

University of California
Berkeley

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Department of Electrical Engineering
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EE225D

Spring, 1999

Ear Physiology

Lecture 15

Introduction : Anatomy - OK , Physiology - NOT OK.

- Anatomical Pathway
- Peripheral Auditory System
- Hair Cell → Auditory Nerves
- Auditory Nerve
 - Adaptation
 - Tuning
 - Synchrony
 - Non Linearities
 - Two Tone Suppression
 - Saturation
 - Masking
 - Combination Tones
- Block Diagram of Periphery

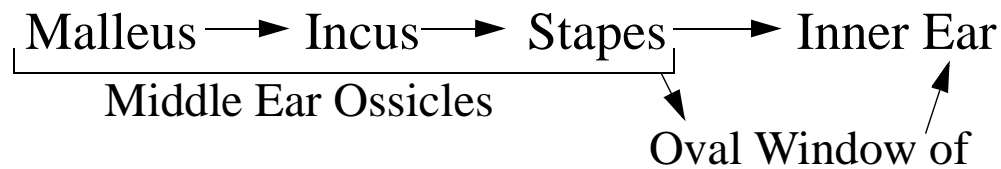
Some Auditory Jargon.

afferent → ascending nerve fibers

efferent → descending nerve fibers

tonotopic → Frequency selectivity vs. place.

{Bank of filters concept}



Innervate — connect to

Cochlea — Inner Ear

- We are somewhat familiar with cochlear nucleus.
- There is also work on auditory neurons in Cortex.

Central Auditory Nucleus	Number of Cells
Cochlear Nuclei	88,000
Superior-Olivary Complex	34,000
Nuclei of Lateral Lemniscus	38,000
Inferior Colliculus	32,000
Medial Geniculate Body (pars principalis)	364,000
Auditory Cortex	10,000,000

Table 14.1 : Cells in the Auditory Nuclei of the Monkey.

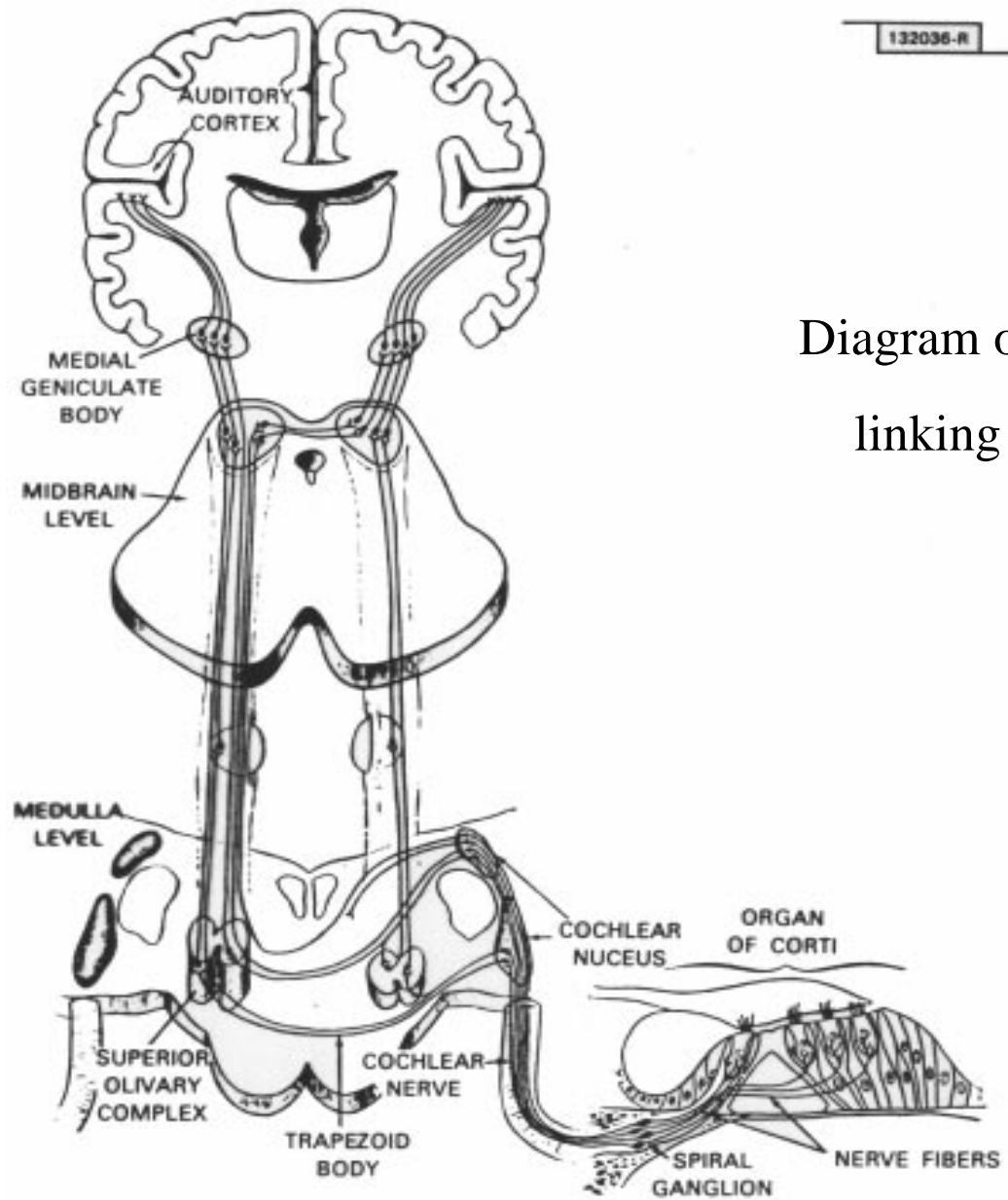


Diagram of the Auditory Pathways
linking the Brain with the Ear.

