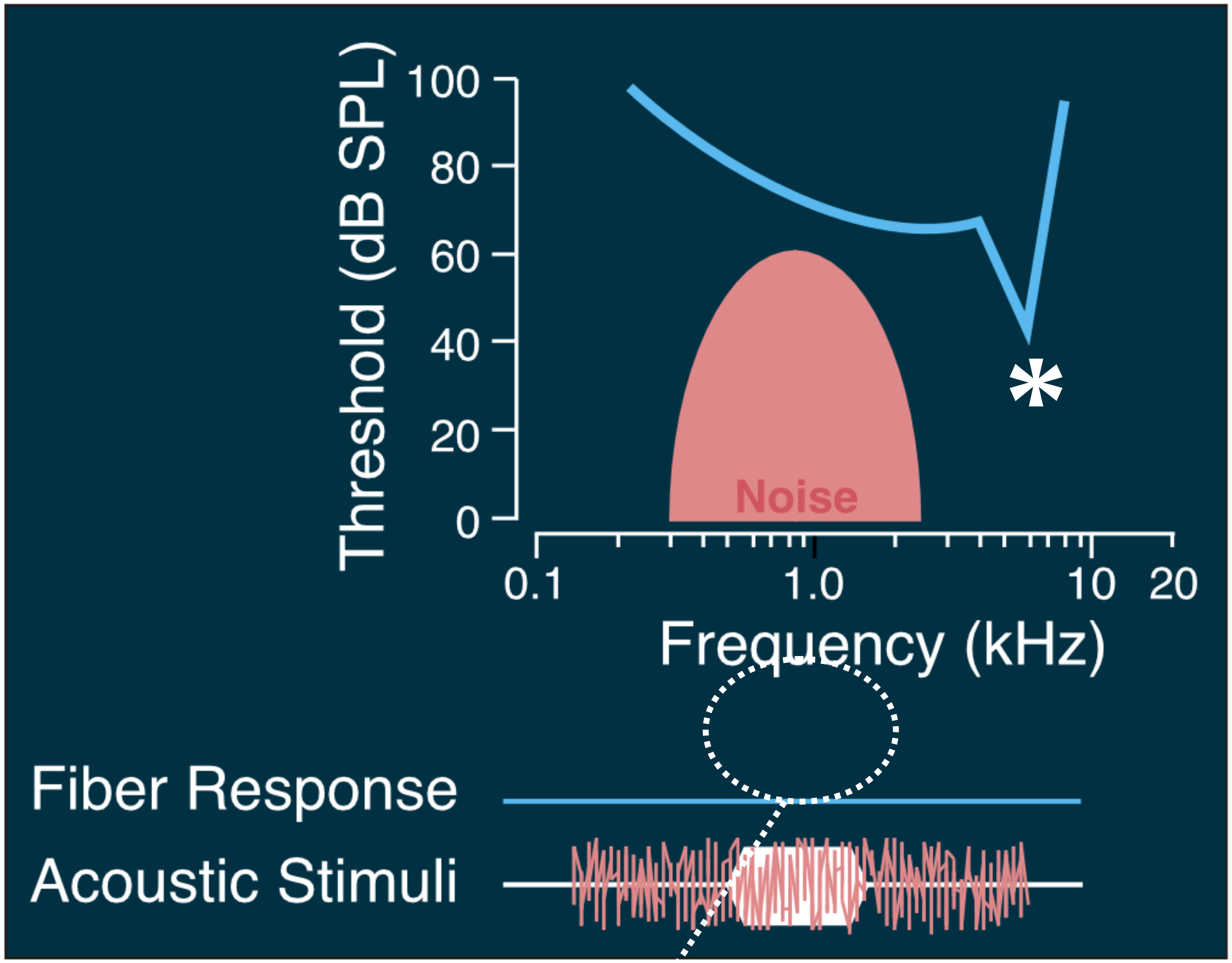
A. Stapedius

1. **Extend Dynamic Range - a gain control system**
2. **Protect the Inner Ear from Acoustic Injury**
3. **Control Masking from Continuous Background Noise**

B. Tensor Tympani

1. **Aid in Middle-Ear Aeration**

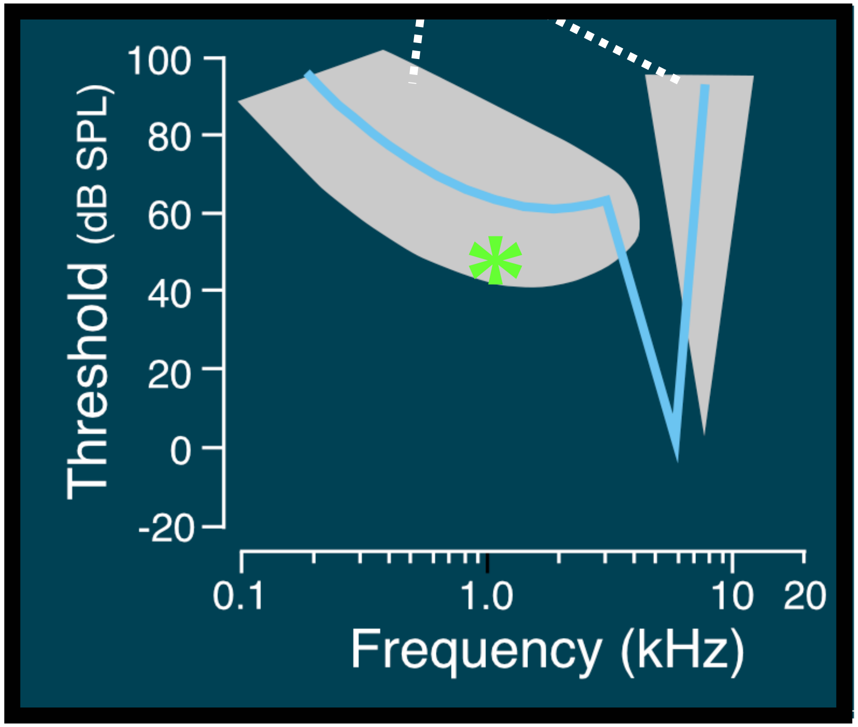
Suppressive Masking

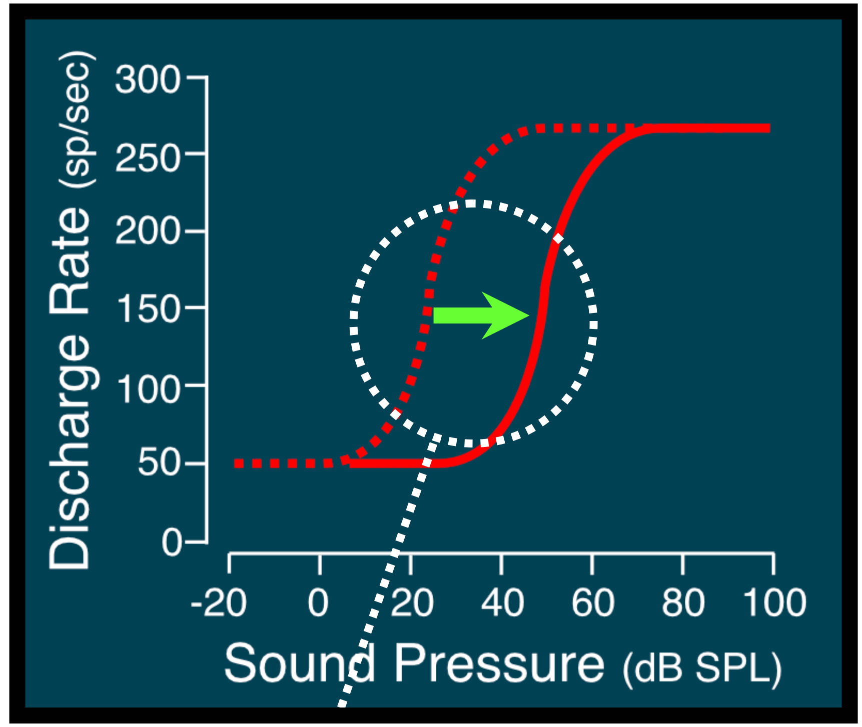


Response to transient suppressed; yet masker elicits no response

Suppressive masking ~ Two-Tone suppression

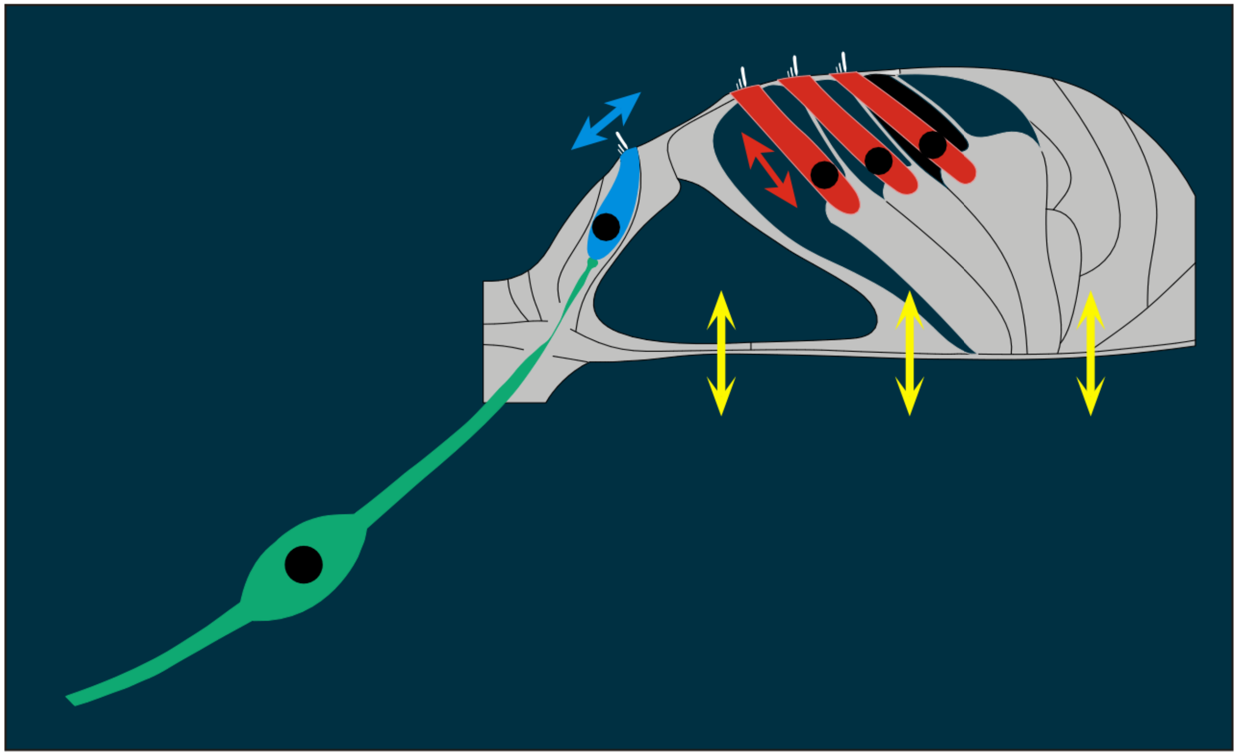
Two-Tone Suppression Contours





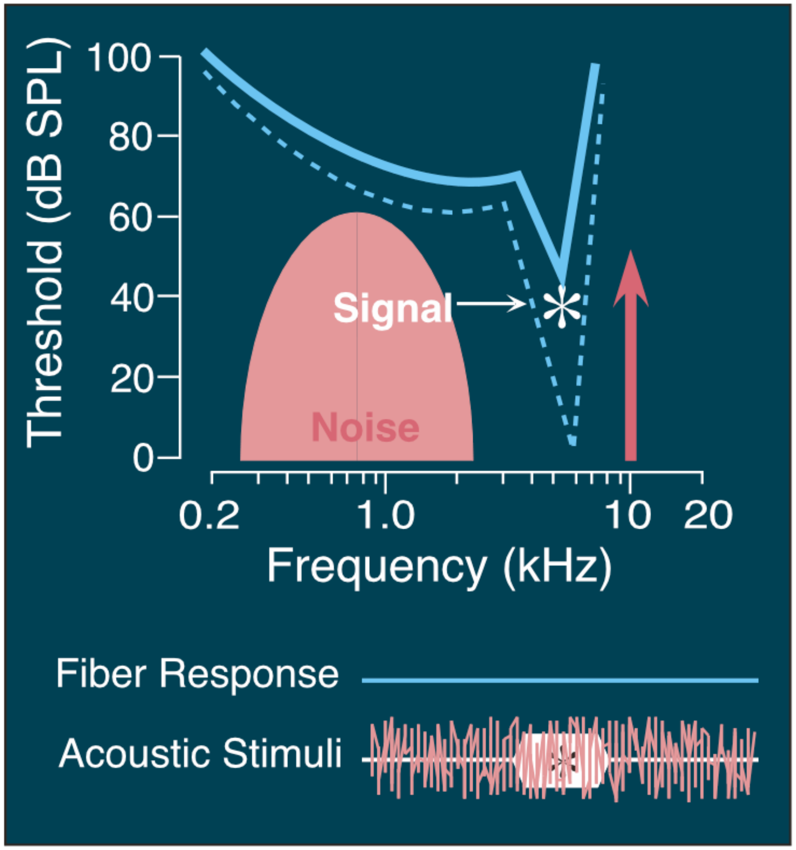
Dynamic Range Shift:
3 dB/dB

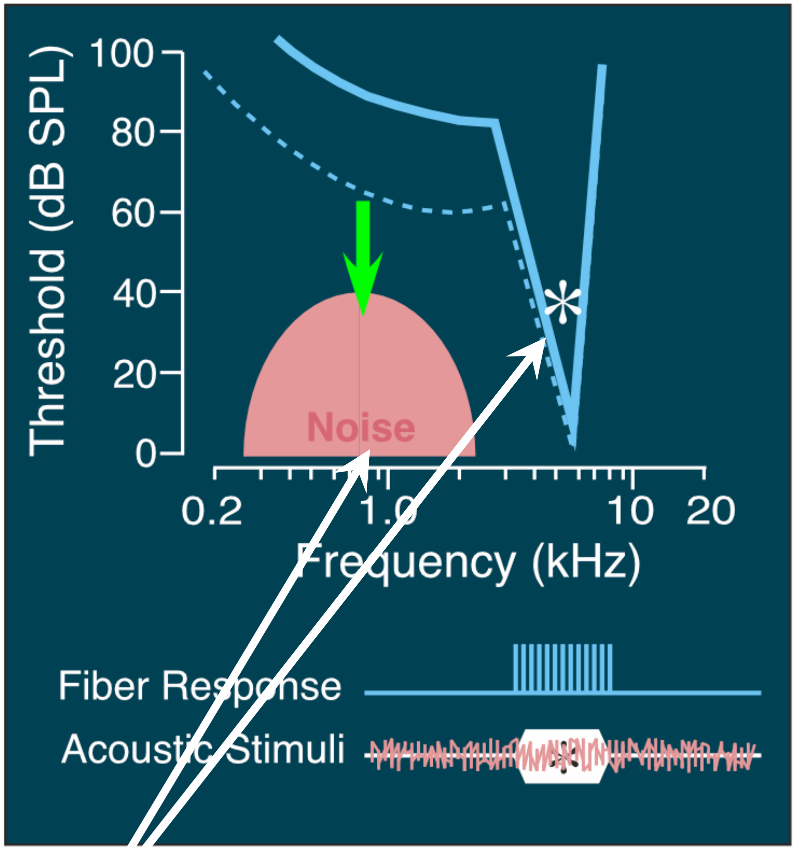
Two-Tone Suppression



- Measured in basilar membrane motion
- Arises from OHC-based non-linearity
- Requires simultaneous stimuli

