

Traveling Wave Theory
Structural Differences in the BM
Frequency Selectivity by the BM
BM as a Low Pass Filter
Traveling Wave Paradox

When sound hits the ear drum, vibrations are transmitted to the oval window by the three middle ear ossicles, mainly the stapes. These vibrations cause movement of the cochlear fluids and the partitions leading to a displacement of the fluid to the round window. This process initiates a wave displacement on the basilar membrane that travels from the base to the apex of the cochlea. The pattern and position of the wave depend on the frequency of the stimulus, where high frequencies localize and are recognized in the base of the cochlea and low frequencies in the apex of the cochlea.

The base end of the cochlea is narrow and stiff, and the apex is wide and floppy. These structural differences in the basilar membrane are important for frequency recognition because different frequencies reach their point of maximum vibration at different points along the basilar membrane due to its width and elasticity. A neural impulse is generated at the point of maximum vibration and then the amplitude decreases rapidly. Mechanical frequency analysis of the cochlea underlies selectivity of the system.

Frequency selectivity depends on the physical mechanics of the basilar membrane and cochlear fluids and how they interact with the hair cells. Bekesy (1960) noted that vibrations of the stapes gives rise to the traveling wave of displacement on the basilar membrane. His work also showed that frequency selectivity at single points on the basilar membrane was poor with a shallow slope on the low frequency regions and a steep slope at the high frequency regions, and therefore the basilar membrane acts as a low pass filter. This means that the further into the cochlea, the more amplitude lessens after a certain point (represented by a shallow slope). Bekesy's (1960) traveling wave theory explains the perception of pure tones but does not explain cochlear mechanics, such as the nonlinearities.

The traveling wave paradox is that the traveling wave is always going to travel from the base to the apex regardless of whether the cochlea is stimulated from the round window or oval window because of the characteristics of the BM.