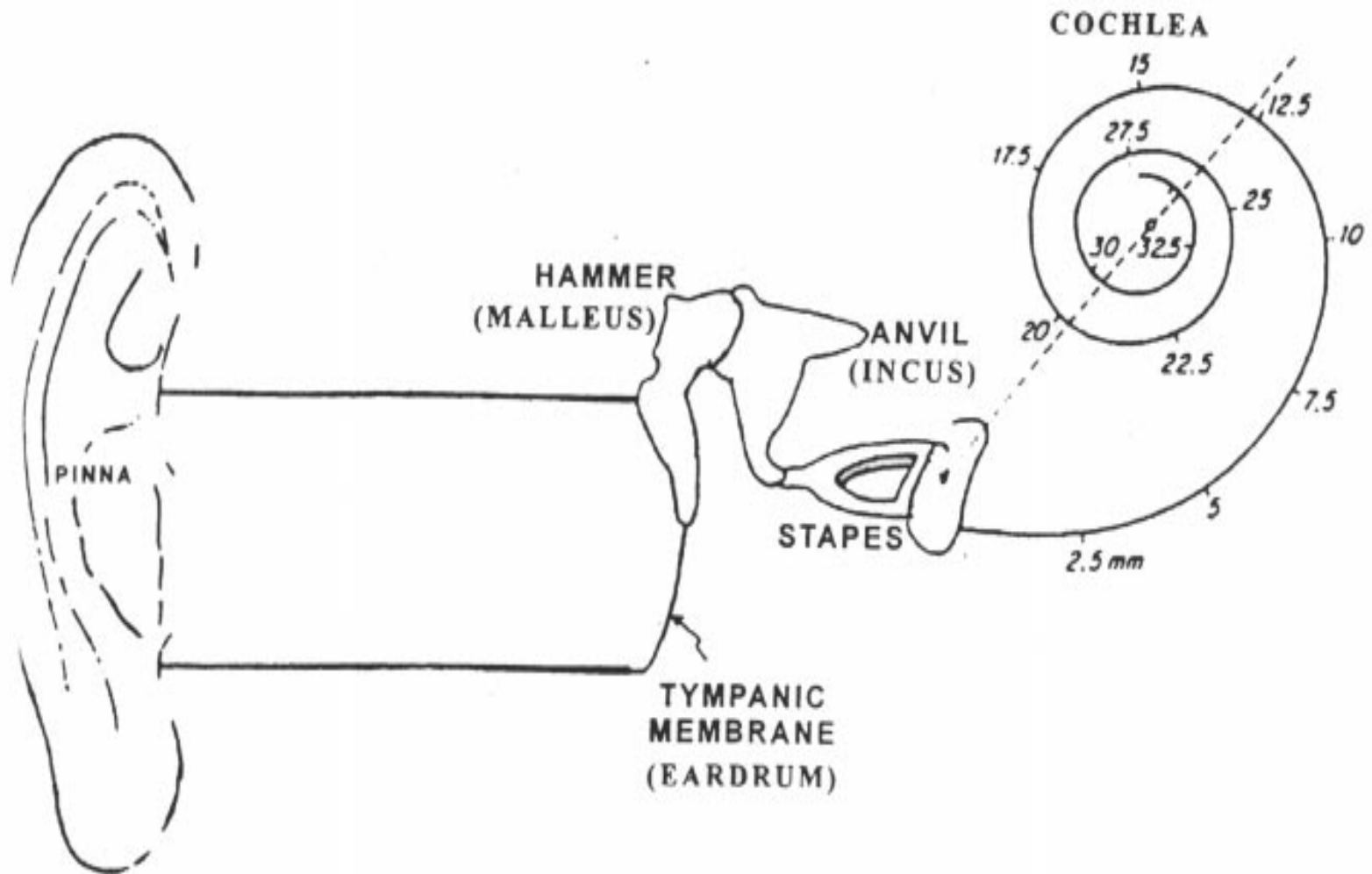
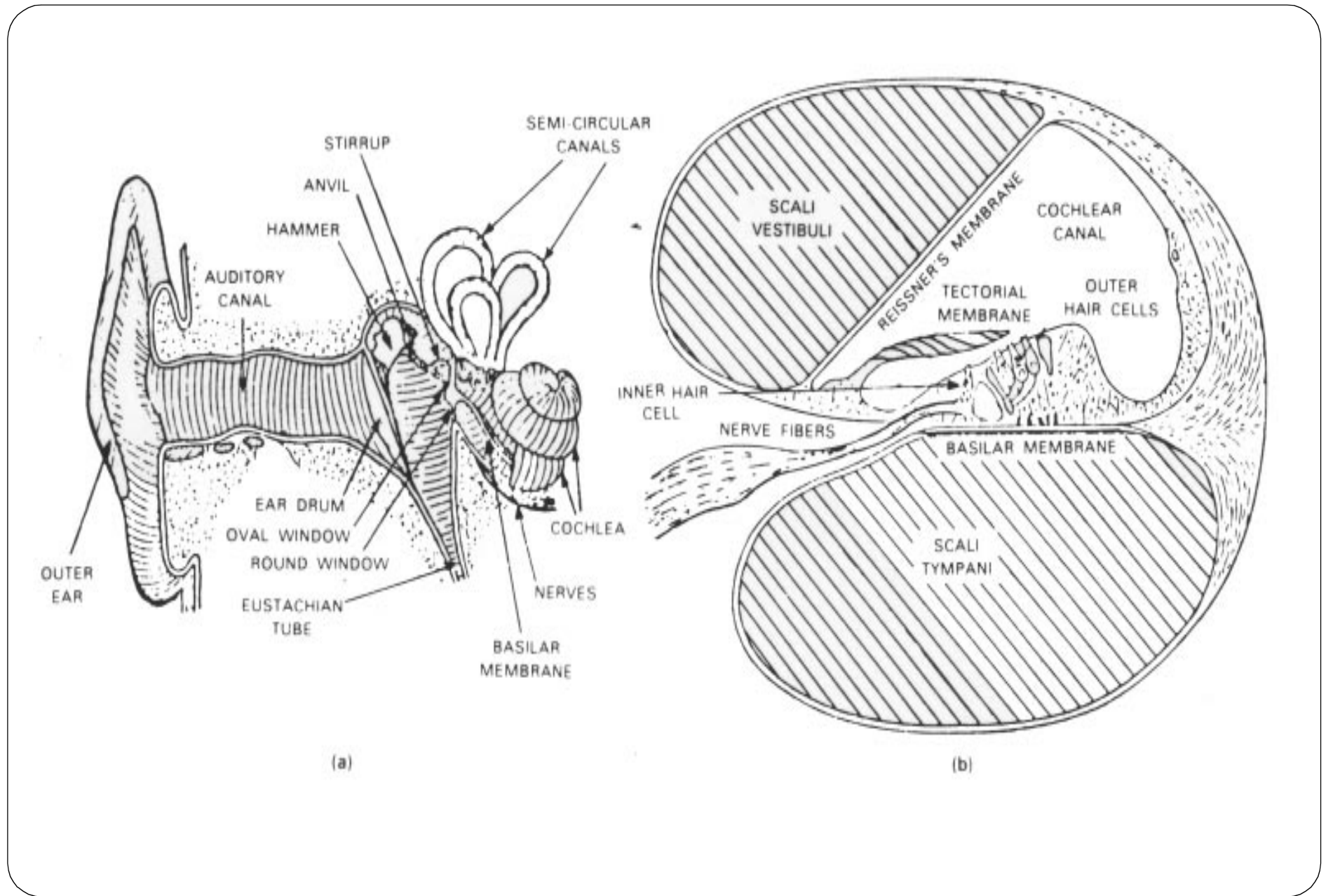
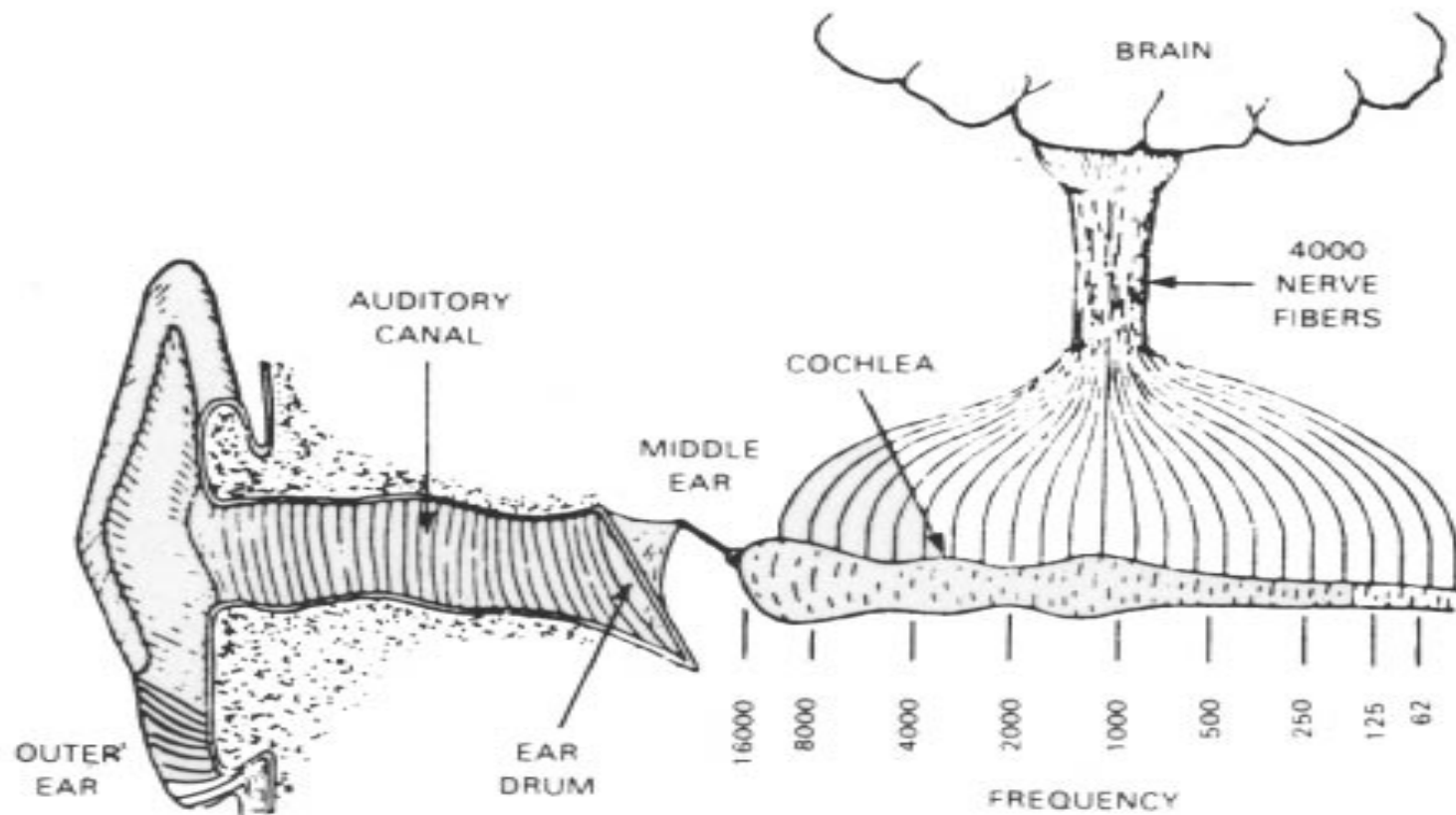