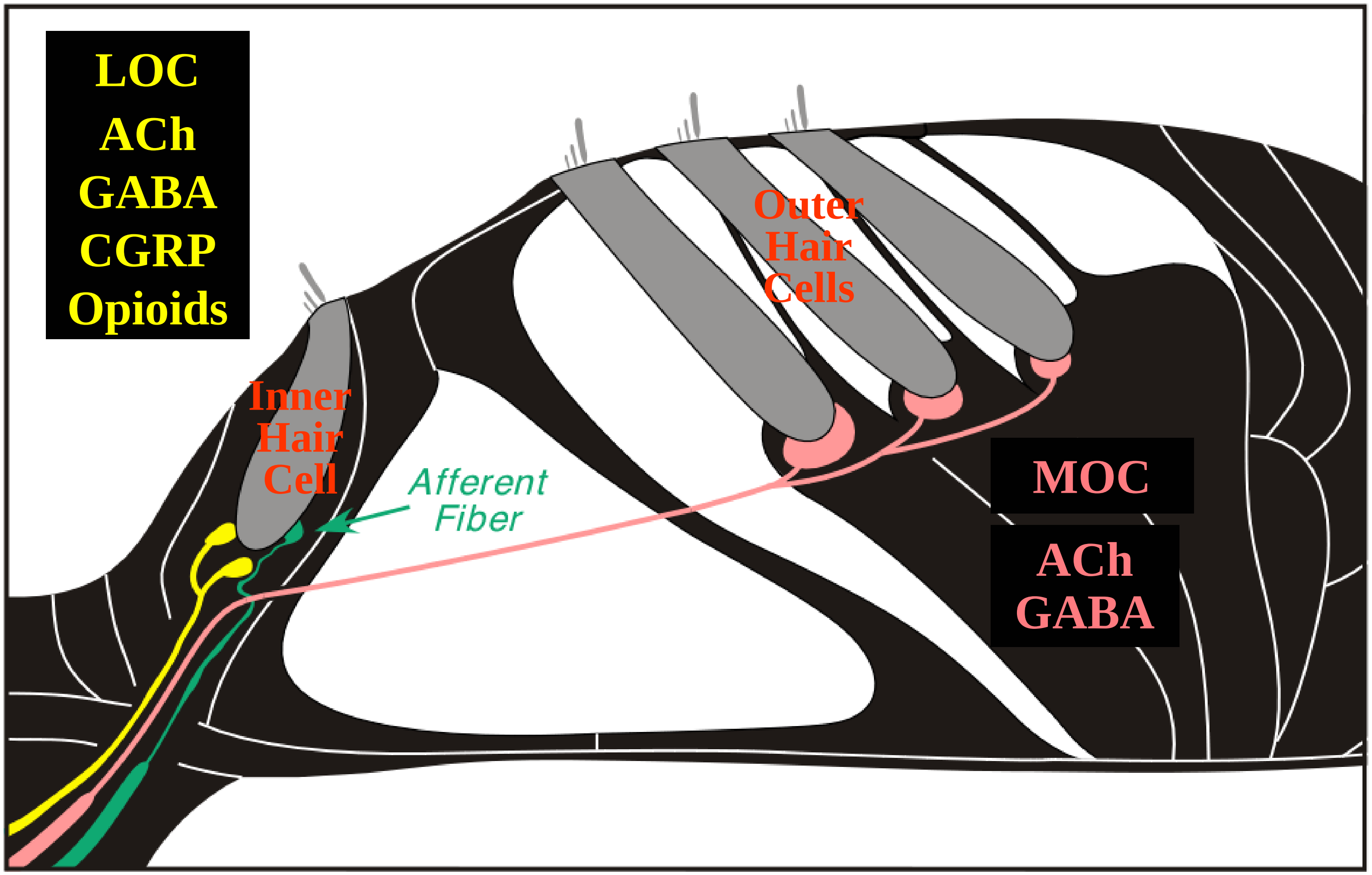
MEMs counteract suppressive masking





MEM reflex (Stapedius) useful for high-frequency signals embedded in low frequency noise