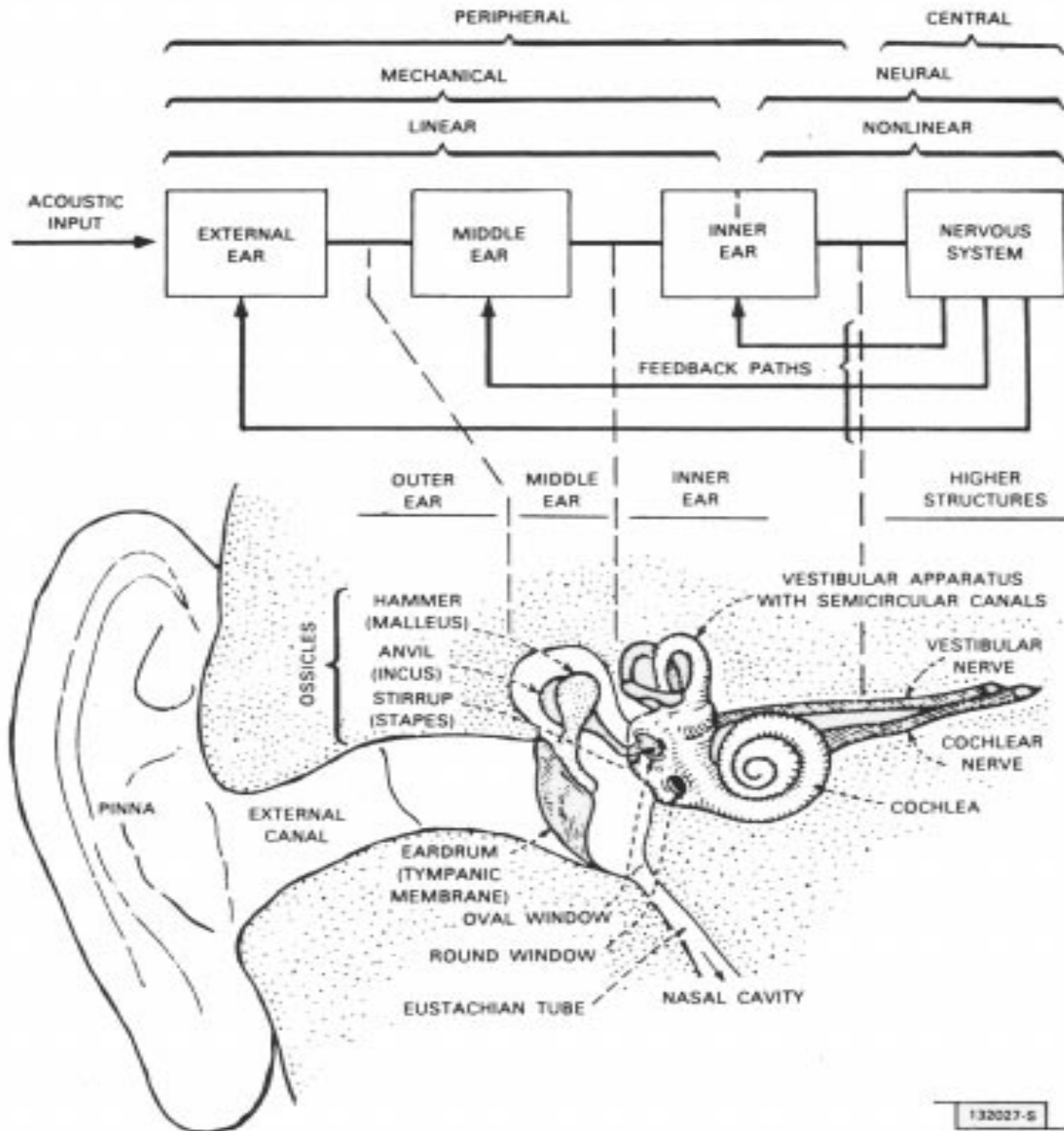
Figure 14.3 : The Peripheral Auditory System.

Boundaries between outer, middle, and inner ears are approximate.

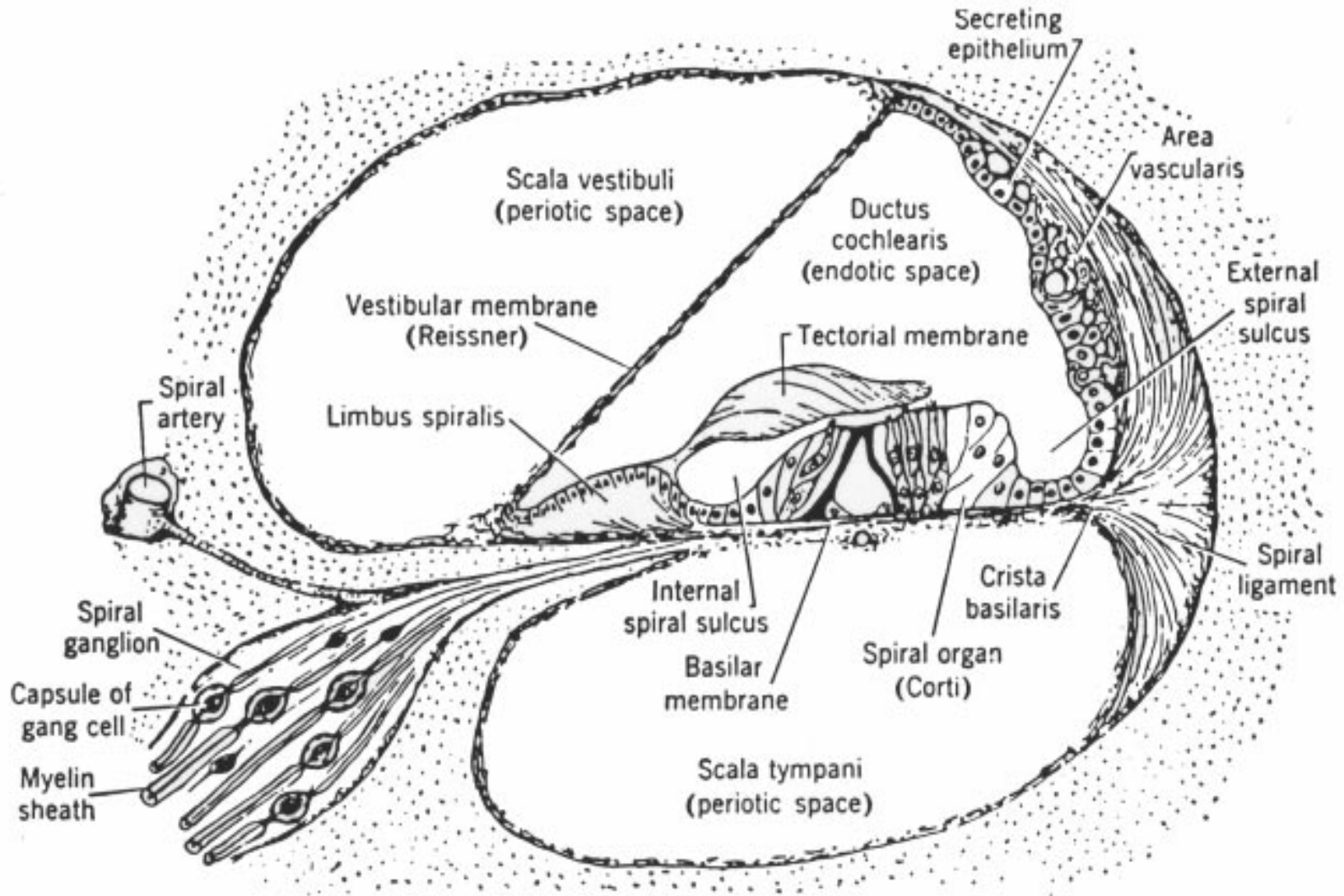




(c)



Block Diagram of Peripheral Auditory System.



We show here a more detailed cross section of the cochlear canal with tectorial membrane, cochlear nerve, basilar membrane, and other structures of significance. (© 1943, Rasmussen.)