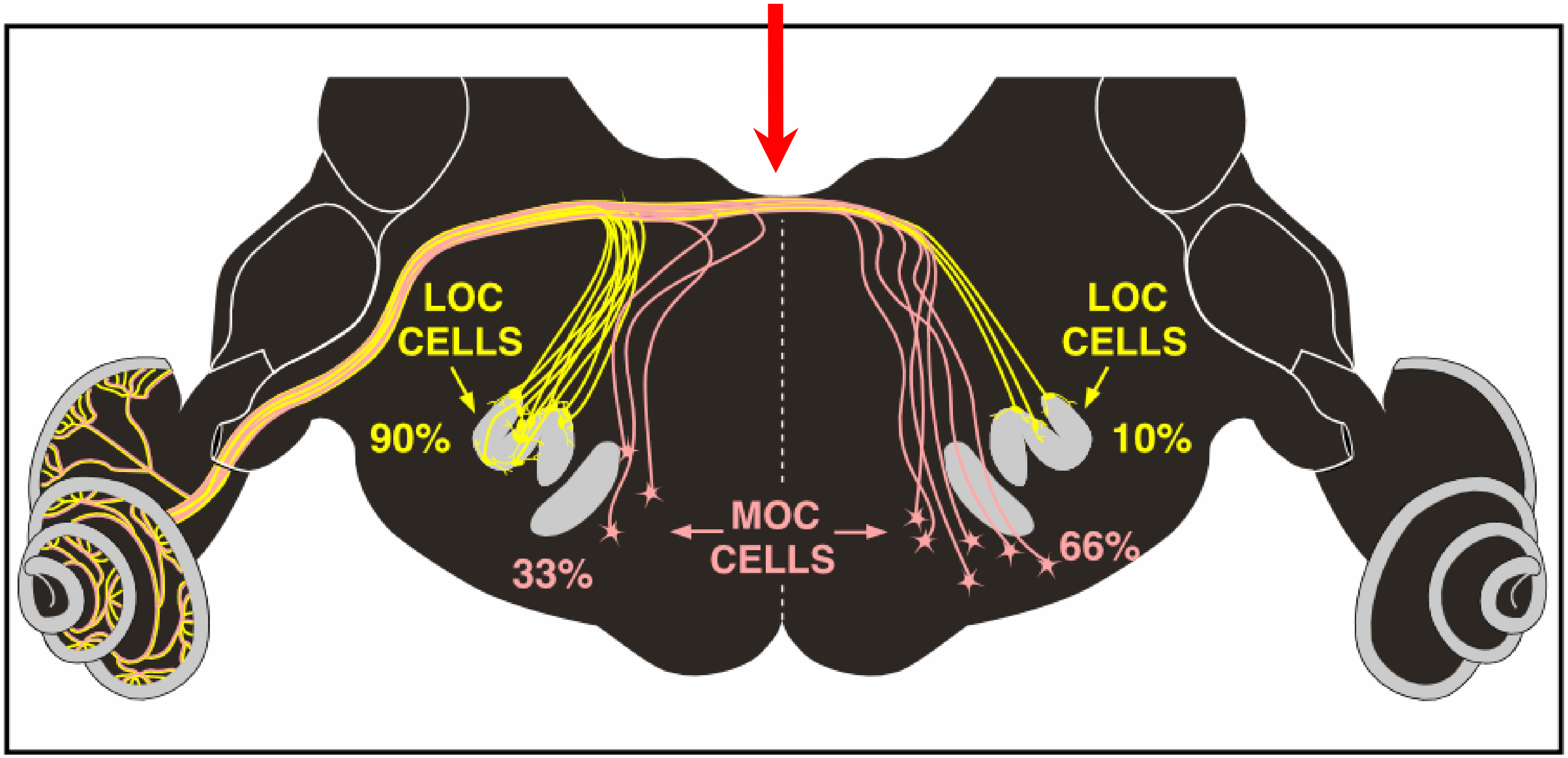
Olivocochlear Peripheral Circuitry



Unmyelinated	Myelinated
Afferent Excitation/Suppression	Cochlear Suppression

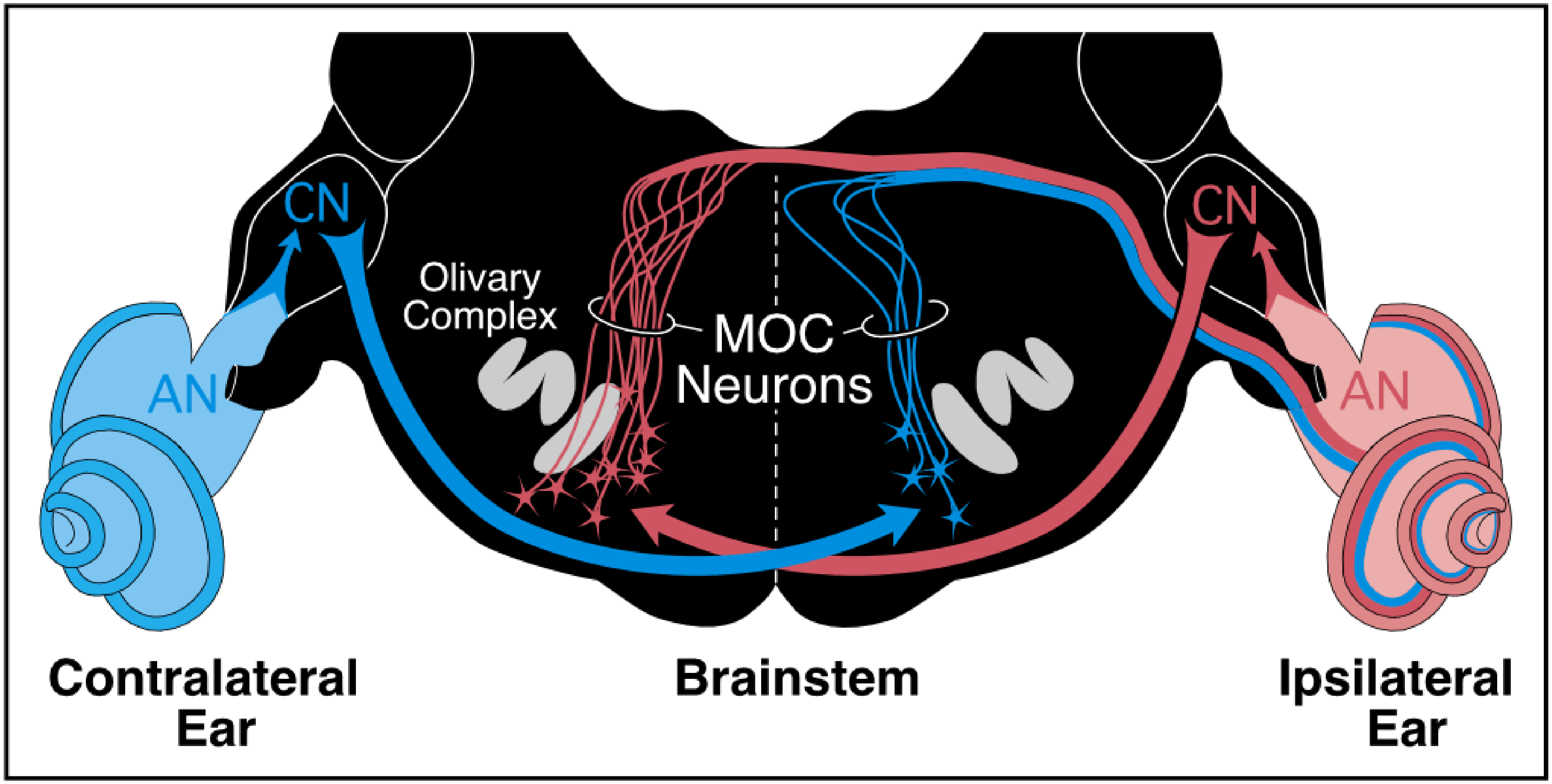
Olivocochlear Central Circuitry

Olivocochlear Bundle:
Superficial at floor of IVth Ventricle



LOC 90% Ipsilateral vs. MOC 66% Contralateral

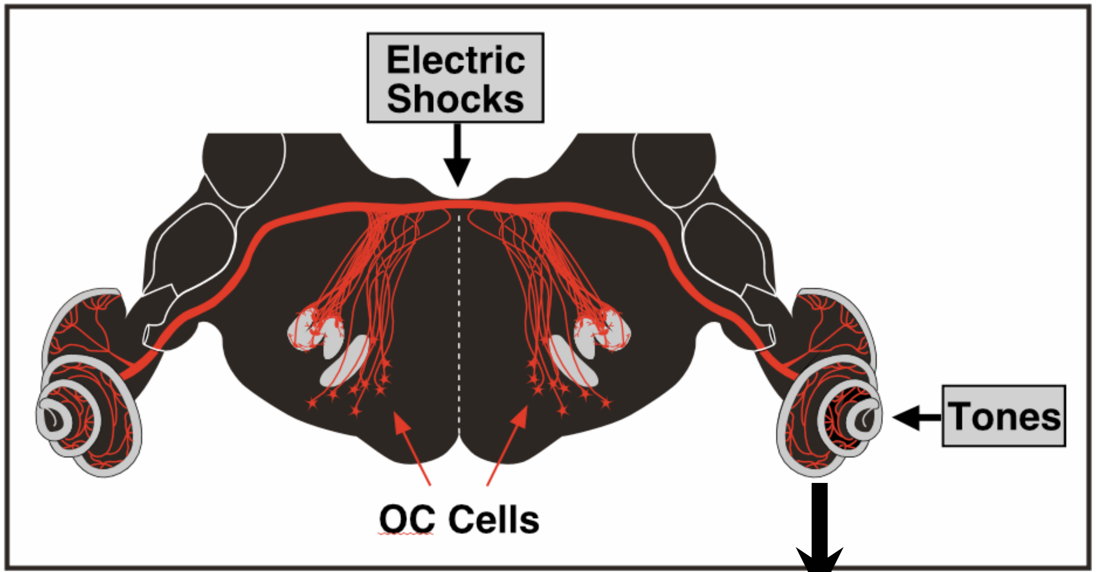
MOC Sound-Evoked Reflex

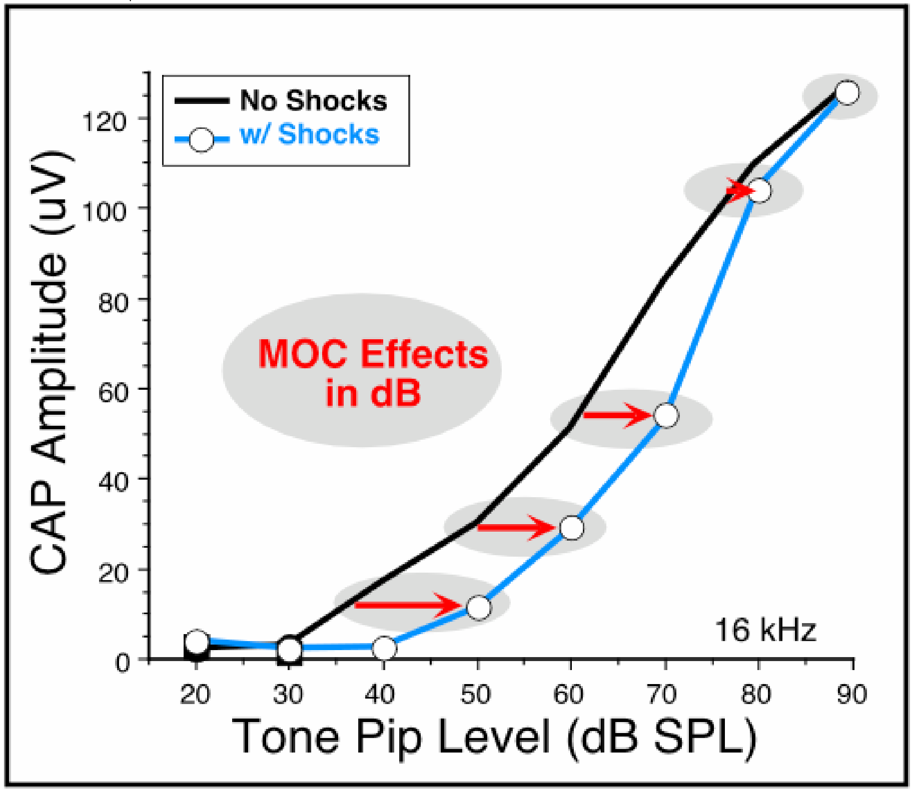


Ipsilaterally Evoked Reflex

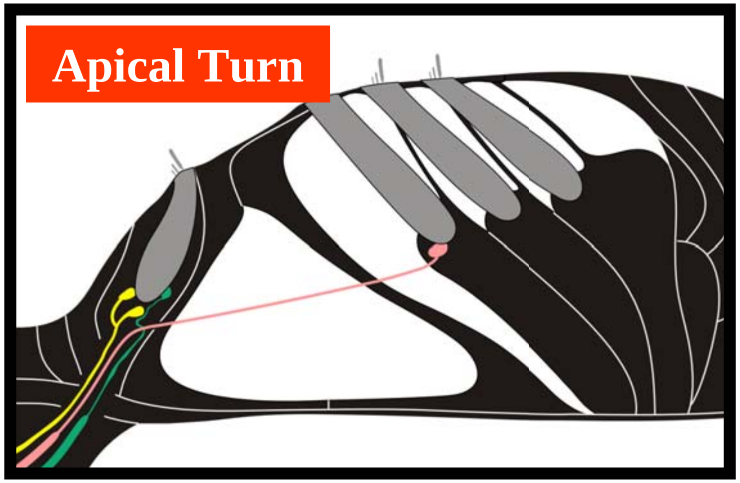
Contralaterally Evoked Reflex

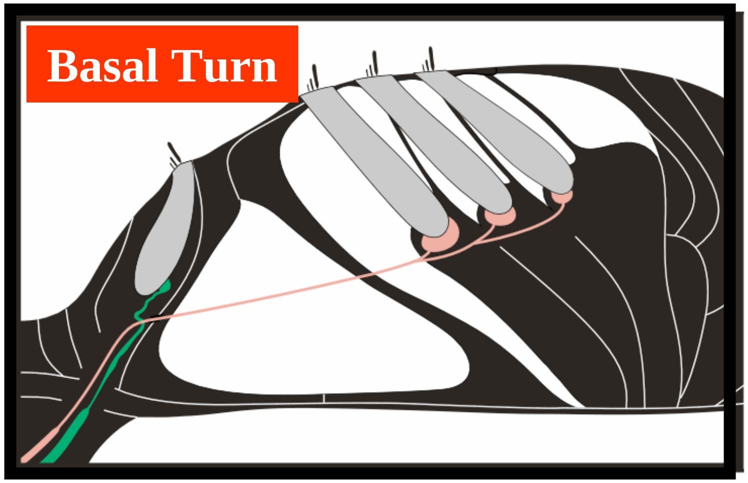
MOC Effects: CAP Suppresion

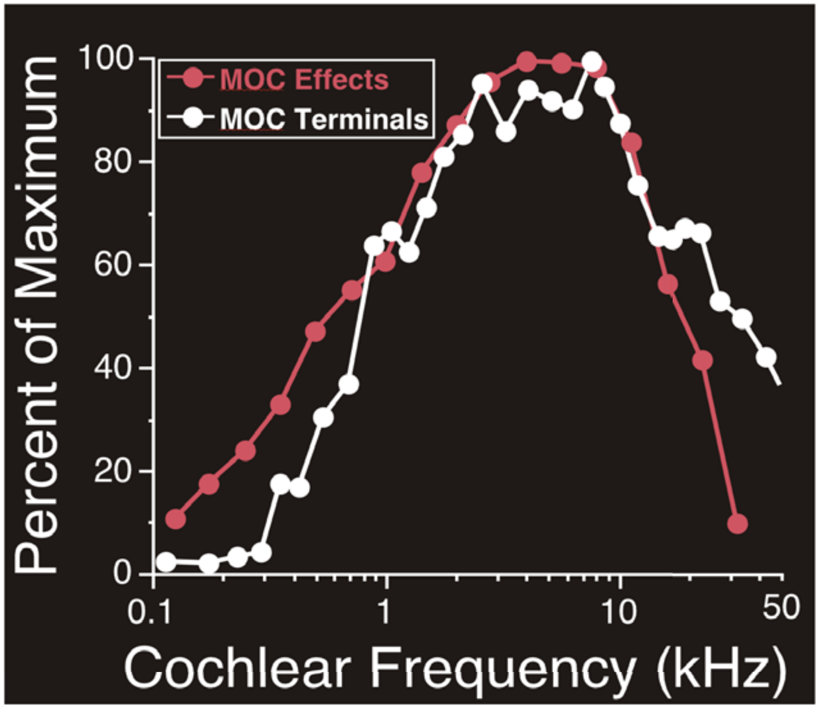


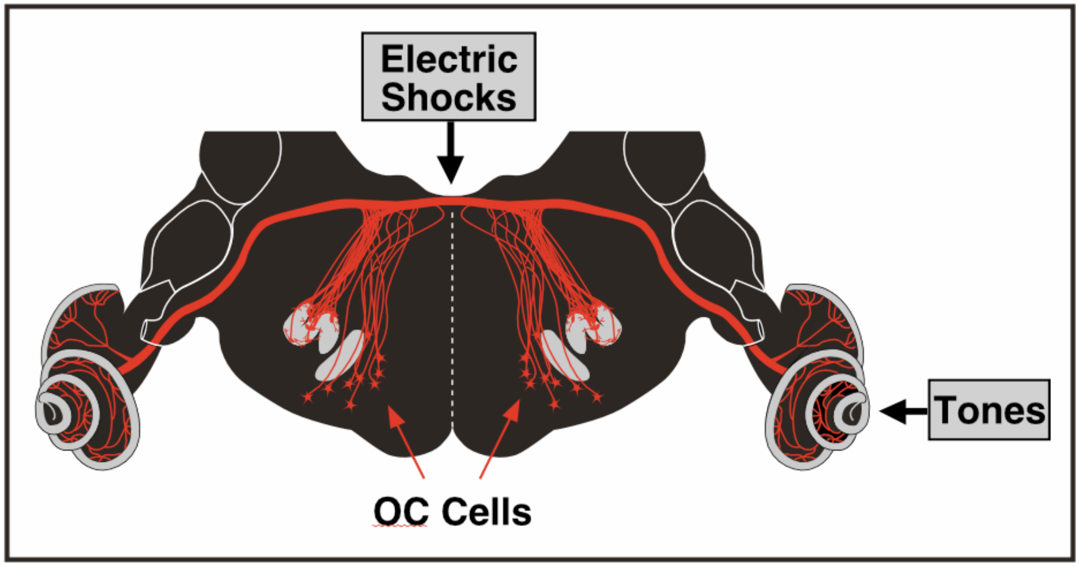


MOC Effects: Biggest at High Frequencies



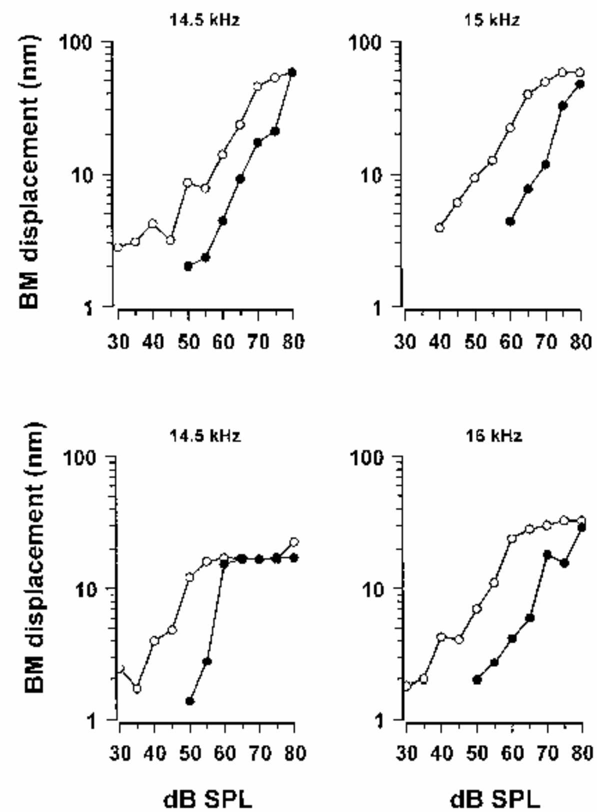






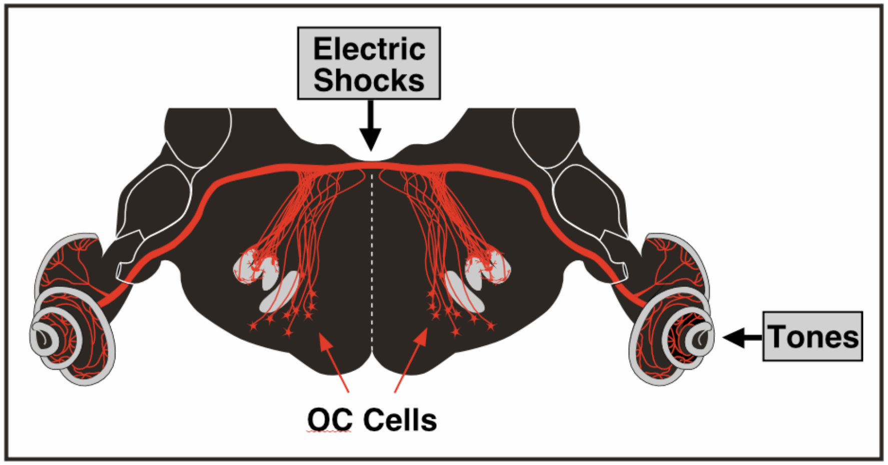
MOC Effects: Suppression in BM motion

Basilar Membrane

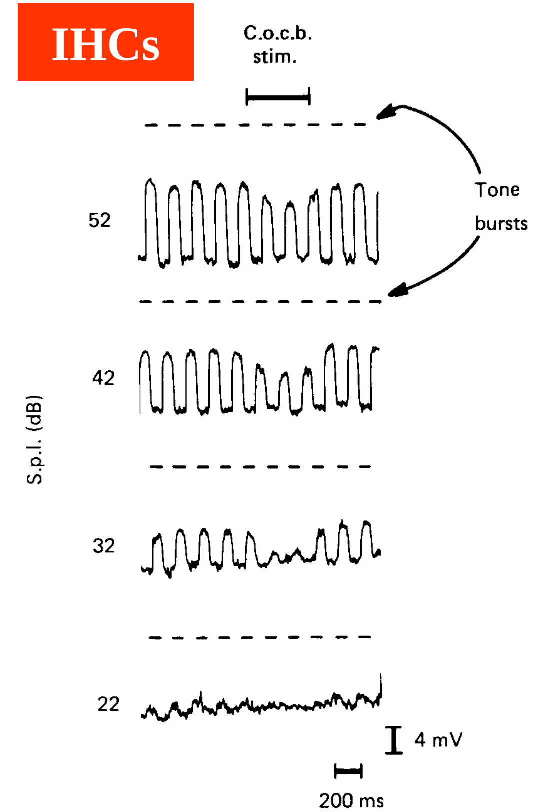


Murugasu E and Russell IJ (1996). The effect of efferent stimulation on basilar membrane displacement in the basal turn of the guinea pig cochlea. J. Neuroscience 16: 325-332.

MOC Effects: Differences between IHCs & OHCs

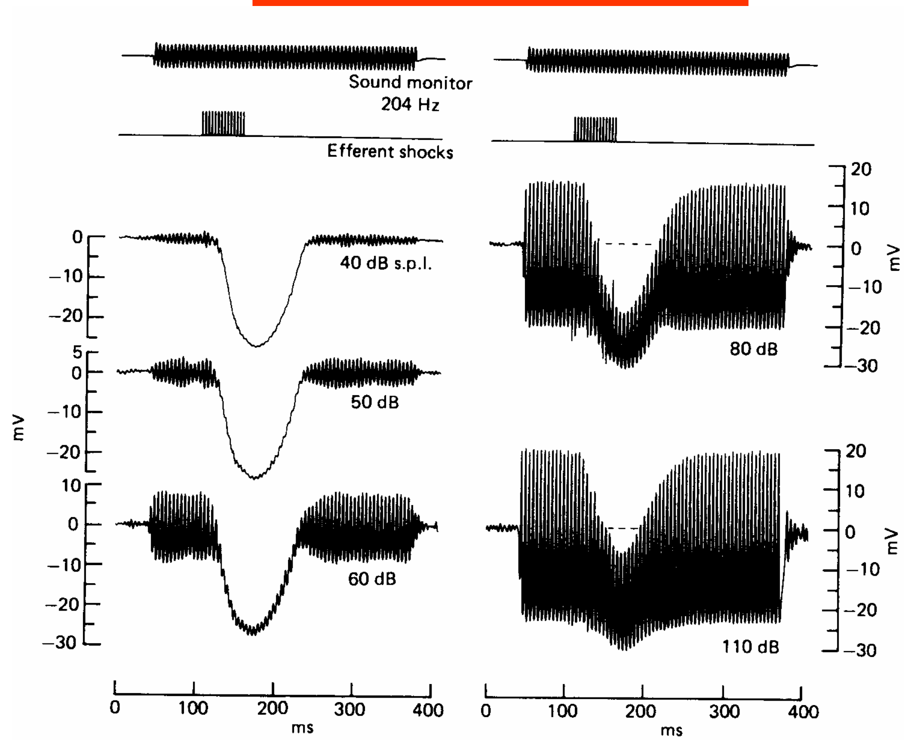


IHCs

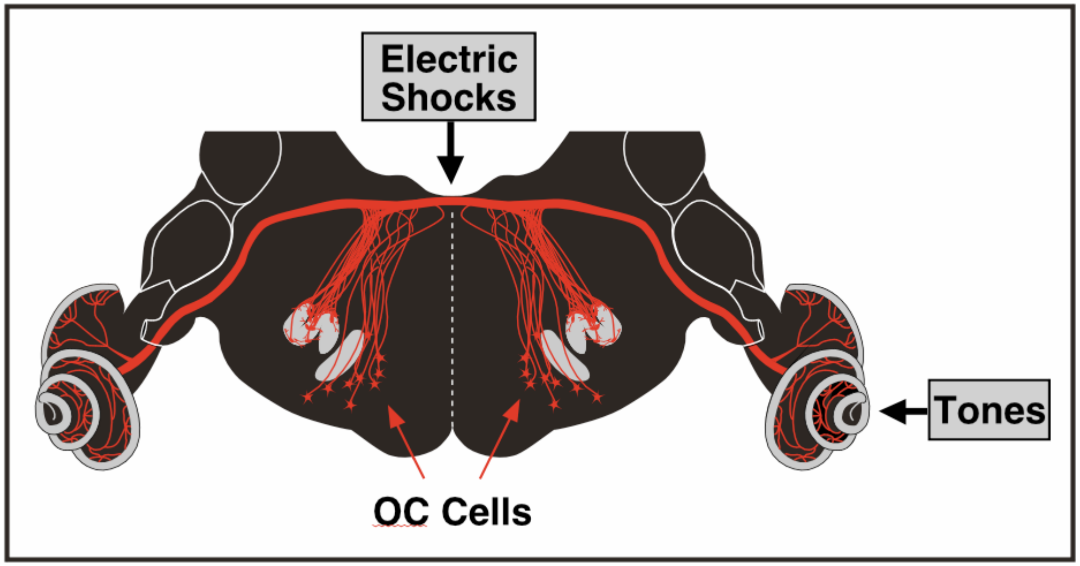


Brown MC and Nuttall AL (1984). Efferent control of cochlear inner hair cell responses in the guinea pig. J. Physiol. 354: 625-646.

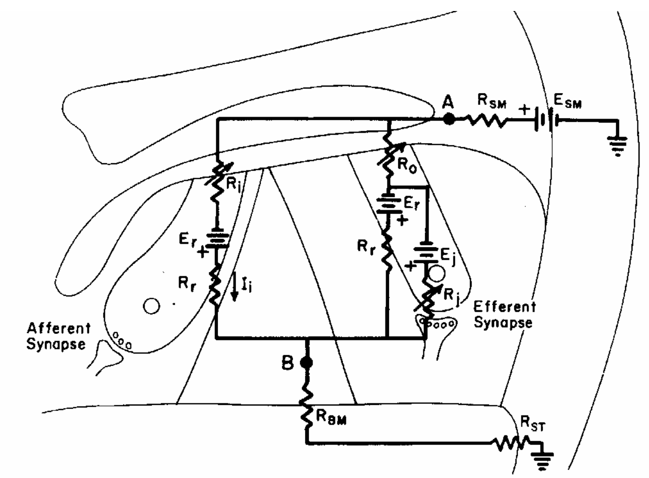
Turtle Hair Cells (OHC homologues)

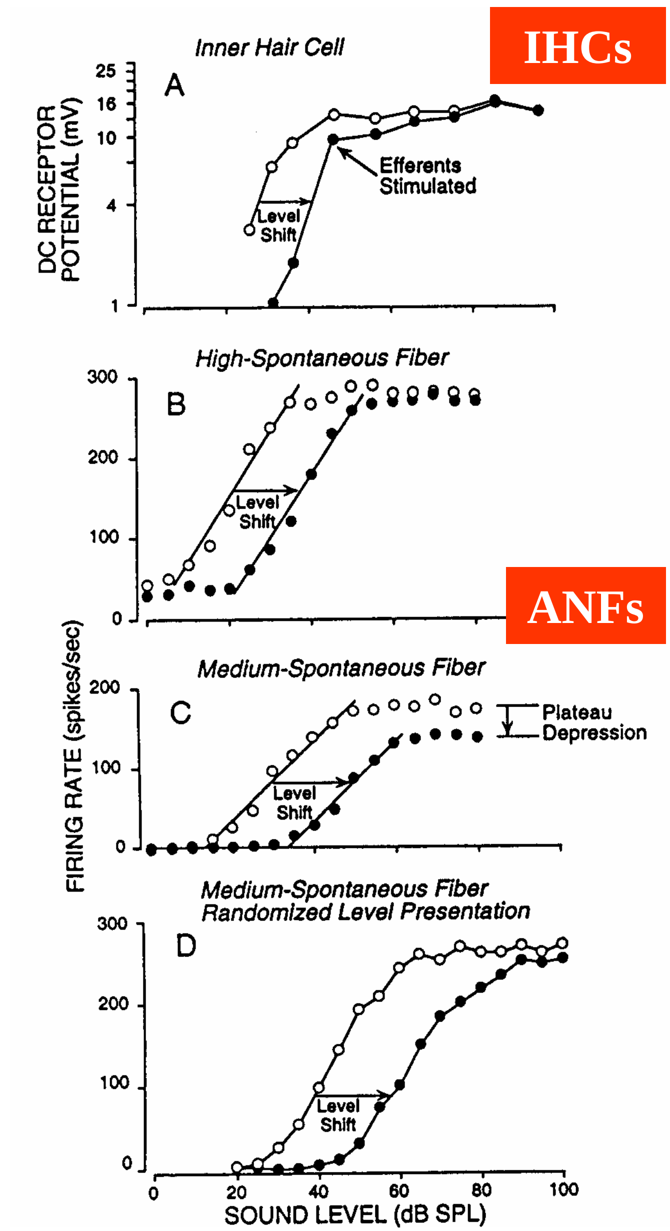


Art JJ, Fettiplace R and Fuchs PA (1984) Synaptic hyperpolarization of turtle cochlear hair cells. J Physiol. 356:525-550.



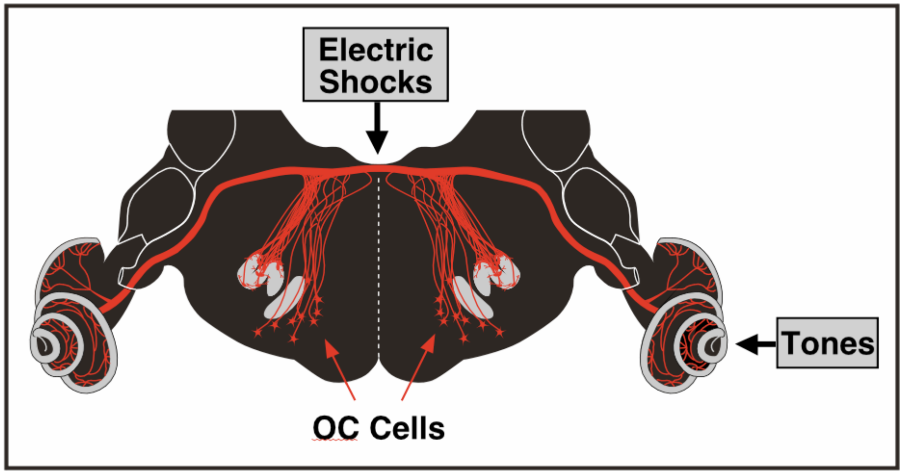
MOC Effects: Suppression in IHCs and ANFs

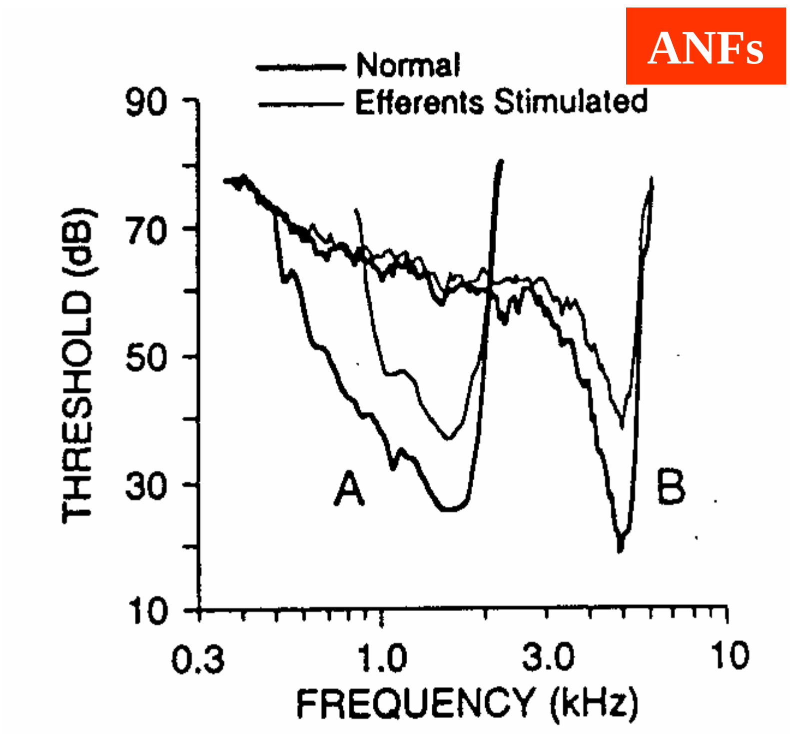


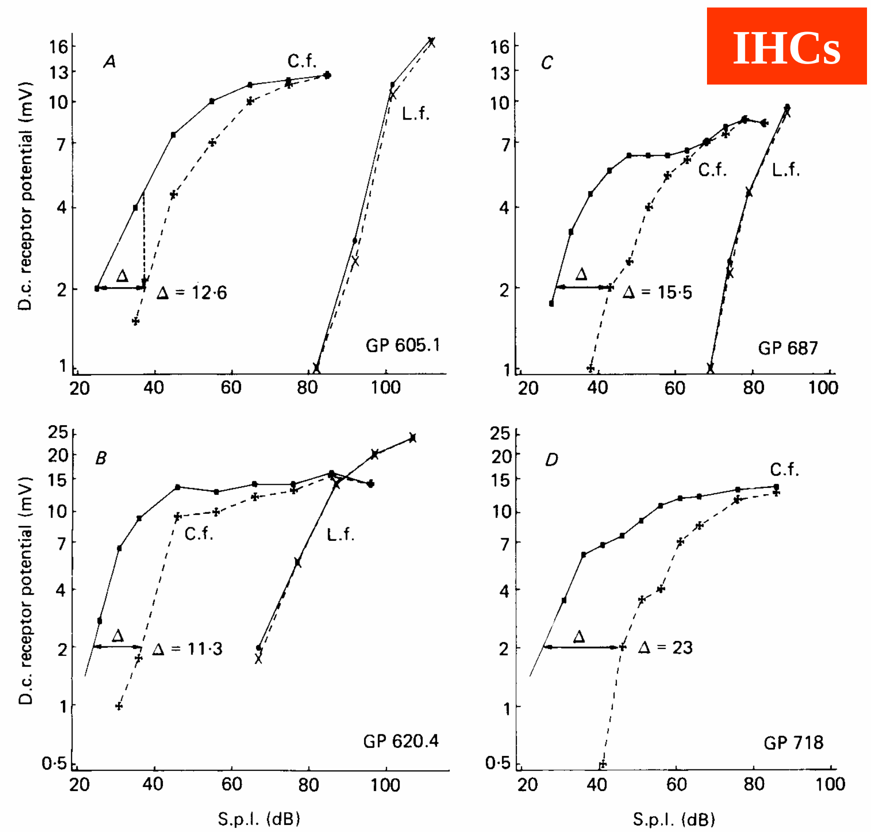


Guinan, JJ (1996) Physiology of Cochlear Efferents. In "The Cochlea", eds. P Dallos, AN Popper and RR Fay. New York, Springer, pp 435-500.