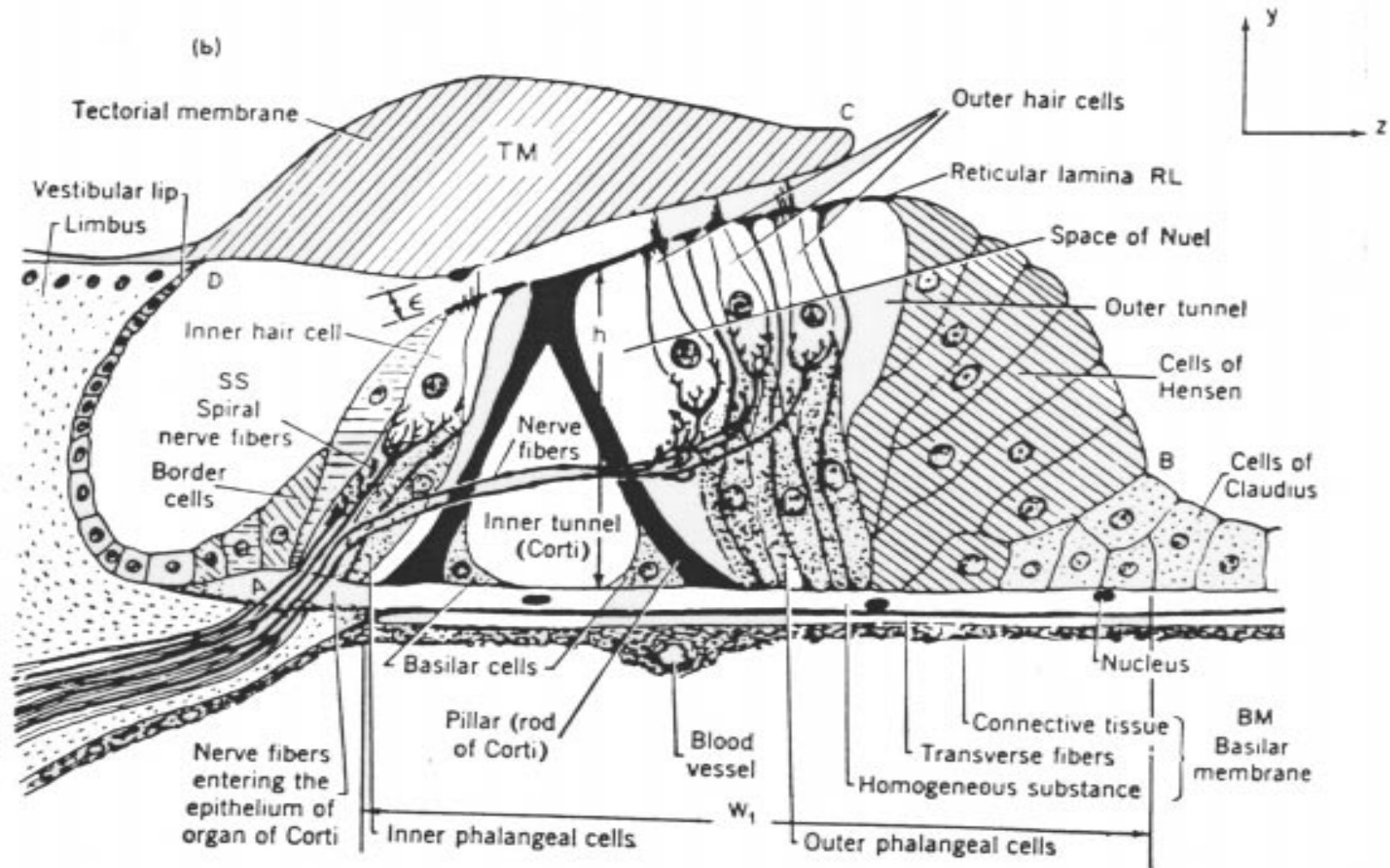


Figure 14.7 : Drawing of the cross-section of the Cochlea.