MOC Effects: Biggest at CF



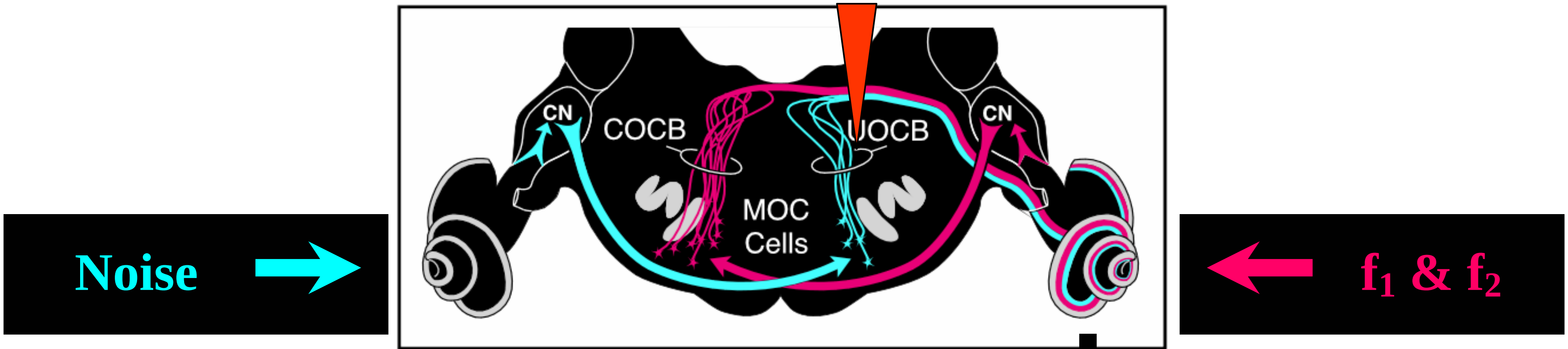




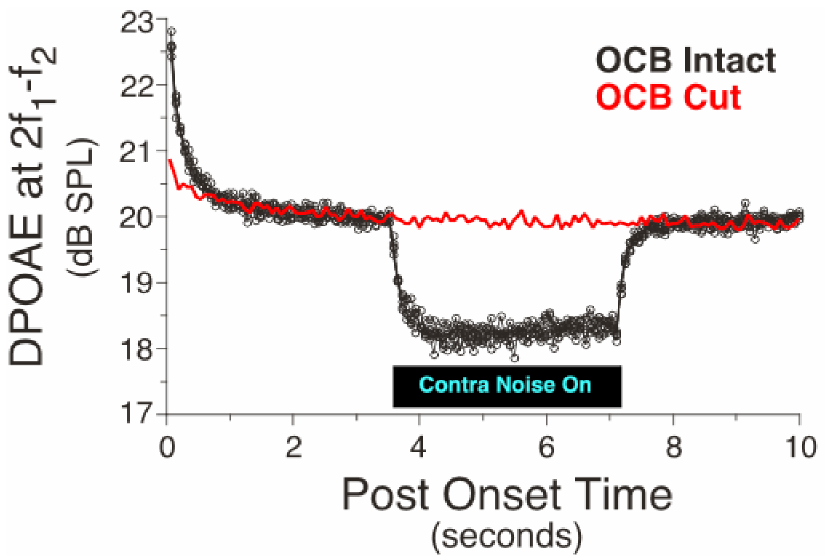
Guinan, JJ (1996) Physiology of Cochlear Efferents. In "The Cochlea", eds. P Dallos, AN Popper and RR Fay. New York, Springer, pp 435-500.

Brown MC and Nuttall AL (1984). Efferent control of cochlear inner hair cell responses in the guinea pig. J. Physiol. 354: 625-646.

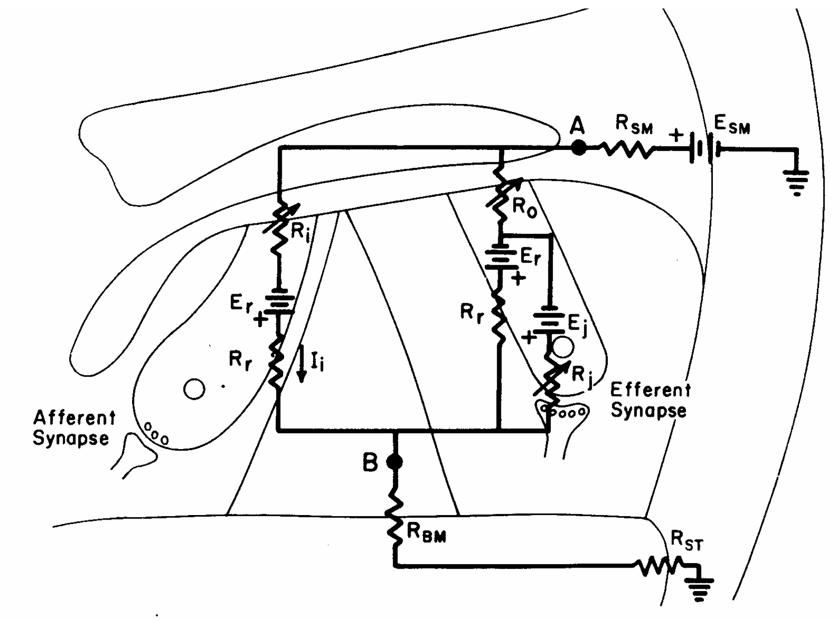
MOC Reflex Affects OtoAcoustic Emissions



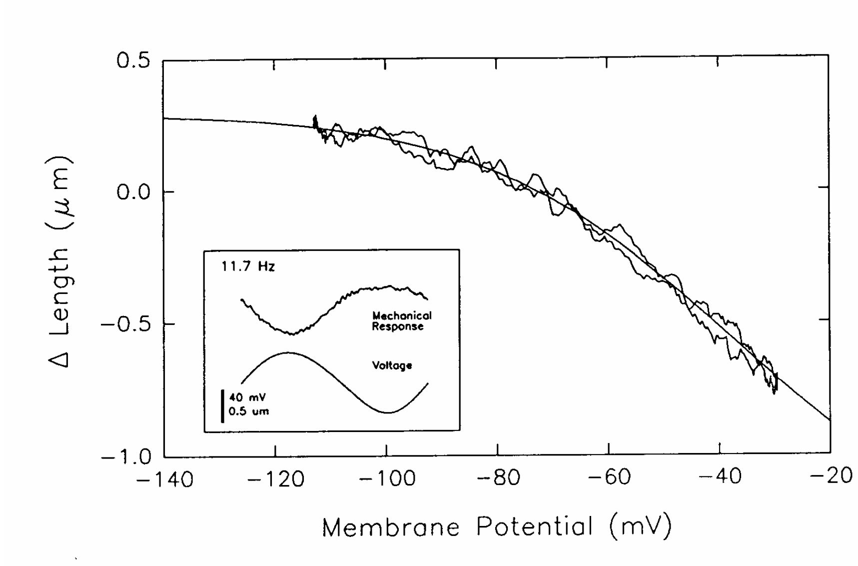
Distortion Product: $2f_1$-f_2



How MOC activity suppresses cochlea ?



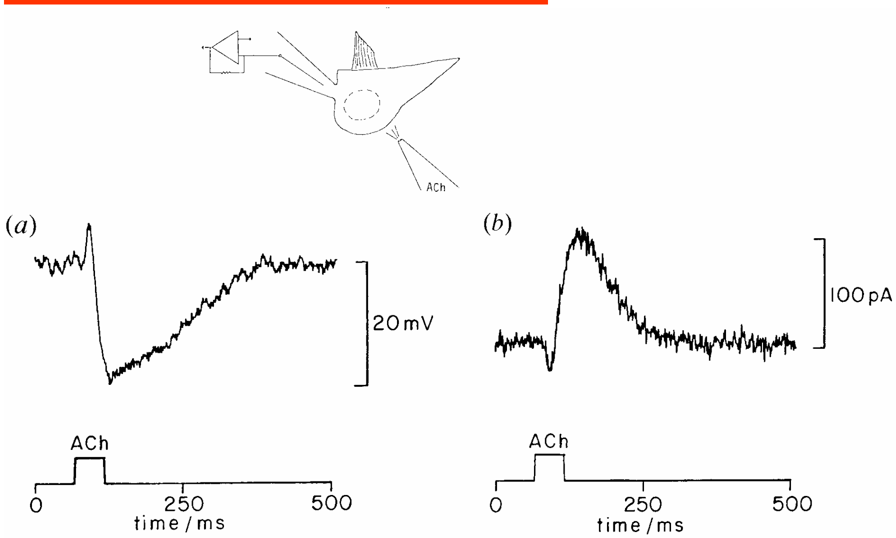
OHC motility decreases w/ Hyperpolarization



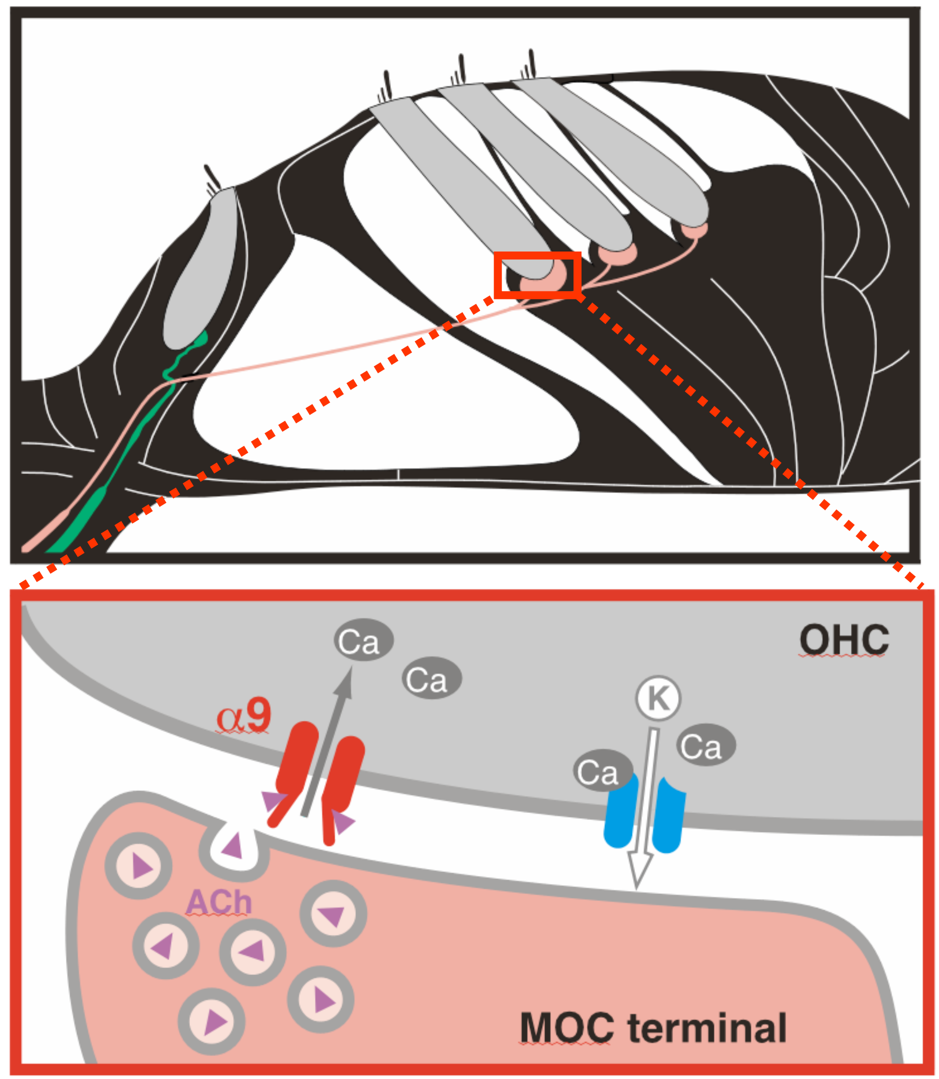
Santos-Sacchi, J. (1991) Reversible inhibition of voltage dependent outer hair cell motility and capacitance. J. Neurosci. 11: 3096-3110

What channels are involved in MOC effects?

Chick Hair Cells in vitro



Fuchs PA, Murrow BW (1992) A novel cholinergic receptor mediates inhibition of chick cochlear hair cells. Proc R Soc Lond B Biol Sci 248:35-40.

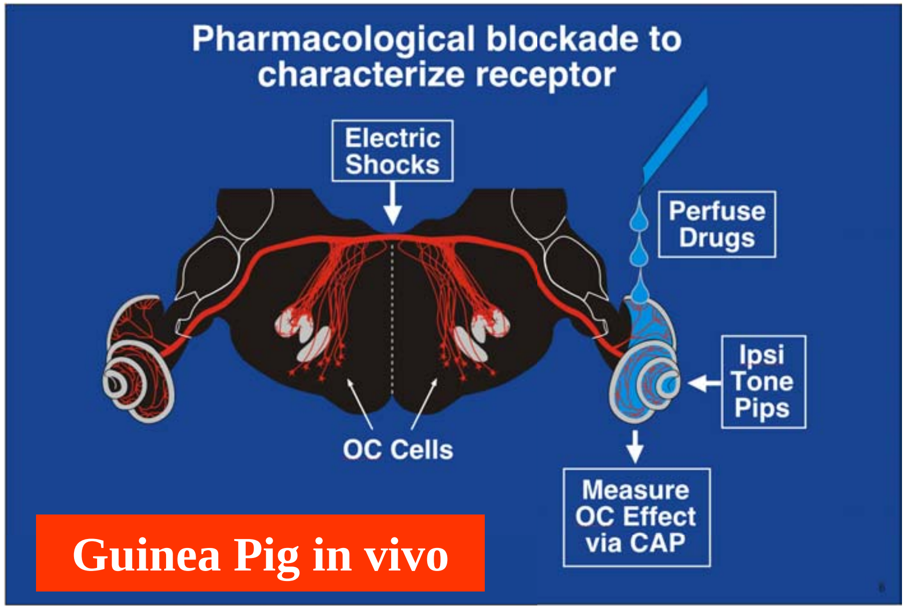


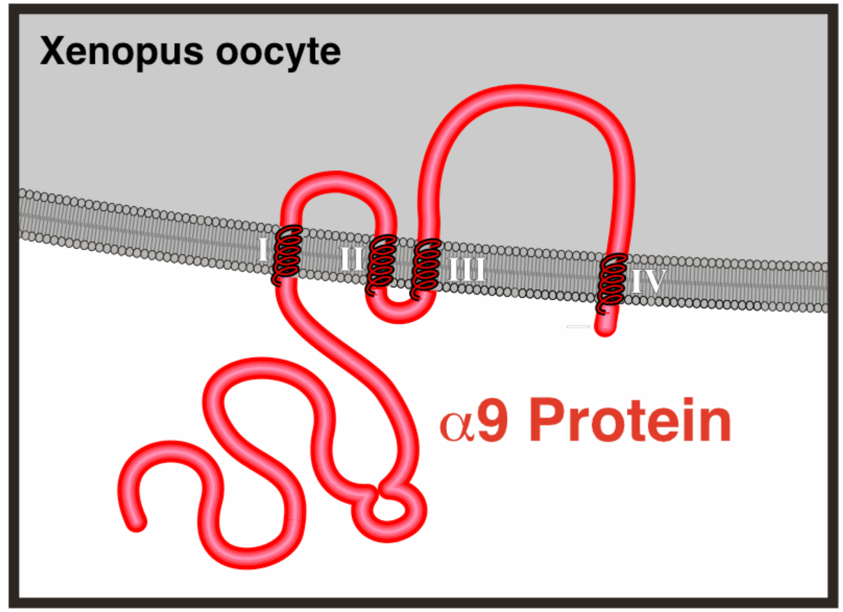
Hypothesis: Two stage effect

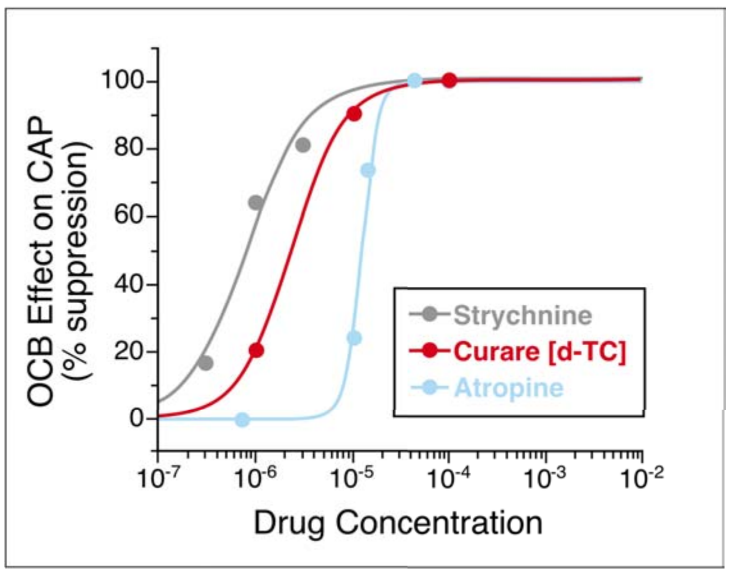
1. ACh activated Ca entry

2. Ca-activated K entry

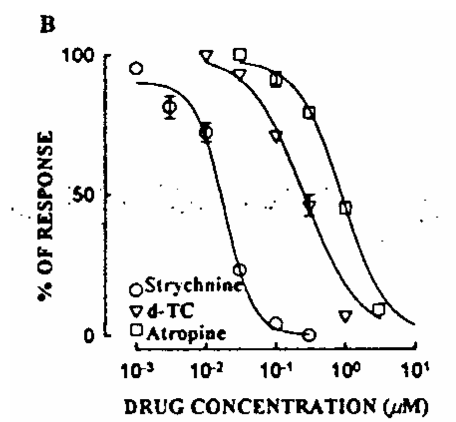
α9 nicotinic ACh receptor







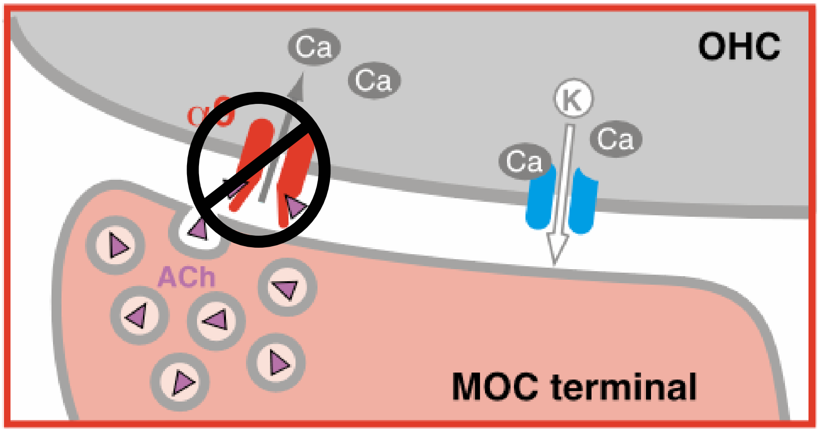
In vitro: heterologous expression

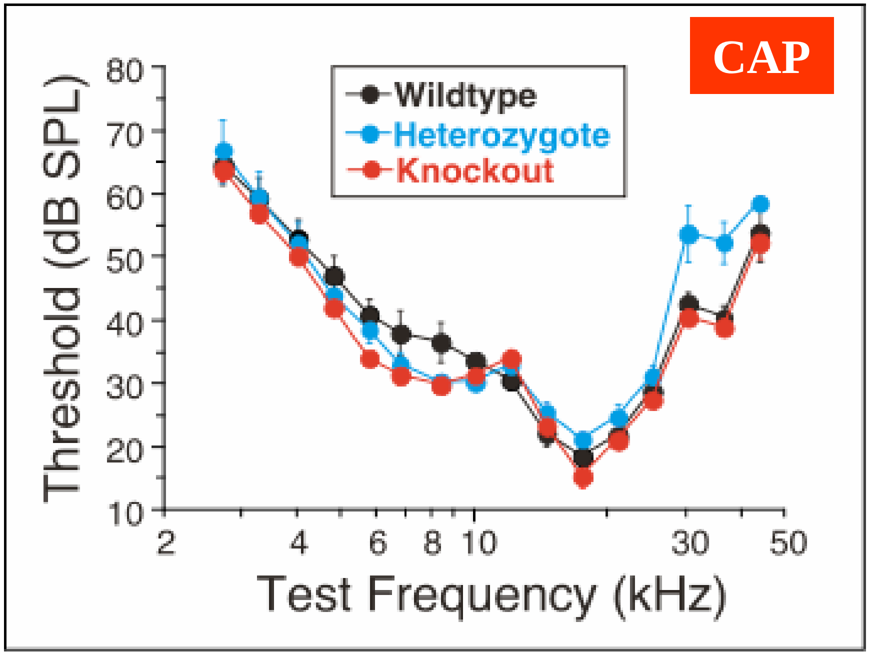


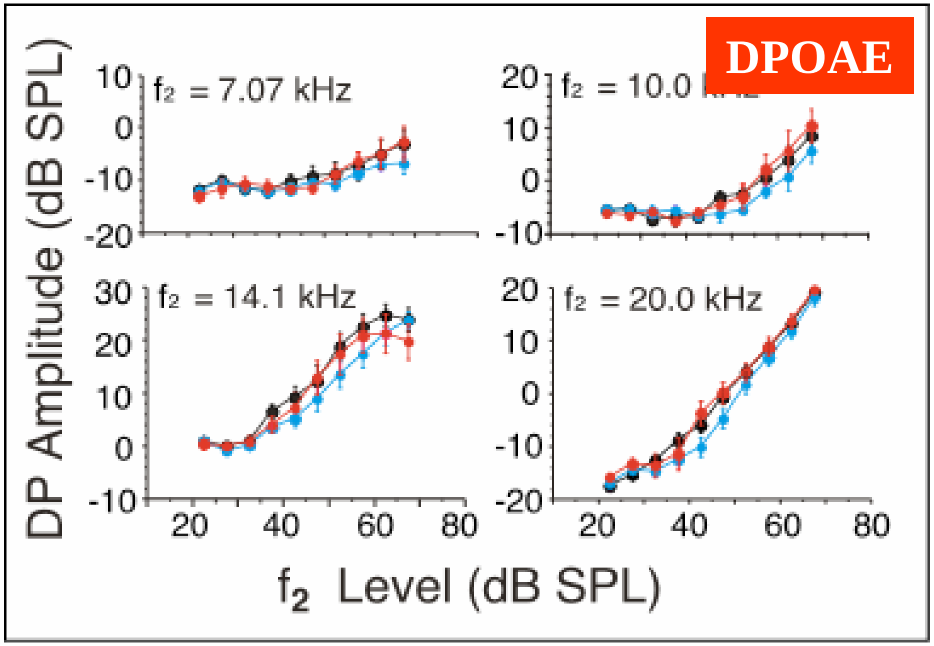
Sridhar T, Liberman MC, Brown MC and Sewell WF. A novel cholinergic "slow effect" of efferent stimulation on cochlear potentials in the guinea pig. J. Neurosci. 1995; 15:3667-3678.

Elgoyhen AB et al. (1994) Alpha 9: an acetylcholine receptor with novel pharmacological properties expressed in rat cochlear hair cells. Cell 79:705-715.

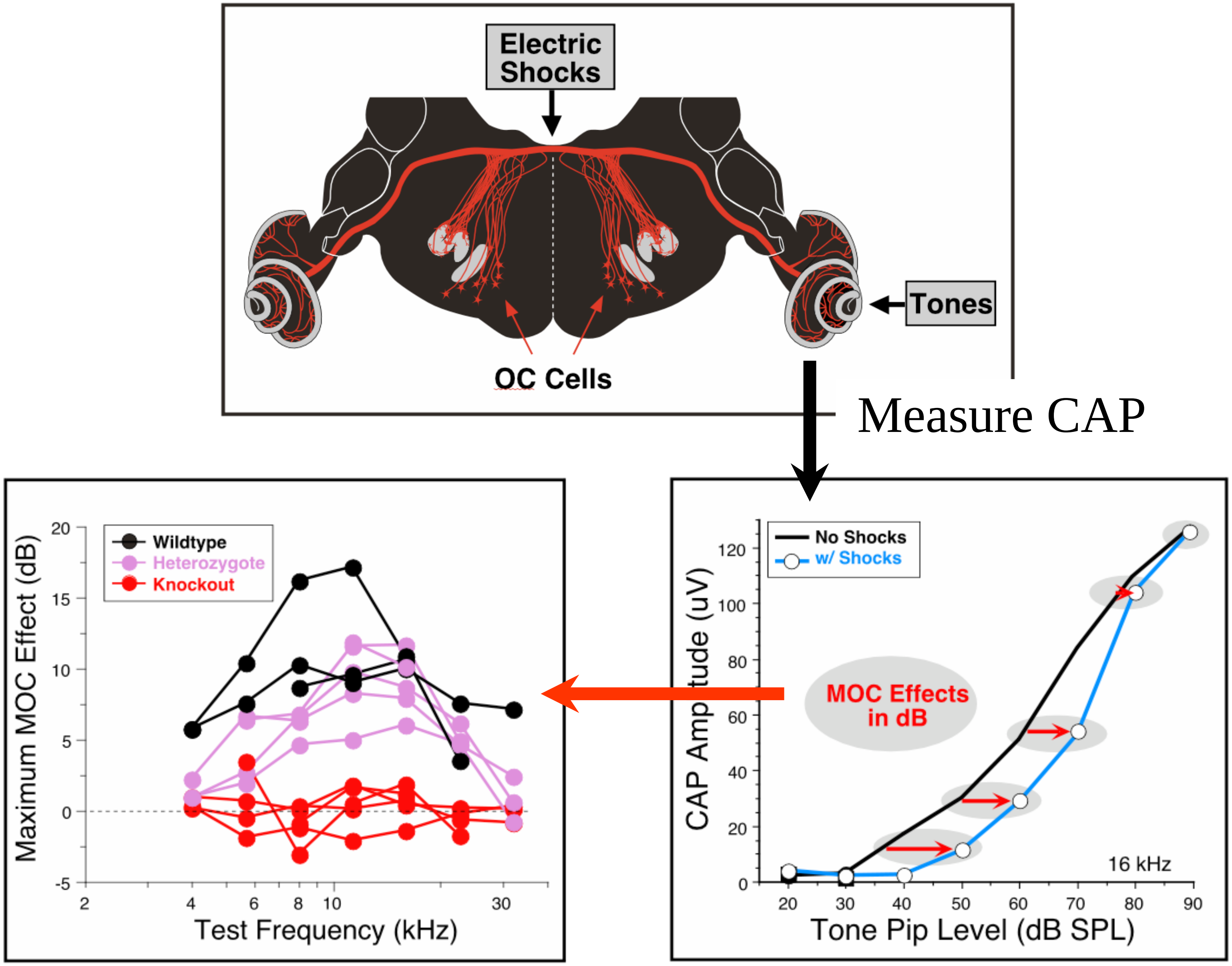
α9 Knockout: Cochlear function normal







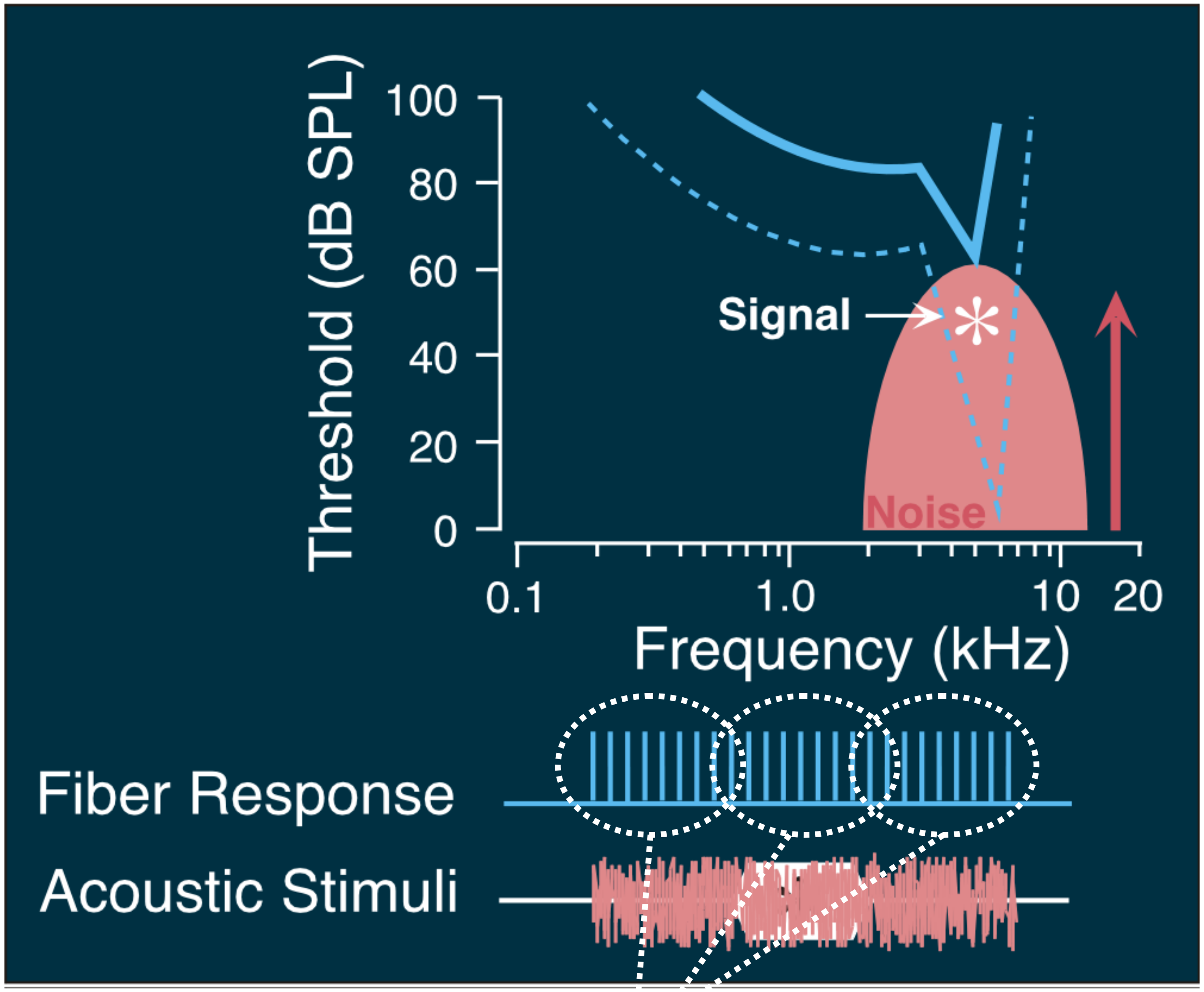
α9 Knockout is functionally de-efferented