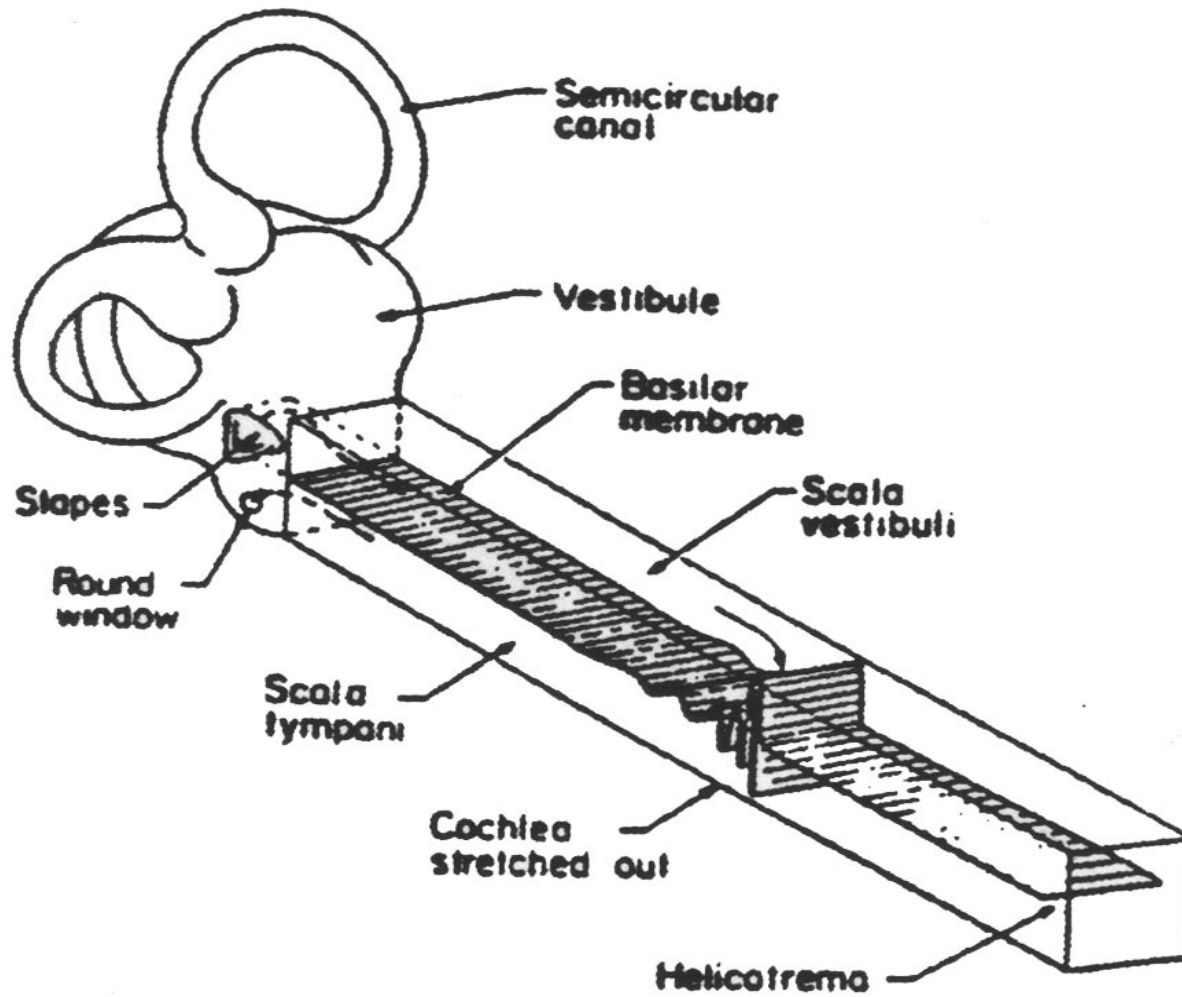
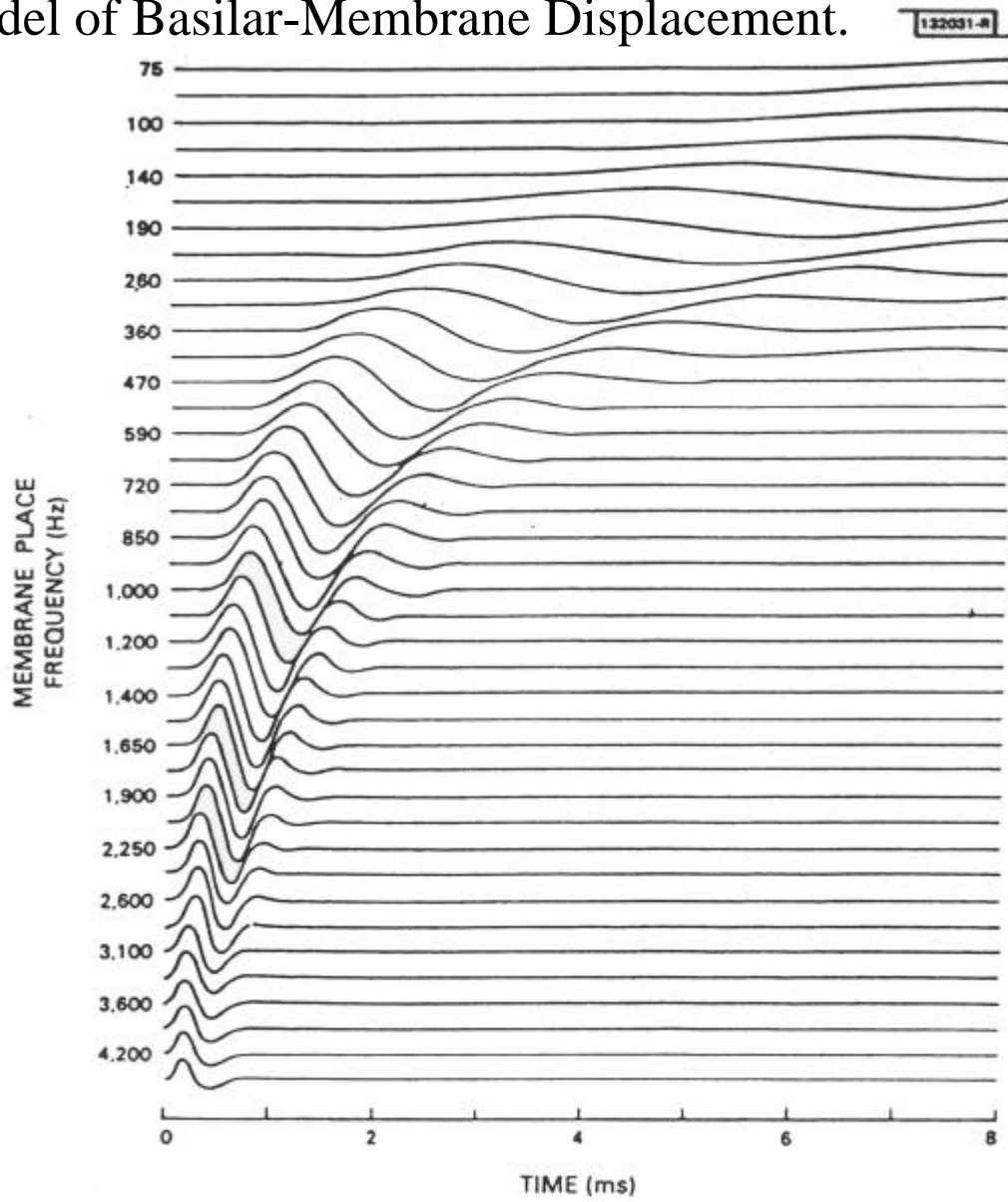
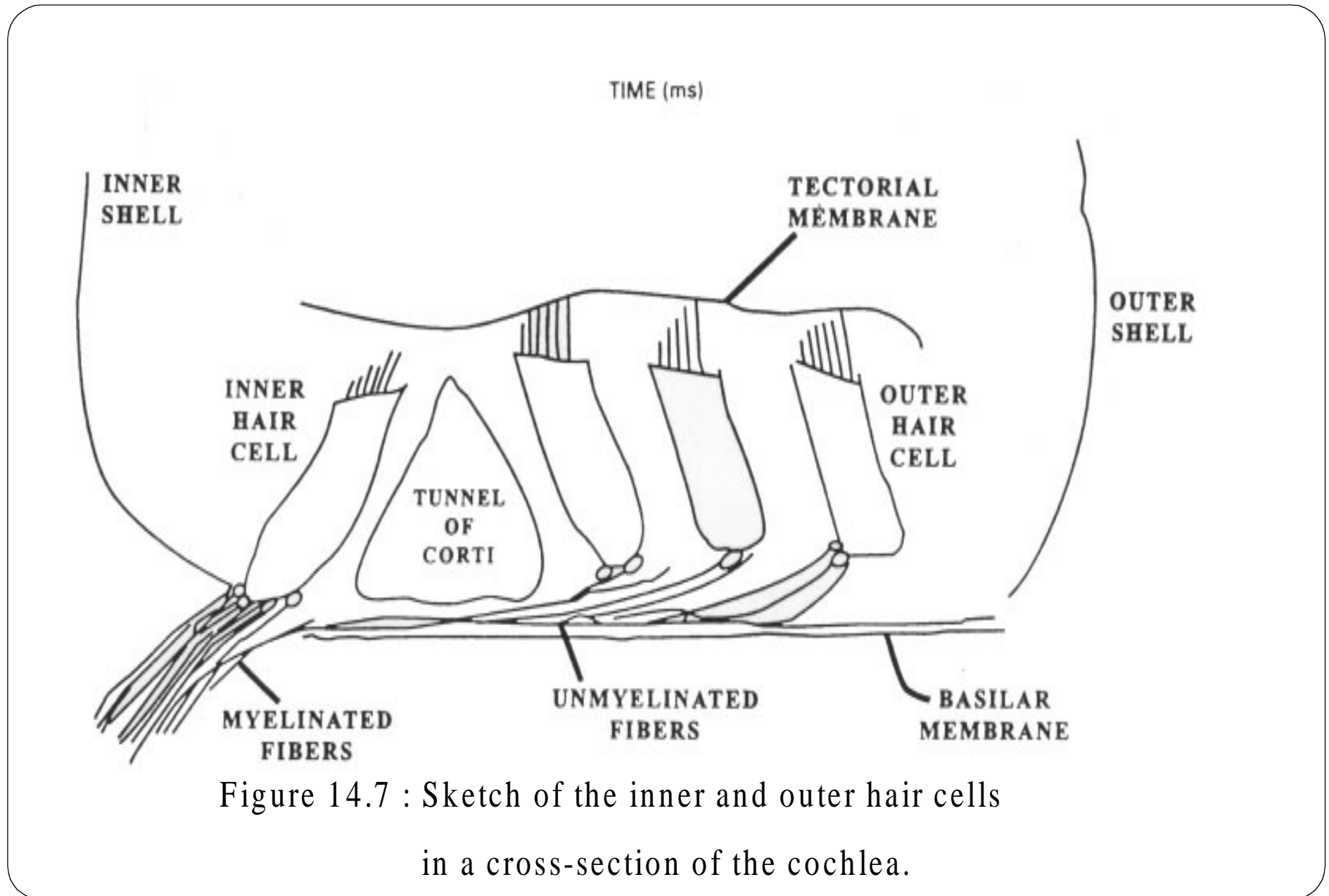