Hypotheses for MOC Function

1. Extend dynamic range - a gain control system
2. Mediate selective attention: auditory vs. visual
   high vs. low frequency
3. Control masking from background noise
4. Shape normal cochlear development
5. Protect the inner ear from acoustic injury

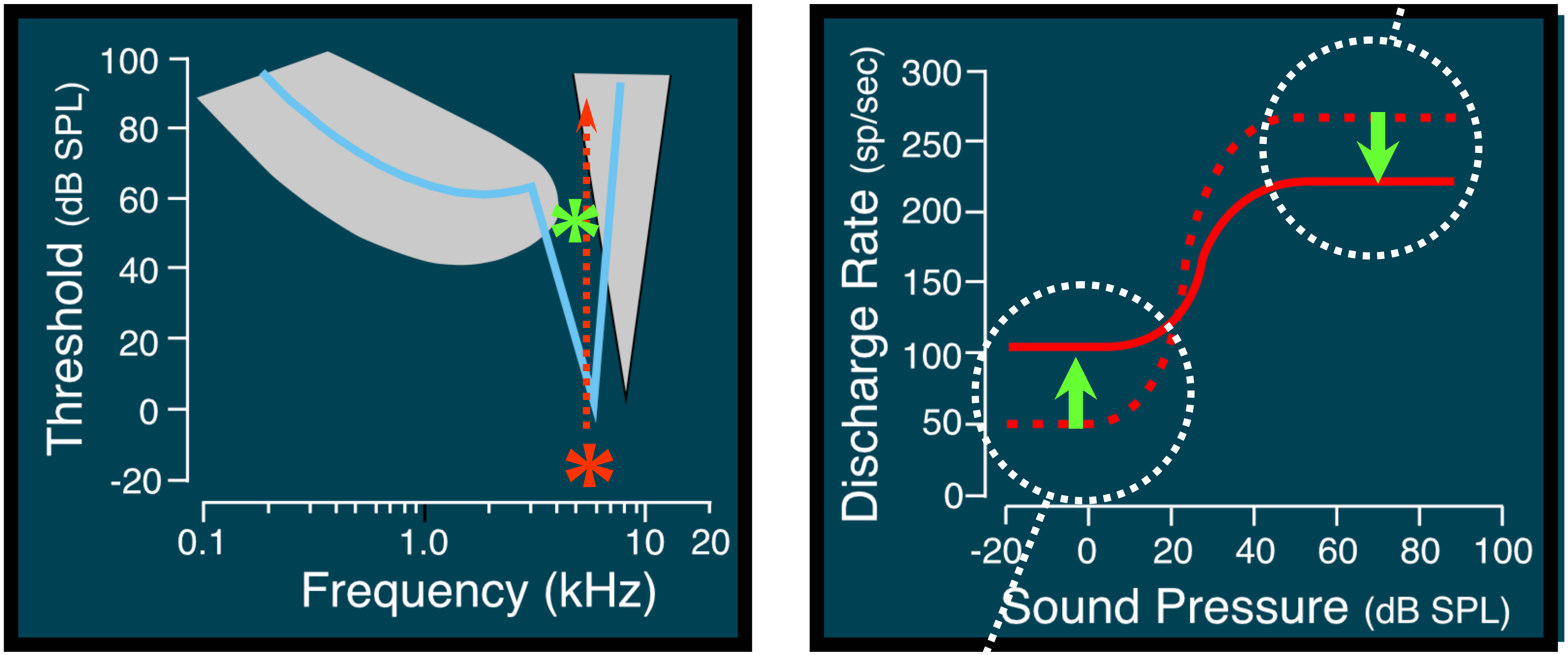
Excitatory Masking



Response to signal decreases (adaptation)

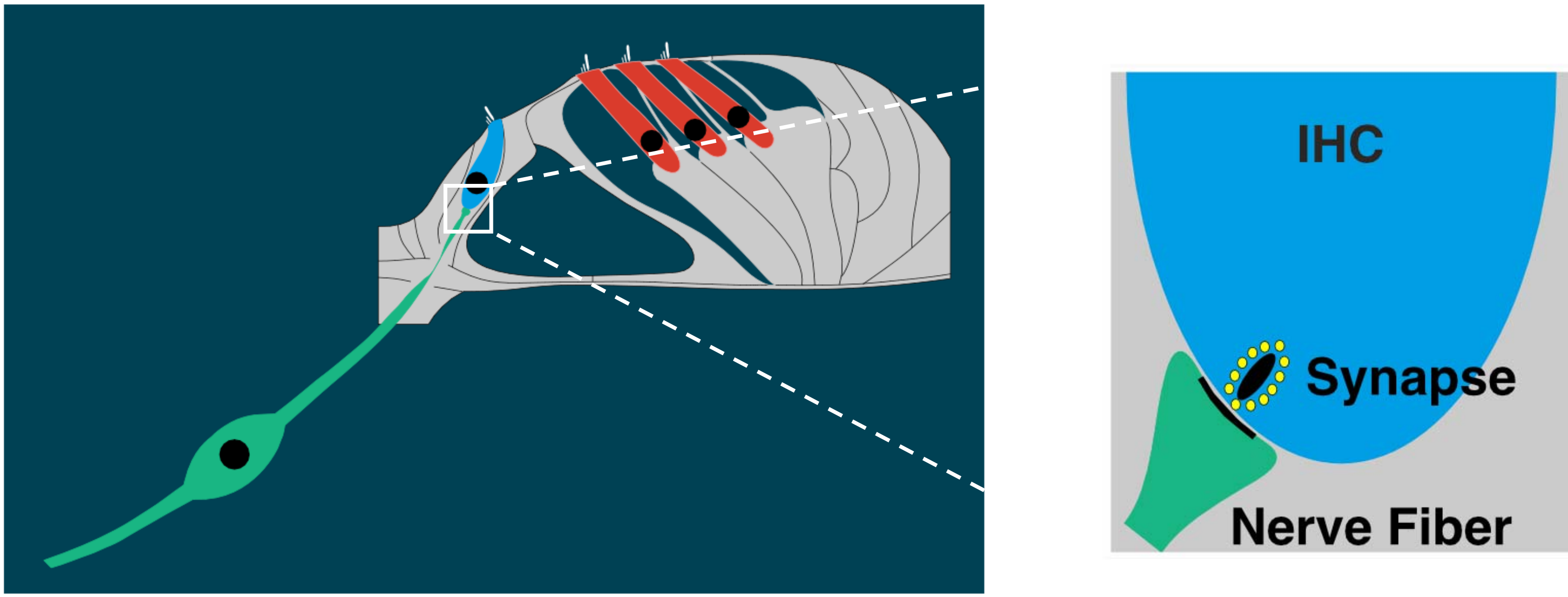
Excitatory Masking - Line Busy + Adaptation

Adaptation



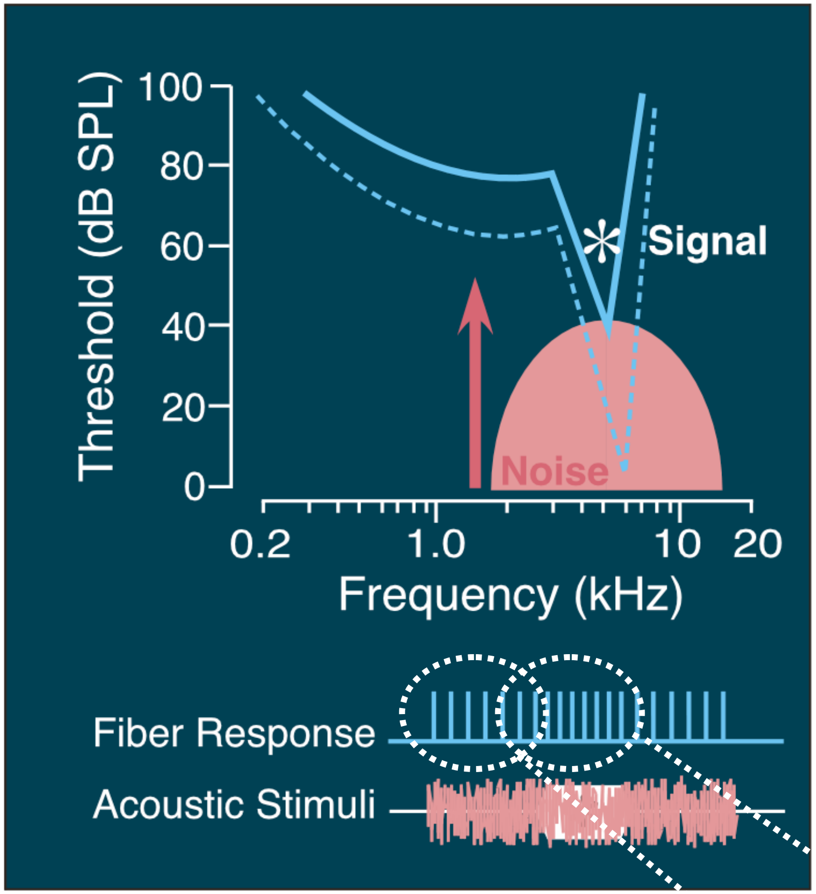
Line Busy

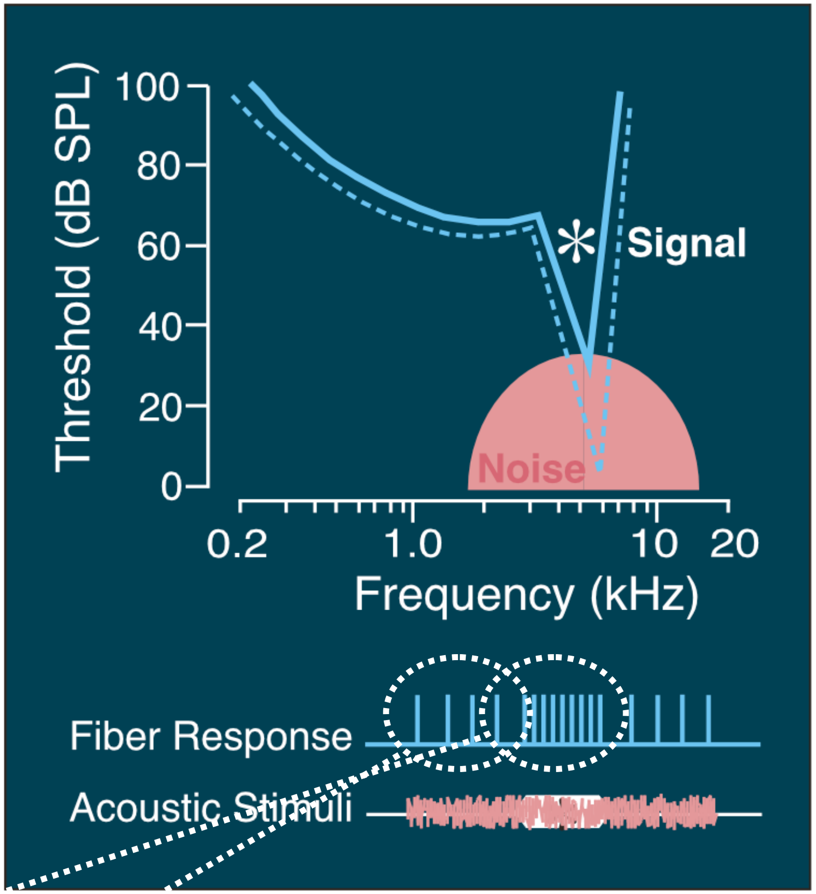
Adaptation component of Excitatory Masking



- **Arises at the synapse - vesicle depletion**
- **Does not require stimulus simultaneity**
- **Mechanism underlying forward masking**