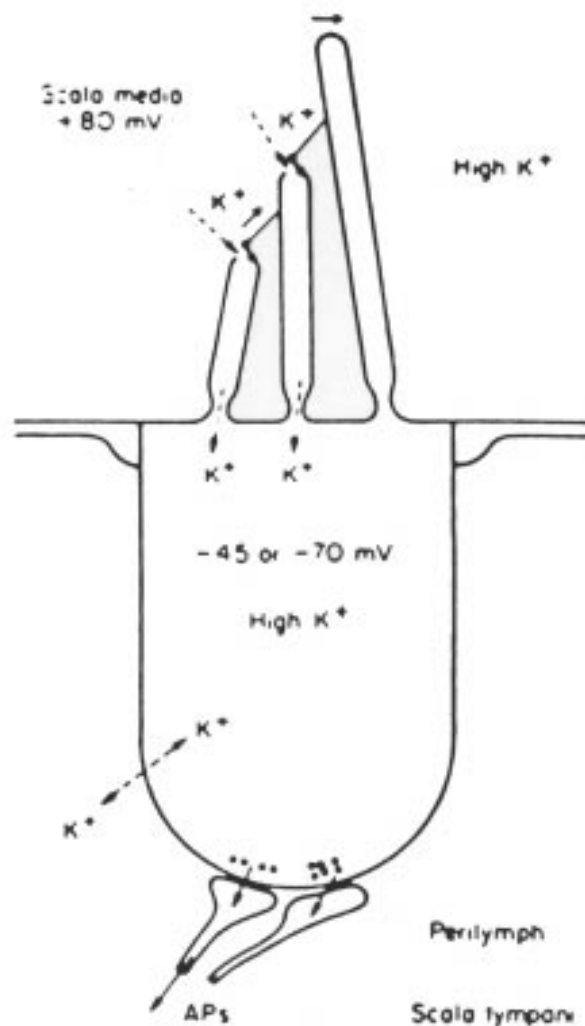
Figure 14.4 : Simplified Model of the Cochlea.

Computer Model of Basilar-Membrane Displacement.





HAIR CELL (Pickles)



Ionic channels in stereocilia open when basilar membrane vibrates.

Potassium ions enter cell, causing depolarization (Voltage increase)

Depolarization opens calcium channels near base of cell.


Influx of calcium releases (Unknown) neurotransmitter.

Neurotransmitter opens channels in afferent nerve fiber.

Sodium flows into fiber, depolarizing fiber.

Depolarization of fiber causes action potential (Spike).

Properties of Auditory Nerves

- Adaptation
- Tuning
- Synchrony
- Non-Linear behavior 
 - Saturation
 - Combination
- Masking

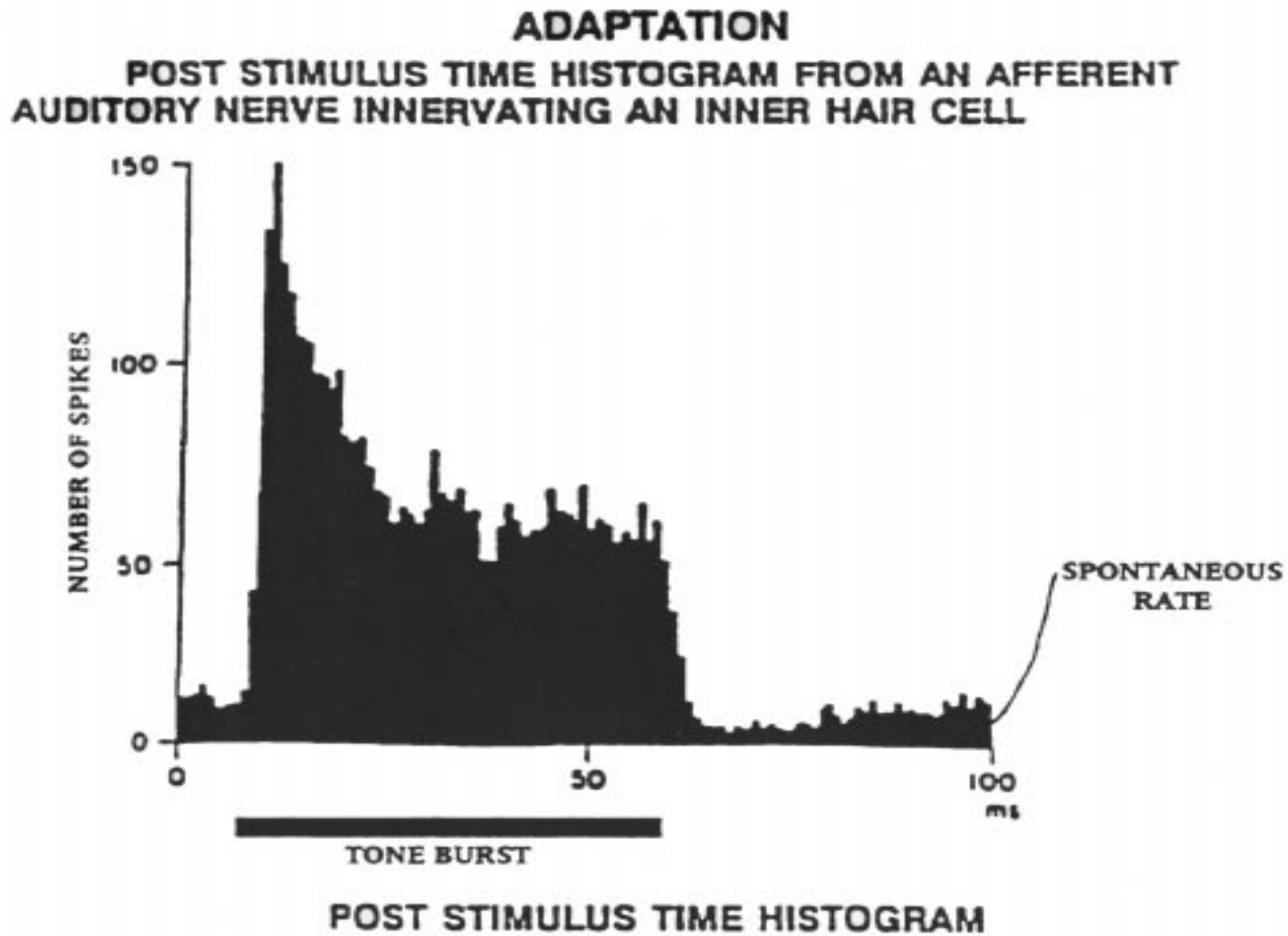
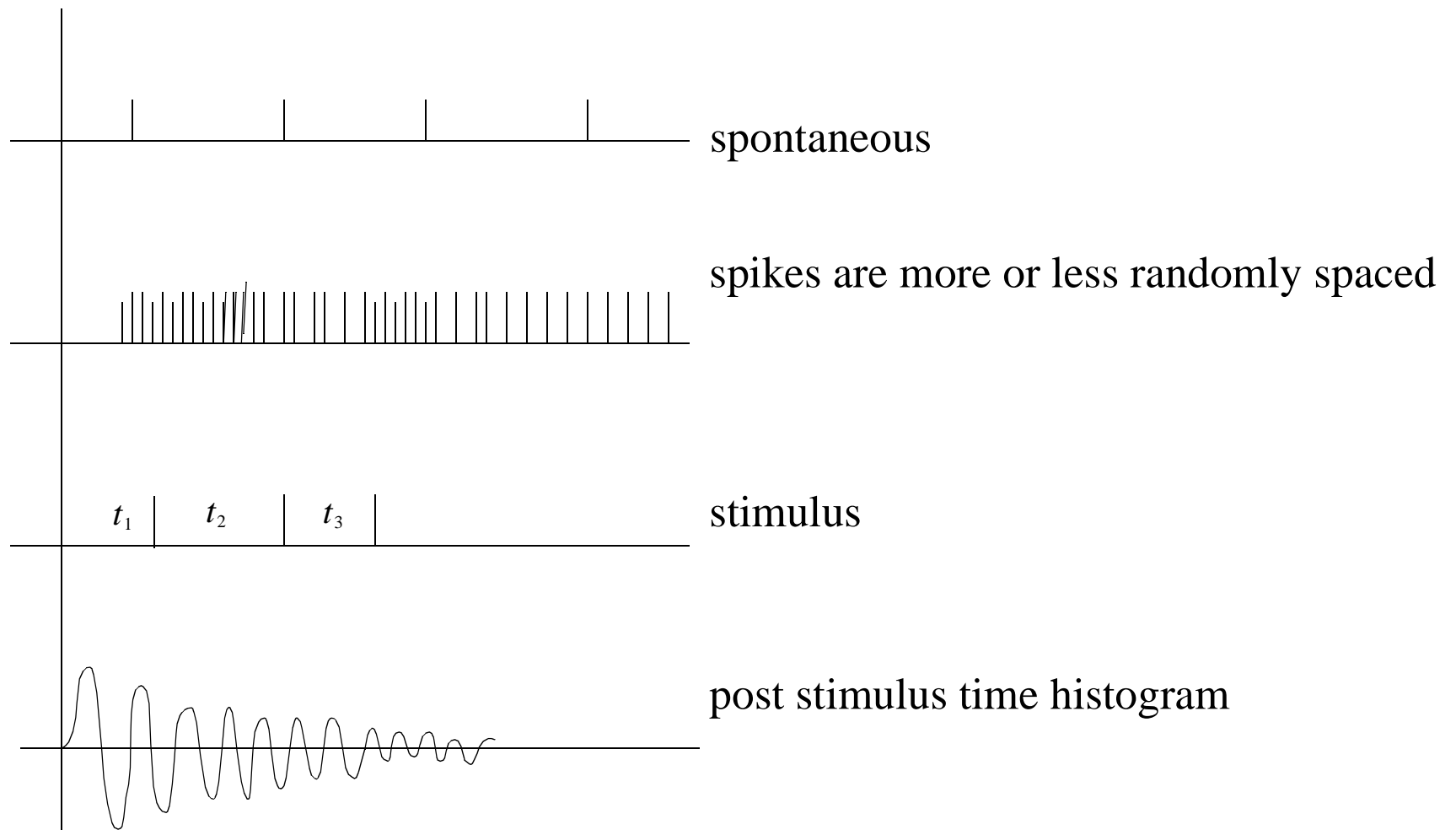
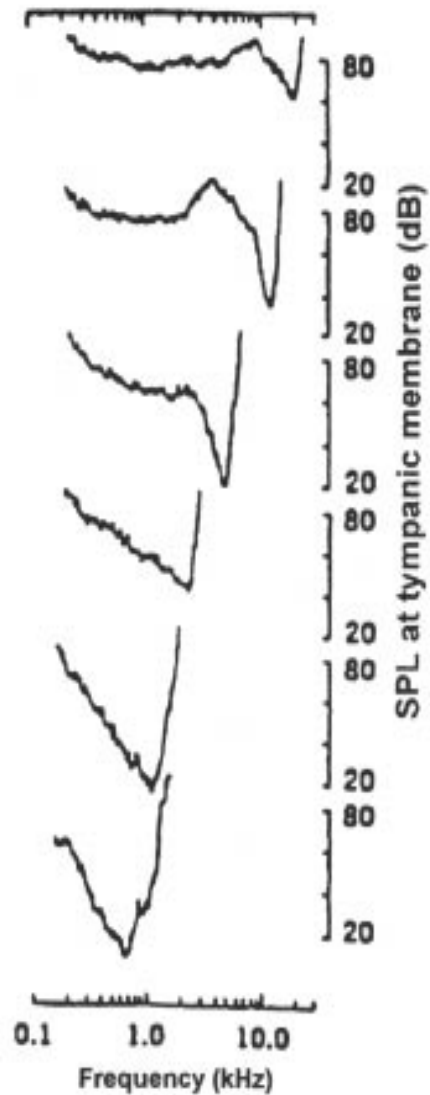


Figure 14.9 : Adaptation by an auditory nerve.





Tuning Curves of Six. Auditory Nerve Fibers. (King & Moxon 1974)

METHOD

1. APPLY 50 MSEC. TONE BURSTS EVERY 100 MSEC.
2. INCREASE SOUND LEVEL UNTIL DISCHARGE RATE INCREASED BY 1 SPIKE/SEC.
3. REPEAT FOR ALL FREQUENCIES