MOC counteracts excitatory masking



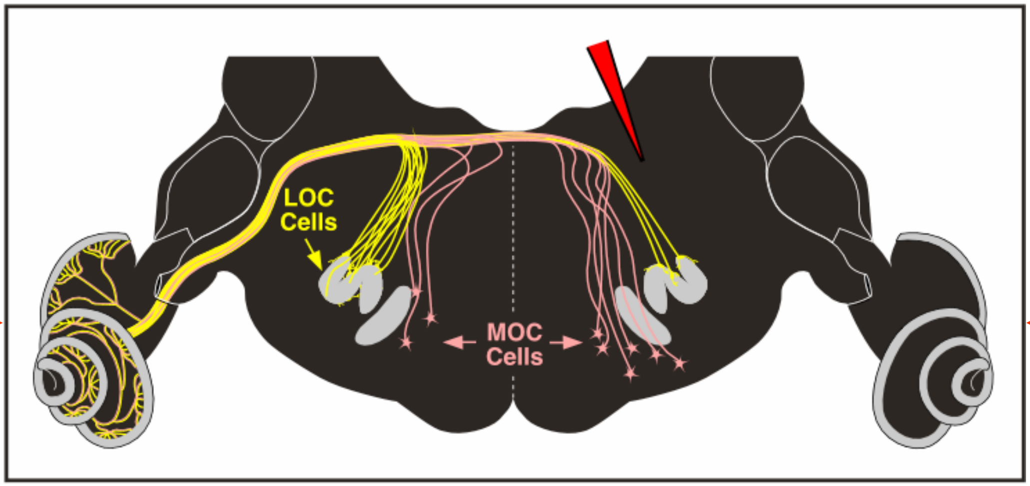


MOC reflex increases response to transients

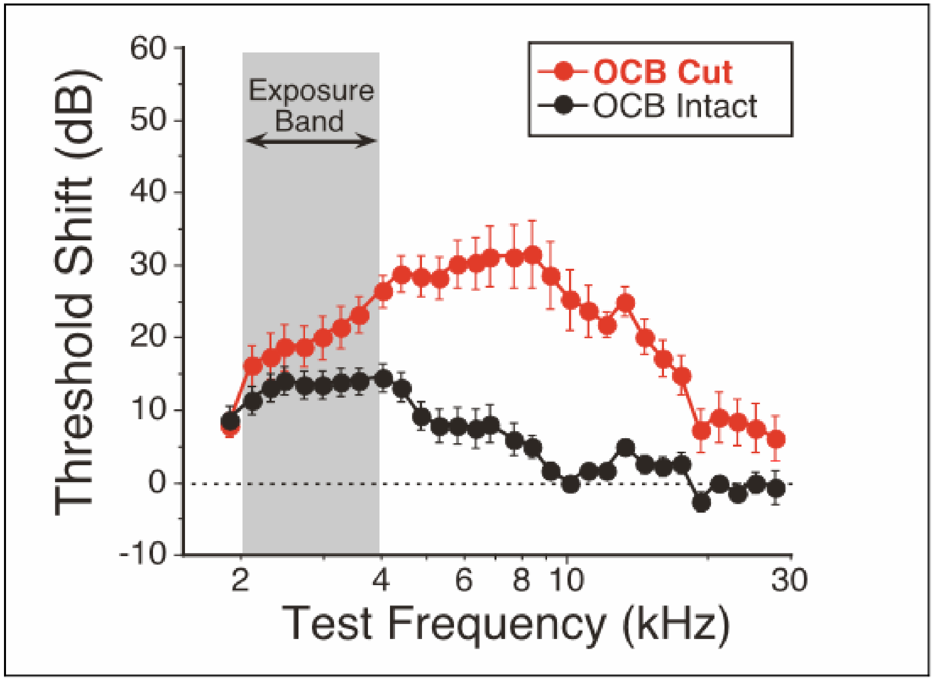
By reducing response to steady noise

Unilateral De-efferentation and Acoustic Injury

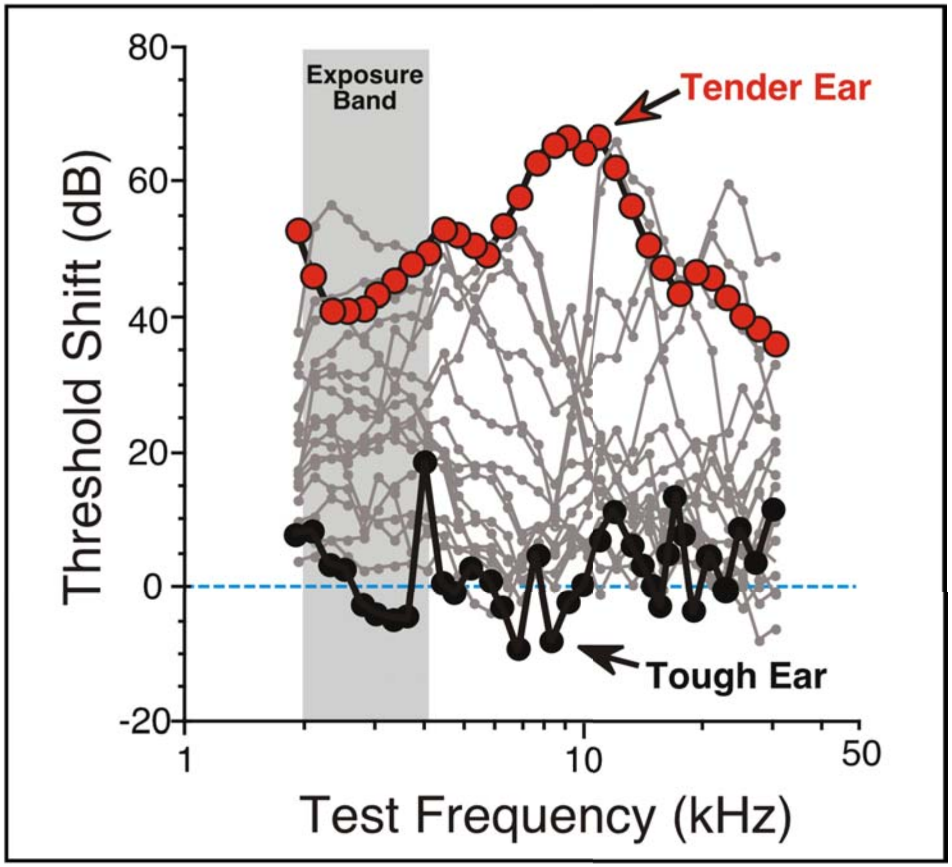
Octave Band Noise



Octave Band Noise



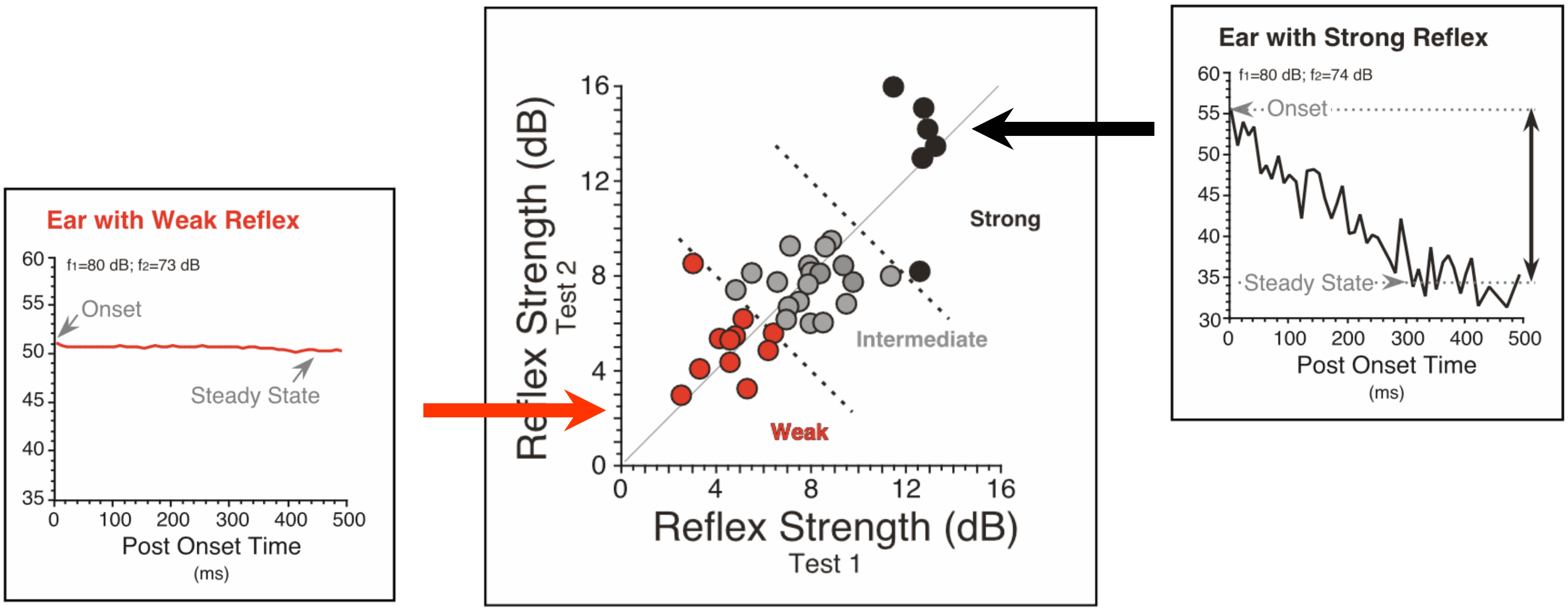
Intersubject Variability in Vulnerability to Acoustic Injury



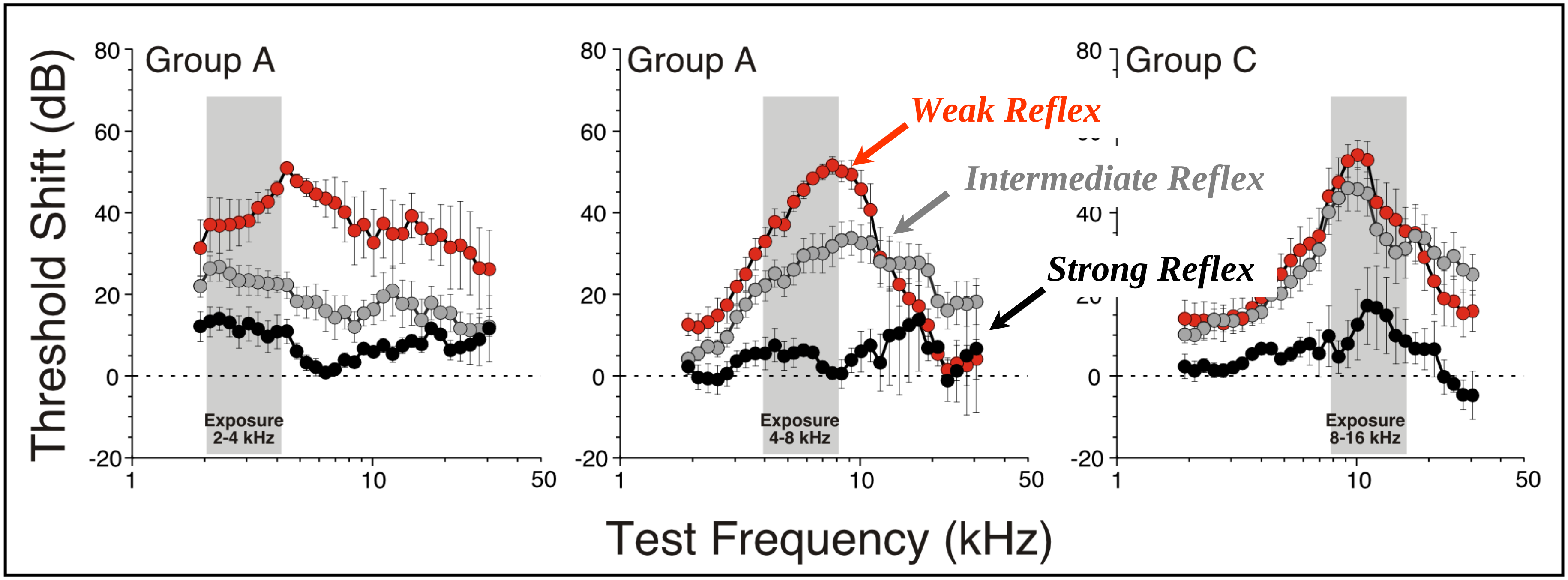
Is Variability due to Differences in MOC Reflex Strength?

Assaying MOC Reflex Strength

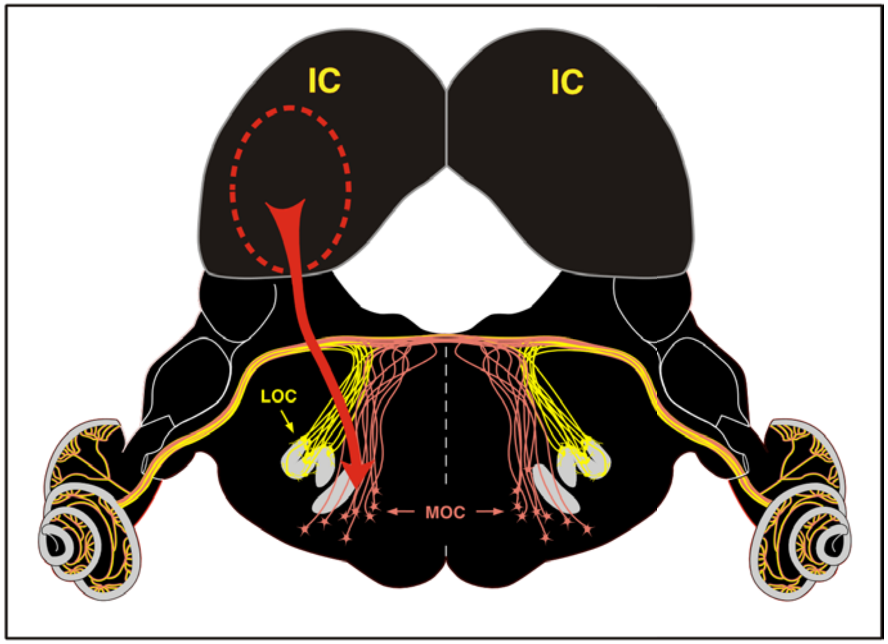
Measure Post-Onset Adaptation in 36 Awake Guinea Pigs

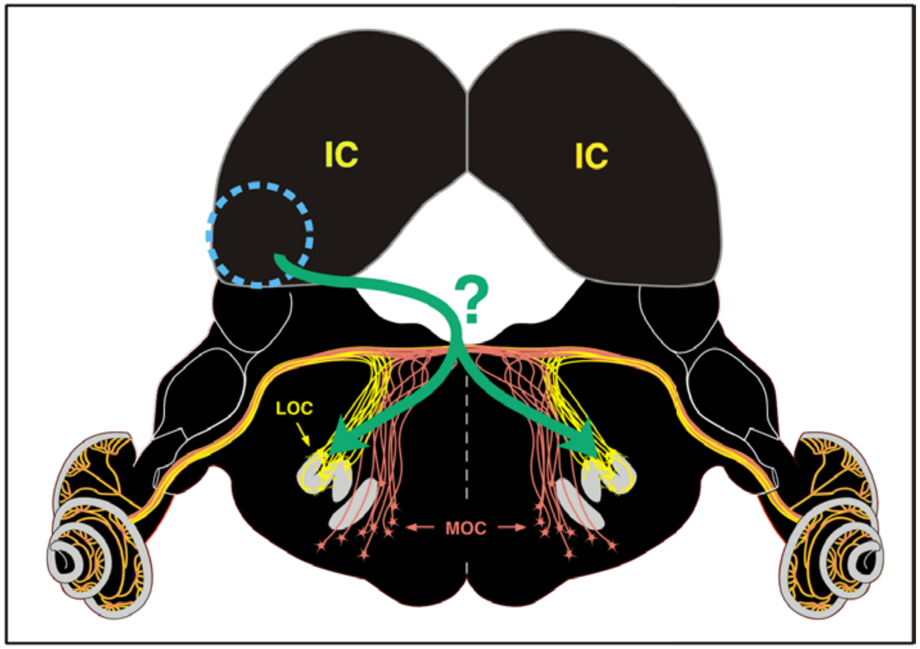


MOC Reflex Strength predicts vulnerability



Activating the LOC via IC stimulation





Activating the LOC via IC stimulation